Harokopio University
School of Digital Technology
Department of Informatics and Telematics

"Analysis of the intertwining factors underpinning Smart Cities: A Systems Thinking Approach"

A dissertation submitted in partial fulfillment of the requirements for the degree of Master of Science in Informatics and Telematics , with a Specialization in Advanced Information Systems in Business

By S.A. Makris

Athens, 2018

Harokopio University
School of Digital Technology
Department of Informatics and Telematics

Examining Committee

Pericles Loucopoulos Professor of Information Systems

Georgios Dimitrakopoulos, Assistant Professor in the area of Cognitive Wireless Networks and Telematic Applications

Christos Michalakelis, Assistant Professor in the area of Technoeconomic Analysis of Communications Networks and Information Systems

Disclaimer

I hereby declare that this dissertation is my own and autonomous work.

All sources and aids used have been indicated as such.

All texts either quoted directly or paraphrased have been indicated by in-text citations; furthermore, those directly quoted are included in quote marks within which italics are used (for example "*italics*" means the exact phrase used from the source named).

Full bibliographic details are given in the Bibliography section.

I am the copyright owner of this original work and to the best of my knowledge this work does not harm persons in any way or offend the intellectual rights of third parties.

I accept that the Library of Harokopio University may, without changing the content of my work, make it available electronically through its digital library, copy it in any medium and / or any format and hold more than one copy for maintenance and safety purposes.

Athens, Greece

S.A.Makris

In the memory of
Nicos Mammonas (1934-2018)
I miss the endless debates and interpretations of the living experience,
based on language, history and politics I had with him for almost 18 years.

Contents

Summary in Greek-Περίληψη στα Ελληνικά

Αυτή η διπλωματική εργασία αφορά την κατανόηση της έννοιας «Έξυπνη Πόλη» (Smart city) μέσα από την ανάλυση των αλληλοεπιδρώντων παραγόντων που τη διαμορφώνουν ακολουθώντας μια συγκεκριμένη συστημική προσέγγιση. Έτσι, και ακολουθώντας μια μεθοδολογία ερευνητικού σχεδιασμού επιχειρήσαμε:

1. Να προσδιορίσουμε το πρόβλημα και να αναδείξουμε τα κίνητρά μας για την αντιμετώπισή του
2. Να καθορίσουμε τους στόχους μας , η εκπλήρωση των οποίων θα μας φέρει κοντύτερα στην κατανόηση του προβλήματος
3. Τη δημιουργία μιας θεωρητικής κατασκευής, εν τέλει μιας θεωρίας, μέσω της οποίας μια θα καταστεί εφικτή η κατανόηση της έξυπνης πόλης

Στην προσπάθεια προσδιορισμού της έννοιας «Έξυπνη πόλη» επιχειρήσαμε μια βιβλιογραφική αναζήτηση σε μια σειρά από ακαδημαϊκά άρθρα ή σε κείμενα εταιρειών ή κυβερνήσεων ή διεθνών οργανισμών με ενδιαφέρον γύρω από το θέμα για να κατανοήσουμε τα βασικά ζητήματα και τα ευρήματα στον τομέα της «Έξυπνης πόλης» όπως αυτά εμφανίστηκαν στο δημόσιο διάλογο τα τελευταία 25 ή περισσότερα χρόνια.

Η έρευνα της βιβλιογραφίας αποκάλυψε ότι η «Έξυπνη πόλη» έχει μελετηθεί κυρίως:

- Ως ένας τομέας εφαρμογής των Τεχνολογιών Πληροφορικής και Επικοινωνιών μέσω των οποίων βασικές λειτουργίες της πόλης αναμένεται να τροποποιηθούν προς το συμφέρον της πόλης και των κατοίκων της.
- Ως μια νέα ατζέντα διακυβέρνησης / διαχείρισης ή μάρκετινγκ που διεξάγεται σε ολόκληρο τον κόσμο και στην οποία από την πλευρά τους συμμετέχουν ένας αυξανόμενος αριθμό ερευνητών στον ακαδημαϊκό χώρο, επιχειρήσεις αλλά και κυβερνητικές αρχές σε τοπικό ή κεντρικό επίπεδο και διεθνείς οργανισμοί.
- Ως μια νέα φάση στον μετασχηματισμό του καπιταλισμού, που αφορά τουλάχιστον στη χωρική του διάσταση

Η βιβλιογραφική έρευνα και μελέτη ανέδειξε επίσης το γεγονός ότι η «Έξυπνη πόλη» αποδείχθηκε περισσότερο "έξυπνη" και λιγότερο "πόλη", καθώς κανένας σύνδεσμος ή αντιστοίχιση ή μια προσπάθεια ένταξης με αδρό έστω τρόπο σε κάποια θεωρία για το Αστικό πλαίσιο δεν προσφέρεται στη βιβλιογραφία. Η πόλη είναι «κάτι εκεί έξω», και πάντως *υπάρχει* και ουσιαστικά θεωρείται ως το κέλυφος στο οποίο προστίθεται η

διάσταση της Τεχνολογίας η οποία και μετατρέπει την πόλη σε «Έξυπνη πόλη». Μολονότι ένας αριθμός από τις πηγές που μελετήθηκαν ασχολείται με την παρουσίαση της πόλης ως ένα «σύστημα από συστήματα» και χρησιμοποιεί συστημική σκέψη στη θεώρηση της «Έξυπνη πόλη», η συστημική σκέψη αποτελεί ακόμα μειοψηφία στο υπό μελέτη ερευνητικό πεδίο.

Έχοντας υπόψη τα παραπάνω, ο δρόμος που ακολουθήσαμε στη συγκεκριμένη διπλωματική εργασία υπήρξε διαφορετικός: Καταρχάς αναζητήσαμε και χρησιμοποιήσαμε μια Θεωρία της Πόλης ή του Αστικού πλαισίου. Το Αστικό πλαίσιο έχει προσεγγιστεί μέσα από το φακό μιας συγκεκριμένης αστικής θεωρίας (αυτής του Henri Lefebvre όπως παρουσιάζεται στα βιβλία του Η Αστική Επανάσταση (The Urban Revolution) και Η Παραγωγή του Χώρου (The production of Space)). Χρησιμοποιήσαμε επίσης και μια συγκεκριμένη προσέγγιση της θεωρίας των συστημάτων, συγκεκριμένα τη Μεθοδολογία των Ήπιων Συστημάτων του P.Checkland (Soft Systems Methodology ή SSM) προκειμένου να κατανοήσουμε τους παράγοντες που αλληλοεπιδρούν και που τελικά αυτή τους η αλληλοεπίδραση παράγει την πόλη (και φυσικά την «Έξυπνη πόλη») ως κοινωνικό σύστημα. Ήταν επιλογή να ερμηνεύσουμε την «Έξυπνη πόλη» "ως τρόπο μάθησης για το Αστικό πλαίσιο" και ακόμη και η οντολογική προσέγγιση που επιχειρούμε αδρά στο κεφάλαιο 6 συμβάλλει ακριβώς σε αυτό: **σημασία έχει η διαδικασία με την οποία όσοι συμπράττουν στη δημιουργία της πόλης πραγματοποιούν αυτή τη σύμπραξη και ποιο είναι το μαθησιακό αποτέλεσμα αυτής της διαδικασίας, πως η μάθηση αλλάζει την πόλη ως κοινωνικό σύστημα** . Τέλος, χρησιμοποιήσαμε μια θεωρία της μάθησης, δηλαδή τη Θεωρία της Δραστηριότητας (Activity Theory), ως μια ενιαία προσέγγιση που συνδυάζει τη μεθοδολογία σκέψης των συστημάτων (κύκλοι διαπραγμάτευσης μεταξύ των εταίρων (Stakeholders) της πόλης μέσω της μεθοδολογίας ήπιων συστημάτων) και τη θεωρία του Lefebvre για την παραγωγή του Αστικού Χώρου. Αυτό μας οδήγησε τελικά στη διατύπωση ότι η "έξυπνη πόλη" είναι μια «πόλη της μάθησης» (Mathesipolis): δηλαδή είναι ένα αστικό περιβάλλον στο οποίο η μάθηση συμβάλλει στη διαδικασία της αλληλεπίδρασης μεταξύ των εταίρων της πόλης και το αποτέλεσμα αυτής της αλληλοεπίδρασης είναι η εμφάνιση νέων συστημάτων ανθρώπινης δραστηριότητας τα οποία είναι ικανά να επιτύχουν αυτό που ο Habermas αναφέρει ως επικοινωνιακή μάθηση ή ενσυναίσθηση.

Λέξεις κλειδιά: «Έξυπνη πόλη» (Smart city), «Μεθοδολογία των Ήπιων Συστημάτων» (Soft Systems Methodology), Henri Lefebvre, «Θεωρία του Αστικού πλαισίου» (Urban Theory), «Θεωρία Δραστηριότητας» (Activity Theory), «μάθηση» (learning)

Summary in English

This dissertation is about the understanding of Smart City through the intertwining factors that underpin and form it. Following a design research methodology we have

1. Identified the problem and our motivation in dealing with it
2. Defined the objectives for a solution and
3. Created a theory artifact to create a domain understanding of the smart city notion

In the attempt to identify the notion we conducted a literature search to understand the main issues and findings in the Smart City field as they have emerged in the last 25 or more years. The literature survey revealed that Smart City has been thought primarily:

- As an ICTization of core city functions
- As a new governance/management or marketing agenda pursued around the Globe by an increasing number of researchers in academia, corporate businesses, government authorities at local or central level and international institutions.
- As a new phase in the transformation of capitalism at least in the spatial dimension

At the same time smart city proved to be more of the "smart" species and less than the "city" one as the literature provided no link or adherence to an Urban context. Implicitly, Urban has been thought to be a "container" in which "smartness" was unfolding. Systems thinking has also been a minority of the work done in the field.

Therefore the road we have travelled had been a different one: Urban context has been approached through the lens of a specific Urban theory (Henri Lefebvre's theory as in Urban Revolution and the Production of Space) and a specific systems thinking approach, namely Soft Systems Methodology in order to produce an understanding of the intertwining factors that produce Urban and of course Smart Urban. It has been our choice to interpret smartness "as a way of thinking about the Urban" and even the ontological approach has also contributed to that. Finally we have employed a theory of learning, namely the Activity Theory, as a unified approach that couples the systems thinking methodology (the Soft Systems Methodology cycle augmented with an ontology representation) and the Urban theory of Lefebvrian production of Space. This has ultimately led the "smart city" to the Mathesipolis approach: that is an Urban context informed with learning in the process of making as learning informed parts of it (ie

Stakeholders networked in Human Activity Systems) interact to achieve communicative learning or empathy.

Keywords: Smart city, Soft Systems Methodology, Henri Lefebvre, Urban Theory, Activity Theory, learning, Mathesipolis

List of abbreviations (and a vocabulary of Greek origin words used)

AR for Action Research

AT for Activity Theory

GST for General Systems Theory

GMP for Global-Mixed-Private

HAS for Human Activity System

ICT is an acronym for Information Communication Technologies

LST for Living Systems Theory

l-c-p or lcp for lived-conceived-perceived (the Lefebvrian triad of Space)

SC for Smart City

SCC for Smart City Concepts

SSM for Soft Systems Methodology

STEM is an acronym for "Science Technology Engineering Mathematics"

and the vocabulary

exetasis means "examination", "examining"

exelixis means "development"

mathesipolis is "a learning city", a "learning polis"

neotita means "youthfulness"

panacea means "a solution or remedy for all difficulties or diseases"

syneidesis means "consciousness" or "acquire consciousness"

theasis means "an angle of view"

«Πολιτικά» και «Μετά τα φυσικά» are works of Aristotle "Politics" and "Metaphysics"

List of tables

List of figures

This page intentionally is left blank

Chapter 1: Introduction

1.1 Context

For more than 25 years, a streaming of scientific (and not only scientific) articles surfaced, to bring light to a new field of research: That of "smart city" or "digital city" or "ubiquitous city" or "wired city" or….to declare a few of the names used to define this field. While, as Angelidou suggests, (Angelidou, 2015) economic, social and geographical structure of cities was always in line with the underlying system of production, this fact itself did not, hopefully in a way, deter the utopian visions of city or the utopias of ideal futures to be an important part of the urban theory collection.

"**Smart city notion**" reflects today the "establishment" of technology as an entirely independent system, placed along the systems of economic activity and socio-political actions and through which this new notion is been sculptured. A proof of the "*neotita*" (ie the youthfulness) of the notion "smart city" is the weakness implied earlier of a commonly accepted definition of smart city: Nam and Pardo (Nam & Pardo, 2011) provide us with a matrix of 7 different definitions:

Table 1 Definitions of Smart City

Reference	Definition
(Washburn & Sindhu, 2009)	The use of smart computing technologies to make the critical infrastructure components and services of a city-which include city administration, education, healthcare, public safety, real estate transportation and utilities- more intelligent, interconnected and efficient.
(Giffinger et al., 2007)	A city well performing in a forward-looking way in economy, people, governance, mobility, environment and living built on the smart combination of endowments and activities of self-decisive, independent and aware citizens.
NRDC	A city striving to make itself "smarter" (more efficient, sustainable, equitable and livable).
(R. E. Hall et al., 2000)	A city that monitors and integrates conditions of all of its critical infrastructures, including roads, bridges, tunnels, rails, subways, airports, seaports, communications, water, power, even major buildings, can better optimize its resources, plan its preventive maintenance activities, and monitor security aspects while maximizing services to its citizens.
(Colin Harrison & Donnelly, 2011)	An instrumented, interconnected and intelligent city. *Instrumentation* enables the capture and integration of live real world data through the use of sensors, kiosks, meters, personal devices, appliances, cameras, smart-phones, implanted medical devices, the web and other similar

	data- acquisition systems, including social networks as networks of human sensors. *Interconnected* means the integration of those data into an enterprise computing platform and the communication of such information among the various city services. *Intelligent* refers to the inclusion of complex analytics, modelling, optimization and visualization in the operational business processes to make better operations decisions.
(Rios, 2012)	A city that gives inspiration, shares culture, knowledge and life, a city that motivates its inhabitants to create and flourish in their own lives.
(Partridge, 2004)	A city where the ICT strengthen the freedom of speech and the accessibility to public information and services.

While a series of different literature reviews (eg (Albino, Berardi, & Dangelico, 2015) , (Hunt, Rogers, & Cavada, 2014) to name a few) offer a plethora of hundreds of definitions. Cocchia in (Cocchia, 2014) offers a range of definitions that finds out to be most cited ones.

Table 2 Definitions of smart city, on most cited papers, source: (Cocchia, 2014)

Reference	Definition
(Giffinger et al., 2007)	"A Smart City is a city well performing built on the 'smart' combination of endowments and activities of self-decisive, independent and aware citizens"
California Institute[1]	"A smart community is a community that has made a conscious effort to use information technology to transform life and work within its region in significant and fundamental rather than incremental ways"
(Caragliu, Del Bo, & Nijkamp, 2011)et al.	"A city to be smart when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance"
IBM (2010) (C. Harrison et al., 2010)	"Smart city is defined by IBM as the use of information and communication technology to sense, analyze and integrate the key information of core systems in running cities"
(Su, Li, & Fu, 2011)	"Smart City is the product of Digital City combined with the Internet of Things"
Northstream[2]	"Concept of a Smart City where citizens, objects, utilities, etc., connect in a seamless manner using ubiquitous technologies, so as to significantly enhance the living experience in 21st century

[1] Although this definition is cited in many articles there is no mentioning of an explicit source (article or other document) that was first appeared. Additionally the site that many researchers point seems (on June 2018) to have been discontinued.

[2] See previous footnote on California Institute

	urban environments"
(P. Hall, 2000)	"A city that monitors and integrates conditions of all of its critical infrastructures, including roads, bridges, tunnels, rails, subways, airports, seaports, communications, water, power, even major buildings, can better optimize its resources, plan its preventive maintenance activities, and monitor security aspects while maximizing services to its citizens"
(Dameri, 2013)	"A smart city is a well-defined geographical area, in which high technologies such as ICT, logistic, energy production, and so on, cooperate to create benefits for citizens in terms of well-being, inclusion and participation, environmental quality, intelligent development; it is governed by a well-defined pool of subjects, able to state the rules and policy for the city government and development"

A particular aspect of these definitions is the use of language in them. "Smart city *is*" reveals a tendency to think about it as an object rather than as a process. Needless to say that "smart city is" simply cannot be. "Smart city may be" or "a city would be smart if" are statements closer to reality. The use of present tense here reveals enthusiasm and admiration for the object of consideration and that is not necessarily good or bad.

But as one goes deeper to the core of the new field an intriguing characteristic comes to light: the weakness of this new notion to bind itself with an existing theory of the urban or, better, to be the cause of a new urban theory. Smart city, rooted in the ICT community is more of a "smart" and less than "city". City is taken for granted or at best as the container for smart. In a sense, smart city is a new layer of something that aims to change but neglects to carefully consider it.

While this lack of "cityness" is a given fact, as researchers from a variety of academic fields enter in, the dimensions that link to the city explode. Even more interestingly governing at an era of smartness becomes an evident new approach as pointed out for example in (Anthopoulos & Vakali, 2012) and (Meijer & Bolivar, 2015) or Linders (Linders, 2012). Paul Mason in article written for Guardian (25/10/2015)[3] points two issues concerning the use of ICT to achieve smartness:

[3] https://www.theguardian.com/commentisfree/2015/oct/25/we-cant-allow-the-tech-giants-to-rule-smart-cities accessed 22/5/2018

(i) *Who* is the owner of data, patterns or habits of citizens that are freely generated by them as they live in the city; data that are also freely captured and utilized as "big data" by a grid of organizations whose objectives are not transparent

(ii) Instead of using new ICT to tackle problems of city in an old-fashioned manner Paul Mason calls for *"the first deployment of new technology should allow citizens to 'raise issues of corruption, equity in the distribution of resources and open the question of access to power' "*.

Another issue quite apparent at the field is that Systemic Theory has not yet embraced the study of smart city per se at this point in time. Despite that a number of authors are dealing with what they call "city domains" ((Neirotti, De Marco, Cagliano, Mangano, & Scorrano, 2014) and their taxonomy in an effort to understand the domains which finally become candidate systems in a systems thinking approach. Tsolakis and Anthopoulos in (Tsolakis & Anthopoulos, 2015) also think in a systemic way by examining via system dynamics methodology different Systems of Systems in an ecocity context. Finally , in an ontological attempt Komninos et al ((Komninos, Bratsas, Kakderi, & Tsarchopoulos, 2015) are examining the influence of already in place smart solutions in areas as transport and energy. There are more exceptions: Harisson et al (Colin Harrison & Donnelly, 2011) think systemically and present a layered systemic representation of city (see paragraph 2.4 for a more detailed presentation of their ideas). Fernández-Güell et al (Fernández-Güell, Guzmán-Araña, Collado-Lara, & Fernández-Añez, 2016) (as found in (Alba, Chicano, & Luque, 2017)) declare "*Cities, understood as complex systems, are adaptive as they evolve and are not readily predictable because they do not necessarily act in a deterministic fashion. Compared to other functional systems, cities have some distinctive features that should be taken into consideration. The change process in the city is not sequential (one thing directly affecting another), but rather simultaneous (many things happening at the same time). The city is a functional system with a heavy inertia, so there are limits to a city's ability to accelerate or slow down the pace of change. Cities are immersed in a space configured by infrastructures and natural features, all of which influences its functional dynamics. Finally, such a complex system is constantly reacting to external changes, so cities strive to adapt or dominate them, otherwise, they decline"*.

They also provide a Conceptual Model of their thinking as below (they call it the integrated model for Smart Cities initiatives).

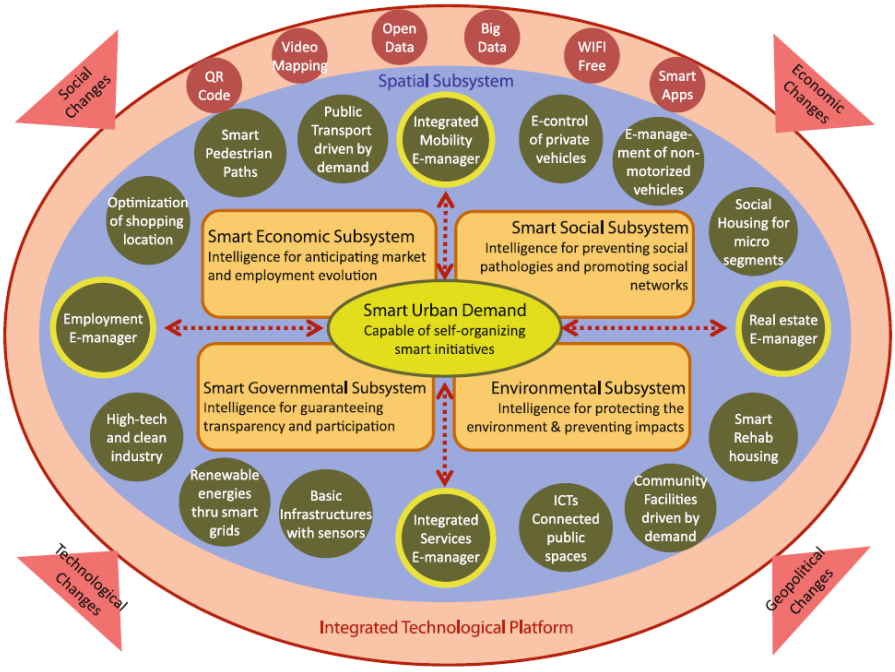


Figure 1 City as Urban and Systems of Systems source:(Fernández-Güell et al., 2016)

Therefore, the discussion of smart city, the different implementation attempts around the globe (Angelidou in (Angelidou, 2017) for further insight) are primarily based on new technologies (from street level applications to elaborate Information Systems) as drivers of smartness, of what smart actually is (or is meant to be). While other aspects closer to the city are surfacing (as for example the question of how this smartness movement may change governance), smartness remains without an anchor to an Urban theory and (more surprisingly) to a distance from systemic thinking. Despite the fact that there is an understanding of the interconnections of different city domains the move to describe those domains through systemic lens is a road not yet travelled. Needless to say, smart city is, clearly, a marketing agenda, used to pursue objectives at the firm or the market level and at a governance level that is susceptible to it.

1.2 Motivation

Much of the motivation of this dissertation (for studying the notion of smart city through the lens of systemic theory) is probably already been implied. Examining smart city from a System of Systems (SoS) perspective combined with an underlying Urban theory (although a whole chapter deals with former (chapter 3, Foundations to approach I - Systems thinking and Soft Systems Methodology) and a paragraph (2.5) with the latter) needs an initial stating here.

To start with:

The establishment of such a macro-level approach emerges as a result of the following:

1. Smart city is a child of city, of Polis and as such emerges within the living ecosystem of it. A macro view will provide –hopefully- of answers of the status and the moments of this new exelixis. Is "smart city" an emergent property of the systems comprising the urban activity of capitalism? Is it natural and self-organized or driven and manipulated? Comes to an answer to…or happens as a diffusion of knowledge. Does it creates inclusion or sets new boundaries of exclusion? And the motivation questions can go on infinitely. An Urban theory on the other hand reveals preferences (at a political or a social level) and sets the systemic thinking methodology in the context of those preferences.
2. City and therefore anything that relates to it (as smart) is a "geography of systems" and itself appears in today's capitalistic phase as the battleground of networks of economic activities, social and political actions and technology mediations. To render **smart city** as a concept within the lexicon of the systems thinking becomes a necessity as the smartness vocabulary defines new areas of spreading. Core areas as city-government, city-economy and welfare and city-nested technology are affected by this new idiom. How each one of them is affected is better described as a "Holon", by focusing on the unified forces of change rather than a micro exetasis of the details of it.
3. Mapping the goals or objectives of both city planners[4] and stakeholders at the macro level helps to bring to focus the way specific interests are clashing or

[4] "***City Designers or planners***, is, for the purposes of this work is a **convenience**: the notion embodies, assumes and in a way personifies **the grid of legislature and executive powers** that need to be coordinated in order to envision and

aligning, providing thus with an understanding of the pursued agendas. That understanding which is particular useful for governance cannot be obtained with a specific analysis of a specific area or technology. A macro level analysis could therefore be a prerequisite for micro level further analysis and decisions as it will provide guidance on what to prescribe or avoid during public policies design and implementation. Following Eric Yu's statement: *"as discovered in empirical studies, (…), poor understanding of the domain is a primary cause of project failure. To have a deep understanding about a domain, one needs to understand the interests and priorities and abilities of various actors and players, in addition to having a good grasp of the domain concepts and grasps*" (Yu, 1997).

4. We have already declared a macro-level (we even named it holistic) approach to follow, throughout this dissertation. That includes our understanding of "smart cities" as an evolving "experiment" in the socio-technical dimension of cities and also the understanding of the concept of "smart cities" **systems of systems** already there in the notion of cities, such as economy, technology, culture, governance, connectivity, security etc. Finally , employing systems thinking will hopefully present with an opportunity to deal with "Holon and away from what Steve Easterbrook characterizes as "computer solutionism" ((Easterbrook, 2014).

1.3 Objectives

The main objectives therefore of this dissertation are, in alignment with the motivation of it:

i. To present a holistic, a macroscopic view of what can be inferred as "smartness" in the urban context. To this end Systems Thinking and a particular strand of it will be used to challenge the problem area of smartness but also a specific Urban Theory will amend systemic thinking creating a

achieve the notion of a smart city. That wide abstraction, results from the fact that it is neither with dissertation's scope to investigate the struggle inside of what constitutes the "city designers" nor to investigate how lobbying can alter the positions of these planners before and during the emergence of the designers' Goals. This is a very powerful assumption (**we will actually refer to it as the "neutral administration principle"**) but it will allows us to focus on the Systems under consideration and present a simplified model of systems thinking. No interactions are therefore presumed **within** the "city designers" group but only between city designers and stakeholders of the various systems.

twofold epistemological device: a methodology not specific to the area and a theory specific to the area.

ii. To analyze the domain concepts and notions in a smart city by employing the tools of Systems Thinking and by designing an ontology type artifact that corresponds to that understanding.

iii. To present a way of identification for the Stakeholders of smart city (the designers, the actors of transformations, the beneficiaries or wounded by the transformations) but also to blend the Stakeholders in the ontology of the smart city through their own existence in different layers (levels) of Systems that assemble *the Polis* as evolves today and as a whole. The level of identification is matched with the level of the urban theoretical approach in an attempt to reveal *Polis* not as a technicality of some methodology but as a living and learning process of social relations.

iv. To employ the notion of learning as the Activity that unifies systems thinking plus urban theory and ontological and epistemological parts of the approach. Learning activity, will reveal, we hope, the holistic and social dimensions of our approach to smartness.

To achieve the above objectives, this dissertation:

a. Adopts a specific research methodology (up to a point relevant to the objectives) (see paragraph 1.4)
b. Calls in for a systemic thinking about smartness, by using a specific methodology in the strand of it together with anchoring the systemic approach to an urban theory (see paragraphs 2.5 and 3.1 and 3.3)
c. Rehearses an ontology type approach for the representation of the smart city domain concepts (see chapters 4 and 6).
d. Uses a learning approach in the attempt to unify things (see chapter 7).

1.4 The Research Methodology

The process of our investigation complies with a Design Research Methodology as for example is presented in (Peffers, Tuunanen, Rothenberger, & Chatterjee, 2008). An adaptation of the proposed method is provided in Figure 2.

Following Peffers *et al* (Peffers et al., 2008) in their activities description, this dissertation will provide:

Activity 1: problem identification and motivation (as previously sketched and further to be elaborated in following chapters) (motivation is addressed in paragraph 1.2 and problem identification in paragraphs 1.2, 2.5, 3.3 and 5.1).

Activity 2: define the objectives for a solution, "*what is possible and feasible*" and because in our case the artifact under consideration is qualitative (heuristic in nature) and therefore a detailed description will be provided as "*how the new artifact is expected to support solutions to problems not hitherto addressed*" (see chapters 5-8).

Activity 3: Creation of the artifact which in our case will be **a methodology** based on systems thinking anchored to a specific theory of the urban to support a learning procedure augmented with an ontology type artifact, through which we expect to create consensus on the smart city domain notion (see paragraphs 1.2, 2.5, 3.3 and 5.1).

Due to the complexity of the problem Activities 4-6 will not be addressed in the current dissertation. Needless to say, fieldwork will be needed to carry out those activities, a task outside the scope of this dissertation.

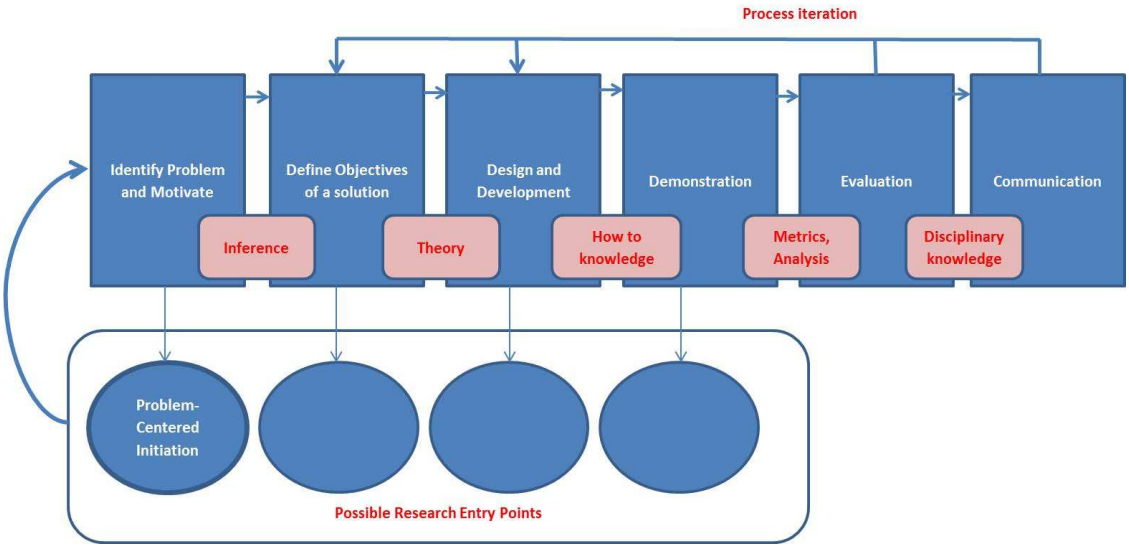


Figure 2 DSRM Process (adapted)

1.5 Dissertation Structure

This dissertation is structured in 8 chapters as follows:

Chapter 1 has so far provided the reader with scope, motivation and context and research methodology: smart city is to be examined via a Design Method finally achieving to come up with an artifact for the unravelling of the elusive smart city notion. The creation of a method to tackle the notion relies on using a Soft Systems Methodology (a strand inside the systems thinking approach) suitable for inferring a learning process and a System of Systems approach to bridge the lands of urban and smartness.

Chapter 2 goes on to provide the reader with further elaboration of the smart cities notion through a selective literature and the notion of the city through the lens of a specific urban theory.

Chapter 3 provides the rationale for the adoption of systems thinking in general and the foundations of Soft Systems Methodology, which is selected specifically as the theoretical tool for the attempted "design" of the process to understand smartness. Soft Systems Methodology will be further elaborated in the course of creating a learning process that aims in aligning different stakeholders' views of smartness.

Chapter 4 provides details on ontology thinking and point to the contribution to analysis.

Chapter 5 is an application, an instantiation attempt of the methodology described: major Systems of Systems are examined to increase the conceptual clarity of the learning process and the design artifact.

Chapter 6 is an attempt towards an ontological description of the Soft Systems Methodology itself with an application to the domain and the notions of smart city.

Chapter 7 discusses how the duality of the approach generates a learning process at the heart of capturing the escaping essence of the city smartness.

Chapter 8 provides a closure of the discussions and reflections on future developments and reassembles the main points of the dissertation in brief.

The above structure is best depicted in the picture below:

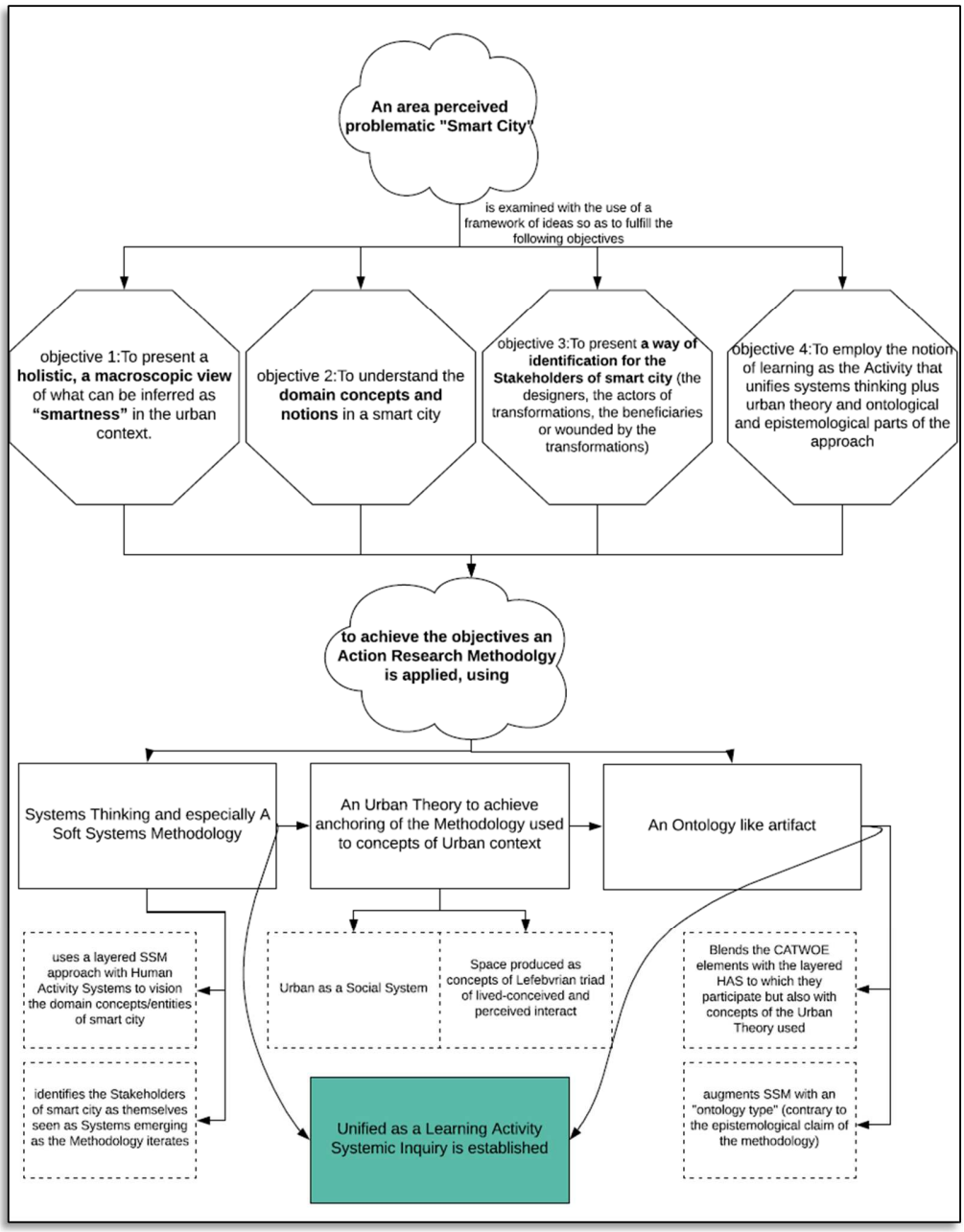


Figure 3 Dissertation's workflow

Chapter 2: Smart cities-current theories, practices and challenges

"Urban is the social meaning assigned to a particular spatial form by a historically defined society"

(Manuel Castells)

2.1 Introduction

As it was already stated in section 1.1, smart city is a new research agenda that roots its beginnings in early 90's, but only currently is been formed as a distinctive and (hopefully) interdisciplinary field. This chapter will attempt to enlighten the reader on the current theoretical schemas offered and the streams of practices in the 25 and more years that have witnessed the birth and evolution of this new field.

In order to understand basic streams and directions of this new agenda we have been embarking in a number of activities:

Firstly, a query was conducted via Scholar and Scopus to reveal the range of articles production.

Secondly, in an attempt to make sense of the notions or the ideas presented under the label "smart city" we have examined

i. A number of literature reviews on "smart city"
ii. A number of specific articles to deepen our understanding on certain issues

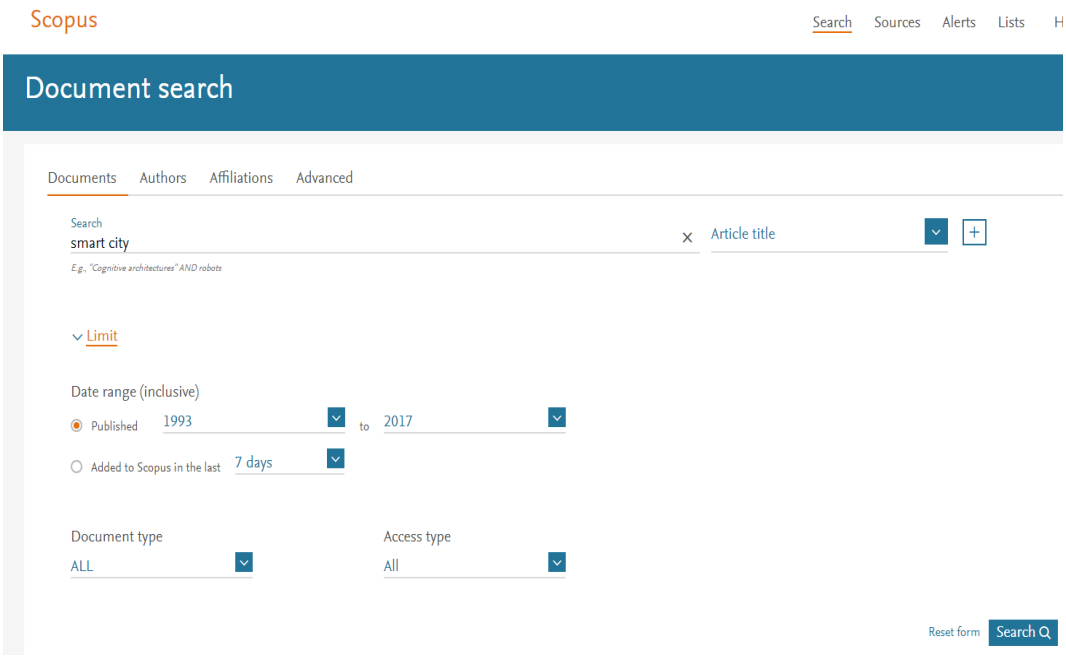
As the literature review has been developing it has given rise to further questions and has led to new questions broadly summarized as follows:

- Has it been there a theoretical ground in terms of urban context that the smart city adopts or at least implicitly follows? In other words, how smartness, as vision relates to urban?
- Has it been there any specific approach followed in the field rather than just a glamorous celebration of ICT as "panacea"?

To answer those questions (to a feasible degree) we start by introducing the smart city research agenda. To do so we have used (a) a variety of bibliometric articles (like Mora et al (Mora, Bolici, & Deakin, 2017)) and (b) our own preferred collection of smart cities notions, practices etc. so as to provide with a sketch of answers to the questions above. In paragraph 2.5 we move to the presentation of a specific Urban theory we feel suits our purpose of bridging smartness land and Urban context.

2.2 Literature search

To understand the play of the game in "smart city" a query was conducted for the time period between 1993-2017 via Google Scholar and Scopus, having as parameters the strings "smart city", "smart cities", "digital city" or "digital cities" in the title of articles and in the case of Scholar excluding patents. The results of the query are presented in Table 3.



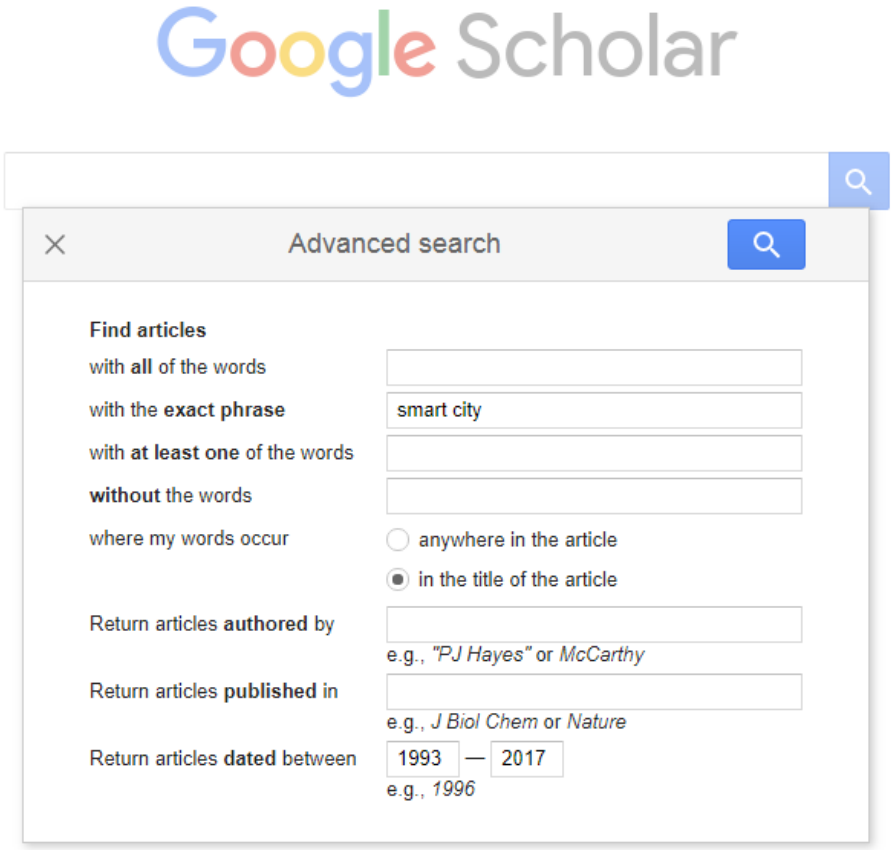


Figure 4 Searching Scopus and Google Scholar

The following table presents the findings of the query:

Table 3 Querying databases on smart city idioms. (updated: May 21st 2018)

Terms searched in title of article (time period: 1993-2017)	**Google Scholar**	**Scopus**
"smart city"	3950	3047
"smart cities"	3900	
"digital city"	592	248
"digital cities"	189	
Totals	8631	3295

The table reveals a common secret: smart city is becoming something of a new "holy grail" for the scientific (and the nonscientific…) community the quest for which drives the production of articles: grasping the essence of smart is almost a crowdsourcing event.

But whoever comes to the field with a sense of distancing from the fever of participation to this modern fox hunt, while at the same time understands the urban context through the lens of systems thinking faces important questions concerning the "smartness" of the current mantra.

To answer those questions a number of articles were examined. The way these articles have been selected (them, the specific ones among the thousands) ***is a matter of time constraints, preferences of the author that can be traced after the selection is been revealed, serving the purpose of the dissertation and sometimes because of the article itself***. Needless to say, such a selective path distances itself of a completeness goal. Completeness could have been a goal in systematic literature review designed to cover extensively all aspects of the smart city notion. The scope of this dissertation is tailored to the needs of producing a smart city notion in the context of systems thinking.

But while doing so, it will also question those theories and practices (already been questioned in the field itself for a variety of reasons) in order to establish a bridge to the second aim of the chapter: to investigate possible, if any at all, connection of the smartness movement to a sound underpinning theory of the urban. Because, and this is an a priori statement, the connection is still vague and smartness depends or rests itself to an ICTization of the city (ranging from a product marketing agenda to an implicit ideological campaign to a certain economic/business pursue or even a tool for the rewriting and realigning of the urban history and course).

As we have been considering the literature questions like the following, seemed missing from the literature of smart city -either academic or commercial- that dominates the field:

i. What is the perception of the urban? Or the City? Is there a theoretical approach in terms of urban context that the smart city adopts or at least implicitly follows? ***In other words, how smartness, at least as vision, relates to urban?***

ii. ***Does the perception of urban or the city change as it is seen through the lens of smartness?*** Does this new field uses a socio-technical approach in describing what is meant to describe? Does the ever growing literature recognize in "smartness" an economic paradigm? Or finds itself to be nothing but a glamorous celebration of ICT as "panacea" or perhaps as a technology push of a specific kind?

iii. Is there a theory of the urban that can predict smartness as a new paradigm of urban or as an emergent new urbanism? ***Can systemic thinking offer a new approach in the quest for smartness?***

iv. Are there tools falling in the smart category that can explain the city as a "machine" or as a "living organism" or perhaps as a landscape of "learning systems"? ***Finally, can systemic thinking reveal (if there is one) a relation of the smartness property to social life or the distribution of the political power?***

Questions **i to iv** are relevant to the journey attempted in this dissertation. Answering them will on one hand provide the current main ideas in the field while on the other hand drives us to explore paths less travelled so far if at all.

2.3 Theories and practices I: A review of literature reviews

Table 4 Elements of "smart city: definitions as in Ojo et al, source:(Ojo, Dzhusupova, & Curry, 2016)

	Definition	Source
Nature	Is a (1) forward-looking city in the areas of economy, people, governance, mobility, environment, and lifestyle; (2) form of urban innovation; and (3) intellectual capital profile of a city	(Giffinger et al., 2007), (Nam & Pardo, 2011) (Zygiaris, 2013)
Essence	Means (1) information access, bridging digital divide, lifelong learning, social inclusion, and economic development; sustainable economic growth and urban development, higher quality of life; and wise management of natural resources; (2) innovative socio-technical and socioeconomic growth of a city	(Hollands, 2008), Vasseur and Dunkels (2010), (Zygiaris, 2013)
Approach	Involves (1) investments in human and social capital; (2) investment in traditional (transport) and modern (ICT) communication infrastructure; (3) promoting participatory governance and engagement of citizens; (4) technological, organizational, and policy innovation	(Caragliu et al., 2011) (Nam & Pardo, 2011)

Not surprisingly **Ojo et al** (Ojo et al., 2016) guided by the common open topics of the field have tried to answer the question of concept and the dimensions that identify it, followed by a product of that, namely the usage of a number of terms that live in the neighborhood of smart city and also searching for trends in the literature concerning the angle of view (ie would it be polemic or favorite, theoretical or design and so forth). In the findings of their study they conclude that current research describes "smartness" to be "actual cities" driven by urban innovation characterized by "high intellectual or human capital". In terms of goals, consensus words are: (the goal of) social inclusion, quality of life and economic development, optimal management of natural resources, sustainable development. Most importantly research focuses on themes such as:

- Smart city attributes
- Smart city implementation
- Smart city policy domains
- Smart city management and governance
- Foundation of smart cities

Ojo et al found that these 5 themes are examined through either analytical approach (46% of cases), creation of a technical artifact (23%), experimentation (8%). They also suggest that **"***a clear gap resulting from the subject are contribution pattern in smart city research is the relative disconnect between smart cities' research agenda and the traditional more mature studies in urban informatics***"**. They also point out that research is at novice levels when it comes to address cities labelling themselves as "smart". In another strong remark the boldly state that "*a significant proportion of the works have no specific research orientation, paradigm or methodology that currently characterizes the smart city research landscape*" and they are "struck" by the fact that smart city research is dominated by computing and engineering as the contribution subject areas, calling therefore for the "*leveraging (of) existing knowledge in urban planning and city transformation for theoretical grounding*".

In their own bibliometric research **Mora et al**[5] search for (by mining 1067 source documents) (a) the characteristics of the literature produced from 1992 to 2012 (b) the

[5] (Mora et al., 2017) "The first two decades of smart city research- a bibliometric analysis" and quite interestingly the article starts with the phrase: "Cities are complex and highly organized systems".

size and the geographical dispersion of it (c) the influence and the productivity of the researchers and (d) the interpretation of the smart city-concept that emerges from the research.

In the authors' words "*Divergence, lack of cohesion and limited intellectual exchange among researchers become even more evident when trying to find a commonly accepted interpretation of smart cities, which is missing*". Research is found to be carried primarily in European Universities and American ICT companies, followed by Asian counterparts. The article suggests that a two-stream research agenda exists: one stream (mainly European) seeks a holistic approach, based on "*a balanced combination of human, social, cultural, economic, environmental and technological aspect*" while the second stream (American based) use a technocratic approach to enhance the city infrastructures in terms of (better) connectedness via technology solutions or software or network and other technologies.

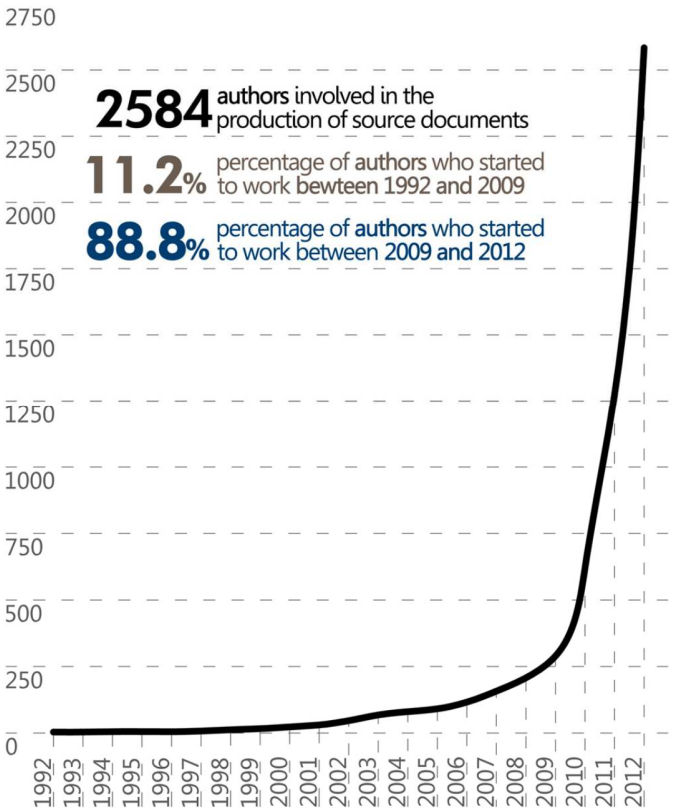


Figure 5 Cumulative growth in the number of authors involved in the production of source documents Source: Mora et al (Mora et al., 2017)

That second stream sees the diffusion of technology as the driver for the creation of smartness. It is also a market driven approach as "*this vision proposes the smart city as an engine that fuels ICT companies and that is expected to generate hundreds of billions of dollars by 2020*".

Again, this second bibliometric article describes the newly born field as already divided in approach, a division that perhaps stems out of the differences of the social organization and the production differences between the models of applied capitalism in Europe and the USA.

Another important issue is that of the origin and the direction of the subject ie "*is smart city leaning positive or social as a field*"? As **Duran-Sanchez et al** (Durán-Sánchez, de la Cruz del Río-Rama, Sereno-Ramírez, & Bredis, 2017) find out in their own survey the field leans "positive" (65% of the articles in Scopus and more than 50% in WoS come from positive sciences). Interestingly enough "Urban studies" are missing in Scopus count and have a 10% share in WoS.

Table 5 Classification of articles according to the thematic areas Source:(Durán-Sánchez et al., 2017)

Scopus			WoS		
Categories	**Articles**	**%**		**Articles**	**%**
Computer science	29	21.97	Computer science	17	22.67
Engineering	29	21.97	Engineering	8	10.67
Social sciences	21	15.91	Environmental science	8	10.67
Environmental science	12	9.09	Telecommunications	7	9.33
Business, management, and accounting	9	6.82	Urban studies	7	9.33
Energy	7	5.30	Planning and development	3	4.00
Chemistry	3	2.27	Business and economics	5	6.67
Economics, econometrics, and finance	3	2.27	Chemistry, analytical	2	2.67
Psychology	3	2.27	Electrochemistry	2	2.67
Arts and humanities	2	1.52	Geography	2	2.67
Chemical engineering	2	1.52	Instruments and instrumentation	2	2.67
Materials science	2	1.52	Multidisciplinary	2	2.67
Mathematics	2	1.52	Public administration	2	2.67
Medicine	2	1.52	Energy	1	1.33
Physics and astronomy	2	1.52	Physics	1	1.33

Agricultural and biological sciences	1	0.76	Political science	1	1.33
Biochemistry, genetics, and biology	1	0.76	Public, environmental and health	1	1.33
Earth and planetary sciences	1	0.76	Social sciences	1	1.33
Multidisciplinary	1	0.76	Sociology	1	1.33
			Thermodynamics	1	1.33
			Transportation science and technology	1	1.33

Finally **Ricciardi and Za** (Ricciardi & Za, 2015), in a similar search found the following allocation of smart city articles among disciplinary areas:

1. Engineering, Physics, Chemistry: 62.3 %
2. Computer Science, Telecommunications: 35.1 %
3. Social and Political Studies: 33.3 %
4. Architecture, City Planning: 13.2 %
5. Management and Organization Studies: 12.3 %
6. Economic Studies: 8.8 %
7. Other: 7.0 %

To summarize findings (before we turn to more specific issues of the field) we conclude that:

- **i.** The smart city notion is widely dispersed
- **ii.** This is a two-stream agenda (a dichotomy as how smart city is approached)
- **iii.** Smart city is researched mainly from an ICT or a STEM approach rather than a social one
- **iv.** Only few articles are bridging the gap between Urban Theory and Smart city Notion
- **v.** No urban theory is used to ground the notion of smart city
- **vi.** Researchers use mainly analytical techniques
- **vii.** ICT solutionism is hindering the field
- **viii.** Even fewer articles address the issues of the complexity and systemicity of the urban, as perhaps an initial point that matters in the quest for the smart saga.

2.4 Theories and Practices II: Specific Issues

In this section we move closer to the notions or ideas of the field, examining specific ones based on a number, a selection of articles. The selection of these articles was based on

1. Importance in the sense of citations
2. A personal choice based on a perceived resemblance of the article ideas to the systemic theory artifacts (for example thinking in terms of interconnectedness –eg domains- even if the "system" word is missing.
3. A critical evaluation of the field.

Giffinger et al (Giffinger et al., 2007) suggest that *"although the term "smart city" is not widely used in spatial planning literature or urban research, it is still possible to identify various aspects as a basis for further elaboration"*. Furthermore, they acknowledge the fact that the term is not used in a "holistic way": it is either used as an "IT – district' or as an identity regarding the smartness of the inhabitants, by using for example the educational status to judge smartness. Finally, smart city is *"used to discuss the use of modern technology in everyday urban life"*. Giffinger et al summarize or rather identify 6 dimensions of smart city namely "Smart Economy", "Smart People", "Smart Governance", "Smart Mobility", "Smart Environment" and finally "Smart Living". Those "characteristics" can further be analyzed to a number of Factors (31 of them) and (one level down) to a bigger number of Indicators (74 Indicators). Then they proceed to the examinations of these indicators across 70 medium sized European cities and rank them accordingly[6]. What is interesting though is that the study is "*concerned with a total population of 120 million people or with 40% of all urban citizens that live between 100.000 and 500.000"* therefore an initial attempt (this is an article of 2007) to create a managerial, hands on, approach to the interested City Designer (should it be a mayor, a Government or something else). It is also a recipe in the following sense: to make (or identify current status of a city as such) "smart city"

A: pick all or some of the characteristics of smartness then

B: for them in A pick the corresponding Factors and

[6] Larissa (capital for the Thessaly Periphery in Greece) scores 60 overall and Patras (capital of Western Greece Periphery) 58 with an astonishing 6 and 5 respectively for Smart Environment).

C: for those factors fill in the prices of the Indicators available.

In a sense this can lead to a snap requirement building which then will be addressed as "smartness".

Caragliou et al (Caragliu et al., 2011) aim in their article to clarify the notion by giving "*clear and focused definition of the term smart city"*. In conducting their research, they summarize "*the characteristics **proper** to a smart city"* as were found in the literature. Among those characteristics two are of economic nature or their goal is explicitly of economic nature namely the utilization of networked infrastructure to improve economic and political efficiency and "*an underlying emphasis on business-led urban development"*. Two of them are of a more "social character", one is dealing with the environment and obviously the last (but not least) is "*the crucial role of high-tech and creative industries in long run urban growth"*. Naturally, the authors own definition of "smart city" is an amalgamation of all those "proper characteristics", as if, smart city was lacking the terminology or the words to be used in the construction of its meaning. So in the writers' words

> "(p7 of 19) *We believe a city to be smart when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and high quality of life with a wise management of natural resources through participatory governance"*

But such rather grandiose statements that includes everything says little if anything at all on possible conflicts, because of different interests that do exist in an urban settlement or because actors may clash around different worldviews concerning the evolution of their own being. It is also perhaps the moment to recall the phrase "correlation is not causation" although the paper, based on a "*partial correlation between urban growth determinants and measure of the economic output which is per capita GDP"* actually follows that path by finding "*partial support for Richard Florida's argument on the role of the "creative class" in determining long run urban performance"*. The paper's conclusion is therefore expected: "*Hence, educating people is on average successful only when investment on education is carried out over a long period with a stable flow of resources; transportation networks must be constantly updated to keep up with other fast growing cities in order to keep attracting people and ideas*".

Despite Mora et al belief that the European stream is a more "holistic" approach and the American stream is focusing on ICT this not the case for **Dirks and Keeling** (Dirks & Keeling, 2010)[7]. While notions as digitization, data, information is quite at the front of the perception provided that is done with some distance from a techno-solutionism stance. Instead, and that is also supported by other voices at IBM, as for example Harrison et al (Colin Harrison & Donnelly, 2011) they call for an understanding of the city through the lens of the "systems". Dirks and Keeling understand the city to be based on Systems and further more on Systems of Systems.

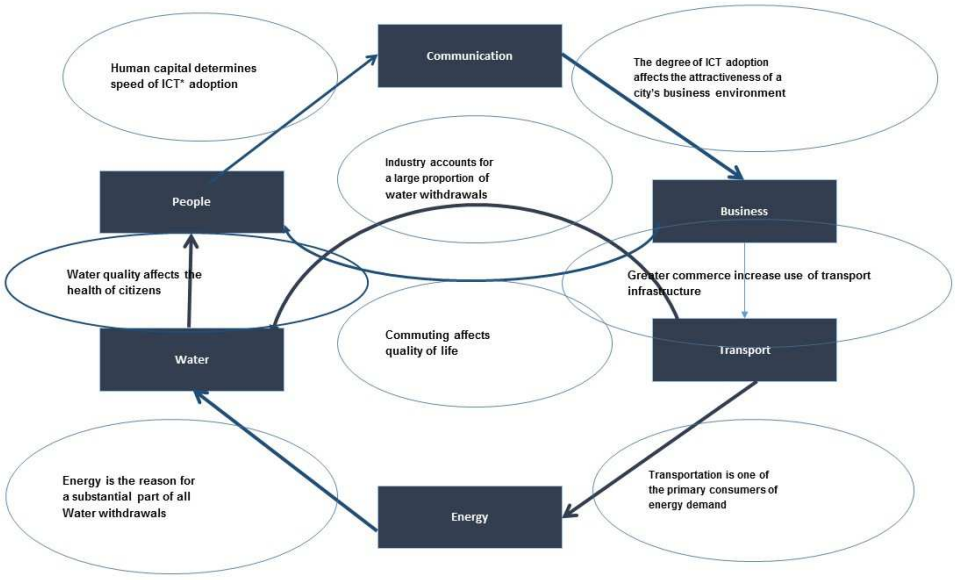


Figure 6 Sample of interrelationships between core city systems. Source: (Dirks & Keeling, 2010)

They identify 6 core systems:

People: "*a city's people system refers to its human and social networks",*

Business: "*a city's business system encompasses its regulation and policy environment and includes planning regulation, openness to foreign trade and investment and labor and product market legislation".*

The rest of the systems are **Transport** (from provision to pricing), **Communication** (which for them is key to smart city), **Water** (supply, sanitation cycle) and **Energy** (which includes waste disposal). Of significant importance to the authors is that

[7] In "A Vision of Smarter Cities: How cities can lead the way into"

"*Understanding one system and making it work better means that cities must comprehend the bigger picture and how the various systems connect".*

They also provide an interconnected diagram of those systems:

For **Harrison and Donelly** in "A theory of Smart cities" (Colin Harrison & Donnelly, 2011) smart cities do exist. The driving force behind current state of urbanization is, mostly, innovative new technologies. Various benefits can be realized by the introduction of information technology in the way Cities (Smart Cities they argue) operate. Needless to say a number of these benefits are drawn from a number of city examples that are categorized under the smart label but they appear for a different area of intervention in each city. So, while New York City was able to reduce consumption of water and energy, Stockholm has improved the utilization of existing infrastructure "*hence improving quality of life*". Singapore managed the publication of real time data concerning the operation of the city with a positive effect to commercial enterprises while Peterborough improved resilience by managing peaks in energy, water and transportation.

But the authors reveal a specific way of city as a machine ready to be improvised by new technology. They claim that recent technology advances have made this vision possible:

"*The development of both computing power and new algorithms that allow these flows of information to be analyzed in near 'real-time' in order to provide operational performance and other insights*"

The authors correctly identify that cross-sector information can be valuable to uncover connections between city functions. They also acknowledge that an assumption of rationality in decision making may be at need when such information flows are organized aiming to the benefit of the many. Because

"*Some participants will understand the purpose of the system and will support its goals"*

But,

"*Other participants may not understand and may make decisions that neither serve them well individually nor contribute to the collective benefits*"

This underlined excerpt is revealing of a Smart Cities imagery where the understanding of "smartness" cannot be achieved in an endogenous way, but is rather dictated from a specific point of view (a certain Worldview) to which any other Worldview is friction or

a polemic entity or at least meanings attributed to world of city by classes of people that are leftovers due to their inability to foster the ideologies or the ways of living of creative tenants belonging to Generation Y or Generation Z (as in (Florida, 2014)).

The authors reject any ad hoc approaches to smart cities notion as being "*pre-scientific medicine*". "Smart cities" they accurately claim is a "*field in want of a good theoretical base*". To that end they examine two approaches both from Systems Thinking. They reject the notion of treating cities through a biological type complex systems lens because "*these theories are lacking hypotheses that can be tested at the micro-level, where direct intervention is possible"*. They favor another systemic stream that "*introduces concepts as interconnection, feedback, adaptation and self-organization in order to provide understanding of the almost organic growth, operation, decline and evolution of cities"*.

Systems thinking approach taken in this article understands a number of thoughts as contributing to the understanding of the city. Namely:

1. "*Every system is perfectly designed to produce the results that it produces"*[8] .
2. The complexity of the city becomes apparent in models such as the ones proposed by Forester's Urban Dynamics (1971) which have among others the value "*the model and the modeler interact to reach consensus*".
3. Complexity is a necessary condition if the city is to function "*well as a healthy system"*.
4. The city is a network of flows of information or equivalently a network of software objects that perform a task based on a flow in order to produce a new flow.

Finally, to map information flows, they create an Urban Information Model (see Figure 7) where city is presented as layers that start from Natural Environment and end (bottom-up to top) at a Social systems layer- but the ordering of which is not important.

This is a functionalist engineering of the city that anchors itself to the Hard Systems tradition (see paragraph 3.2.3) in which systems are out there, ontologically, and builds on the ontological tradition of positivism. In authors' words "*the person is an external agent, exercising judgment and volition, on a set of choices that are available at a given*

[8] A phrase coined by the authors to Demming, in Paulker et al 2005 'Creating a safer Healthcare system finding the constraint, JAMA, vol 294'

time and place". To add "*it is implicit that macro-level operations of the city are the consequences of very large numbers of decisions made by individual people in selecting and adopting their People Systems and how resulting Actions compete or collaborate through Services and Resources"*.

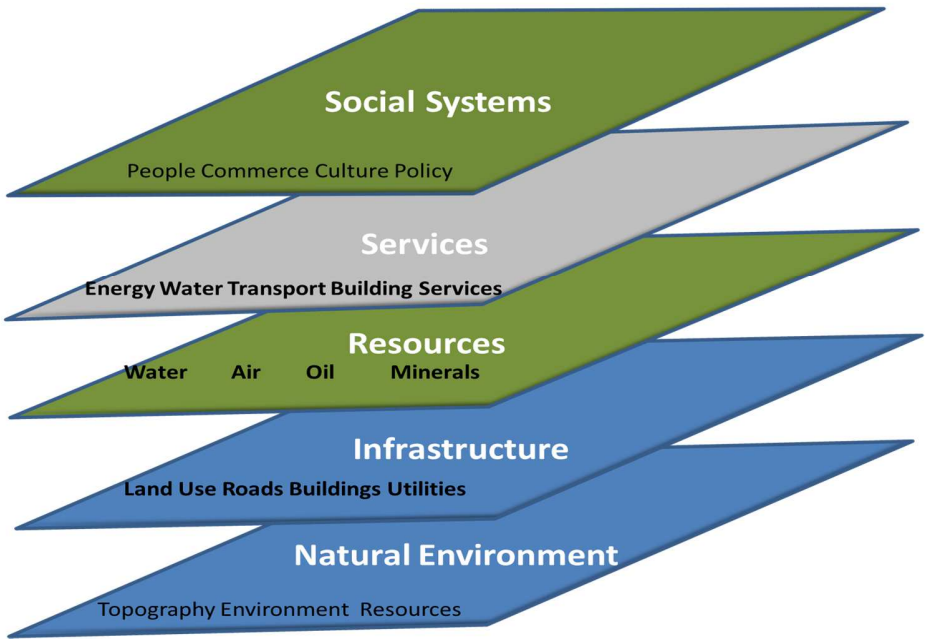


Figure 7 A simplified view of a multilayered city representation. Source: (Colin Harrison & Donnelly, 2011)

Later at this dissertation a quite different approach is adopted: while People do act at an individual level, as they live and inhabiting city, as they practice their daily routine using Services of the City (the spatial practice level) and as they conceive urban space that surrounds them in an abstract, logic and ideologic way (see paragraph 2.5), but as they act they change the urban space they occupy. People act and react and as they acquire increasing learning capabilities; they themselves produce and reproduce the way of living and the information flows while they are constrained, embedded and in constant battle with the level of abstraction set by hegemony of ideas and a certain mode of production. Setting Nature systems apart, we will argue that all other layers presented here are social systems of Human Activities that we use as epistemological devices to understand, to learn about Urban and smart city notion. But despite the differences in Worldview, the

article of Harrison et al (Colin Harrison & Donnelly, 2011) is an important contribution to the theory of smart cities.

On the other hand **Washburn et al** (Washburn & Sindhu, 2009), in defining smart city, they do adopt a techno-centric view. The use of smart computing (seen as "a new generation of integrated hardware, software and network technologies that provide IT-systems with real-time awareness of the real world and advanced analytics") to web the critical infrastructure and services provided by the city is a straightforward declaration: ***technology is here, use technology and smartness is achieved.*** They also move to identify three cycles of tech growth and digestion and mark 2008 as the point of smart computing comes to existence as in Figure 8. To them and a stream of other writers technology is the factor that makes the city smart.

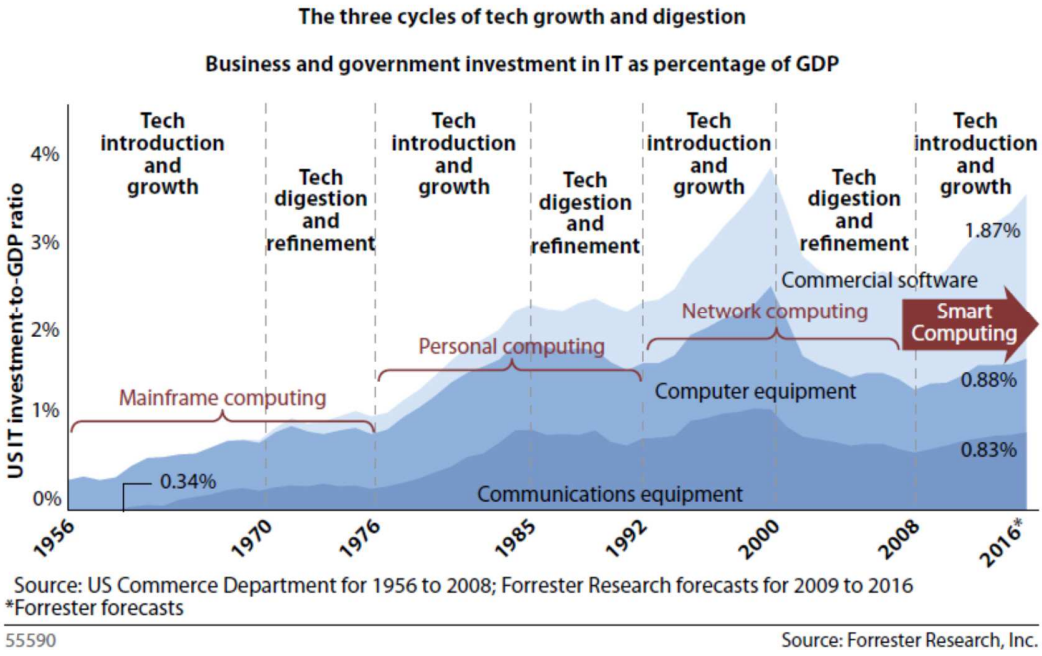


Figure 8 Technology adoption and digestion cycles Source: (Washburn & Sindhu, 2009)

2.5 The Missing Link: Urban Theory for a smart city

One of the issues that we have mentioned as missing from the literature of smart cities field is the lack of an urban theory on which the notion of smartness could be anchored. Why such grounding is needed is clearly depicted in the description of smart city

literature as suffering from solutionism (in general and ICT one more specifically): "Doesn't my application or view or analysis of domains or technology or great idea or ontology of objects make the city intelligent-smart-elegant" could summarize the situation. Market-driven efforts also lead to such direction. Richard Florida in Creative Cities[9] provides perhaps the most comprehensive theory of smartness (or creativeness) through a change of direction in the analysis: it is now a certain breed of people that make the Urban around them a creative hub. In Brenner et al (Brenner & Schmid, 2015) , smart city is described as a strand of techno-scientific urbanism: *"Contemporary discussions of 'smart cities' represent an important parallel strand of technoscientific urbanism in which information technology corporations are aggressively marketing new modes of spatial monitoring, information processing and data visualization to embattled municipal and metropolitan governments around the world as a technical "fix" for intractable governance problems"*.

In all those attempts, the Urban, as both a battleground of where nature and people meet and as a complexity phenomenon with historical evolution that is the hub of many social systems, therefore belonging to a class of problems that are called wicked, is merely ignored. The idea of smartness is going down the path of reduction and analysis, ignoring ideas of first geographers who has identified systems (of systems) within the city[10], sociologists who shed light to the Urban as social organization, or even evolutionists that understand the city as a metabolistic organism[11]. The emptiness of the smart as being Urban itself as well as the making of a scientific "experience" as a one horse carriage for describing smartness is so apparent that a one should quote Henri Lefebvre (in Urban Revolution, p69 (Lefebvre, 2003)) *"Knowledge cannot be equated with skill or technique. (…) Knowledge escapes the "all or nothing" dilemma. The technocratic*

[9] (Florida, 2014) "The Rise of the Creative Class revisited" 10th anniversary edition

[10] See for example Berry in Cities as systems (Berry, 1964): "It is clear that cities may be considered as systems--entities comprising interacting, interdependent parts. They may be studied at a variety of levels, structural, functional, and dynamic, and they may be partitioned into a variety of subsystems. The most immediate part of the environment of any city is other cities, and sets of cities also constitute systems to which all the preceding statements apply. For systems of cities, the most immediate environment is the socio-economy of which they are a part" or the works of McLoughlin *(as in* Urban and Regional Planning: A Systems Approach) and Chorley (as in Chorley, R. J., & Kennedy, B. A. (1971). Physical Geography: A systems approach).

[11] As for example in the collective volume "In the Nature of Cities" by (Heynen, Kaika, & Swyngedouw, 2006)

ambition of being able to synthesize from a given technique or partial practice (the circulation of traffic, for example, or merchandise, or information) falls apart as soon as it is formulated".

Our argument for the need of an urban theory attached to smart city stems from the belief that the techno-centric approach and the analytical-reductionist method are not sufficient for an understanding of smart city as a social problem. This is not the point for an exhaustive literature review in the strand of Urban Theory or Urban Studies. But in search for a suitable theory we have moved towards a path of selection based on the criteria stated by Brenner in "What is critical urban theory" (Brenner, 2009) (an evaluation of the critical school (the Frankfurt School) on Urban studies) together with (Brenner & Schmid, 2015) "Towards an epistemology of the Urban"; in the first article Brenner suggests four major criteria that a theory to be considered under the critical label should fulfill:

1. The need for abstraction and the avoidance of a "handmaiden" to specific practicalities or instrumental choices
2. Urban questions are historically specific and mediated through power relations
3. To "*reject instrumentalist, technocratic and market-driven forms of urban analysis that promote the maintenance and reproduction of extant urban formations*" and
4. To search for alternatives that are systematically suppressed within contemporary systems.

In the second article seven theses on how the urbanity is perceived today are presented (we use thesis 2 in our implementation based on Soft Systems Methodology in paragraph 5.1 "*The urban is a process, not a universal form, settlement type or bounded unit"* as the more clearly based to a Lefebvrian urban, an urban context we choose as the theory context of the methodology of understanding aspects of smart city). Those *theses* constitute a panorama of today's Urban Studies epistemological lens but also of the ideological trends stemming from the field ranging from: **urban triumphalism** (cities as engines of all good things as for example innovation) to **technoscientific urbanism** (with "*aspirations to reveal law-like regularities within and among the world's major cities*

often serve to naturalize the forms of sociospatial disorder, enclosure and displacement that have been induced through the last several decades of neoliberal regulatory restructuring and recurrent geoeconomic crisis"). And from **debates of Urban sustainability** where the cities are thought as socio-technical arenas that pioneer suitable responses to environmental crises to **debates on Megacities** that depict the planetary explosion of the Urban phenomenon and the creation of a global North to global South distinction.

The theory, we felt, that smart city is in need, should achieve all criteria 1-4 above while achieve a process view of the urban context as thesis 2 dictates.

Finally, we have considered that "smartness" is equally about the How are things constructed and stabilized rather than the "Why" they are constructed that way. Therefore our selected theory needs to cope with urban networks some of them being "liquid" some of them being "thin air" ones. Therefore, agency should be less embedded in predefined processes (either political or social) and more identified as networks of people, material things and abstract ideas branch constantly by attaching and detaching. To achieve in this dimension one may employ **assemblage theory criteria**. **Kamalipour and Peimani** in ((Kamalipour & Peimani, 2015) "Assemblage thinking and the City:implications for Urban Studies" apart for being a valuable source for the important literature of Assemblage theory discuss the range of concepts that constitute the theory and the connections of it to the City and Critical urbanism. For assemblage theory, city is a multiplicity not a whole, a mesh network rather than a hierarchical structure or as P.McGuirk suggests (in (McGuirk, 2012) "*an assemblage approach explores how heterogeneous arrays of elements and actors, objectives and techniques are assembled together –often across diverse spatialities- to compose the city, its governance and politics*". As McFarlane points out in ((McFarlane, 2011)) "*For Deleuze*[12]*, the only unity of assemblage is that of 'co-functioning: it is a symbiosis, "sympathy". It is never filiations which are important but alliances, alloys; these are not successions, lines of descent, but contagions, epidemics, the wind' (ibid.). This means that urban actors, forms or processes are defined less by a pre-given property and more by the assemblages they*

[12] Gilles Deleuze, was a French philosopher. Assemblage theory is thought to be based on a book he co-authored with F.Guattarri *"A Thousand Plateaus"* (more in: https://plato.stanford.edu/entries/deleuze/)

enter and reconstitute. The individual elements define the assemblage by their co-functioning, and can be stabilized (territorialized or reterritorialized) or destabilized (reterritorialized) through this mutual imbrication. But this is not to say that an assemblage is a direct result of the properties of its component parts. It is the interactions between human and nonhuman components that form the assemblage—interaction as mutually constitutive symbiosis rather than just parts that are related—and these interactions cannot be reduced to individual properties alone".

To convince of the need for an Urban Theory as an underlying theoretical structure in which to embed the smart city notion one could mention Manuel Castels in his opening sentence in The City and the Grassroots: (Castells, 1983)*"Cities are living systems, made, transformed and experienced by people. Urban forms and functions are produced and managed by the interaction between space and society that is by the historical relationship between human consciousness, matter, energy and information"*. If "smartness" is nothing but a new turn, a new episode unfolding inside the historical relationship Castells is talking about and is produced as the Urban context changes – then embedding this new notion or structure or process to a theory of the Urban may be a fruitful thing to do in the pursue for learning about it and at the same time in learning how this new emergent property of the urban changes the methodology or the theory itself. If, on the other hand "smart city" defies the social-material associations that until now we have thought to organize the Urban, then is itself producing a new theory, being the bearer of this new theory: but then again such a theory should be formulated. Because the term and all the knowledge accumulated are only recent, the theory we seek cannot be of minor hypotheses: testing hypotheses on transport routing choice with available data may not be sufficient to declare that smartness has emerged, only because we can choose a suboptimal scenario of transport routing with more confidence. But also, a grand theory, that unifies or attempts to unify everything should also be rejected since it will be either too complicated to elaborate or even too hard to achieve completeness. Following Robert Merton, it is a middle rage theory that could be useful here. As R.Merton suggests[13] (Merton, 1949)*"It is intermediate to general theories of social systems which are too remote from particular classes of social behavior, organization, and change to*

[13] "On sociological theories of the middle range" , 1949

account for what is observed and to those detailed orderly descriptions of particulars that are not generalized at all. Middle-range theory involves abstractions, of course, but they are close enough to observed data to be incorporated in propositions that permit empirical testing. Middle-range theories deal with delimited aspects of social phenomena, as is indicated by their labels".

To this end a choice is made to present as an Urbanization theory that fulfills the needs described above, H.Lefebvre's theory of the Urban as that was presented mainly in The Urban Revolution ((Lefebvre, 2003) but also in the Production of Space ((Lefebvre, 1991) (as well as in other works of Lefebvre).As the unfolding of the ideas comprising the theory will take place, an understanding of the choice will become clearer (we hope). But before we sketch a hermeneutic of Lefebvre's theory of the Urban we stress two important principles of the theory that we think justifies the selection of it as a theory of the Urban:

1. "**The Urban is the result of the complexification of the social**" or in the words of Lefebvre (p127, (Lefebvre, 2003)) *"(The Urban) is the result of a history that must be conceived as the work of social "agents" or "actors", of collective "subjects" acting in successive thrusts, discontinuously (relatively) releasing and fashioning layers of space. (…) From their interactions, their strategies, successes and failures, arise the qualities and the "properties" of the urban space".* And the way this complexification is achieved is through the notion of Difference and Difference is by definition *"proximity relations that are conceived and perceived and inserted in a twofold space-time order: near and distant."* For Lefebvre, Difference is informing and informed ie is an internal feedback mechanism of the Urban that creates and recreates form, which in Lefebvrian mode is an abstraction of context: (p119, (Lefebvre, 2003)) ***"the urban is a concrete abstraction, associated with practice. Living creatures, the products of industry, technology and wealth, works of culture, ways of living, situations, the modulations and ruptures of the everyday life-the urban accumulates all content"*** . (In an interesting turn Lefebvre does not accept that urban can constitute a system or in terms of system language. (to this point we refer later on and what is possibly meant by this denial)).

2. **"Something is always happening in urban space"** and the phrase can be understood in the following sense: First, urban space is the space of the ephemeral, the multifunctional, the polyvalent or the transfunctional. The Urban is not just a collection of fixed structures (material or social) defined by visible boundaries but is also home of actions or activities that come to existence only to live shortly before they "soon destroyed". (Something that in Chapter 5 of this dissertation gives rise to what is referred to as "***thin air networks***"). This is the concept of "everydayness" or of everyday life.

It is not clear if Lefebvre, in The Urban Revolution, uses a kind of systemic thinking. There are also contradictory parts concerning the Urban as system. For example, he writes against (explicitly) the reductionism as a scientific paradigm for thinking about the Urban. It is not useless, "*but such fragments do not constitute Knowledge*", of the Urban (p49, The Urban Revolution). When he especially talks about the "*language of the Urban*", he declares that "*the city and the Urban phenomenon can't be reduced either to a single system of signs or to a semiology"*. But, unlike that, **the city is about several systems, on several levels** (p50). Should the city had been a single system of something then that system would become of an unescapable dominance. Lefebvre calls for a "multi-science" approach to the studies of the Urban mentioning, as fields to participate in that **episteme of the Urban,** set theory, statistics and cybernetics (and also history, linguistics, psychology or sociology). This is central in the approach: It is in fact a prerequisite for the need of "totality" as opposed to the fragmentary or residual knowledge achieved by its discipline alone. **But that is systemic thinking per se**. And it goes to more profound level by suggesting "the intentionality of the system that is dissimulated beneath the apparently "objective" nature of the scientific object". Instead ***the real object is "an image and an ideology".*** That is much in alignment with soft systems theories that embrace conceptual modelling based on certain Weltanschauung or Worldviews (see chapter 3). Lefebvre calls the urban phenomenon a "virtual object" that is constructed as a result of what he refers to as the process of urbanization which leads to social life. So, knowledge about the Urban is not about an object but about image and ideology, transforming Urban into a virtual object created and recreated as our knowledge about it changes (as learning occurs). In Lefebvrian mode *"the methodology*

of the models is said to continue and refine the methodology of concepts" - double-loop learning is implied here. Because of that Lefebvre proposes not a construction of models to re-assemble the notion of Urban but a critical reflection that will eventually open a path to the understanding of the Urban. He urges against the testing of minor hypotheses based on science because such hypotheses always contain "*an ideological component once they have been formalized and axiomatized (p67)*". The learning concept (although masked under a philosophy label) is core in his attempt to explain Urban as an evolutionary process. For Lefebvre, the Urban is not "*a prefabricated goal*" or the meaning of a history that is moving towards it. That actually happens because at the human scale there are "needs" which prior to becoming installed at an Urban perspective are "a something" (that is not yet a thing) like *"impulse, élan, will, desire, vital energy, drive (p69)"*. Although he uses an anthropological path to articulate that the slow maturation of the human being implies educability (ie learning) and an astonishing degree of plasticity, this maturation can be interpreted as the learning property that emerges with the urban phenomenon. That can be summarized as follows:

"From something that is not yet a thing and because of the slow maturation of the human being, learning emerges as human activity systems, like habiting or habitat, occur in the Urban context" or in Lefebvre's own words (p71-72) *"Form appear, conceived and willed, capable of modelling (the human) material according to various postulates and possibilities. These forms act at different levels"*.

But where the Lefebvrian thinking comes into the systemic plane is the definition of the levels an Urban context can be analyzed. He distinguishes a global level G, a mixed level M and a private level P (which calls the level of habiting). These are levels of emerging economic or social structures reached by every Urban society from a rural to an industrial and finally to critical one, according to the Lefebvrian space-time evolution of the Urban. In the following lines we provide a short description of those levels.

Global level G is the most abstract and it accommodates the abstract but essential relations like capital, labor and politics of space. It is also the level of the logics (various ones) that form and structure the level G, namely the socio-logic or ideo-logic. This level is simultaneously Social-Political and Mental (logic-strategy). As Lefebvre notes ***"It is the level associated with what I refer to as institutional space (along with its corollary,***

***institutional urbanism)*". This assumes, if not a system of systems of explicit action, at least some form of systematized action (or "concerted" actions that are conducted systemically)"**. It is the surface area of the social relationships and G *"harbors a multiplicity of those abstractions (various juxtaposed, superimposed and sometimes conflicting markets for products, capital, labor, works of art and symbols, housing and land"* and is also the level where agents at a global scale appear. This particular point of agents at a global scale allows us to consider that level as also a Human activity level (or system of systems level, since the activity is now abstracted as logic (socio or ideo-logic) and appears as strategies of the global level actors (or stakeholders).

Mixed level M (or mediator level) is the specifically Urban level. What constitutes that level is streets, squares, buildings, churches, schools etc. It is the level where forms bind with functions to provide new structures such as transport or trade. Mixed level M is then a terrain where various strategies align or battle and according to Lefebvre "this includes anything associated with level M, namely, institutions, organizations and urban "agents" (important people, local leaders)". M is the level of means but can never be an end. It is where, between G and P clashes are actually taking shape. M is the plane of systems that the battle when generality attempts to cease peculiarity or the global attempts to absorb the local.

Finally P is the Private level of the urban or the level of habiting. For Lefebvre P is not only locus of "minor" economic or sociological agents or cannot only be perceived in a micro-macro bifurcation. Is in itself a source of foundation, functionality and transfunctionality. It is the locus of everyday life.

There is at least a morphological analogy of the GMP model of the Urban as described above and the Human Activity Systems used by Soft Systems Methodology (see paragraph 3.3) and especially the idea of leveling in systemic thinking. The idea that Lefebvre's theory implicitly (at least) is systemic in nature will be revisited later on this dissertation. For the time being let us quote a few lines of The Urban Revolution that suggest such a systems thinking: *"(p 86) At the highest level, the socio-logic level, "objects" constitute a system. Every object communicates to every action its system of signification, which it acquires from the world of commodities, for which it serves as a*

vehicle. Every object contaminates every action" and *"Social logics are located at different levels; there are cracks and crevices between them"*.

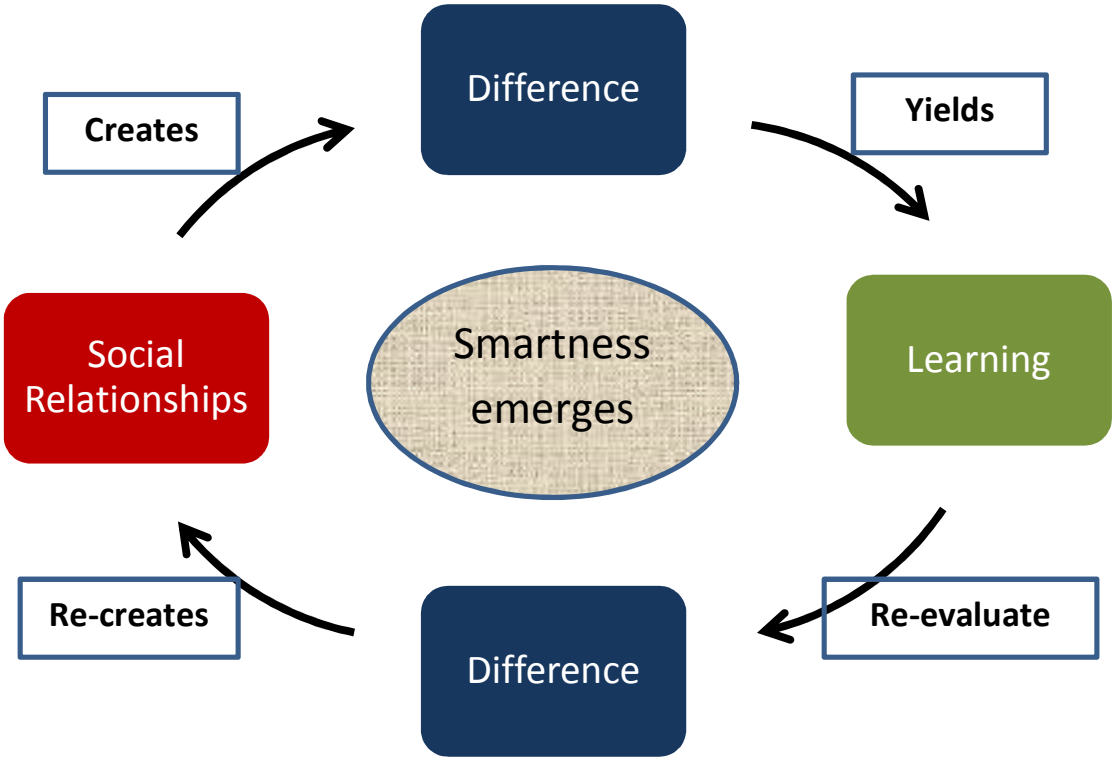


Figure 9 Smartness as learning occurs as a result of interconnectedness

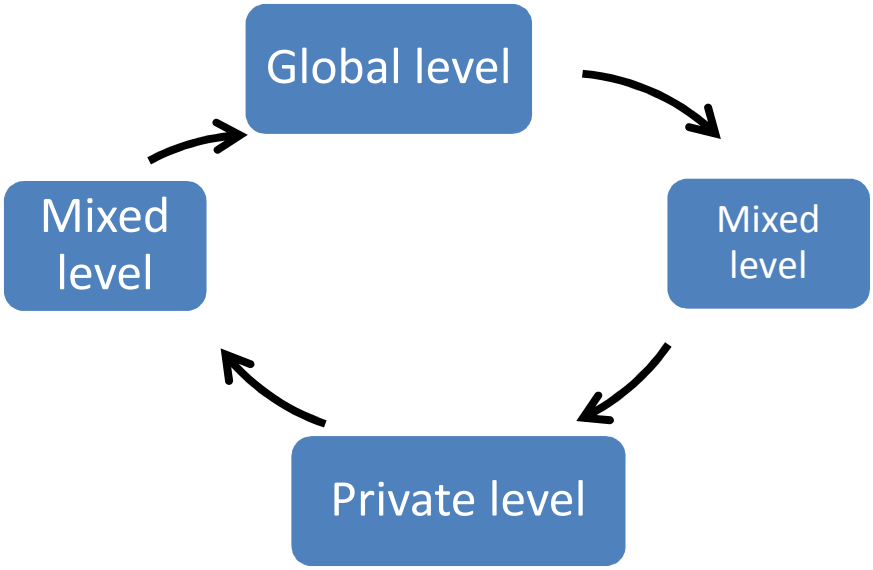


Figure 10 Lefebvre's levels of Urban in The Urban Revolution

Should we seek a description of smartness as an Urban property then a path like the following can be valid: Smartness is produced as Difference occurs between social relations in the Urban context. The Difference happens at a number of levels (systems of systems in a systems thinking language) and also at a number of activities (human activities) in each of these levels. Therefore, smartness can be traced in all GMP levels: from habiting to mediator level to abstract global level. And smartness is emerging as learning is accumulated, in each and every level, as difference translates objects to image and ideology. The above is depicted in Figure 9 and in Figure 10.

For Lefebvre, Space (Urban Space that is), has become in the advent of capitalism not only the stage of all social actions (either individual or collective ones) but also an indispensable part of its reproduction machine, one of the forces that constitute the logic of capitalism evolution (along with nature, labor and capital, technology and knowledge). And as such, space co-evolutions with them. Therefore, Space, that is Social Space, which we cannot assume to be isomorphic to the physical Cosmos, is being endogenous within the capitalism reproduction. In Lefebvre's own words "*As it develops, then, the concept of social space becomes broader. It infiltrates, even invades, the concept of production, becoming part –perhaps the essential part –of its content*" (p93, The Production of Space). More specifically Space is produced by and contributes to

i) The biological production of the family
ii) The reproduction of the labor power per se
iii) The reproduction of the social relations of production

Since Space is endogenous to those forces, Lefebvre is creating an epistemological device, the Lefebvrian triad of Space, to elaborate on the creation of the Space-Production synergy. Namely:

Spatial Practice or the Perceived Space: is what bonds and embraces production, reproduction and the particular locations. It is the pairing between daily reality and urban reality. Spatial Practice is linked to the idea of mediation and mediators as described in p.85 of POS, (see (Lefebvre, 1991)) "*A social space cannot be adequately accounted for either by nature (climate, site) or by its previous history. Nor does the growth of the forces of production give rise in any direct causal fashion to a particular space or a particular time. Mediations, and mediators, have to be taken into consideration: the*

action of groups, factors within knowledge, within ideology, or within the domain of representations. ***Social space contains a great diversity of objects, both natural and social, including the networks and pathways which facilitate the exchange of material things and information****. Such 'objects' are thus not only things but also relations. As objects, they possess discernible peculiarities, contour and form. Social labour transforms them, rearranging their positions within spatia-temporal configurations without necessarily affecting their materiality, their natural state (as in the case, for instance, of an island, gulf, river or mountain)*".

Representations of Space (R of S) or conceived space: "*tied to the relations of production and to the 'order' which those relations impose and hence to knowledge, to signs, to codes and to 'frontal' relations*" (p.41, PoS). The R of S, the conceived space is the space produced by intellectuals, geometers, architects and City Designers as the institutionalized actors that create a new learning of Space (an abstracted Space) as they elaborate on Spatial Practice (but also of Representational Spaces) by the means of formalization and logical order. As Pugalis (Pugalis, 2009) notes: "*The complex policy fields of 'doctors of space' (to borrow Lefebvre's terminology), including architects, regeneration practitioners and planners, is a messy entanglement of formal and informal pathways of collaboration, interactions and contests over claims to privileged knowledge. Spatial policy-making (including implementation) is a process whereby the different interests of actors and actants struggle for control over meaning*".

Representational Spaces or the lived space: this is everyday life, space as directly, bodily, materially lived through its associated images and symbols and hence the space of inhabitants and users. This is the dominated space that imagination "seeks to change and appropriate". Lived space is "*Ego, bed, bedroom, dwelling, house; or: square, church, graveyard.* ***It embraces the loci of passion, of action and of lived situations, and thus immediately implies time****. Consequently, it may be qualified in various ways: it may be directional, situational or relational, because it is essentially qualitative, fluid and dynamic*". The following picture represents the trialectical relation of the l-c-p triad of Space:

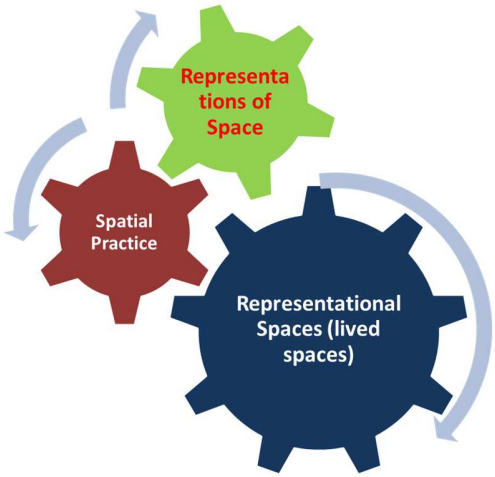
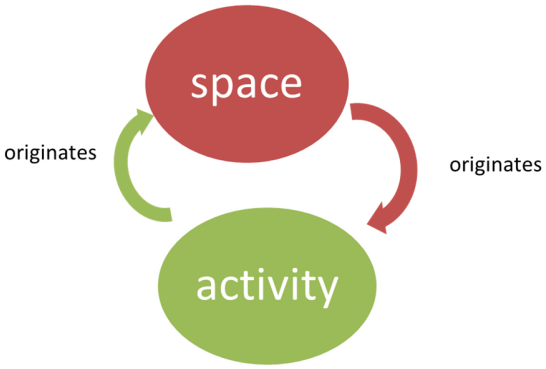


Figure 11 the l-c-p triad of Space

How this triad is producing space is vividly being explained by Lefebvre (p71-72, PoS) and it amounts in the following scheme:



An activity (a human activity) starts when a need rises to achieve a purpose. To that end the body mobilizes to use **material** -as eyes and mind- and ***matériel***[14] -as language, relations, agendas- elements. The process driven by purpose and means creates relations and logic (order of things in spatial context and temporal succession). The lived space is informing Spatial Practice while at the same time uses the Rituals of the Spatial Practice level (ie the Services level) to facilitate its dynamic. As actions aggregate in these levels, meaning is produced and travels to the next level, that of conceived space where is re-imagined and abstracted. It is not really a circle; it is a destruction-construction trade-off,

[14] As found in https://dictionary.cambridge.org (assessed on May 2018) the French meaning is "(ce qui est nécessaire à une activité) ensemble des objets, des machines nécessaires à une activité" that is the aggregations of things or apparatus needed for an activity.

most of it happening as representations of possible re-configurations of space are decided.

2.6 A recap

Our effort in this chapter has been two-fold: first to reveal the current state of affairs of "smart city" notion and secondly to introduce a bridge to Urban theory.

To identify the "as is" state of "smart city" research we used (a) articles of systematic literature and (b) articles that were of some specific interest. The search revealed that

1. Smart city has staged itself for more than 25 years as both a research agenda and a political-managerial vision of the city.
2. Despite that a consensus has not yet been reached as to what "smart city would be" or to what the "domain notions of it" are. It is also rather Science Technology Engineering Mathematics (STEM) oriented field than Social Sciences. Yet to form a discrete field or become part of a multidisciplinary area, smartness is at most an ICTization of the core city functions. But a gradual change of that has started as researchers from social or urban studies have interested in the field.
3. It also lacks an elaborate bridging to the Urban context which declares to be its target of change. **Smart city is more of smart and less of city**.
4. It is also conceived as an ontological being, in a functionalist way, in a hard way: it is there to grasp. So, someone can carefully design and cleverly produce an ontology of some kind.
5. Smart city has not yet received interest from the systemic thinking. Attempts to identify smart city as ill-defined problem, thus in need of a systemic approach, are rare but (let us be optimistic here) not marginal.

The introduction of an Urban theory as the discourse of our Knowledge concerning city is justified as:

1. "Smart city" has "city" as its domain while perhaps creates a new range. Therefore "smartness" is at least as a starting point a recreation of the Social Space of Urban, as new mediations and reconfigurations of it are produced or attributed to Technology.

2. Lefebvrian urban theory provides us with a meso-theory (not specific but also not too abstract) that is "*historically specific and mediated through power relations*" , denies a technoscientific triumphalism, sees the city as process than structure and allows for the assemblage and re-assemblage of stakeholders, things and ideas as activities create space and then enslaved to it to form spatial practice and conceived space which in turn dictate difference and via it, learning and the cycle begins again.

In Chapters to follow we lay down our approach to include:

1. The introduction of a systems thinking methodology to address the "wicked" nature of the problematic area "smart city". Not surprisingly, as we understand the problematic area as an ill-defined situation, surrounded by a lot of different Worldviews by a vast and changing number of stakeholders we adopt a Soft Systems approach.
2. The augmentation of the methodology with an ontology like artifact in an effort to overcome an epistemological-ontological divide and to introduce the concepts of the Urban theory (of paragraph 2.5) as essential parts of our investigation for the smart city domain notions.
3. Finally, a learning approach as a unification method. Our wicked problem should be tackled as a coordinated Action Research, which follows the steps and provisions of Soft Systems Methodology, Urban Theory and an Ontological artifact that anchors the methodological concepts to the ones provided by the Lefebvrian approach.

Chapter 3: Foundations to approach I - Systems thinking and Soft Systems Methodology

3.1 Introduction

So far in Chapter 2, we have sought a familiarization with the notion "smart city" and an understanding of the emerging concepts of it through the reviewing of selected literature resources. During the course of literature reviewing two important issues have been identified, namely: (a) Usage of systemic theory is quite limited in the field and (b) an Urban theory to bridge smart and city is missing. The latter we have already dealt with in paragraph 2.5. The former is attempted throughout the current chapter (Chapter 3). To make a case in favor of systems thinking use we firstly present a rationale of it, explaining why systems thinking may be useful in the understanding of "smartness" in an Urban context. Next we move to present some of the main schools of systems thinking. We do so (a) to stress the fact that reductionism as a scientific paradigm is not appropriate for addressing the ill-defined problem of smart city and (b) to introduce with basic concepts and paths of development in the systems thinking field as a guide to finally help us select a specific approach (the Soft Systems approach) as the most suitable one. A whole paragraph (3.2.4) is dedicated to the exploration of smart city as a "wicked-problem" and the reasoning in favor of Soft Systems Methodology as a methodology that fits the purpose of disentangling the notion smart city. Finally, we provide an overview of the selected methodology. Chapter 3 is (together with Chapter 4 and paragraph 2.5) where the foundations of the approach, needed for our analysis, are presented.

3.2 Rationale for the adoption of a systems thinking approach

Why systems thinking for smart cities? To answer the question, we revisit literature of smart cities with a goal to reveal implicit or explicit fragments of systemic thinking. We are looking for concepts prevailing in the domain of smart cities, of layered representations or for interconnections between components or domains and communication issues in general. Although those can only be rather a coincidence (not the intention of those authoring the papers selected) there is a story telling through them that may be useful in taking the last few steps to systemicity.

Let us start with those articles that explicitly use a systemic approach. Harisson et al (Colin Harrison & Donnelly, 2011) for example (see Figure 7 A simplified view of a multilayered city representation. Source: (Colin Harrison & Donnelly, 2011) understand smart city **as a multi layered system of systems**. Each layer represents a system of systems and by starting from natural environment at the bottom and ending to Social systems at the top a hierarchy of systems is present at that level of abstraction. But the article does not clarify if System of Systems within the layers are also hierarchies of some kind or something else. Systems are also ontologically thought: there are out there patiently waiting for a discovery and description. They are having identifiable boundaries and work as exchange of information happens between those boundaries. In our second example Fernández-Güell et al ((Fernández-Güell et al., 2016)(see Figure 1) understand the city as a systemic levels of urban demand , served by urban supply, constrained by spatial configurations, served by a technology system and suffering from external shocks. The idea is depicted in Figure 12.

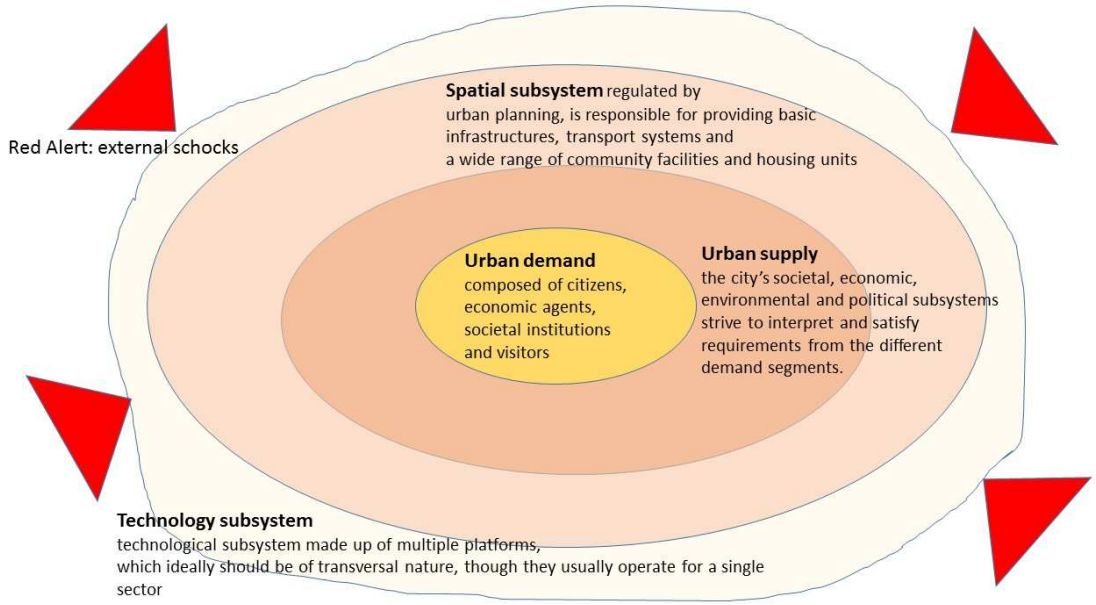


Figure 12 A systemic representation in a functionalistic way source:(Fernández-Güell et al., 2016)

As the authors explain "*Though it can be perceived as reductionist, this systemic conceptualization of the city has a clear advantage: it displays a simplified, intelligible abstraction of the inherent complexity of our urban reality, which is easily understood by technicians, local stakeholders and citizens. It also analyzes the diverse relationships between urban components as well as it exposes the dominant or dependent positions of both stakeholders and functional subsystems. Thus, the systemic approach strives to reach a better understanding of the urbanization process as well as to establish a common ground for reconciling technologists and urban planners*". Again, this artistic representation, describes systems (of systems) in an ontological fashion, by devising abstraction levels (like demand and supply or spatial and technology) that seem to exist independently from one another, but having interconnected lives and perhaps common enemies stemming from the environment outside the boundary they preserve.

If we now proceed with the papers on smart city that are lending themselves implicitly to the systemic thinking (which can be traced by the literature review of chapter 2), a common aspect in many of the attempts to define the city is around the ideas of concepts or components, where concepts/components being areas that we all in everyday language refer to as systems. Sometimes interconnections are sought for those concepts to grasp something of the essence of urban, which in these respects is taken as granted, as a container of those "concepts". For example Nam and Pardo in (Nam & Pardo, 2011) in "Conceptualizing smart city with dimensions of technology, people, and institutions", conclude their paper by acknowledging that a multiplicity of the smart city concepts emerge as they have explored a plethora of definitions and that these concepts could be classified under broad categories as technological, human or institutional. But what matters is the interconnection between them in an urban context. They suggest "*However, social factors other than smart technologies are central to smart cities"* and "*Leading a smart city initiative requires a comprehensive understanding of the complexities and interconnections among social and technical factors of services and physical environments in a city. For future research based on a socio-technical view, we must explore both "how do smart technologies change a city?" and "how do traditional institutional and human factors in urban dynamics impact a smart city initiative leveraged by new technologies?""*". Figure 13 sets the strategic vision of smart. In

describing the vision meanings -not quite explained- are used such as: "*new level of complexity*", "*smart cities integrates …into organic network", "emergent properties*". Clearly, these are systems thinking notions but without any reference to systemic theory per se.

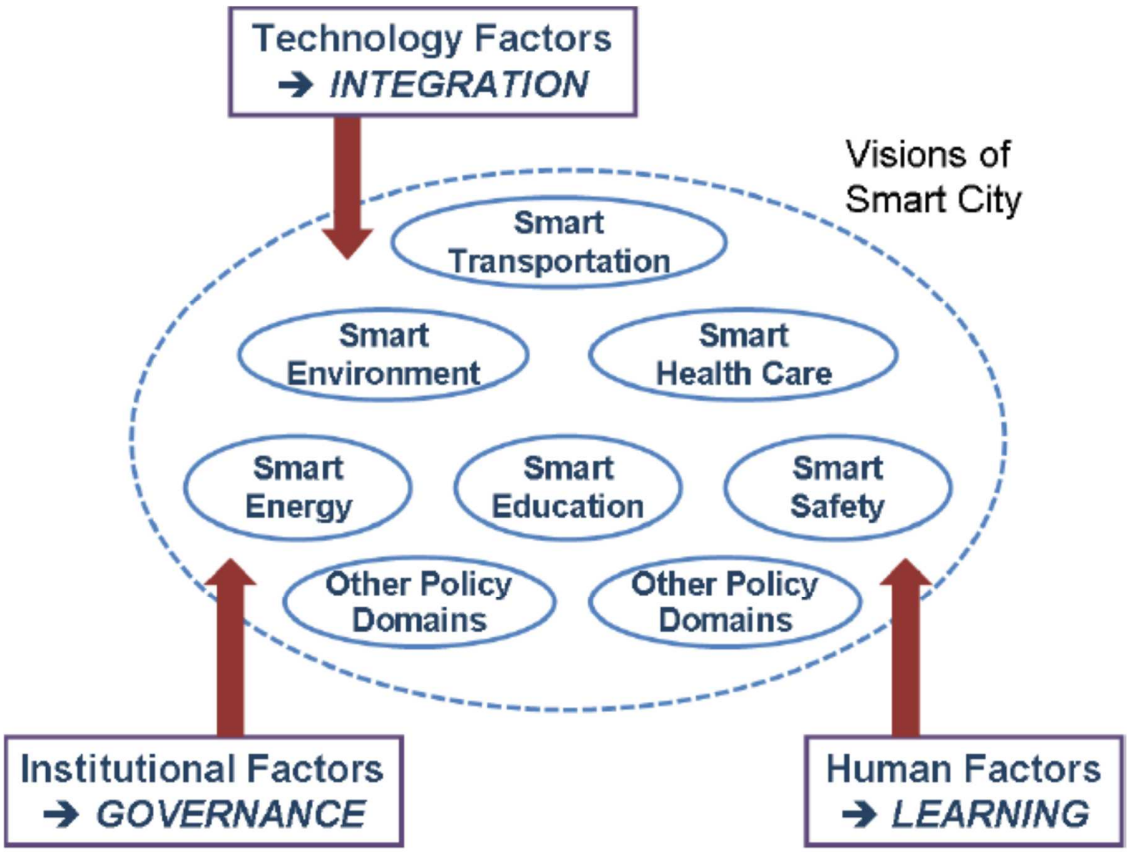


Figure 13 Taken from Nam and Pardo ((Nam & Pardo, 2011)) :a view full of systemicity but not recognized as such.

There are plenty of articles that follow the same pattern of introducing domains in the study of city (for example (Chourabi et al., 2012)) as presented in the their "Smart cities Initiative Framework" (see Figure 14). For Chourabi et al "*Outer factors (governance, people and communities, natural environment, infrastructure, and economy) are in some way filtered or influenced more than influential inner factors (technology, management, and policy) before affecting the success of smart city initiatives. This counts for both direct and indirect effects of the outer factors. Technology may be considered as a meta-*

factor in smart city initiatives, since it could heavily influence each of the other seven factors".

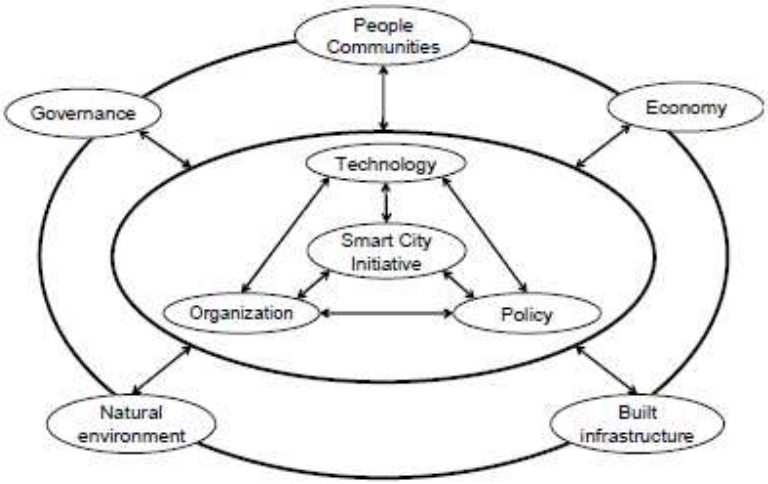


Figure 14 Smart cities initiative framework source:(Chourabi et al., 2012)

Smart city is also achieved as layers are built at the top of city layer (being layer 0) from Green layer (layer 2) to Innovation layer (layer 6) as in (Zygiaris, 2013). These layers are the "*interconnected, instrumented, and application layers are distinguishing parameters to estimate city's 'smartness'*".

Neirotti et al ((Neirotti et al., 2014) describe cities as "complex systems", characterized by interconnected things such as "*citizens, businesses, different modes of transport, communication networks, services and utilities*". They understand the variety of "visions and facets" about smart city as being an expression (a direct analogy) "*of the multitude of urban living domains to which technology and policy interventions can be applied*". The authors contribute to the discussion on domains of city life by collecting (via literature sources) and taxonomizing domains of the city, in six wide categories[15] arrange them in subdomains and provide the main, the top objectives for each of the subdomains. They also taxonomize domains into hard domains (having to do with infrastructures) and soft domains (Human Capital and Government). They also introduce levels in the discussion although in a loose manner "*the number of urban living domains covered by the spectrum*

[15] Namely: Natural resources and energy, Transport and mobility, Buildings, Living, Government, Economy and People

of a city's project, reflect the effort made to improve sustainability at various economic, social and environmental levels" ((Neirotti et al., 2014)).

Here again the notions of complexity, interdependence or interconnection and a loose idea that smartness is a social (at least also) thing surfaces. A Hard-Soft systems notion is also mentioned despite the fact that this is seen as a dichotomy. There are Hard and Soft domains (systems) in a city and they are mutually exclusive.

But the real story telling behind those numerous attempts to think about the smart city needs another angle of viewing. The plethora of definitions, the conceptual plurality of overlapping or not overlapping terms, the marketing agendas, reveal bewilderment, a sense of being overwhelmed by the complexity of the issue. Smart city, even if for a minute we think of it as **city plus**, as something of the city or atop the city we cannot escape the unescapable: **that it inherits the full complexity of the Urban context which it inhabits**. It goes beyond that: **smart city will be, there is none**. So, complexity leaves the plane of own experience and reserves future configurations (or should I say assemblages…) negotiated and battled by stakeholders some of them present but the majority of them not yet produced. Tsoukas et al for example in ((Tsoukas & Hatch, 2001) , mentions a number of dimensions of complexity that fully come to play in the understanding of smart city notion, as presented in Table 6.

Table 6 Dimension of Complexity and their correspondence to Smart City notion adapted from source:(Tsoukas & Hatch, 2001)

1 Complex **systems** are non-linear: there is no proportionality between causes and effects. Small causes may give rise to large effects. Nonlinearity is the rule, linearity is the exception.	Stakeholders are at the same time cause and effect, social relations emerge at different levels and cause alterations to lower levels as they recurrently being informed by lower ones
2 Complex **systems** are fractal: irregular forms are scale dependent. There is no single measurement that will give a true answer; it depends on the measuring device. For example, to the question 'how long is the coastline of Britain?' there is no single answer, for it hinges on the scale chosen to measure it. The smaller the scale, the larger the measurement obtained.	Purpose matters
3 Complex **systems** exhibit recursive symmetries between	Levels of abstraction/

scale levels: they tend to repeat a basic structure at several levels. For example, turbulent flow can be modeled as small swirls nested within swirls, nested, in turn, within yet larger swirls.	layers of systems
4 Complex **systems** are sensitive to initial conditions; even infinitesimal perturbations can send a system off in a wildly different direction. Given that initial conditions cannot be adequately specified with infinite accuracy, complex systems have the tendency to become unpredictable.	History is implied here. Initial conditions in a city come from past configurations ie from the memory of the city and may alter the way of new representations of the city.
5 Complex **systems** are replete with feedback loops. Systemic behavior is the emergent outcome of multiple chains of interaction. As the level of organization increases, complex systems have the tendency to shift to a new mode of behavior, the description of which is not reducible to the previous description of the system's behavior. These emergent novelties represent points of bifurcation.	If for example smart city is an emergent behavior that cannot be analyzed to something of the type city plus technology.

Therefore, an answer to the opening question is now been formed: Smart city, is thought complex, domain dense and domain interconnected, layered in levels that bring new light to the functioning of it. But ultimately is city.

We have dealt with the latter, the city in paragraph 2.5. The choice of a theory of the city that understands the city as a "social system" and through the device of the Lefebvrian triad points, also, to systemic thinking coupled with a theory that is Urban specific.

To deal with the complexity we engage in systemic thinking. We do so because smartness couples with complexity to all dimensions in the table above. To instantiate the effort and finally select a proper systemic methodology we follow a line of major moments of the historical exelixis of systems thinking. It is both a way to reach a selection but also to develop an arsenal of ideas that may be useful with the selection. After providing a condensed presentation of systemic thinking ideas we move to finally selecting one as the core systems methodology that facilitates the purpose of disentangling the smart city notion. It is for that reason that, in paragraph 3.2.4 we view another aspect of the problem: the problem itself as an ill-defined or a wicked one. That is also an answer to the opening question.

Therefore, because, a. the complexity of the situation is perceived, b. the city is perceived as a social system and c. the need for sense making of the problem, leads us to systemic thinking and a specific strand of it.

Figure 15[16] tells a history of the systems thinking evolution and basic schools. But it does not say much about the dilemmas that moved and shaped the field and neither reveals how systems thinking can enter the thinking about city smartness. To move away from a static or even a linear representation of how systems thinking has been evolving since the early 1930's[17] (and finally bringing clarity to the reason it may be helpful in the shaping of thinking about smart city)

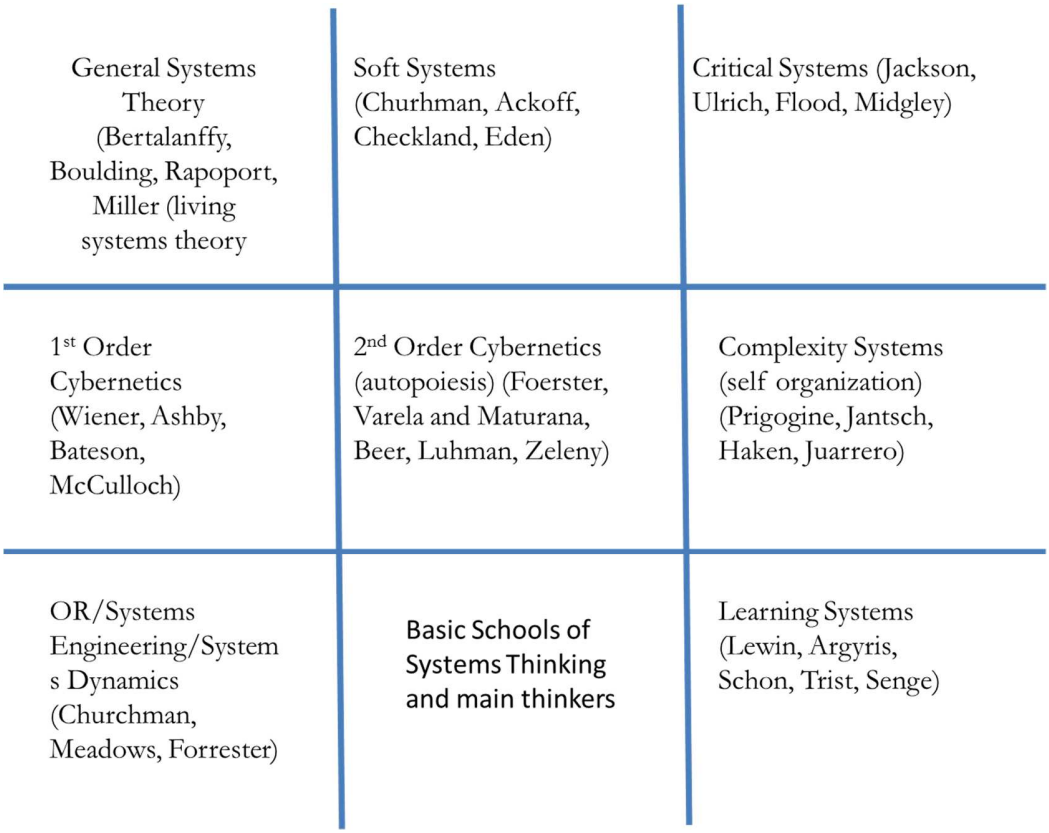


Figure 15 Systems thinking schools of thought (a crude depiction)

we sketch the answers to the following questions

[16] A fine work of visualization of systems thinking is due to Brian Castellani and may be accessed in http://www.art-sciencefactory.com/complexity-map.html

[17] 1930's marks the beginning of System Theory Schools in the Western Tradition. Before that Tektonomics by Bogdanov in mid-1910's are a quite similar attempt, Shelley Ostroff (Ostroff, 2000) goes as back as to 6th century BC to trace origins of the field in Aristotle.

I. What are (some of) the great streams within the evolution space of systems thinking?

II. Is some (or at least one) path inside the evolution space that finally better suits the end of describing smartness?

3.2.1 The birth crossroad: a case against reductionism

In our understanding, there are three main crossroads in the evolution of systems thinking. The first is the emergence of the field, as Midgley suggests in his contribution for (Williams & Imam, 2007)[18] as "*an antidote to reductionist science*". To place the argument carefully here, the Newtonian (or perhaps the Kuhnnian) paradigm of the breaking up of a phenomenon (which we are interested in) to its alleged parts and then re-synthesizing to re-assemble a model matching the phenomenon finds its final frontier when phenomena we observe no longer can be understood by a never-ending reduction to the parts or when the models they provide astonish the Cartesian view taken: can you split an elephant into two halve and got two elephants? ***No, but sometimes yes!*** Nancey Murphy in (Murphy & Stoeger, 2007)[19] calls this kind "***methodological reductionism***". A result of methodological reductionism is "***epistemological reductionism***", that is the idea that "*laws or theories at the higher levels should only be known to follow from lower level laws and ultimately from the laws of physics*". Murphy also identifies another three kinds of reductionism, namely:

- **Logical or definitional** ("*the view that words and sentences referring to one type of entity can be translated without residue into language about another type of entity*"),
- **Causal reductionism**: the view that causation moves upwards only. Behavior at the top is determined only by behaviors at the bottom.
- **Ontological reductionism** which she splits to
    - a. ontological one (keeps the same name for it as the collective category) referring to the view that as one examines higher levels of complexity does not need to introduce forces that produce them as "vital force" or "entelechy" and

[18] Gerald Midgley in "Systems Thinking for Evaluation" (Midgley, 2006)
[19] "Reductionism:how did we fall into it and how can emerge from it?"

- b. atomistic one, since the *really real* entities are the lower ones (for example the atoms).

Contrary to that scientific example and following a synthetic and holistic view General Systems Theory (GST) at first and many of the Systems Schools later suggested that hermeneutics could well be better off when organized elements, identified as such by purposeful acting, have revealed properties not to be found in each of them or in any inferior organized entity included within their structure. To reverse the course of thinking, an entity is something different than its sum of parts. GST has called such entities "open systems" and the properties they reveal at their level of arrangement "emergent properties" at that level. A system therefore was not a mere collection of bits and pieces just hanging around: it was (is) an arranged and purposeful "other" compared to its ingredients, defined or set to existence because of the emergent properties of it. Furthermore, the first systemic thinkers (Bertalanffy, Wiener, Ashby, Boulding or Rapoport) introduced the notion of boundary of a system and the way it worked: the hierarchy between its parts and the roles played by those parts. Reductionism was seen as a dead end. Holism introduced as the new way of understanding phenomena both in the nature and particularly in human society (or perhaps in the hybrid formations of the two). The distinction between the Newtonian analysis and synthesis method and the Systems Thinking lies at a critical point that becomes a point of symmetry between those scientific paradigms: that of hypothesis testing. Following Checkland and Holwell (P. Checkland & Holwell, 1997)[20] "*The implicit belief behind hypothesis-testing research in information systems is that social phenomena and social reality are at core not fundamentally different from the physical reality which biologists, chemists and physicists investigate. An alternative view is that social reality-what counts as "fact" about the social world- is continually being constructed and re-constructed in dialogue and discourse among human beings, and in action which they take. Researching social reality then becomes an organized discovery of how human agents make sense of their perceived worlds, and how those perceptions change over time and differ from one person or group to another. That kind of researcher does not expect to discover unchanging "social laws" to set alongside the laws of physics*".

[20] Page 22

Returning to Bertalanffy ((Bertalanffy, 1973) *"Similar general conceptions and viewpoints have evolved in various disciplines of modern science. While in the past, science tried to explain observable phenomena by reducing them to an interplay of elementary units investigatable independently of each other, conceptions appear in contemporary science that are concerned with what is somewhat vaguely termed "wholeness," i.e., problems of organization, phenomena not resolvable into local events, dynamic interactions manifest in the difference of behavior of parts when isolated or in a higher configuration, etc.; in short, "systems" of various orders not understandable by investigation of their respective parts in isolation. Conceptions and problems of this nature have appeared in all branches of science, irrespective of whether inanimate things, living organisms, or social phenomena are the object of study."*

Therefore, the first crossroad is **the birth crossroad**: Systems Thinking emerges in the Western 20th century as the child of need to describe what cannot be parted to pieces and assembled again and of the suspicion of a certain "isomorphy" between laws in different areas of science.

Let us also reflect for a moment the implications of moving into systems thinking rather exercise some form of reductionism in the problematic area "smart city": we can use methodological reductionism to city, because city exist in a common sense meaning. But we cannot really apply "smart" to those we may identify as atomic parts of the city, those *really real* parts of the city, since these parts are for example no lesser than human beings. If we can create or think of a "smart human being" then, and in the same reductionist fashion, we have to further analyze that smart human being to its own atomic parts. Then reductionism collapses: if we can do that, suddenly we may have smart molecules. We may even start by a definition of smart atoms or molecules in the upward causation habit of reductionism and transfer "smartness" finally to the city. Or, in case we steer our attention to a more social partition of the "smart human being" then we are faced with the problem of sub-human but still possible social divisions. In any case, the methodology of splitting to understand comes to a dead end.

3.2.2 The second crossroad: Cybernetics- Autopoiesis and the Organismic trend

While through the work of Bertalanffy, Rapoport and Boulding in the early 50s set the theoretical framework of the new field, the General Systems Theory, was becoming more and more popular, it was the emergence of Cybernetics (and Information Theory) that marked the systemic thinking for the first decades after the second war. Ostroff (Ostroff, 2000) (but others also) describe this particular stream as the Mechanistic trend (as opposed to Organismic one). Stemming out of the work of Norman Wiener ((Wiener, 1988) or (Wiener, 1961)) Cybernetics focused systems adaptation to change or to put it in equivalent terms, by introducing the **feedback mechanism** to the way a system maintains its steady state (negative feedback) or how evolves beyond it to collapse or a new steady state (**positive feedback).** Further to feedback mechanism and in an attempt by early pioneers to become "*neatly organized in a coordinated bundle of concepts*" (see (François, 1999)), Wiener and others soon realized the connections of the theory to other scientific fields ranging from sociology, psychology and organization theory to mathematics, logic and information theory or thermodynamics. The main ideas of Cybernetics have evolved around the notions of control, regulation, feedback and information flow as a means used by a system to achieve homeostasis. According to a definition provided by Klir and Valach ((Klir & Valach, 1967)) "*Cybernetics is a science dealing on the one hand with the study of relatively closed systems from the view point of their interchange of information with the environment on the other hand with the study of the structure of these systems from the viewpoints of the information interchange between their elements".*[21]

Cyberneticians as Ashby, Shannon and Weaver (Information Theory) and McCullogh and Stafford Beer are today thought to be founders of what is called **1st order cybernetics** or **the cybernetics of the observed system.**

A critical moment (and a peak in that direction) was the Viable System Model (VSM) presented by Stafford Beer between 1972 and 1985. The core logic of VSM is that a system is well described as far as five management functions of it can be detailed: **S1**

[21] As found in (McLoughlin & Webster, 1970) "Cybernetic and general-system approaches to urban and regional research: a review of the literature"

operations, S_2 co-ordination, S_3 control, S_4 intelligence and S_5 policy (see Figure 16). Should anyone attempt a metaphor, Beer's view for the system is a "model", in the sense that a system can be logically described via a conceptual schema or a representation. But despite that, the model in cybernetics, ie the system under consideration remains a machine type system having input and output and what happens between input and output is well and logically organized in the above-mentioned subsystems, each of them achieving a certain autonomy but also been dependent on the others.

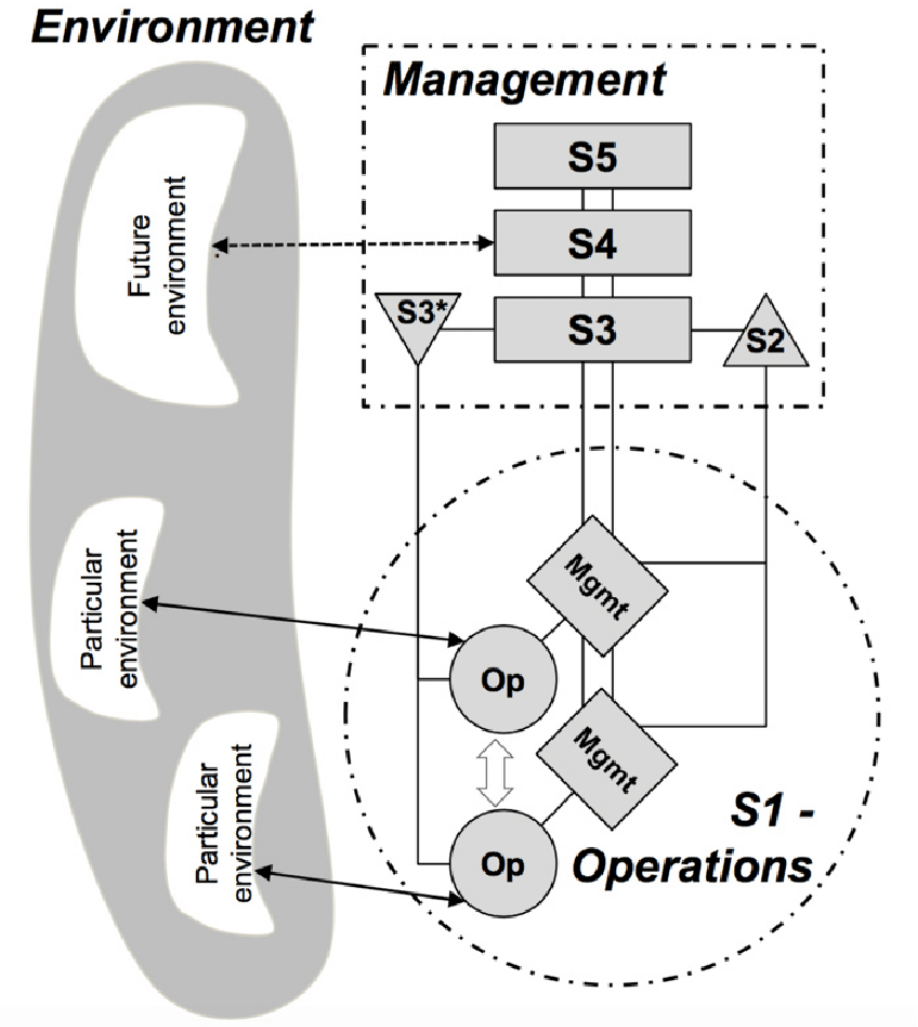


Figure 16 Beer's Viable Systems Model, Source: (Sadi, Wilberg, Tommelein, & Lindemann, 2016)

Not surprisingly, what is also apparent in the cybernetic view is the existence and obvious traceability of the boundary of the system and the subsystems. By deploying the 5 core subsystems in the way it does, cybernetics leaves no room for vagueness, in what

constitutes the boundary of a system. It is through these well-defined boundaries that functions as "shared visions" travels to lower systems. The objective here (from a managerial worldview) is to make the systems under consideration "survival worthy". As Mingers and White (Mingers & White, 2010) point out "*the model aims to specify the minimum functional criteria through which an organization can be said to be capable of independent existence or to maintain its identity in a changing environment"*.

But, in an article published in 1960, by H.Von Foerster (Foerster, 1960) the boundary of any system as something possibly described came under scrutiny. And with that Cybernetics found themselves to travel the path of **2nd order Cybernetics** or the **Cybernetics of the Observing System**. In his attempt to describe a self-organized system, H.Von Foerster seeks for what comprises the boundary of such a system. What is the structure to declare self-organizing versus what is not is separated by a boundary that inside of self-organizing is actually happening? That brings the observer in a situation that she constantly needs to move the boundary not only because she may got unlucky in her first choice but because, as the self-organizing system would increase the organization of it would push the boundary further. But that creates a problem for the validity of any observer's claims or descriptions. In H.von Foerster's words "*The first problem arises whenever we have to deal with systems which do not come wrapped in a skin. In such cases, it is up to us to define the closed boundary of our system. But this may cause some trouble, because, if we specify a certain region in space as being intuitively the proper place to look for our self-organizing system, it may turn out that this region does not show self-organizing properties at all, and we are forced to make another choice, hoping for more luck this time. It is this kind of difficulty which is encountered, e.g., in connection with the problem of the "localization of functions" in the cerebral cortex*".

Following the description of Bernard Scott ((Scott, 2004)*"The constructivist phenomenal domain of the observer may be taken as a starting point to account for the joint construction of the scientific domain. In turn, the "scientific" may be taken as a starting point for an account of how observers evolve to become members of a community capable of constructing consensual domains"*. In ((Foerster, 1960)) the above notion is depicted by the following description "*Assume for the moment that I am the successful*

business man with the bowler hat in Figure 17, and I insist that I am the sole reality, while everything else appears only in my imagination. I cannot deny that in my imagination there will appear people, scientists, other successful businessmen, etc., as for instance in this conference. Since I find these apparitions in many respects similar to myself, I have to grant them the privilege that they themselves may insist that they are the sole reality and everything else is only a concoction of their imagination. On the other hand, they cannot deny that their fantasies will be populated by people—and one of them may be I, with bowler hat and everything!

With this we have closed the circle of our contradiction: If I assume that I am the sole reality, it turns out that I am the imagination of somebody else, who in turn assumes that he is the sole reality. Of course, this paradox is easily resolved, by postulating the reality of the world in which we happily thrive".

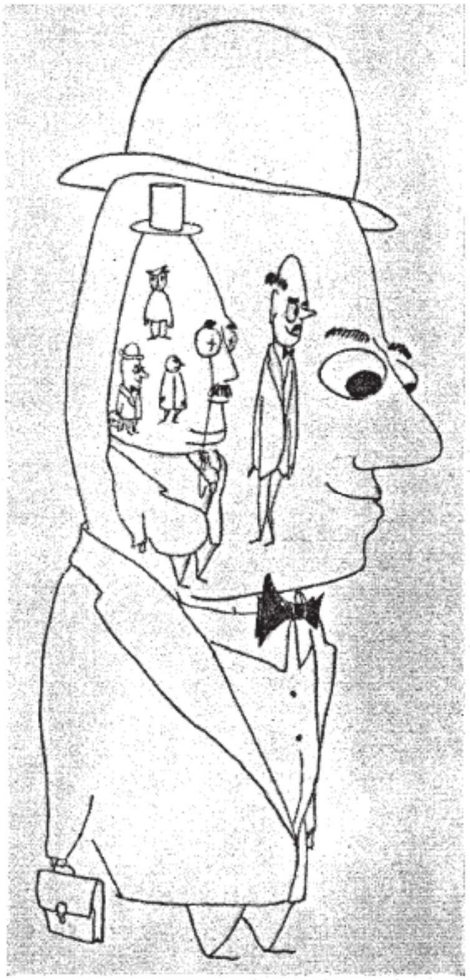


Figure 17 Foerster on Reality source:(Foerster, 1960)

As a result of the understanding of circularity or reflexivity a new stream of Cybernetics emerges at 70's and brings into the fore ground ideas such as "auto-learning", "auto-organization" and "autopoiesis" as Maturana and Varela work on the living organism, and especially the cell, as an "autopoietic machine".

The idea of "autopoiesis" becomes the new frontier of Cybernetics trend. Stemming out form then state of the art developments in fields such as biology, psychology, epistemology and cognitive sciences in general redirects systemic thinking. The basic notions of the autopoiesis movement are: "Organization", "Structure", "Topological Boundary" and "Autopoietic System". Following Maturana et al ((Maturana & Varela, 1991) the Organization is a unity of a network of components which (a) participate in the same network that produced themselves (and therefore participate in a recursive mode of production) and (b) constitute the network of productions as a concrete unity in the space and time those components exist, forming in that way the topological boundary of the system.

Should the urban have been imagined as an autopoietic scheme then one should imagine the neighborhoods in it as both self-producing and self-demolishing themselves as a result of a space-temporal algorithm (which in that case would represent the organization of the Urban) while those neighborhoods would also be the Urban itself in a snapshot of time and define the boundary of the Urban agglomeration. But of course, the example may not be appropriate as is in the case of the Gaia theory. The snapshot in a space-temporal moment of that Urban is the Structure of the autopoietic system. One should note that, because the theory stems from biological formation that are self-produced as the cell or the neuron and the nervous system, the topological boundary, produced by the system itself and not imposed by any surrounding environment is evident to the observer of the system, making therefore the autopoietic system closed and autonomous. It is now also clear that an autopoietic system is defined by: 1. The Organization of Relations between components (the system belongs to some class of that Organization) 2. The Structure as a spatiotemporal instance of the class of Organization realized at specific space and time 3. A self-production process (of production, destruction or transformation in general) since ((Maturana & Varela, 1991) page 79) "*its defining relations of production must be continuously regenerated by the components they produce*" and 4. A

topological boundary is produced by the system itself and is evident to an external observer. Should a system maintain all the above identities then it is considered to be an autopoietic system. The living systems belong to the class of autopoietic systems and indeed "the notion of autopoiesis is necessary and sufficient to characterize the organization of living systems".

But Varela is arguing against the application of the notion of autopoiesis outside the biological or the physical domain: extending autopoiesis as a tool to explain social domains can only be of a metaphoric value (Varela, 1981) as found in Cadenas and Arnold (Cadenas & Arnold, 2015). For Maturana and Varela ((Maturana & Varela, 1987)) the social systems is only a third order aggregate of autopoietic systems and are both social and biological phenomena, thus not autopoietic. But other scholars advanced their research in the opposite direction. Zeleny (see for example (Zelený & Hufford, 1992) and Luhman (Luhmann, 1986) both considered autopoiesis as a systemic model for Social Systems.

Another important point of autopoietic systems should also be stressed here: autopoiesis as theory does not need any kind of teleology or teleonomy. Autopoietic systems either exist or do not exist (there is no intermediate systems) and their existence is the result of the relations that have produced them and retain them as long as they can be reiterate themselves ("given the proper components and the proper concatenation of their interaction, the system is realized"). Therefore, they can be concrete systems or disintegrate but they lack purpose or aim "Living systems, as physical autopoietic machines are purposeless systems" because "aim necessarily lies in the domain of the observer that defines the context or establishes the nexuses".

A third stream, The Organismic one appears while Miller (Miller, 1978) builds on Bertalanffy and the idea that systems are hierarchies of other systems or the idea of levels in the systemic inquiry. Jantsch (see The self-organizing universe, (Jantsch, 1980)) also produces a general theory of Dynamic Systems focusing on self-regulation and self-reference in contrast to the "solid" or "static" systems structures and components. In the words of Prigogine (1989) order is possible through fluctuation.

Living Systems Theory (LST), introduced at late 70's by the work of J.Miller is a theory developed to conceptualize the ecology of living systems. The LST starts as low as the cell and moves to successively more complex systems as organ, organism, group, organization, society and finally supranational system by applying a System of Systems approach: each of the successive systems is part of the next in hierarchy system and shares the same vocabulary of notions and are commonly conceptually modeled as SoS of 20 (19 plus timer subsystem) critical subsystems (doing a different job at each level form cell to organ, but all present). For Miller, the living system is a special subset of the set of all concrete systems but, contrary to the autopoiesis paradigm, is an open system with significant inputs and outputs and they maintain negative entropy ("negentropy") in their effort, or better to achieve their purpose, of sustaining a steady state. The main system of the 20 critical sub systems is the "Decider", ie the system responsible for the coordination of all others subsystems "in the sense that a system cannot be parasitic upon or symbiotic with another system for its deciding" (p 67-69). The notion of a "decider" subsystem resembles the functioning of an electronic amplifier because "*the number of alternatives or degrees of freedom in the information output of a decider is smaller than its information input…*" One may attempt to present the city having 20 critical subsystems as follows in the Table 7 of next page.

Table 7 The 20 critical Subsystems of a living System Source: (Miller, 1978)(with adaptations)

	LST code of subsystems	Analogy of the City subsystems (if there is)
1	**Reproducer** (capable of giving rise to other systems similar to the one in)	
2	**Boundary** (the subsystem at the perimeter that holds together the components which make up the system, protects them from environmental stresses and excludes and permits entry to various sorts of matter-energy and information)	Administrative jurisdiction / geography-spatial ties /airport-port- railway station
3	**Ingestor**[22] (brings matter energy across the system boundary from the environment)	Energy, culture, safety…
4	**Distributor** (carries inputs from outside or from other subsystems and distributes them to the components(	transport
5	**Converter** (changes inputs into more useful products)	Economic production system
6	**Producer** (the subsystem which forms stable associations that endure for significant periods among matter-energy inputs to the system or outputs from its converter, the materials synthesized being for growth, damage repair, or replacement of components of the system, or for providing energy for moving or constituting the system's outputs of products or information markers to its suprasystem).	Economic production system
7	**Matter-energy storage** (the subsystem which retains for different periods of time deposits of various sorts of matter-energy)	Energy-Economic Production
8	**Extruder** (transmits matter energy out of the system in the forms of products or wastes)	Environment/Waste/Energy or Social Welfare
9	**Motor** (moves the system or components of it in relation to the environment)	
10	**Supporter** (the subsystem that maintains the proper spatial relationships among components on the system, so that they can interact without weighting each other down or crowding each other)	Governance
11	**Input transducer**[23] (the sensory subsystem that brings markers bearing information into the system, changing them to other matter-energy forms suitable for transmission within it)	Culture
12	**Internal transducer** (the sensory subsystem which receives from subsystems or	Culture

[22] Systems 3-10 are processing matte and energy

[23] Systems 11-20 are processing information

	components within the system, markers bearing information about significant alterations in those subsystems or components, changing them to other matter-energy forms of a sort which can be transmitted within it).	
13	**Channel and net** (the subsystem composed of a single route in physical space, or multiple interconnected routes, by which markers bearing information are transmitted to all parts of the system)	Communication
14	**Timer** (the subsystem that transmits to the decider information about time-related states of the environment or of the components of the system. This information signals the decider of the system or the deciders of the subsystems to start, stop, alter the rate or advance or delay the phase of one or more of the system's processes, thus coordinating them in time).	
15	**Decoder** (the subsystem that alters the code of information input to it through the input transducer or internal transducer into a "private" code that can be used internally by the system)	Communication
16	**Associator** (the subsystem which carries out the first stage of the learning process, forming enduring associations among items of information in the system)	Education/Culture/Governance
17	**Memory** (the subsystem which carries out the second stage of the learning process, storing various sorts of information in the system for different periods of time)	Culture/Governance/Education
18	**Decider** (the executive subsystem which receives information inputs from all other subsystems and transmits to them information outputs that control the entire system)	Governance, but not only (Economy, Sociopolitical and Technology systems)
19	**Encoder** (the subsystem which alters the code of information input to it from other iformation subsystems, from a "private" code used internally by the system into a "public" code which can be interpreted by other systems in its environment)	Culture
20	**Output transducer** (the subsystem which puts out markers bearing information from the system, changing markers within the system into other matter-energy forms which can be transmitted over channels in the system's environment).	Culture

The LST creates three classes of systems: the concrete system, the conceptual system and the abstracted system. For LST the Concrete system is out there, independent of the observer that observes it and is a non-random accumulation of matter and energy organized into interrelated subsystems and components. It is the case of the living system. A Conceptual system belongs to the land of symbolic meaning because it is a collection of terms, words or numbers "including those in computer simulations" ((Miller, 1978), p16). Interestingly enough an Abstracted system is a set of relationships abstracted or selected by an observer "*in the light of his interests, theoretical viewpoint or philosophical bias. Some relationships may be empirically determinable… but others are not, being only his concept*" (p.19). It is then no surprise that the boundaries of the abstracted systems correspond to the needs of the observer. And, contrary to aimless autopoietic systems, living systems in LST are purposeful: the definition of Purpose in LST stems from the "answers" the system ***chooses*** when in a state of stress in response to environmental (ie outside the boundary of the system forces) conditions that cannot control bringing the variables of the subsystems into a Strain, that is outside their steady state (equilibrium) condition. Choice is made possible as the information subsystems are translating the outside stress to new configuration of the variables (in all 20 critical subsystems) so as homoeostasis to be retained. During the invasion of the new conditions, preferential paths are explored and hierarchized, giving thus what Miller calls a preferential hierarchy of values "*that give rise to decision rules which determine its preference for one internal steady-state value than another. This is Purpose. It is the comparison value which it matches to information received by negative feedback in order to determine whether the variable is being maintained at the appropriate steady-state value. In this sense it is normative. (…) When disturbed, this state is restored by the system by successive approximations, in order to relieve the strain… (…)Any system may have multiple Purposes simultaneously*".

At this point, one should clear teleology as hidden in LST definition of purpose. **Purpose is rather another way to refer to a range of possible future steady-states that are possible because of the initial steady-state.** Therefore the purpose of a living system according to LST, is not defined in terms of the observer but as an endogenous rearrangement or corrective actions in the process of homeostasis.

Another difference with autopoietic systems (which are closed and well structured as a result of a self-imposing referentiality) is that LST sees structure as emerging in the process of the trade-off between the environment and the code (genetic or other) of the system.

3.2.3 The third crossroad: The Human Systems Inquiry or Soft Systems Versus Hard systems

"System" is the main concept of systemic theory. Systems thinking uses the notion of system to achieve a better understanding of the world. Natural systems (in both macrocosmos and microcosmos) were of the first to be explored. Biological systems or life-environment systems perhaps was the cause for the systems thinking development. A number of techniques or methodologies, based on the knowledge capital of sciences that has accumulated over the years, have developed to address reality through them. Operational Research methods, Systems engineering and Systems Analysis in a RAND fashion, certain streams of Cybernetics (for example Beer's Viable System Model) created a stream in Systems Thinking that become known under the label "Hard Systems": notions such as optimization, Differential equations and a stream of mathematical model building and the dawn of data gathering (data to be used in the optimizing saga or advanced statistical techniques) used in the attempt to understand system notions. And systems, in the case of "Hard systems" stream were thought as an ontological being, independent of the observer and governed by laws isomorphic to the laws of nature. Then the systems under consideration thought (either implicitly or explicitly) as closed or at least partially closed, with a concrete boundary observed by any observer that was "outside" the system. But beyond the way a system was perceived the use of the system notion was used in problem solving under major assumptions such as:

The system had goal or goals to accomplish

The system was able to set goals as a result of his existence

The system ontologically existed

The system had a well-defined boundary

The system was used as a problem-solving machine, therefore the problem it meant to help solving was well defined and a solution existed.

In Checkland's words the Hard Systems had a pattern of thinking (P. Checkland, 1983) *"…the same pattern emerges: formulate the problem as an objective to be achieved; build a model of the situation;(…) derive from "experiments" on the model the solution which best achieves the objective; implement the solution*" while in an earlier article (P. B. Checkland, 1980) he noted "*they are clearly predicted upon a philosophical position, usually unquestioned. This assumes that the phenomena investigated have an existence independent of the investigator, and can be described in accounts independent of the observer, and hence can be "optimized" in a way which will gain universal assent*".

The "Soft Systems" strand however refused that problems faced by, for example the manager, are well-defined problems or that there are objectives to be pursued (whose objective?) or that systems were ontologically existed. Instead Soft Systems is a label under which systems are not goal seeking machines but they are discourses or cultures or even political battlegrounds. Learning has substituted optimization as a wishful result.

In Checkland's description there four main thoughts as the basis of the Soft Systems stream:

(1) Human activity was thought to happen as people were attempting to bridge a current situation that was considered not satisfying by taking "purposeful action" which would eventually lead them to a desired situation. This has created the Human Activity Systems approach: people were linked by their activities, purposeful but not always in a goal seeking context (that may exist but is subsumed in the broader scope of purposefulness) and that has been the notion of Human Activity Systems. Systems were not anymore "entities" but "networks of activities" as defined by an observer.

(2) The notion of purposeful action, that binds human activity, is an emergent property of those Human Activity Systems based on the idea of Worldview (Weltanschauung). Worldview in its simplest form may be the angle from which the situation is perceived (and reveals the preferences, the culture, the politics of the observer or of the stakeholders of the situation) to full range of political or cultural analysis through which elaborated ideas or perceptions about the World are formed and then examined and modeled as Conceptual Models to be compared with the problematic situation and used as devices of prescribing

meaning to what previously had none. Therefore, there is no optimizing of any kind but instead there is *learning* accumulated as the Action Research of shaping or inquiring via Human Activities creates meaning out of experience.

(3) The recognition that systems thinking is no longer but an inquiry, results in the idea that designing could only be participatory, involving not only those interested or acting for the situation but also for all kinds of stakeholders that are profiting or wounded by it. Stakeholders are participants in the Action Research that builds the Conceptual Models of the system. In Pouloudi and Whitley for example (Pouloudi & Whitley, 1997), four principles of for the understanding of stakeholders' identification is provided: (i) stakeholders depend on specific context and frame (ii) they interact with each other (iii) they change over time and (iv) they cannot fully achieve what they want.

(4) Human Activity Systems are analyzed in Levels of other Human Activity Systems and interconnect. Checkland describes it in (P. Checkland, 2012) as "*Firstly, and obviously, any entity called "a system" may also contain within itself, functional subsystems, and may itself, as a whole, be a functional part of a wider system. So, a system will, in principle, be part of a "layered structure" making a hierarchy of systems. Which level is that of "system", which that of "sub-system", or "wider system" is a matter of judgement made by the person making use of the concept*".

The Soft Systems stream relocates attention to process instead of the entity-object. This is presented in a neat way in (Brocklesby, 2007) where a comparison and assessment of the work of Vickers and Maturana is attempted. Brocklesby explains how in the framework of their work, process precedes object, even in the explanation of the language itself. Because language "*It is not as many would argue, an abstract set of symbols for describing an observer-independent world, rather it is coordinated actions between people in constantly unfolding social networks. Through this process of languaging objects "arise" as proxies for coordinated actions; they are not pre-existing entities. (…)*".

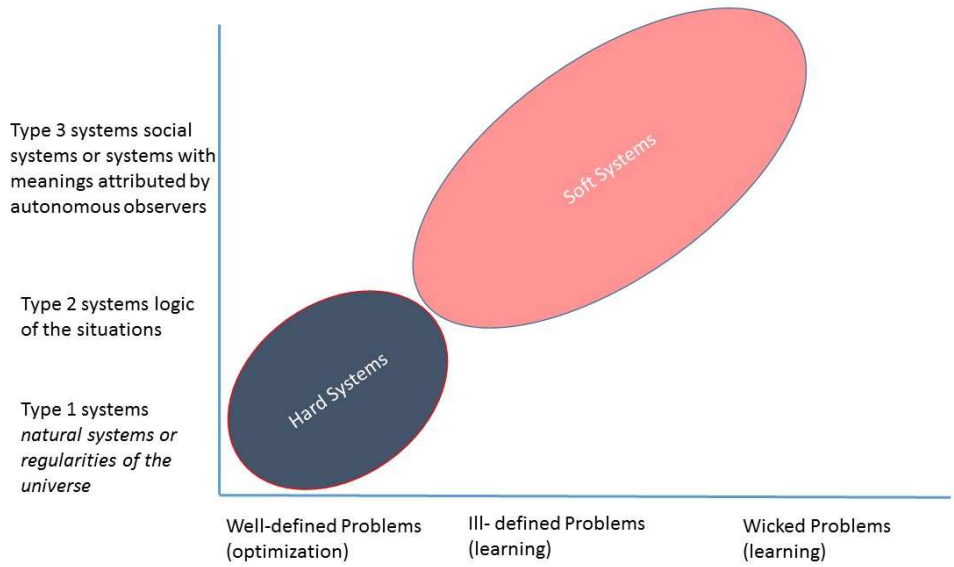


Figure 18 A representation of the Hard vs Soft distinction using Chekland's type 1, 2 and 3 systems and Horst-Rittel problem taxonomy

3.2.4 Smart city: A Wicked problem addressed by Soft Systems Methodology action research to emerge as a learning property of the urban.

As already noted the smart city notion is actually a problem for which we lack a common understanding. In fact perhaps the only consensus surrounding it is the fact that in the taxonomy of problems lies in the category of "wicked" ones: Following Rittel's et al taxonomy of problems (Rittel & Webber, 1973) the smart city notion is perceived as a member of a *"class of social system problems which are ill-formulated, where the information is confusing, where many stakeholders have conflicting values and where the ramifications in the whole system are thoroughly confusing"*.

This is the case of smart city as it is the case for city. Calling in any ICT solutions does not alter the facts already there in the making of urban context. It actually leads to a multiplication of complexity by the "product" of a new system, that of technology, claiming its own pace into the cityscape.

In fact our wicked problem can be described briefly as follows: "*an urban context of today, not been satisfactory in our own eyes for a lot of different and conflicting reasons*

is hoped to be transformed to something visionary and futuristic which we agree to call the smart city".

It is more than evident that our transformation process is an "austere" black box.

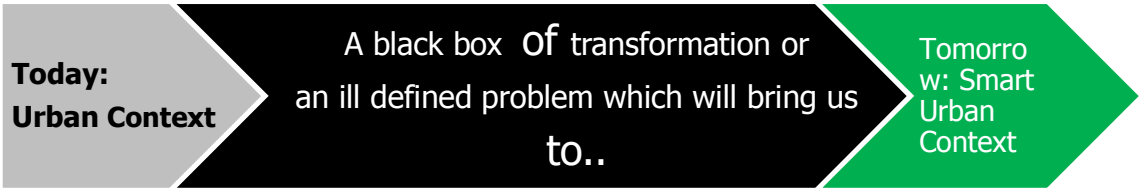


Figure 19 Is smart city a black box?

The urban context is the only fact, although a disputable fact, to enter the box, where a transformation is supposedly happening, nothing we know about it, except that it needs to use technology and thus produce something we may in the future call the "smart city".

If someone sees the problem in a time line it could be stated like that: *"In a future time t_n when we look back at time t_0 we can identify a transformation process, say T, that eventually has modified an urban context at time t_0 to what is perceived to be the urban time at current time t_n"*. Of course, neither the time periods nor the urban contexts at those periods are known to us: neither have we possessed any knowledge about the transformation itself. More calmingly, urban context is an issue that is open to perception and mirrors the values, beliefs and preferences of many stakeholders. A plurality of goals, objectives, values and power distribution makes it impossible to formulate the problem or to apply any hard approach. Smart city is together a management problem, a society evolution process and a mirage of power distribution at a given phase of capitalism evolution. Therefore, cannot suffice to reduce it to its parts, cannot be reduced to a data intensive problem (who gathers what? For what purpose?); so statistics fit in here only as a wikihow; *the landscape of smart city resembles that of a desert altered by strong winds.*

It is appropriate in dealing with the problem to call in Jackson's extended version (as in (Jackson, 2003) of Jackson and Keys' 'ideal-type' grid of problem contexts.

Table 8 Jackson and Keys' 'ideal-type' grid of problem contexts

	Participants		
Systems	UNITARY	PLURALIST	COERCIVE
Simple	Simple-Unitary	Simple-Pluralist	Simple-Coercive
Complex	Complex-Unitary	**Complex-Pluralist**	**Complex-Coercive**

It is not the scope of this dissertation to continue this path of analysis. We have used it to declare that the nature of the smart city notion can be taxonomized as a problem ranging from Complex-Pluralist to Complex-Coercive. Furthermore if we for example draw a table of preferences vs the systems complexity, the latter ranging from complex-pluralist to complex–coercive and the former from low to high (concerning the degree of involvement) we produce the following table (we call it an initial negotiation table because it may be used to analyze the initial standings of all participants. We also present it here as a heat map).

Table 9: The preferences vs complexity

	Systems perceived complexity		
Preferences of Stakeholders	Complex-Pluralist		Complex-Coercive
High			
Medium			
Low			

The problem of smart city depicted as a "wicked problem" is a sufficient reason to turn the discussion to systems thinking (without abandoning other ways of thinking but seeking at least complementarity) because, perhaps in the hope of, as Peter Senge (Senge, 2006) sets out in the 5th discipline, to understand the structure that generates patterns of behavior and then events around the smart city notion.

Following the laws of the 5th discipline, we understand the smart city problem as one fully abiding those rules. In short we present the following table with a correspondence of the rules to the smart city problem.

Table 10: Smart city and the laws of the 5th discipline

Law of the 5th discipline (systems thinking)	Relevance to the smart city notion
1. Today's problems come from yesterday's solutions	Smart is a proposed (as a technological) remedy in dealing with problematic areas of the city functioning where past decisions (solutions) failed.
2. The harder you push the harder the system pushes back	(Komninos et al., 2015) are astonished to discover how little smart solutions contribute to improvement in city life and how short they fail to the radical expectation of a radical change in the city because of them. They also point to a limited if not absent cumulative effect which is due to "low structuring and

	complementarity" of smart applications.
3. Behavior grows better before it grows worse	See point 5 as an example.
4. The easy way out usually leads back in	There is a wide and growing understanding in the literature that ICT solutionism may rest itself as it either provides non sustainable solutions especially when it comes to environmental consequences or even in political terms.
5. The cure can be worse than the disease	Barcelona area 22 is an example of it as pointed out by (March & Ribera-Fumaz, 2016) *"This is not new in Barcelona. During the 2000s, the city changed land zoning in the 22@ district of Poblenou. In that case, land exclusively designated for industrial use (22a in the city planning nomenclature) was transformed into 22@ land to carry out ICT and creative economic activities. This allowed the construction of office and retail buildings in what was previously reserved for manufacturing activities, thereby increasing the value of the land. The results of this change were firstly a strongly contested speculative production of place and gentrification, and then, with the arrival of the economic crisis, a severely compromised development of 22@.*"
6. Faster is slower	See points 5 or 7
7. Cause and effect are not closely related in time and space	The "green" problem backfires and as (Viitanen & Kingston, 2014) vividly write "*A study conducted in Greater Manchester found that for many fuel-poor households, improved thermal comfort meant significant improvements in physical and mental health. This illustrates how CO2 reduction and social justice can be 'odd bedfellows*'.
8. Small changes can produce big results-but the areas of highest leverage are often the least obvious	Not-intended consequences
9. You can have your cake and eat it too -but not at once	See previous point
10. Dividing an elephant in half does not produce two small elephants	Yes, but sometimes no. This is a case against reductionism as a paradigm of

	scientific thinking that is unable to offer understanding of complex problems.
11. There is no blame	Smart city research is a rather ongoing search not an established procedure under law.

What comes out of the matrix above is an understanding of why using a systems thinking approach is suitable for the study of smart city. In the words of Peter Senge (in (Senge, 2006) pp 69): "*Systems thinking is a discipline for seeing the "structures" that underlie complex situations, and for discerning high from low leverage change" and because "as the fifth discipline, systems thinking is the cornerstone of how learning organizations think about their world*".

The other argument in favor of the systems thinking approach in dealing with smartness in the city is the city itself. The argument can be stated following Lefebvre in ((Lefebvre, 2003) , pp119) "*and yet in spite of its socio-logic, the urban does not constitute a system. There is neither an urban system nor an incursion of the urban into a unitary system of forms, because of the (relative) interdependence between form and content. This precludes a definition of the urban phenomenon (the urban) in terms of a system or as a system*". This bold statement leaves ground to picture the urban process as a System of Systems (SoS) following Boardman and Sauser in ((Boardman & Sauser, 2006) "*a SoS is a system but of matters, and it forms an antithetical stance to the gathering together for the type of system that subordinates its parts and relationships to meet its purpose*". That is also implied by Lefebvre's own three dimensions in the conceptualization of space, namely Global, Mixed and Private. For Lefebvre, the Global level is the level of the outmost abstraction when considering the urban context, the level of "*relations such as capital markets and the politics of space*". It is also the level of institutions activity , "institutional space" making Lefebvre to conclude "*This assumes, if not a System of Systems of explicit action, at least some form of systematized action (or "concerted" actions that are conducted systematically*" ((Lefebvre, 2003). This notion of the urban as systemic (in the SoS mantra) is amended by Brenner and Schmidt in ((Brenner & Schmid, 2015) by adding three further dimensions of urbanization – spatial practices, territorial regulation and everyday life. Relevant for the discussion is the matrix Brenner and Schmidt provide (fig2, p171 in (Brenner & Schmid, 2015)) where the phenomenon

of urbanization is reproduced in a historical line and the three dimensions the authors refer to.

Table 11:Thinking in dimensions of the urban context ((Brenner & Schmid, 2015)

		Dimensions		
		Spatial Practices	Territorial regulation	Everyday Life
Moments in the urban Transformation	Concentrated Urbanization	The production of built environments and socio-spatial configurations to harness the power of agglomeration	Rule-regimes and planning systems governing socioeconomic and environmental conditions associated with the power of agglomeration	The production of social routines, everyday practices and forms of life associated with the power of agglomeration
	Extended urbanization	The activation of places, territories and landscapes in relation to agglomerations; the subsequent creation, thickening and stretching of an "urban fabric" connecting agglomerations to the diverse sites od socio-metabolic and socioeconomic transformation upon which they depend	Governance systems oriented towards the socio-metabolic and socioeconomic processes that support major urban centers and facilitate the thickening and stretching of an urban fabric across territories	The social routines, everyday practices and forms of life that emerge (a) as diverse places, territories and landscapes are operationalized in relation to agglomerations, and (b) as a broader urban fabric is thickened and stretched across territories and scales
	Differential Urbanization	Recurrent pressures to creatively destroy inherited geographies of agglomeration and associated operational landscapes	Mobilization of state institutions and other regulatory instruments to promote, manage, accelerate or otherwise influence the ongoing reorganization of urban agglomerations and the broader fabric of extended urbanization	The reorganization of social routines, everyday practices and forms of life in conjunction with the creative destruction of built environments and the urban fabric at any spatial scale

Combining those views , we move to a SoS approach in our effort to describe the smart city as an episode of the urban context development and through the lens of SoS representation and systems thinking we will try to identify *systems of systems* that are (following (Boardman & Sauser, 2006))

- autonomous enough to exercise their own purpose
- dynamically connected in a network habit to enhance SoS capability

- comprising of constituent systems which belong to the SoS
- diverse enough to fulfil the purposes of the greater system they are perceived to belong to.

To achieve the targets set above a specific methodology will be examined, namely Soft Systems Methodology. In the paragraphs to follow an investigation of the methodology is presented as an introduction to terms and the thinking of it, with a view that a more detailed presentation of Soft Systems Methodology will lead us **to the learning artifact** declared to be the scope of this dissertation. The rest of the paragraph builds on the argument that Soft Systems best fits our purpose.

There was a time in the evolution of Operational Research (OR) and Planning Theory that an understanding was gradually formed that (Rittel & Webber, 1973) "*by now we are all beginning to realize that one of the most intractable problems is that of defining problems (of knowing what distinguishes an observed condition form a desired condition) and of locating problems (finding where in the complex causal networks the trouble further is)*" or in a more explicit way "*To find the problem is thus the same thing as finding the solution; the problem can't be defined until the solution has been found*".

The emergence of Soft Systems Methodology comes almost at the same time (early 70s) that Rittel and Webber produce their article. It is a clear indication that both OR and Systems Thinking are coming to understand how increasingly "wicked" are the problems a manager deals with. The originator of the SSM strand, P.Checkland, in his 2011 article "Autobiographical retrospectives: Learning your way to 'action to improve' – the development of soft systems thinking and soft systems methodology" ((P. Checkland, 2011) suggests that the Rittel mantra became known to him as late as 1973 when he was in pursue of a holistic thinking via systems thinking as a response to wicked problems situations. In his own words "*When I later came across Rittel and Webber's phrase 'wicked problems' (1973) I found it an excellent description of what managers continuously struggle with. Wicked problems resist sharp definition, are unique, and when you think you have them under control, they change their form: new features emerge as important or features you thought important disappear.*" He then continued to explore whether systems ideas were suitable as work horses of a holistic approach to wicked problems and especially for tackling those problems.

In that same article P.Checkland provides us with a short description of how ideas of C. West Churchman shaped his own ideas towards the evolution of SSM. He goes on to describe , in an autobiography mode, how a one week course named "The systems Approach", conducted in a local Lancaster hotel had become an inspiration for the introduction of Weltanschauung (the "Worldview") that anyone involved or interested in a wicked problem situation possessed.

P. Checkland describes a number of real life projects he was involved in (the Concorde one being the most famous) and through which the Soft Systems Methodology has been raised. Among common characteristics of these problems/projects were

- **The great number of different worldviews of those involved**
- **The changing nature of the Worldviews even among the members of the same group**
- **People act purposefully and not randomly**

But while the influence of Churchman and Ackoff was an initiator for Checkland ideas he moved to a different path than his colleagues by rejecting the idea of an "ideal system" to which focus should be attained.

So in the birth article of SSM, (P. B. Checkland, 1972), Checkland denounces any ideas for designing a system to fit a particular problem and moved to the idea of "notional systems" relevant for the systemic exploration of the problem under consideration. He finally declares that (SSM) "*is not a methodology of systems design, only of conceptualization and design of changes*".

What is also relevant to the theory of SSM is the idea of Action Research (AR), a term first coined by the psychologist Kurt Lewin in 1946 (see for example (Lewin, 1948) pages 201-202) when he described AR as "*a spiral of steps each of which is composed of a circle of planning action and fact finding about the result of the action*".

In their article "Nature and Validity of Action Research" Checkland and Holwell (P. Checkland & Holwell, 1998) describe AR as follows: "*particular linked ideas F are used in a methodology M to investigate an area A as depicted in the following graph*".

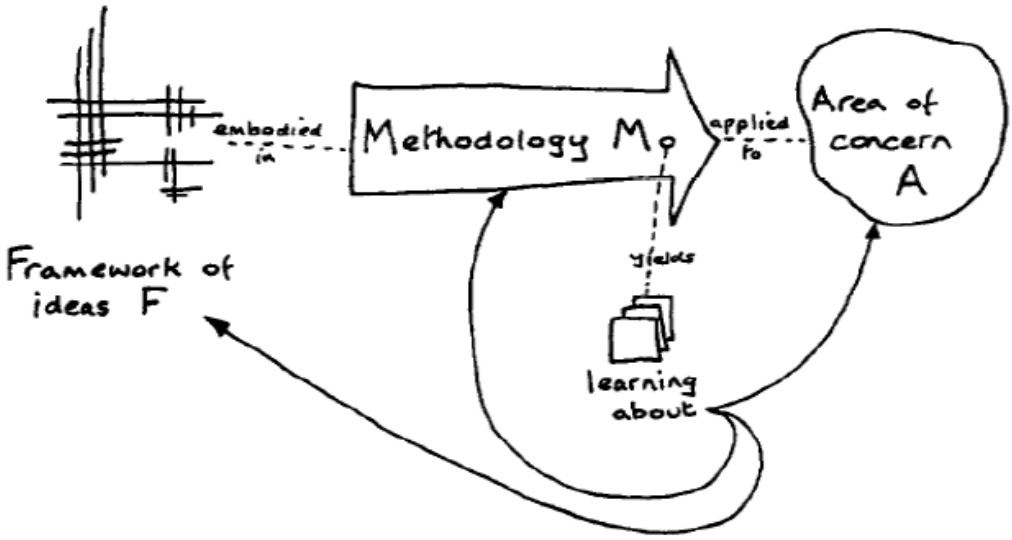


Fig. 2. Elements relevant to any piece of research.

Figure 20 The Essence of Action Research

Thus for example if A is the "smart city notion" and is the area of concern, a notion we declared to belong to the class of wicked problems, one cannot reduce it to standard hypotheses to be tested…but rather seeks the framework of ideas F surrounding the problem and a methodology M to form an action research. In the case of "smart city notion", F, could well be sustained in the vast literature on different smart city aspects or in the Worldviews of those actors interested in delivering the notion. M could be the Soft Systems Methodology that yields the learning curve about but also accommodates different views of the various stakeholders during the cycles of the negotiation processes.

A final warning: because F, Mo and A are stated in every iteration, therefore are public knowledge, then any independent researcher should be able to **recover** the process.

SSM is a methodology that lists itself under this broader AR label, a point that will be clarified as we will describe the methodology in detail. One important point is that the criteria for judging the outcome, the "findings" in an AR based methodology. As stated by Checkland and Scholes in ((P. Checkland & Scholes, 1990) and Peter Chekland and Sue Holwell in "Action Research: nature and validity ((Kock, 2007) Framework F, Methodology M and area A should be known for every iteration of the process by everyone interested in the research (i.e. that is not the researcher), making thus the whole

process “recoverable”. The recoverability criterion stands between the demand for “repeatability” (in quantitative sciences) and “plausibility” (meaning the simple believing a story).

Therefore the relevance of SSM for the examination of the smart city problematic area is based (a) on the promise of the methodology to identify and accommodate different and changing worldviews of the stakeholders (as it did in many projects around the world from the time it first came into action) for a pluralist number of stakeholders (see the CATWOE) and (b) on the anchoring of the methodology in the broader Action Research Methodology fabric permitting thus a managed and recoverable learning on the issue under consideration.

We further elaborate here statement (a), in paragraph 3.3, by providing a detailed description of the methodology and some account concerning the wide use of SSM for different originated problems either in a standalone mode or in companion with other methodologies. An instantiation of the Methodology in the case of Smart City is presented in Chapter 5: Applying SSM to Smart City Domain. Learning emergence through the usage of Soft Systems Methodology is addressed as a unifying context for our artifact and is presented in chapter 7.

3.3 Soft Systems Methodology in brief

One of the most notable characteristics of the SS methodology is the use of pictures to describe a problematic situation. These pictures were finally called “Rich Pictures” and according to Checkland and Scholes (P. Checkland & Scholes, 1990) these are “*pictorial/diagrammatic representations of situation entities (structures), processes, relationships and issues*”. We will follow the path of rich pictures in our attempt to briefly discuss the methodology of Soft Systems. As the scenario of the story develops, a rich picture will tell hopefully more than words can explain. Comments attached to the rich picture may add a needed clarification or will serve as the narration of it. The scenario about to run refers to the mature phase of Soft Systems Methodology and not to historic line of evolution. The interested reader may refer to (P. Checkland, 2011) for such a script.

The scenario drives from SSM's Constitutive Rules (as presented in (P. Checkland & Scholes, 1990) and then continues to present elements of SSM epistemology (again following table 10.1, page 288 from (P. Checkland & Scholes, 1990)).

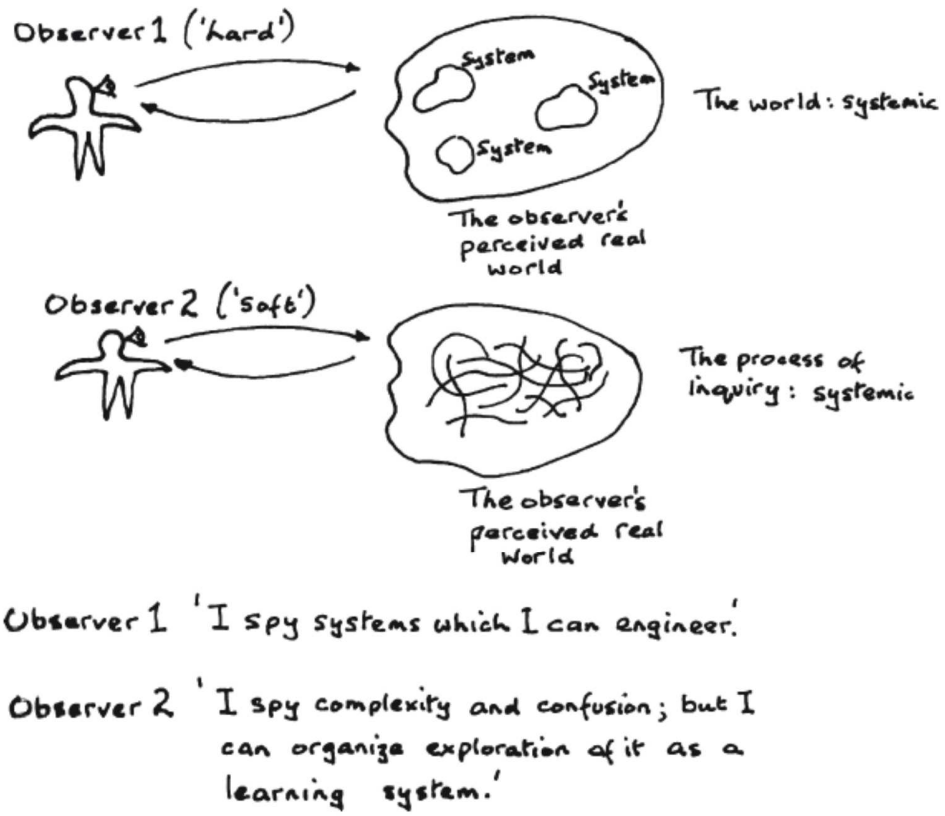


Figure 21 SSM soft and epistemological

This is the essence of SSM: departing from the "hard" science stance of seeing a world of systems (especially of human such) the focus is steered away from the systems in an ontological fashion, away from interaction between systems perceived to be "out there". Instead, the messy situation, is regarded as "tangle to solve" via a learning approach. As Checkland and Poulter present it (in (P. Checkland & Poulter, 2010)

> "*In order to incorporate the concept of worldview into the approach being developed, it was necessary to abandon the idea that the world is a set of systems. In SSM the (social) world is taken to be very complex, problematical, mysterious, and characterized by clashes of worldview. It is continually being created and recreated by people thinking, talking and taking action. However, our coping with*

it, our process of inquiry into it, can itself be organized as a learning system. So the notion of systemicity ('systemness') appears in the process of inquiry into the world, rather than in the world itself."

The following picture, adopted from (P. Checkland & Poulter, 2010) (fig 5.8 p206) provides an explanation of the 1st Constitutive Rule:

Episode I: The 1st Constitutive Rule of SSM

R1: SSM is structured in a way of thinking which focuses on some real world situation perceived as problematical. The aim is always to bring about what will be seen as improvements in the situation no matter this concern everyday managerial work or a special highlighted study.

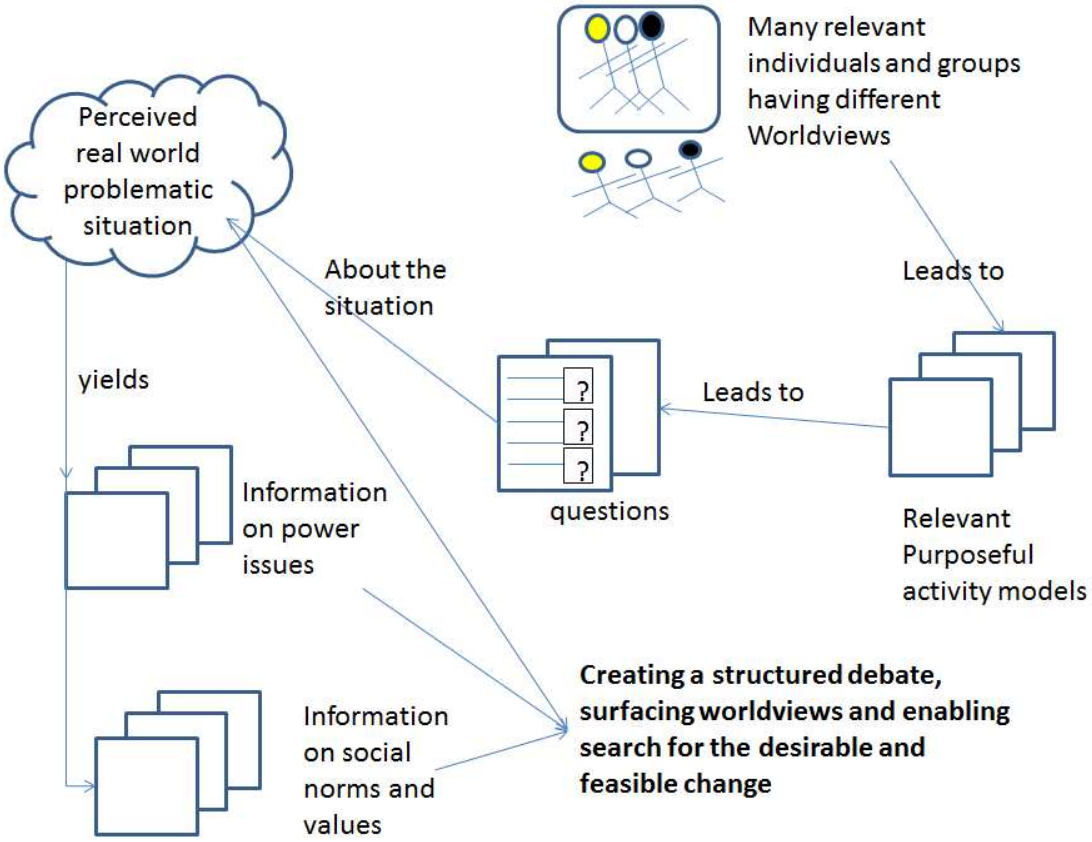


Figure 22 How SSM thinks of a messy situation

The above representation can only be that of a learning cycle that goes on. Starting from a broad "perception" of a problematical area, those interested in it (the **stakeholders of the problem**, despite the angle each one is concerned about it and despite the many different and changing over time worldviews that those stakeholders possess) are

gathering to discuss relevant purposeful activity models (those would be "Human Activity Systems" or HAS) that lead to questions about the situation under consideration. Those questions will reveal information on the power issue (not only among the interested stakeholders but perhaps the grid of power surrounding the situation either in the global or in the local scale) and also social norms and beliefs that shape the discussion. In a further step those initial rounds will create, finally (a) a structured debate (b) a comparison between the messy situation and the relevant HASes and finally (c) the action needed to tackle the situation.

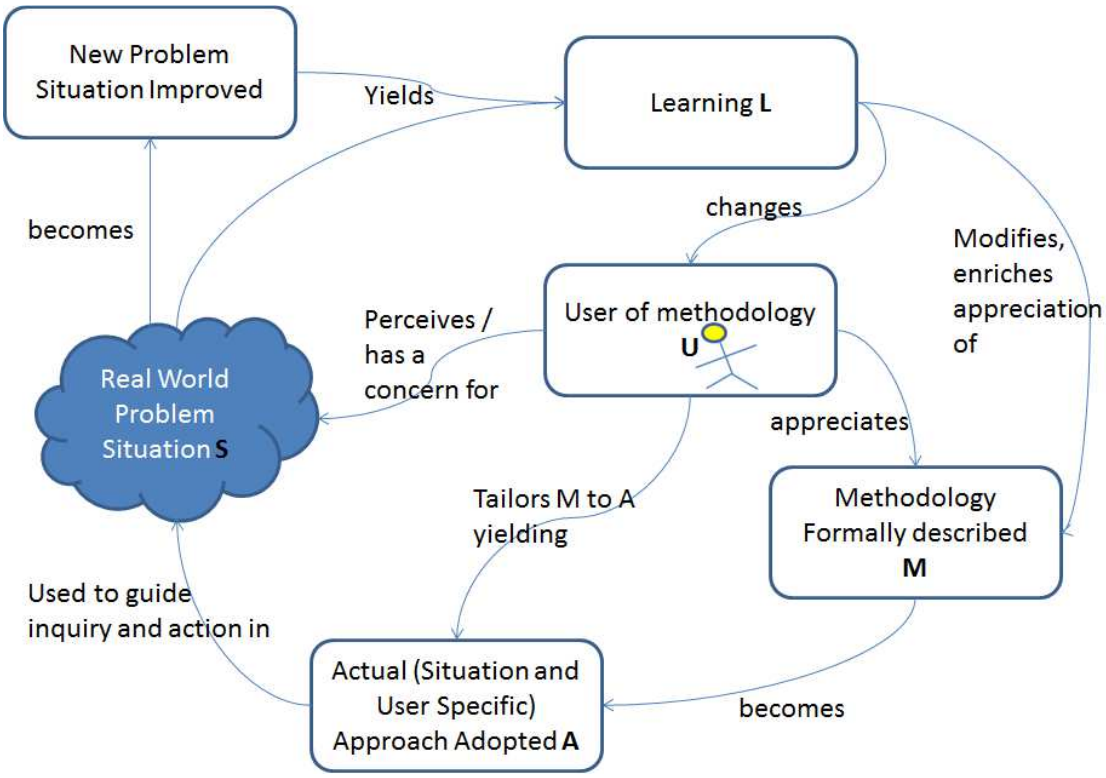


Figure 23 The LUMAS model as presented in (Peter Checkland, 2000)

Figure above tells the story of the learning cycle of Soft Systems Methodology. It actually explains how learning is emerging during successive SSM cycles between the interested Actor(s) or Stakeholders. It requires for a start to have a role named User of a Methodology (and that can the researcher or the owner of the research), who, dealing with the problematical situation S, armed with an explicit and written and publicly available methodology M, tailors M to S in order to achieve an initial approximation adopted by all (or the most of stakeholders) , let us name it A, with which compares

situation S to the yielding of M on to S. Needless to say the result of the round may or may not bring consensus or even better accommodation between the stakeholders as of the revised, the new problem situation appears. But it definitely yields learning L, which in turn will change the User U, the Methodology M and therefore, in that second round the result of the updates on M to S, creating a new A1 and the cycle goes on until an accommodation is to be found.

We will move now to the inner technique used by the SS methodology to cope with "messy situations" and how to untangle them.

Episode II: The 2nd Constitutive Rule and the Epistemology of SSM

R2: SSM's structured thinking is based on systems ideas and its whole process has yielded an explicit epistemology. Any account of work which lays claim to being ***SSM-based*** must be expressible in terms of that epistemology whether or not SSM language was used as the work was done. The epistemology is summarized in the table below.

Table 12 SSM's epistemology: the language through which the process makes sense (source:(Checkland & Scholes, 1990)

Soft Systems Methodology	
Real world	The unfolding interacting flux of events and ideas experienced as everyday life.
Systems thinking world	The world in which conscious reflection on the 'Real World' using systems ideas takes place.
Problem situation	A real-world situation in which there is a sense of unease, a feeling that things could be better than they are, or some perceived problem requiring attention
Analyses One, Two, Three	Analysis One: examination of the intervention of interaction in terms of the roles; 'client' (caused the study to take place), 'problem solver' (undertakes the enquiry) and 'problem owner' (plausible roles from which the situation can be viewed, chosen by the 'problem solver'). Analysis Two: examination of the social (cultural) characteristics of the problem situation via interacting roles (social positions), norms (expected behavior in roles) and values (by which role-holders are judged). Analysis Three: examination of the power-related (political) aspects of the problem situation via elucidation of the 'commodities' of power in the situation.
Rich pictures	Pictorial or diagrammatic representations of the situation's entities (structures), processes, relationships and issues.
Root definitions	Concise verbal definitions expressing the nature of purposeful activity systems regarded as relevant to exploring the problem situation. A full RD would take the form: do X by Y in order to

	achieve Z
CATWOE	Elements considered in formulating root definitions. The core is expressed in T (transformation of some entity into a changed form of that entity) according to declared Weltanschauung, W. C (customers): victims or beneficiaries of "T", A (actors): those who carry out the activities, O (owner): the person of group who could abolish the system. E: (the environmental constrain which the system takes as given).
The 5Es	Criteria by which T would be judged: Efficacy (does means work?); Efficiency (are minimum resources used?); Effectiveness (does the T help the attainment of longer term goals related to O's expectations?); Ethicality (is T a moral thing to do?); Elegance (is T aesthetically pleasing?).
Conceptual model	The structured set of activities necessary to realize the root definition and CATWOE, consisting of an operational subsystem and a monitoring and control subsystem based on the Es.
Comparison	Setting the conceptual models against the perceived real world in order to generate debate about perceptions of it and changes to it which would be regarded as beneficial.
Desirable and feasible changes	Possible changes which are (systemically) desirable on the basis of the learned relevance of the relevant systems and (culturally) feasible for the people in the situation at this time.
Action	Real-world action (as opposed to activity in conceptual models) to improve the problem situation as a result of operation of the learning cycle for which this epistemology provides a language.
The system to use SSM	The language and structure of Figure below provides an epistemological sense of the process of using SSM.

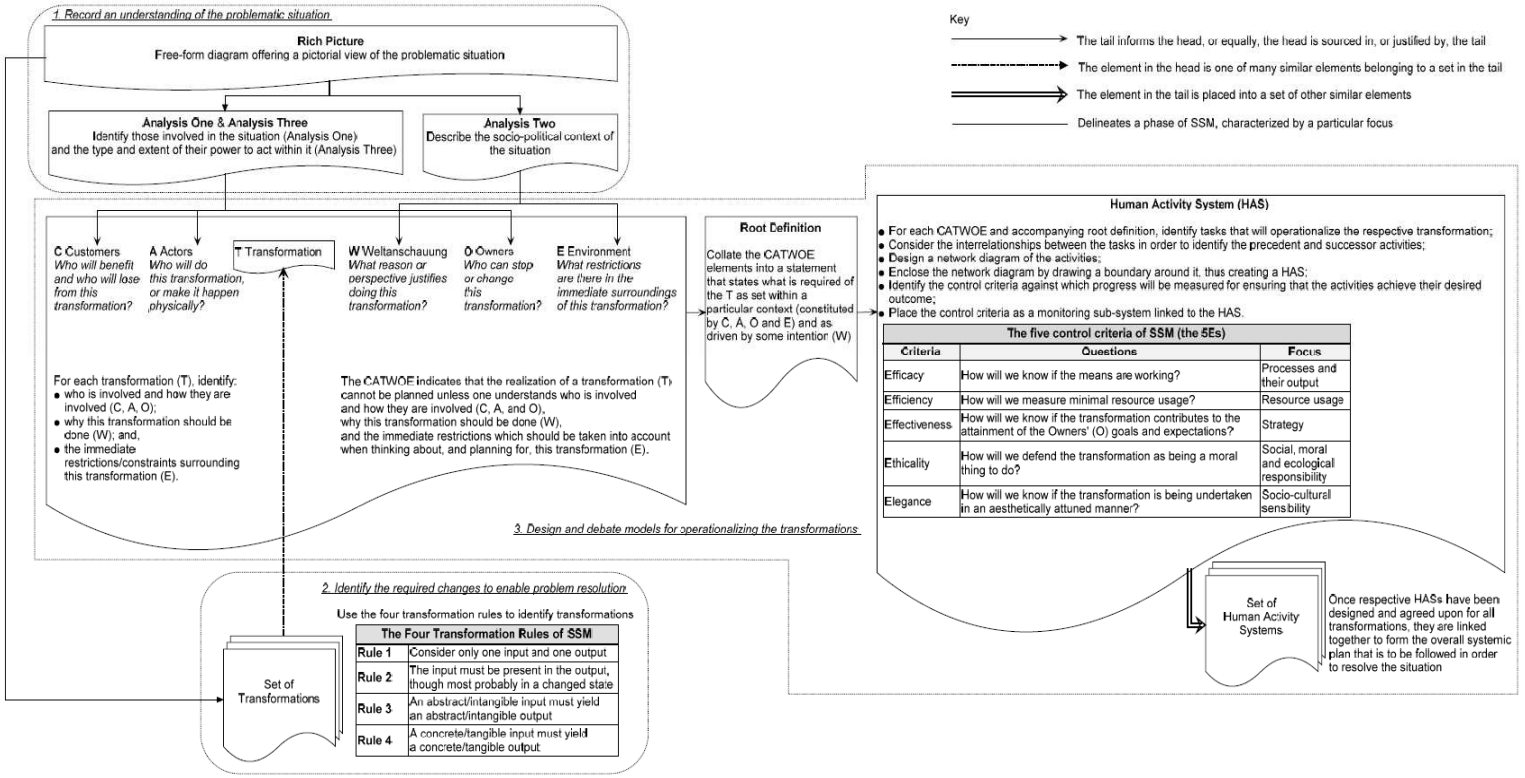


Figure 1 Visual overview of a configuration of SSM in three phases

Figure 24 SSM epistemology as found in (Georgiou, 2015)

The diagram presents not only the constitutive rule 2 at work (and as a matter of fact all five constitutive rules) but also adds a procedural scope to those rules. We will briefly discuss the elements and the flow of the procedure.

A **rich picture** is (as already mentioned), the fanciest characteristic of the methodology. As Georgiou vividly points out in (Georgiou, 2015) ("Unravelling soft systems methodology") "*The rich picture is…a free form drawing, its utility ranges from being an ideal icebreaker to a cathartic exercise.*" But the rich picture is so important that "depending on the quality of this diagram, it can serve to inform the three analyses and even help in the identification of Transformations in the second Phase". The meaning of creating a free form rich picture is, as Checkland points out in (P. Checkland, 2000) to create an artifact, an exploratory tool and return with that in hand to the stakeholders of the problem and ask them "*Have we got it right from your perspective?"*. As happens for the whole SSM process, rich picture may be revised as the learning cycle repeats itself.

After the ice-breaker happens, that is the informal part, the brainstorming or in the terms of Figure 23, the real world situation S is being described via the rich picture, comes the more formal part of the analyses 1,2 and 3 or respectively "Analysis of the Intervention", "Social System Analysis" and "Political system analysis". But the route towards those analyses starts (as can be deduced by diagram in Figure 24) with the identification of the CATWOE elements and the corresponding to a particular CATWOE construct "root definition".

To start with, **CATWOE** is an acronym of convenience, so anyone involved in an SSM-based action research may easily identify the elements of the systemic enquiry of the complex situation under research. So

C stands for "customers" meaning the victims or the beneficiaries of the Transformation T

A stands for "actors", meaning those who would perform or participate in the Transformation process T or carry the activities of the system.

T is the "Transformation Process" and simply put is a process via which inputs are thought to transformed to outputs.

W from the the German "Weltanschauung" is the worldview that is the context (social, political etc) in which the transformation T is applied.

O stands for "owners" of the whole Action under consideration in the sense that owning the systemic enquiry they can stop it or alter it to a new direction.

E stands for "environmental constraints" that is any exogenous to the purposeful activities system elements, which are identified as such and considered to be given.

Finally a **"*root definition*"** combines the CATWOE elements into a grid or a network of purposeful activities that is built upon a set of ideas (the Worldview) that in turn reflects the Roles[24], Norms and Values of a given social system and the balance of political power[25] that surrounds the complex situation. Or in the words of Checkland and Poulter (in (P. Checkland & Poulter, 2010))

"*The task is to construct a model of purposeful "activity system" viewed through the perspective of a pure, declared worldview, one which has been fingered as relevant to this investigation. In order to do that, we need a statement describing the activity system to be modelled. Such descriptions are known in SSM as Root Definitions (RDs), the metaphor "root" conveying that this is the only one, core way of describing the system.*"

Associated with the root definition is the technicality of the PQR formula which a mnemonic for "*do P by Q in order to contribute to achieving in R*" ((Peter Checkland, 2000) "which answers three questions: what to do (P), How to do it (Q) and Why to do it (R)".

One should bear in mind that SSM based research (and action) aims at identifying naming a relevant system to use as an artifact for the systemic inquiry of the messy situation under scrutiny. The messy situation is for a reason not acceptable and a transformation to something else more acceptable is needed. Therefore, the root definition and the CATWOE are tools to create a notional system, ie a Human Activity System (HAS), containing a number of activities that will result to a Conceptual model of

[24] In the definition of Checkland (P. Checkland & Scholes, 1990) "*By role is meant a social position recognized as significant by the people in the problem situation. (…) A role is characterized by expected behaviors in it, or norms. Finally, actual performance in a role will be judged according to local standards, or values. These are beliefs about what is humanly "good" or "bad" performance by role holders*".

[25] Quoting Checkland (ibid) "*This not the place for a deep discussion of the nature of politics, (…) politics is taken to be a process by which differing interests reach accommodation- a view which may supported with reference to the literature of political science*".

the system. The creation of a HAS is concluded when a Conceptual model is reached and the monitoring criteria (as described in Table 12) are met. Note that is the first round of learning: the conceptual model should be tested against the initial perceived messy situation and probably a wider acceptance amongst the stakeholders (the CATWOE stakeholders) may lead to a new round of informing the process has described in the LUMAS model of learning.

To achieve for a certain CATWOE and root definition to create a conceptual model, the activities needed to operationalize the transformation, the researcher:

1. Defines the level or the layer or the hierarchy of the HAS, that is the level of where the transformation T is to be carried. In a Systemic fashion that consequently creates a next lower level of systems or the subsystem level –and that is the level of activities which, when performed create the change of transformation T, as an aggregation process. In terms of network, as agents of the CATWOE interact in that level, they create new formations (eg markets, cultures or new communications channels) that are "notional systems" quite unlike those in the lower levels. It is also the level in which we identify the answer to "how" in the PQR formula while the system level (the Transformation level is the "what" level. But there is also a wider system, identified to be the Owners' land or the "why". Caution is needed that these are pure notional systems in the SSM realm and not "real systems" out there. Therefore they are "observer binded" and different observers or researchers or owners may dictate different hierarchies of systems.
2. Defines the network of activities and suggests a boundary around it: the HAS is now been created (giving birth to a wider-HAS and a sub-HAS).
3. Applies the control criteria (well known as 5e's)
    a. Efficacy (does it work?)
    b. Efficiency (logos of output to resources used)
    c. Effectiveness (is T meeting the longer term aim?)
    d. Ethicality (is T morally accepted?)
    e. Elegance (is this an aesthetically accepted Transformation?)
4. Compares the Conceptual Model to the Perceived Complex Situation

The above is the essence of SSM evolution during the 40 or more years from its appearance as a branch of systems theory deviating from an ontological systems approach (as the general systems theory or cybernetics or living systems theory or autopoiesis and dynamic systems theory). One could well delve into the details, the conflicts or the caveats of the theory. For the purposes of this presentation though what follows is the visualization of the previous description in the form of pictures (rich ones in all aspects) which tell the story of SSM.

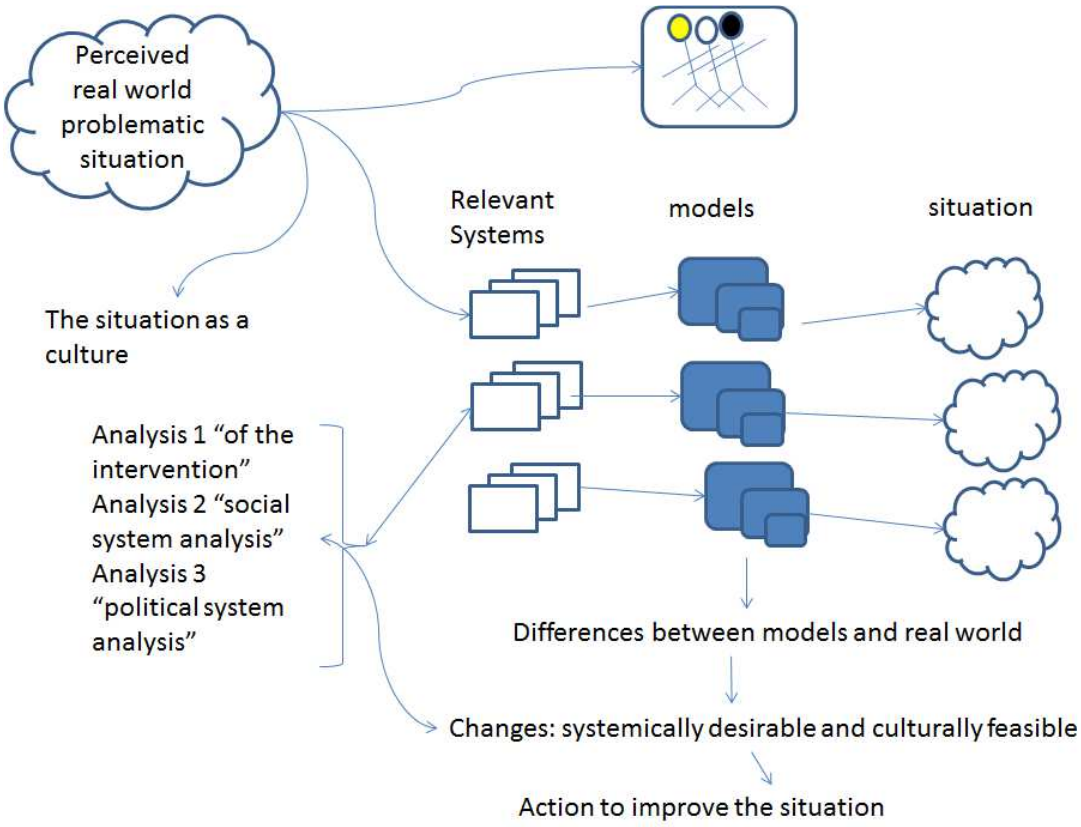


Figure 25 The process of SSM as two streams: logical (the right hand stream) and cultural (the left hand stream)

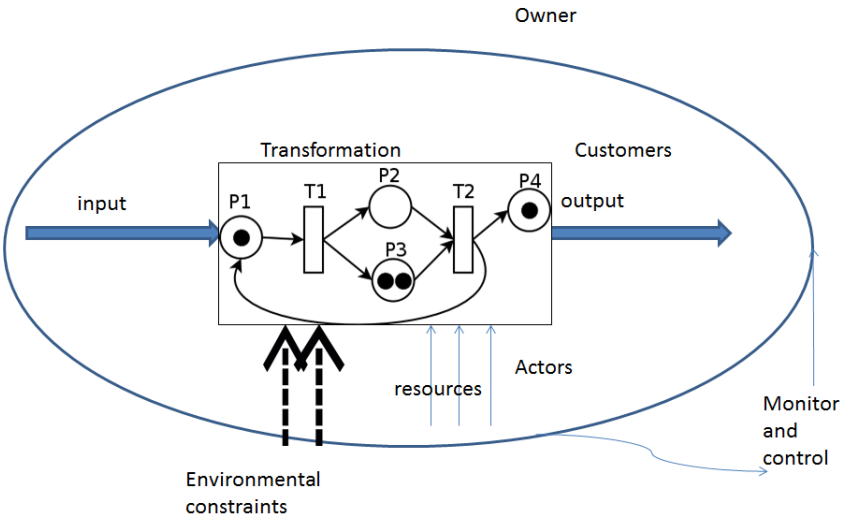
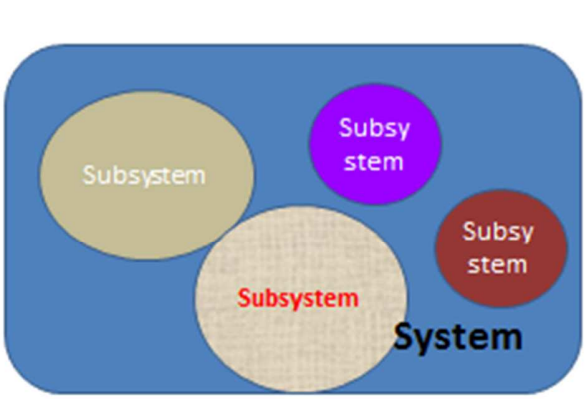


Figure 26 The CATWOE elements (adapted from (Wang, Liu, & Mingers, 2015)) The idea that transformation may be described as a Petri Net comes from (Lamp, 1998).



Why? Level 0 system ("wider system")
What? Level 1 system ("system")
How? Level 2 system ("subsystem)

"system", "subsystem", "wider system" are relative terms chosen by an observer
If level 3 is "system" then 2 is a "wider system" and 4 is a subsystem

"system" is the level of Transformation T: activities contributing to doing T is then subsystems. The wider level is that of O in the CATWOE, the level that can stop or alter the T.

The systems thinking ensures thinking at the three levels
What? (system)
How? (subsystem)
Why? (wider system)

Do P by Q to achieve R covers the three levels

Figure 27 System thinking entails thinking in layers defined by an observer (adapted by ((P. Checkland, 2000))

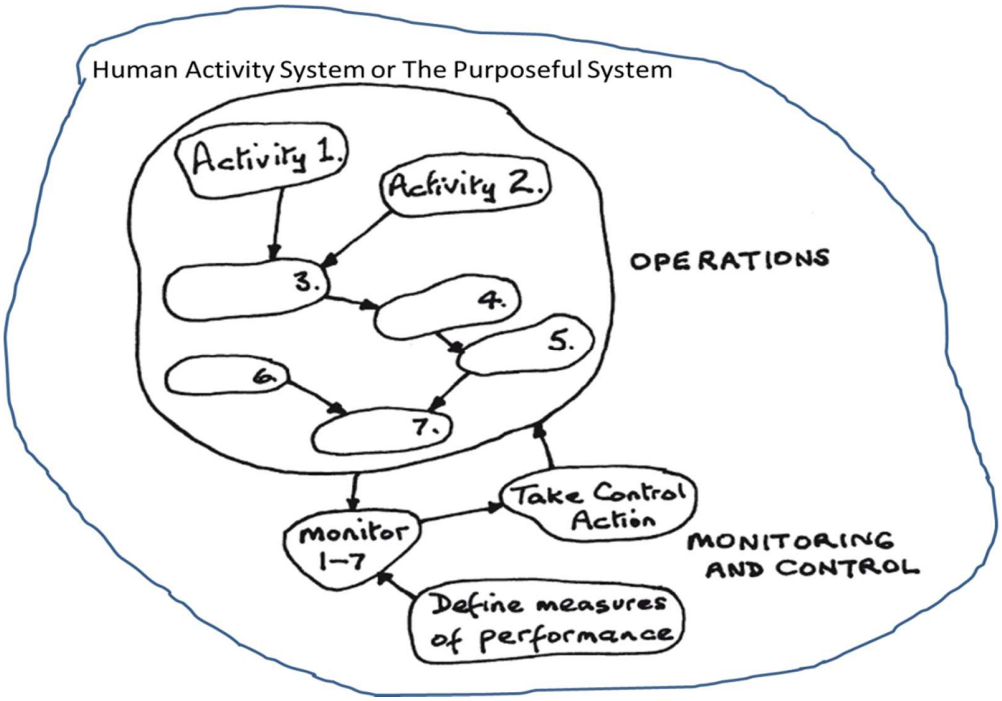


Figure 28 The Purposeful System of Activities (source:(P. Checkland & Poulter, 2010))

The Human Activity System generic presentation of Figure 28 depicts the notion of a systemic approach in a world of **purposeful activities**, exercised by the Owner, the Actors and the Customers as defined in the CATWOE. Wilson in (Wilson, 2001) states that selecting and understanding purposes of activities of the different stakeholders is the key for opening the door to a specific Human Activity Systems. In the SSM, those HAS are relevant to the situation under investigation, serve as the tools of a learning process and result in the creation of a conceptual model but none of them are an ontological representation of something that really exists out there. Therefore, the researcher or the Owner of the investigation may ask for the creation of multiple such models (and therefore HAS) in order to validate them not against a persistence reality but to validate against the purpose it supposed to identify and against another such model or models: when, in the learning cycle of selection, the criteria to monitor the HAS are better fulfilled, a new model may arise and on again. In a way, the monitor criteria –as presented in Figure 29- define the limits of training for the whole process of model selection and the reason for accepting the model or not. A purpose in system or a sub-system as defined in Figure 29 has two unique characteristics: is contained in the Root

Definition and is achieved by the logically connected activities. It is then the role of "monitor and control" activities to validate the network of those activities against such issues as degree of achievement of the purpose suggested in the RD, exhaustion of logical connections (as Wilson asks in (Wilson, 2001), p18) "*Have all the logical connections between activities been included*?"), proper resource allocation and authority within the system boundary[26]. HAS do belong to a hierarchy of systems: as described in Figure 27 the hierarchy starts at level-0 or the wider system (that of the Owner or of the reason, the "why" of the situation), then the level-1 system, which is the "what" system or the system of the Transformation level: it is through this system that the transformation described in the CATWOE is declared. Finally, a number of sub-systems may exist within the system servicing different purposes and answering the question of "how" the transformation is attempted, "how" the resources available are allocated, "how" the purposes are served. One should bear in mind that these are schemas of systemic representations and because of the complexity or the multidimensionality of messy situations different schemas or collection of schemas may be suitable for the tackling of the messy situation. For example smart city may be regarded as a transformation in economy terms or social terms or technological terms solely. But it may be considered as a product of Transformation that considers all those aspects as interconnected in a network of actions characterized by all three dimensions. The HAS to describe for example the domain of the smart city may well be differentiated in those cases.

Before we move to a presentation of the caveats and the critique on SSM we will finally use a last example of a total use of all elements as provided in (Wilson, 2001) (see Figure 29).

[26] In the early years of SSM development the need for a generic HAS , that is a template to include the ideal structure and flow of a model to achieve the status of HAS has been attempted through what was named a Formal Systems Model or FSM. The attempt was later abandoned in favor of simplicity. The FSM was a list of notions of the systemic literature such as Connectivity, Purpose, Measures of Performance etc that a system of activities should contain to be declared a HAS.

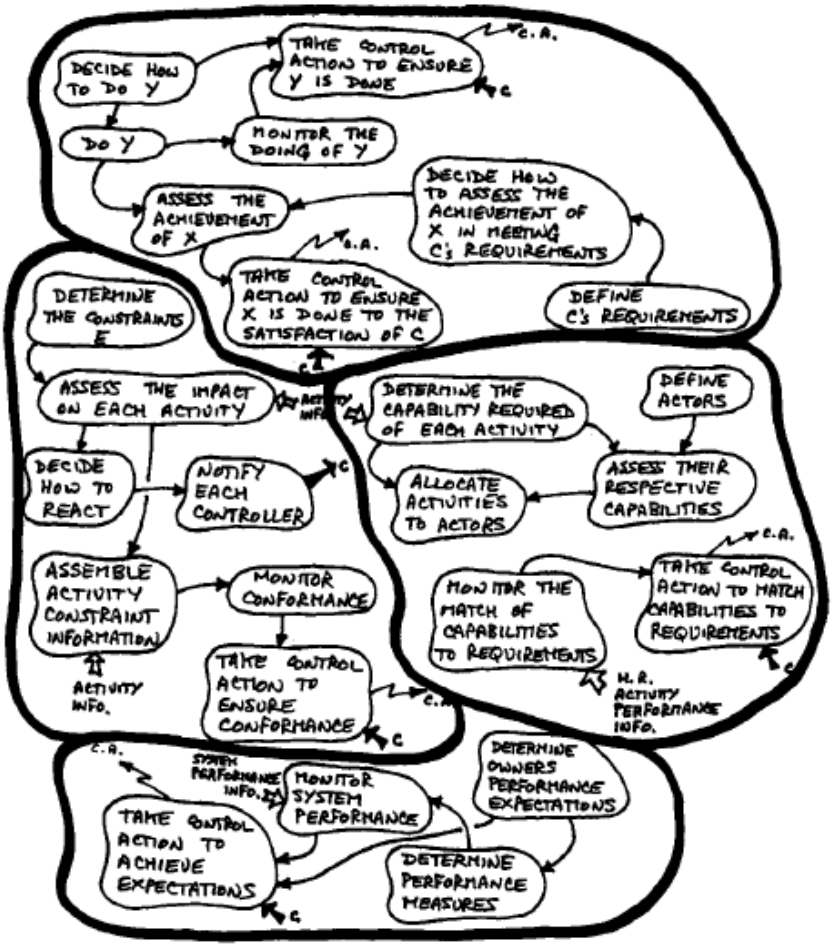


Figure 29 Reproduced from (Wilson, 2001) : A model of T and W, incorporating C,A,E and O decomposed into subsystems

The HAS model provided above tells the story of using Soft Systems Methodology elements in a nutshell: a generic RD for the model would be stated as follows:

(Wilson, 2001) "An O-owned system, operated by A, to do X by Y in order to satisfy the requirements of C within the constraints E"

The model's representation here is different of the one presented in Figure 28 regarding to the monitor and control mechanisms which are included in each of the subsystems since as Wilson points out "*the control system must be there to ensure that the purpose defined by RD is achieved.(…) However, in a more complex example, where this systems model was one "subsystem" among others there would be multiple controllers and their specific purpose would needed to be stated within the control activity in order to differentiate between them*". But apart that the model of Figure 29 implicitly suggests the

"existence" of classes of subsystems (and subsequent HAS) attributed to the specific elements of CATWOE. Thus there are Human Activity Systems representing the activities of the Owner, the Actors and the Customers. It also points out that a notional HAS should be reserved to identify the constraints of the environment E. In this representation the Transformation is "distributed" across the subsystems and (as also in the classical configuration of the Figure 28) no mention is provided for "die Weltanschauungen" (the Worldviews) that is governing the notional systems under consideration. More on this will be discussed in the paragraph to follow. For now we will consider the meaning of the Worldview in the SSM as well as the two streams analysis (as provided in Figure 30).

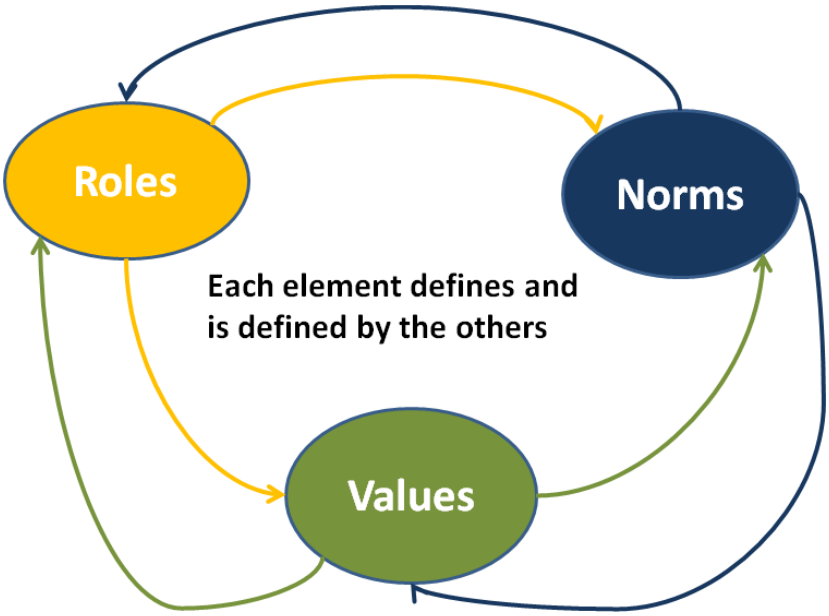


Figure 30 : "Social System" Analysis or Analysis 2

Because SSM evolved as stream of logic-based enquiry, therefore as a toolkit for researchers and practitioners, lacked from the birth of it of a systemic in nature approach of the social environment where it was supposed to happen. Despite Checkland's assertion that a social system analysis was not handy and had to be developed for special use in SSM and the claim that a usable model was not provided by social science, the choosing of Vickers "appreciative systems" as a simple but not simplistic model proves otherwise. Finally the schema of Figure 30 provides the essence of what social system analysis is in SSM: "social system" is a language convention of everyday life than

anything else, what we all think when referring to "system", and is, according to Checkland, "*not likely to emerge in response to direct questions*" ((P. Checkland & Scholes, 1990). Thus it should be regarded as what results of the ongoing interaction of three elements: roles, norms and beliefs of the CATWOE stakeholders. **A role** is a social position that all the CATWOE stakeholders are aware of. It may be an institutional one or defined as a result of a certain behavior. Therefore "a teacher" and 'a solid citizen" is both roles. **A norm** is the expected behavior of a role and a value is the appraisal (of society) of the expected norm. To give an example of the Analysis 2 , the researchers of a Private Hospital in Turkey provide the following paragraph as their Social Analysis ((Torlak & Müceldili, 2014):

"***The role holders*** *included nurses, physicians, patients, members of SSI in the accounting department, HP, members of the administrative board, hospital shareholders, support staff and other staff.* ***Regarding norms****, the Ministry of Health expressed the expectation from physicians who should be in charge of specified duties. Since Turkey was a developing country in the health sector, health policies were changing rapidly and rendering the HPs' remarks on responsibilities. According to HP, the behaviors expected from physicians were to raise the quality of health service in the region while abiding by the requirements of medical ethics.* ***The hospital's values were****: being responsible for developing community health standards; using medical resources efficiently; being patient and autonomous; meeting patients' concerns adequately; being capable of making right decisions on patients' health; preserving the image of the hospital and increasing the value of hospital stock in the stock exchange*."

But, as other SSM based research suggest, Analysis 2 is more than a perception of the individuals and groups that because is "*seen as continuously socially constructed and reconstructed*" ((P. Checkland, 2000) lapses into obscurity. Instead, following (Georgiou, 2015) context matters and analysis 2 is "*a means for decision makers to note social, political, religious, cultural and historical influences playing upon the problematic situation*". Furthermore, demanding (via the 5E's) for changes decided by the methodology to be culturally feasible, the researcher is bound to use Analysis 2 as (at least) a contextual framework useful at least for the validation of the Conceptual Models.

In an organizational context models such as those of (Dauber, Fink, & Yolles, 2012) (in Figure 31) may well be used to supplement a shortage in the Methodology.

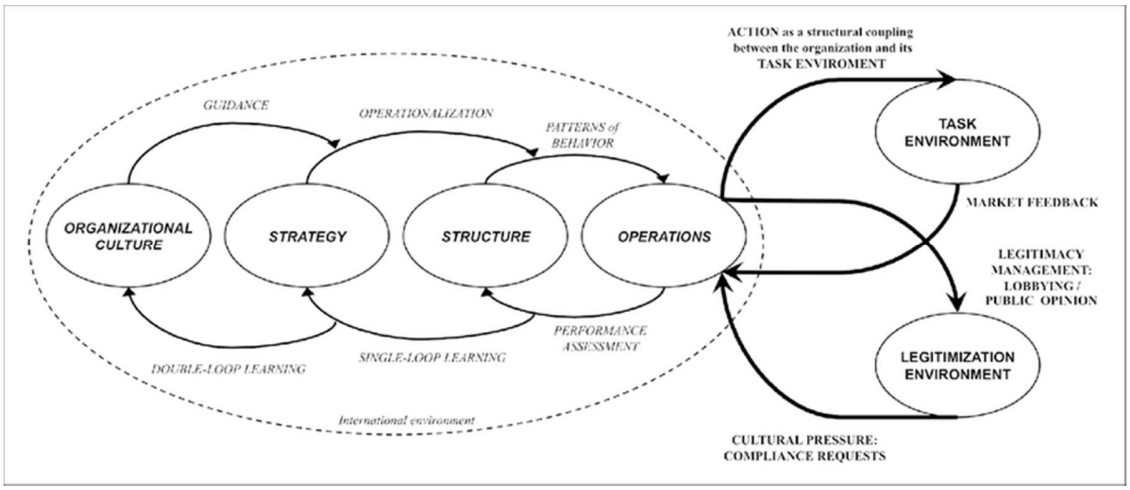


Figure 31 Configuration model of organizational culture source: (Dauber et al., 2012)

Analysis 3 or the "political system" analysis has again emerged as an answer to critiques that either the methodology paid no attention to the matters of the distribution of political power or that, and perhaps because of leaving them outside the scope of methodology, favored the status quo at least implicitly. But then again as in the case of social system analysis, the political system analysis declared to use the "system" word in an everyday language motto. Any "deep" understanding of a political theory to support the analyses was put to a halt or thrown to the researcher's will to do some investigation of the literature of political science. The essence of doing the analysis has come down to form some basic ideas as how the power in politics defines, finally, an accommodation of the different interests. In (P. Checkland & Poulter, 2010) what the analysis is doing is being attributed in the Aristotelian idea of "accommodating interests" as laid out in Politika[27]:

> *"Now it has been said in our first discourses, in which we determined the principles concerning household management and the control of slaves, that* ***man is by nature a political animal****; and so even when men have no need of assistance from each other they none the less desire to live together.* ***At the same time, they are also brought together by common interest, so far as each achieves a share***

[27] Aristot. Pol. 3.1278b http://perseus.uchicago.edu/perseus-cgi/citequery3.pl?dbname=GreekFeb2011&getid=1&query=Arist.%20Pol.%201278b.1 accessed on June 2018

of the good life. *The good life then is the chief aim of society, both collectively for all its members and individually; but they also come together and maintain the political partnership for the sake of life merely, for doubtless there is some element of value contained even in the mere state of being alive, provided that there is not too great an excess on the side of the hardships of life, and it is clear that the mass of mankind cling to life at the cost of enduring much suffering, which shows that life contains some measure of well-being and of sweetness in its essential nature.".*

As Checkland states in (P. Checkland & Scholes, 1990) "*politics is taken as a process by which differing interests reach accommodation- a view which may be supported with reference to the literature of political science" while "accommodating those interests is the business of politics and the concept will apply to a company or work group or a sports club as well as to a city or a nation state*".

One way to address the issue of how the power is distributed is the metaphor of a commodity that embodies power and how these commodities are processed (ie used, inherited, passed on etc.). In the SSM, commodities include *"formal (or role based authority), intellectual authority, personal charisma, external reputation, commanding access (or lack of access) to important information, membership or non-membership of various committees or less informal groups, the authority to write the minutes of the meetings etc"* ((P. Checkland & Scholes, 1990).

Another important issue that has developed as experience has been accumulating is the Mode 1 versus the Mode 2 usage of the Methodology. In general, a Mode 1 ideal type of using the methodology is defined as a formal application of it by conforming to all stages described in

Figure 25 or in Figure 24. Mode 1 means an intervention into the flux of events and ideas that stem out of the area perceived problematic from a researcher "outside" the flux. On the other hand, Mode 2 ideal type is a "meta-level" of the methodology. The Framework of ideas is SSM itself, reflects on the methodology interactions with the flux of events and ideas (to which now is internal) and "*takes as its focus of enquiry the process of learning one's way to purposeful improvement of problem situation*" ((P. Checkland & Scholes, 1990). The use of the term "ideal-type" means that any SSM based inquiry may

found itself closer to either Mode 1 or Mode 2 side, meaning that the usage of the one does not preclude the usage of other; indeed it may be useful that elements of the two are suitably blended during an inquiry. Figures and are graphically present Mode 1 and Mode 2 notions. (adapted from (P. Checkland & Scholes, 1990)).

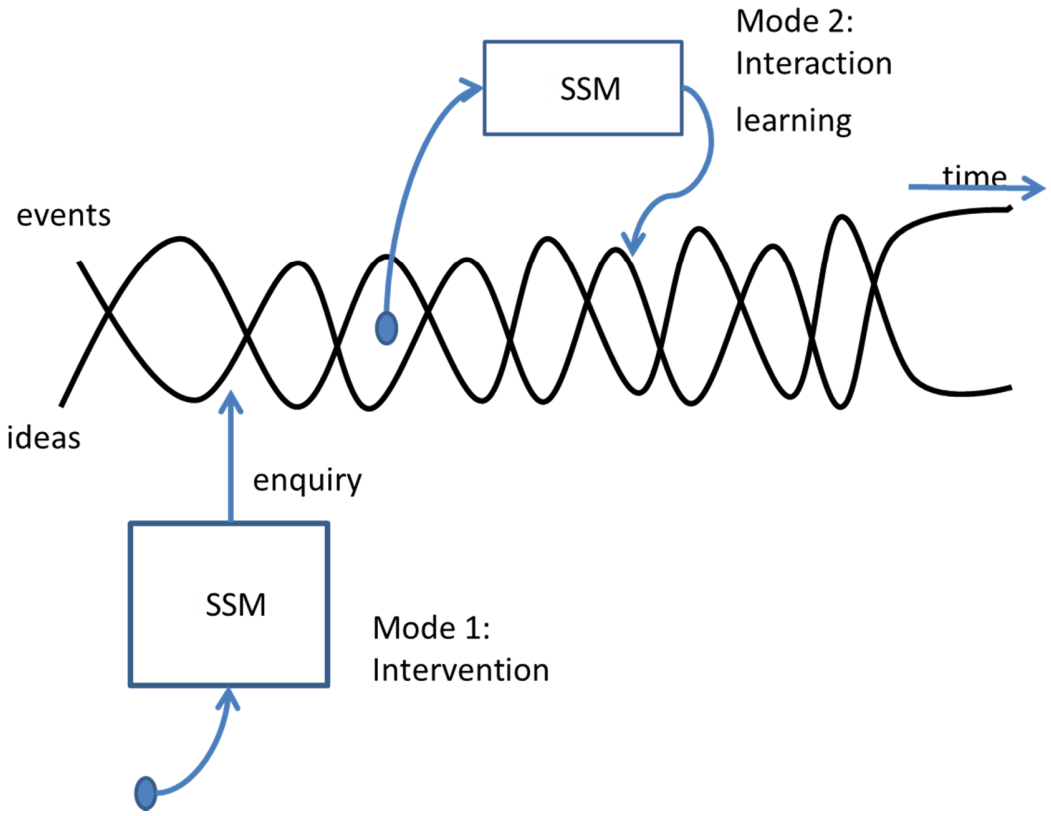


Figure 32 Mode 1 and Mode 2 of SSM

We reserve here two general remarks:

First, both in the cases of Social system analysis and Political system analysis the methodology allows itself to carry characteristics that , at least in a declaration level, are not systemic and by doing so lends itself more to a learning methodology than a systemic approach problem solving methodology. **It is a surprise to understand the world of the problematic situation through the conceptual models based on notional systems of human activity and at the same time to understand both The Social or The Political as externalities, to be treated as contextual scripts with no systemic relationship with the HAS of the Analysis 1**. One expects a similar treatment, if not the description of the social construct and the distribution of power that surrounds the problematic as notional

systems themselves, perhaps subsuming or explaining the E and the W of the CATWOE mnemonic.

Second, to declare a Social analysis that is different from a Political analysis could result that, against the declaration of communication between the two analyses, Roles, Norms and Values are not a proper example to illustrate the political being while power commodities as the ones described above lack a social anchor.

Finally, themes as the Economy or the Technology that surrounds the problematic situation are not considered at all and one can add themes less wide than these two, such as organizational culture to be neglected. Needless to say, the construction of Social and Political system analysis is seen in an independent way, as having no interaction either between them or with other elements of the Methodology.

A number of critiques have developed both from people that used and followed the Methodology but also from those that have been critically against it.

As (Mingers & Taylor, 1992) reveal in their 1992 paper (with SSM being around for less than two decades) a considerable number of academics and OR practitioners have already been used the methodology in a variety of areas and with a variety of purposes. To achieve an understanding of SSM's usage, 294 questionnaires have been sent to OR practitioners, managers and academics or researchers otherwise "unconnected with SSM". Of them 137 replied out of whom 90 responded that have used the methodology. That resulted to about 30% of the initial sample of 294 have used the methodology while the main reasons for using it were: "to ease a problem situation" or "to develop understanding". Areas of application of the SSM included Organizational Design, Information Systems or General Problem Solving and are reproduced from the paper in table below.

Table 13 Application areas of SSM source:

Organizational Design	Restructuring of role Design of new organization Create new organization culture
Information Systems	Defining information needs Creating IS strategy Knowledge acquisition Initial scoping/players Evaluate impact of computerization
General Problem Solving	Understanding complex situation

	Initial problem clarification
Performance evaluation	Performance indicators Quality assurance Monitoring as organization
Education	Defining training needs Course design Causes of truancy Analysis of language teaching
Miscellaneous	Project management Business strategy Risk management methodology Case for industrial tribunal Personal life decisions

Respondents identified as the main benefits for using SSM

The framework/structure it provides when managing an intervention

The clarity of thought and the shared of thinking in thinking processes

The understanding of the people's perceptions and perspectives

So, back in 1992 the authors conclude their findings in a rather pessimistic tone: "*Despite the relative success of SSM outlined above, this survey found that SSM was not widely recognized or used within practicing OR groups. The conclusion seems to be that SSM is used by particular individuals who have some previous experience of it, rather than being a standard approach in the repertoire of OR groups. The successes reported in this paper should encourage OR groups to invest in training in SSM*".

The survey of Mingers and Taylor was replicated by Ledington and Donaldson, 5 years later, in 1997 and this time in an Australian context (namely inside the members of Systems Study Group (SSG) of Queensland Department of Primary Industries (QDPI)). As the authors point out "*the group itself is shaped by an interest in contemporary developments in management ideas but is not in any sense an SSM support group*". Research questions are summarized as follows:

*"(a) to establish **the extent and level of exposure** to SSM within the SSG*

*(b) to establish **the nature of the exposure** to SSM within the SSG*

*(c) to establish **the extent and level of usage** of SSM within the SSG*

*(d) to establish **the level of success** in the use of SSM within the SSG".*

349 questionnaires have been sent to achieve a response rate of 56.2% (196 replied); 156 of those were aware of SSM (which is close to 45% of original sample). 102 people

replied that they have used the methodology (60% of which declared that it had done so with success). Adoption of SSM in Australia, five years later than Mingers and Taylor's report on the UK results, seemed to outperform the UK based survey results. Again, main areas tackled with SSM were "general problem solving and problem definition", "Rural development and policy formation" and "IS development". Authors claim "*The results do however suggest that some elements of the ideas associated with Soft Systems Methodology are more readily assimilated than others. In this sense the results support Mingers and Taylor's conclusion that SSM requires a reasonable amount of time and training to assimilate*".

In 2000, Sue Holwell, in an article titled "Soft Systems Methodology: Other Voices" (Holwell, 2000) examines as many as 250 item references from a wide range of journal papers, conference papers and textbooks. Of interest here is Holwell's reference to adaptation of the methodology. There are three ways of that usage: One, as a standalone methodology, secondly "*as part of an eclectic methodology (such as in Multiview) and as a basis for structured methods (such as in FAOR and OPIUM)—the most common is to use it as a front end to traditional IS methods, which is clearly the case with the addition of a mechanistic SSM to the Feasibility Stage of SSADM*" and thirdly as an "*as an overarching framework for the ISD process*".

To explain further Holwell's view on the adaptation of SSM or the combination of SSM with some other methodology (either Soft or less Soft one) we have drawn the mind map of Figure 33. The map is produced using table 1 in (Mingers, 2000b).

Finally, in 2017 Hanafizadeh and Mehrabioun in "Application of SSM in tackling problematical situations from academicians' viewpoints" (Hanafizadeh & Mehrabioun, 2017) researched 149 articles published between 2000 and 2017 to identify the application areas and levels of application of SSM. According to their results main application areas of SSM were: Information Systems development (28.8% of the cases), General problem solving 16.1%, Education 8.7%, Project management 8.7%, Performance management 8.0%, Sustainable development 7.3%, Knowledge management 6.7%, Miscellaneous 13.4%. The results concerning the main areas of application match the 1992 Mingers-Taylor research on the same issue. In another finding concerning the use of main activities of an SSM cycle they found out that: 99.3%

of research studies have dealt with the finding out phase, 85.9% with the modelling phase, 57.7% with debate and discussion phase and 45.6% with presenting to improve situation phase. As for the levels of application employed by the researchers the findings were: A part of them used SSM as a descriptive tool for achieving an understanding of the problem. Some of the studies used it as a single action oriented methodology (SSM alone) until a feasible was achieved and embraced. As the writers note "*The second set of studies have used SSM as a single action-oriented methodology in order to change and enhance the problem situation. The current study indicates that those studies which used SSM to change the structure have been attempting to reduce the communication barriers among people. Such a change is in line with Habermas' communicative rationality in which actors have come to a shared understanding and resolve their differences through argumentation*". Thirdly, a set of researchers have used SSM jointly with other methodologies or as the writers note in "hybrid approaches". Authors provide a full list of articles reviewed taxonomized according to the application area, application and the SSM activities that were engaged.

3.4 A recap

If smart city is a wicked problem, then reductionism does not fit. If Urban context is the discourse universe where actions form activity systems and meaning is attributed and both "smart" and "city" are intertwining to produce new emergences of Urban context, then systems thinking is appropriate to deal with the complexity at hand. Again, if our wicked problem is socially constructed then emergence of new constructs should be understood through the lens of systems thinking and a special stream of it, namely Soft Systems. Soft as opposed to Hard Systems: because it is the inquiry that can be "designed" in a systemic fashion. Urban provides a context of Social Relations: lived, conceived, and perceived in a continuous explosion-implosion mode, Urban is not "of systems", but can be conceptualized through them. Soft Systems Methodology provides us with a way to understand the Social Relations between the Stakeholders that produce the Urban space, which in turn alters the relations that have historically shaped it, for the cycle to start again. History matters as change.

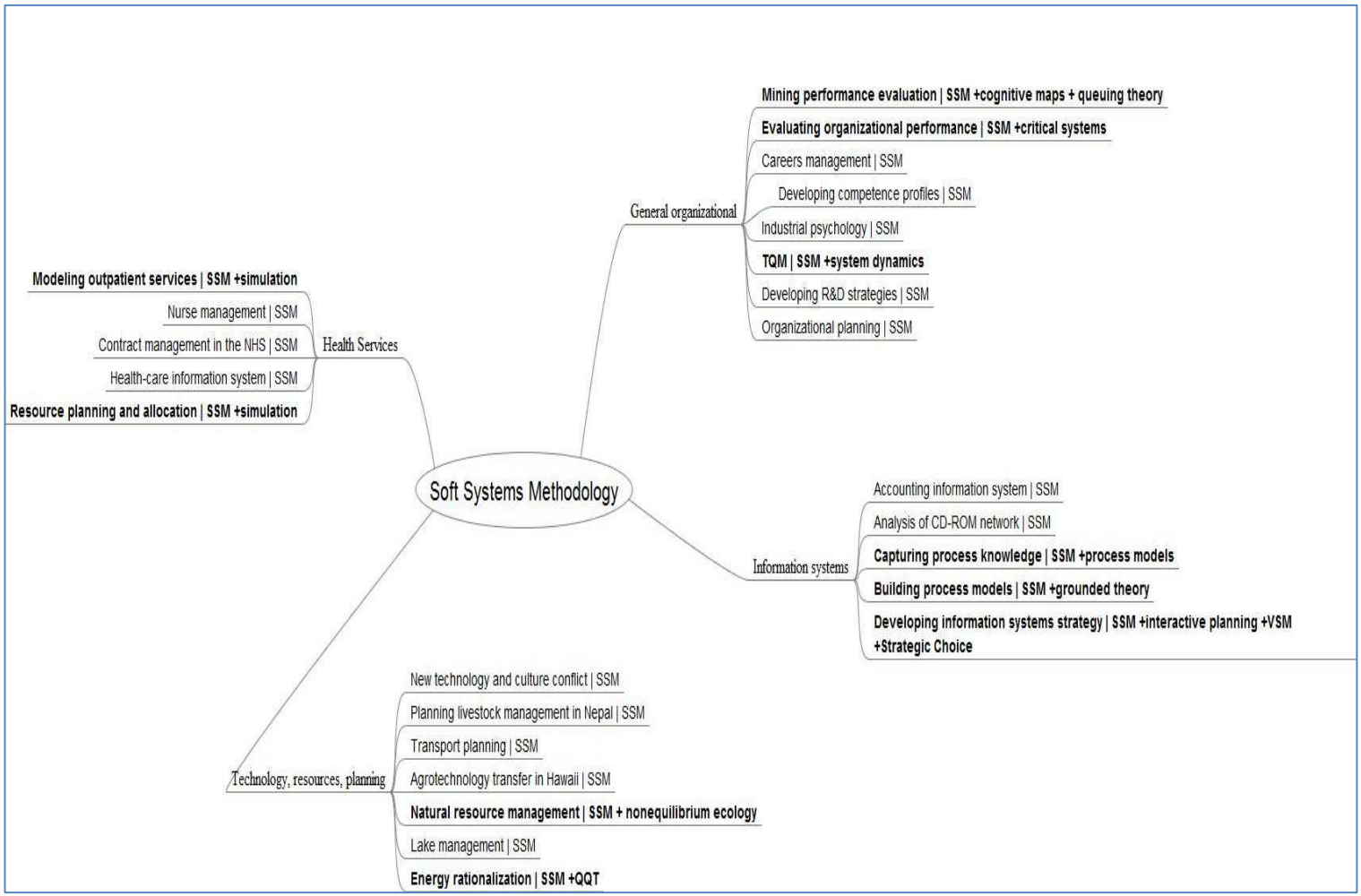


Figure 33 Soft Systems Methodology application areas (adapted from (Mingers, 2000b))

Chapter 4: Foundations to approach II- Ontological thinking and contribution to analysis

4.1 Introduction

This is a rather "strange" chapter, but an important one. Soft Systems Methodology clearly belongs to the epistemological tradition. Thus the systemic thinking in SSM terms is about the inquiry and the conceptualization of an area perceived problematic. Systems aren't really out there to grasp. But how solid can that stance be? Are there any possible cracks? Could we use at least an "accommodation" of some kind between an epistemological device and the world it describes by introducing an essence of, a certain mutation of ontology?

We seek some insight on the matter in this Chapter. After presenting some basic concepts of ontology, we move to clarify SSM's stance against ontologically being systems. A fictitious dialogue serves our purpose. The introduction of a certain kind of ontology is discussed as a remedy to denial. An SSM-friendly ontology may then emerge.

4.2 Basic ontology concepts

As has already been stated the aim of this chapter is to examine SSM relation to ontology and the benefits (if any) of using ontology tools as an augmented stage of the SSM's system thinking. To do so we first introduce basics of the ontological thinking that we will later on the chapter we refer to, then we examine the relation of Soft Systems Methodology to ontological thinking and finally we seek if a conceptual model of SSM can be described through the lens of ontology.

The interested reader should consult, for a thorough investigation of ontological thinking, textbooks (freely available on web) such as those of Van Nquyen "Ontologies and Information Systems:A Literature Survey" ((Nguyen, 2011) or Keet "Lecture Notes Ontology Engineering"[28]. Needless to say, the topic is broad and researched from the beginnings of Information Science.

[28] Available at http://www.meteck.org/teaching/OntoEngLectureNotes15.pdf accessed May 28th 2018.

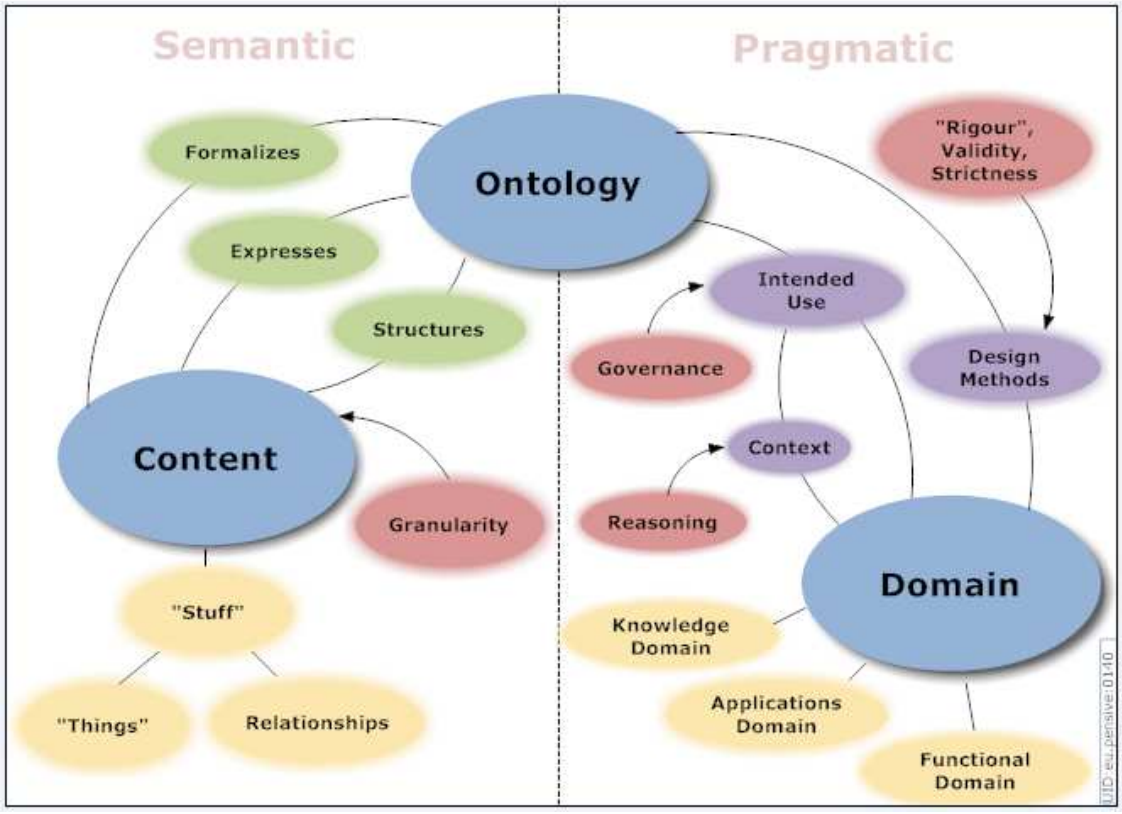


Figure 34. The "Dimension map" of ontologies, made by the attendees of the Ontology Summit 2007 (intended as a "Template for discourse") (source: https://keet.wordpress.com/ accessed on 15 April 2018)

One should also make an initial distinction between **O**ntology (with a capital O let's say) and ontology/ies. The former, **O**ntology, is stemming out of or overlaps with what in philosophy is the study of "being": from Aristotle's "Metaphysics" («*Μετά τα φυσικά*») and all the way through science, religion and philosophy **O**ntology deals with questions and attempted answers to questions as: (Bunge, in Treatise on Philosophy , (Bunge, 1979), vol.3)

"Is the world material or ideal- or perhaps neutral? Is there radical novelty and if so how does it come about? Is there objective change or just an appearance of such due to human ignorance? How is the mental related to physical? Is a community anything but the set of its members? Are there laws of History?"

Although questions as those is not just relevant to the scope of this dissertation they are probably hanging around it as the quest for smartness via systemic thinking inevitably (either explicitly or implicitly) lends itself back to those questions by the force of choice:

choice of mastering the one instead of the other language of smartness in urban context, define or reveal a path that eventually answers those questions in a specific manner. Because "smartness" is a word which semantic could well be an instrument or an apparatus in a material world or an idea forgotten and called back form the shadows but also because it is used as an answer to the question of novelty. An adjective does that before a noun, brings in a novelty never before existed as part of the noun. Is then smartness socially described? Does it come in form after a historical path of the urban revolution?

To follow Bunge's favorite script of **O**ntology (Bunge, 1979)*"(…) metaphysics studies the generic (nonspecific) traits of every mode of being and becoming as well as the peculiar features of the major genera of existents"*. **And as such it does so by examining the real world through science in a clear and systematic way. It is through this systematic way that can produce a "unified picture of reality"** (reality here used as the concrete world's reality).

So, even if **O**ntology is a stream of philosophy, ontology (with a small letter O) resembles it, having the same aspiration, that of examining and forming into a coherent new speak, the modes of the Thing, being or becoming. But it (hopefully) does that with the humility coming out from the acknowledgement of the rigid boundaries of the specific. Bunge's suggest that even **O**ntology, as ontological theory contains and intersects with ontological categories, seen as **generic concepts representing features of the world**. He vividly points out *"Ideally, an ontological system or theory is a system of ontological categories"* where categories include notions as "thing", "property", "law".

We are now at a point to initially define, that is to start thinking, of what ontology-ies will come to mean. According to Guarino (Guarino, 1995) ontology can be seen as a way to understand the nature of the world *"independently of the form of our knowledge about it"*. Therefore formal ontology is (Guarino, 1995) *"a theory of a priori distinctions among the entities of the world (physical objects, events, quantities etc) and among the meta-level categories used to model the world (concepts, properties, qualities, states, roles, parts etc)"*. In his 1998 article "Formal ontology and Information Systems" (Guarino, 1998) Guarino provides the following definition for ontology:

"An ontology is a logical theory accounting for the "intended meaning" of a formal vocabulary, ie its ontological commitment to a particular conceptualization of the world. The intended models of a logical language using such a vocabulary are constrained by its ontological commitment….models".

But in 2009 article "What is ontology", revisiting ontologies, Guarino et al, (Guarino, Oberle, & Staab, 2009) provide a more loose definition: *"(computational) ontologies are a means to formally model the structure of a system"* ie the relevant entities and relations that emerge from its observation and which are useful to our purposes.

In a seminal article of 1995, Grüber (Gruber, 1995) provides a definition that has proved the most quoted since. The definition goes as

"an ontology is an explicit specification of a conceptualization".

But the above-mentioned conceptualization is something that should be thoroughly thought. In that attempt Borst (Borst, Akkermans, & Top, 1997) added the notion of "shared" conceptualization to express the fact that ontology should accommodate shared views of different parties (stakeholders). Studer et al (Studer, Benjamins, & Fensel, 1998) then reformatted the Grüber definition as follows:

"an ontology is a formal, explicit specification of a shared conceptualization".

Because in an SSM fashion the construction of Conceptual Models is a core part of analysis 1 and because analysis 2 and 3 (social and political analysis) are also required we turn our focus on the issue of conceptualization in an ontological context. Should there be any attractive feature of an augmented with an ontology SSM, this may reveal itself in the potential representation of accommodated views (during the learning cycle of SSM as prescribed by its learning model) of the CATWOE stakeholders as foundational or domain ontologies. Before we say more on the issue we provide a clearer view of conceptualization according to Guarino et al (Guarino et al., 2009)

"An intentional relational structure (i.e. a conceptualization) is a triple C= (D,W,R) with

D is the universe of discourse **(or in SSM the area perceived problematic)**

W a set of possible worlds **(or in SSM the different worldviews)**

R a set of conceptual relations on the domain space (D, W) **(which in SSM format are Transformation T and the environmental constraints plus the checks for feasibility, effectiveness, efficacy etc.)**

Then a subset of the natural language, say L, will be created in an axiomatic way, that will actually allow us to actually rehearse the conceptualization through the means of ontology."

The next figure is an adaptation from Guarino et al (Guarino et al., 2009), page 9).

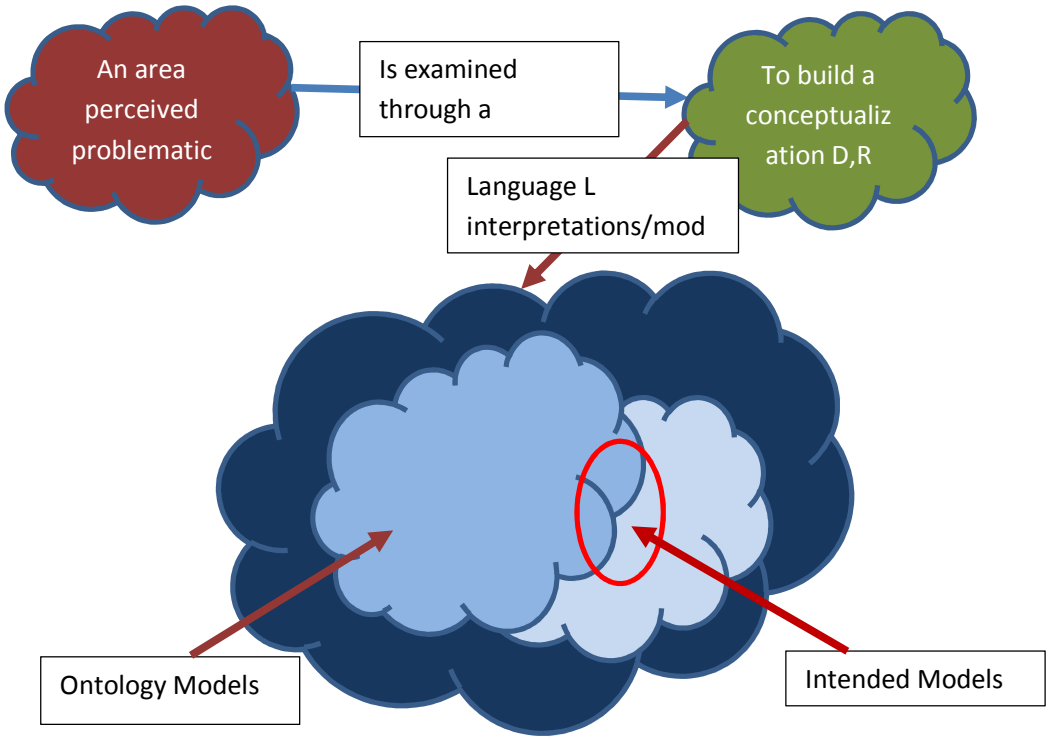


Figure 35 An ontology definition adapted from Guarino et al ((Guarino et al., 2009)

The importance of "shared conceptualization" is crucial: a conceptualization can have an adjunct ontology and that to be useful, stakeholders should be able to understand it in the same way. That has two presuppositions: an accommodation of the different views by the design of conceptual models and then the use of a well-founded and axiomatized ontology. That is depicted in the following picture (Figure 36, adapted from (Guarino et al., 2009)).

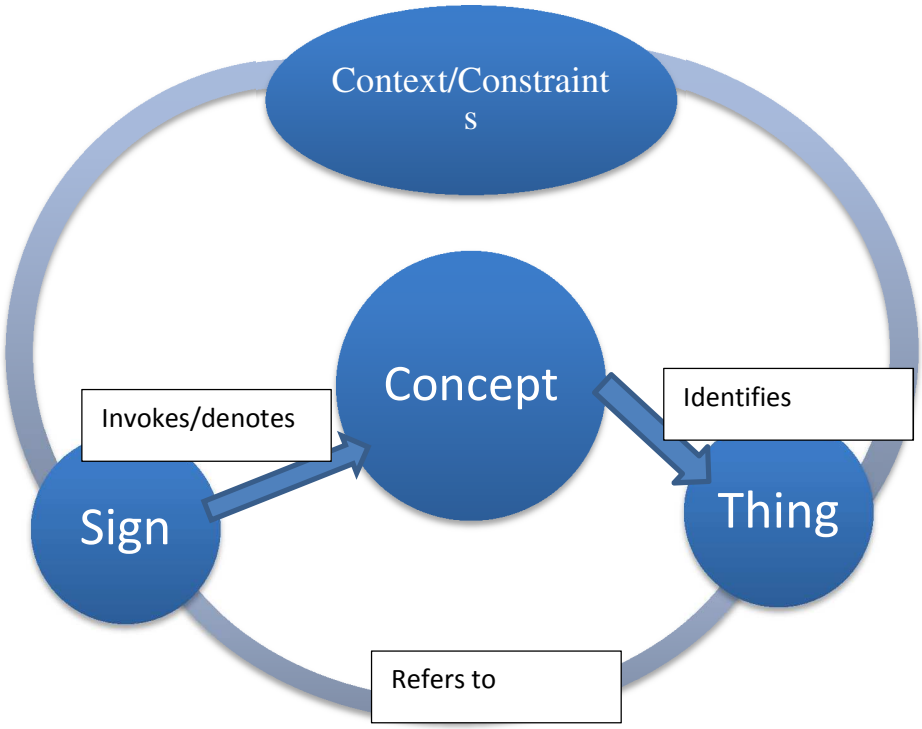


Figure 36 adapted from Guarino et al ((Guarino et al., 2009)

A number of methodologies have been deployed for the building and sharing ontologies (eg Mentodology and Onto-Agent). VanNguyen (Nguyen, 2011) describes 5 phases of how to build an ontology (with Onto-Agent):

(1) Generalization and Conceptualization of the domain

(2) Alignment and merging

(3) Formal specification of conceptualization

(4) Formal specifications of ontology commitments

(5) Ontology evaluation

VanNguyen also describes 5 stages in the developing of multi-agent system ontology

1. Identify the roles for agents and characteristics of the problem solving process (different types of agents are determined in this stage, for example **interface agents** that is *"agents that assist a user in the querying process"*, **manager agents** as "agents that receive requests from interface agents and send requests to information agents", **information agents** as *"agents that search for and retrieve information as well as send the requested information to smart agents"* and **smart agents** as *"agents that analyze and assemble the received information"*.

2. Decide how ontologies are contributing or adding to intelligence gain (for example by facilitating the decomposition of the problem or by assisting the process of information gathering and analysis or by enhancing communication).
3. Organize the collaboration of agents in the system by assigning roles to agents or by building different scenarios of collaboration depending on the complexity of the system).
4. Construct the individual agents
5. Consider the security of the ontology authentication, availability, confidentiality, non-repudiation and integrity). Security is *"(…) to identify important factors related to security requirements such as the most critical agents, security-relevant actions and environmental factors, and parts of the system most susceptible to attack. For example, agents that are exposed to the outside world are more critical with respect to security than agents not exposed in this way"*.

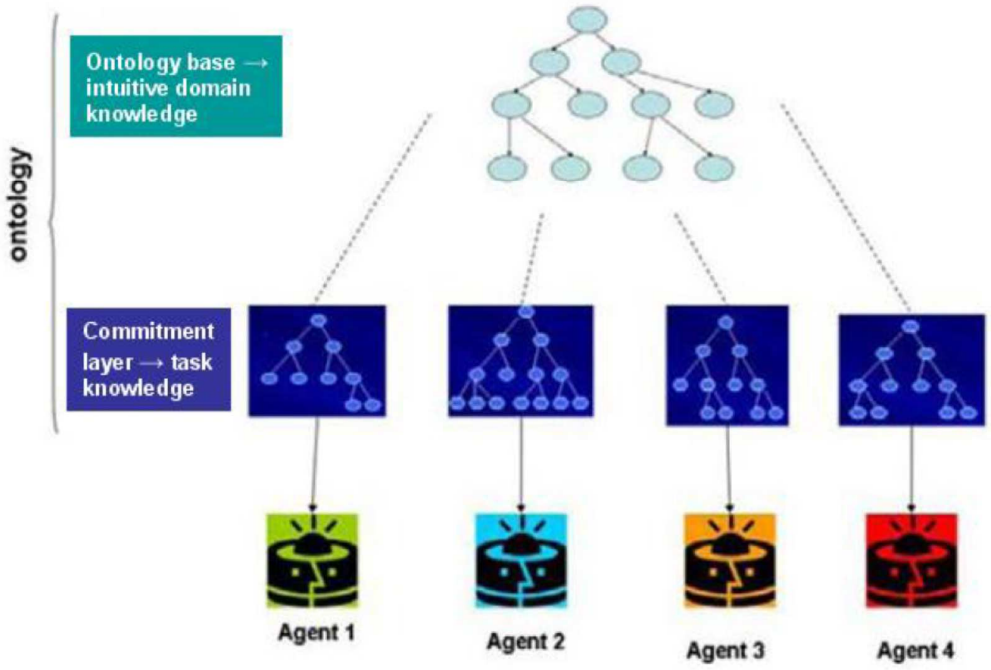


Figure 37 Source: VanNguyen Ontologies and Information Systems: A Literature Survey (Nguyen, 2011)

Those ideas are presented in the Figure 37.

Another important aspect of ontological thinking is ODCM, an acronym for "ontology driven conceptual modelling". Verdonck et al, (Verdonck, Gailly, de Cesare, & Poels, 2015) provide the following table of terminology:

Table 14 Definitions of concepts Source: (Verdonck et al., 2015)

term	definition
Conceptual model	A conceptual model is composed of (1) a mapping feature, meaning that a model can be seen as a representation of the 'original' system, which is expressed through a modeling language; (2) a reduction feature, characterizing the model as only a subset of the original system and (3) the pragmatics of a model, which describes its intended purpose or objective. (Stachowiak, 1973)
Ontology	Ontology can be defined as the set of things whose existence is acknowledged by a particular theory or system of thought (Ted Honderich, 2005).
Conceptual modeling	Conceptual modeling is the activity of representing aspects of the physical and social world for the purpose of communication, learning and problem solving among human users (Mylopoulos, 1992).
Ontology-driven conceptual modeling	**Ontology-driven conceptual modeling** is the utilization of ontological theories, coming from areas such as formal ontology, cognitive science and philosophical logics, to develop engineering artifacts (e.g. modeling languages, methodologies, design patterns and simulators) for improving the theory and practice of conceptual modeling (Guizzardi, 2012).

Verdonck et al provide a systematic mapping and literature review of the ODCM field and point out that ontologies have been used as **(i)** an evaluation tool of the soundness of *"conceptual modeling language and its corresponding concepts and grammars"*, **(ii)** the theoretical foundations of a conceptual model by expressing fundamental elements of the domain (or the universe of discourse or the area perceived problematic) **(iii)** the base for the developing of new conceptual modeling languages and **(iv)** as means of translating or interchanging information by attaining semantic integration for translating between different models, methods, languages or paradigms (Verdonck et al).

To further illustrate the ontology-conceptual dialectic we reproduce the following picture from Fonseca et al (Fonseca & Martin, 2007):

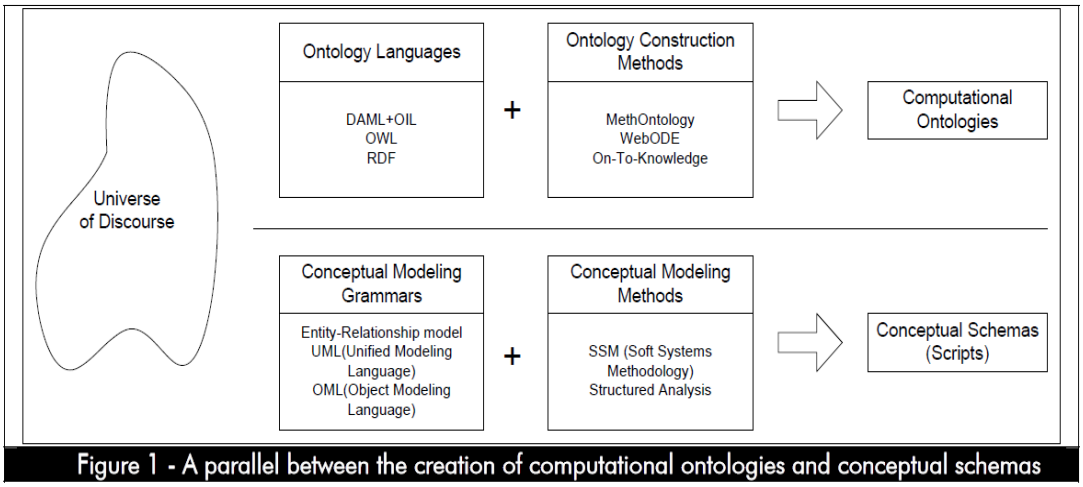


Figure 38 Source: (Fonseca & Martin, 2007)

In Fonseca's view "*Conceptual schemas are built with a specific information system in mind. They have the practical purpose of defining, constraining and limiting what is going to be registered and manipulated by the information system. This fact shapes the objectives of a conceptual schema. Ontologies are theories that explain a domain by revealing it as a coherent whole. They make predictions and they bring expectations*".

4.3 SSM: from problem action to learning activity system still denies ontology

A number of researchers have used the Burrel-Morgan classification scheme (in Sociological paradigms and organizational analysis (Burrell & Morgan, 1979)) to address the issue of how SSM addresses social reality. The scheme (presented in Figure 39) creates a mapping of sociological paradigms to the dimensions of "objectivity-subjectivity" and "sociology of regulation-sociology of radical change".

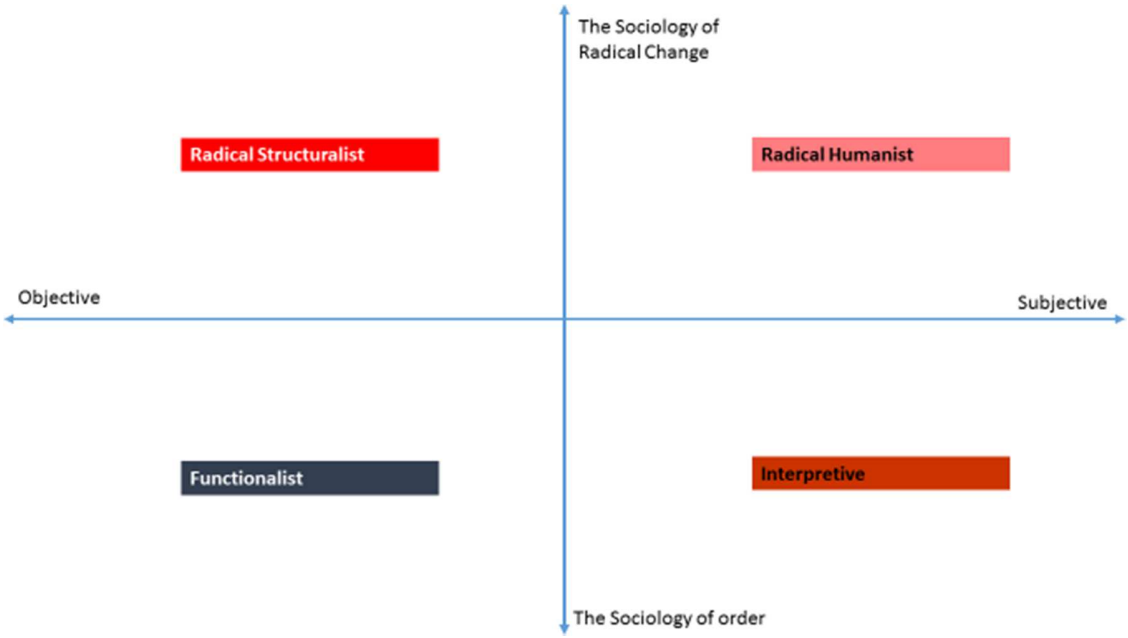


Figure 39 The Burell-Morgan model of paradigms (adapted)

Building on the model, Hirschheim et al in "Information Systems Development and Data Modelling" (Hirschheim, Klein, & Lyytinen, 1995) in their attempt to explain the main strands of Information Systems development grounded on philosophical (despite implicit or explicit) assumptions concerning the social context of their development they provide a similar model as follows.

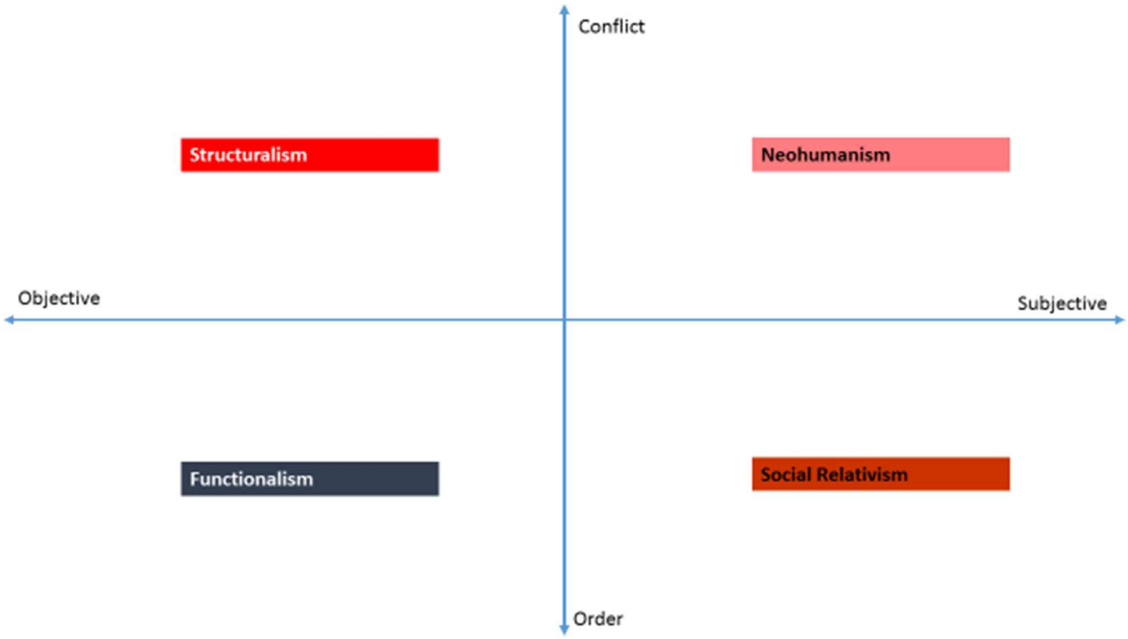


Figure 40 The Hirschheim et al model of IS systems

Both models identify (a) an axis of understanding reality; that is the objective-subjective one. By doing so they postulate a dichotomy between existence and learning and (b) an axis of Change or Action for Change which beyond the revisionist degree is also an axis of a Historical "learning-existence" trade off with the order seen as "objects of past", and Conflict as "objects in present and future". The creation of such a representation inserts if not a disjoint, between the ideas of ontology as objectivity and epistemology as subjectivity, at least a clear contradiction.

The implementation of the Hirschheim et al classification brings the Soft Systems Methodology (and Soft OR in general) to the Social Relativism quadrant since the main assumptions under the quadrant are:

- The epistemology of anti-positivism: no causality or empirical explanations are possible (or at least useful) for social phenomena. Instead sense-making should prevail both for oneself and the other participants in such phenomena
- The ontology is one of nominalism (constructivism): "*reality is not a given, immutable "out there" but is socially constructed. It is the product of human mind*".

In a discussion for a possible classification of SSM within the Burrel-Morgan model, Houghton and Ledington (Houghton & Ledington, 2002) provide a mapping of SSM against the Burell-Morgan diagram based on the views of (a) Checkland himself (b) Jackson and finally (c) a version combining a number of critiques. The discussion is summarized in Figure 41. And while there is common belief that SSM is placed at the Interpretive/Social Relativism quadrant it seems that there are also aspects of both Critical Theory (i.e. Radical or Neohumanism) and Functionalism embedded in it.

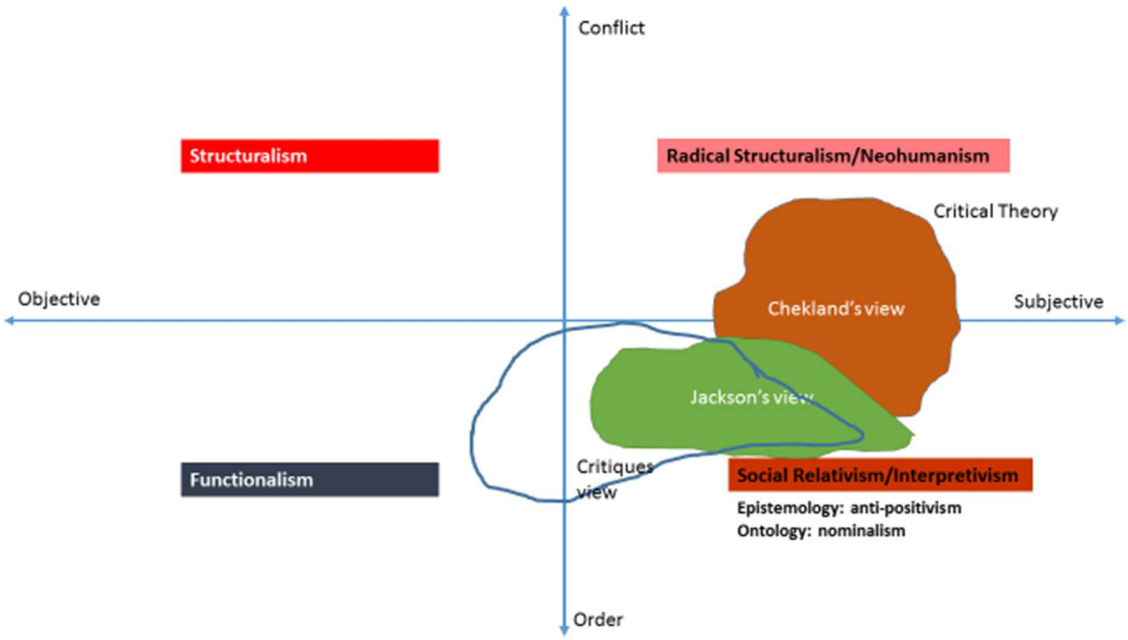


Figure 41 SSM as epistemology and ontology source: Houghton et al

To further illustrate SSM stance against ontology we present a fictitious dialogue. The dialogue (that never happened on personal basis, but is based on the participants views) highlights what SSM claims to be by the founder (Checkland) and how is perceived by some its critics (Mingers, Jackson, Hirschheim etc).

The non-existent dialogue is concerned with how SSM conceives the world.

Checkland: *"(We) need to remind ourselves that we have no access to what the world is, to ontology, only to descriptions of the world, . . . that is to say, to epistemology. . . .Thus, systems thinking is only an epistemology, a particular way of describing the world. It does not tell us what the world is.* ***Hence strictly speaking we should never say of something in the world 'It is a system', only 'it may be described as a system'*** *(Of course keeping to that rule is tedious)*".

And "*Consider the human observer who, although himself part of reality, can by a familiar act think about his own intellectual engagement with the rest of reality, R, in which he uses particular mental processes or Methodology, M. One common stance, paradigm I, makes the following assumptions:*

(i) R is systemic; the world contains systems

(ii) (ii) M can be systemic

(…) *The alternative paradigm, paradigm II, (...), are as follows*

(i) R is ***problematical****;* ***we cannot know it ontologically***

(ii) M can be systemic

(based on (P. Checkland, 1983))

Mingers: *"Checkland is right to recognize that we do not have access to the world in a pure, unmediated way. Clearly, as human beings we can only ever experience anything through our perceptual and linguistic apparatus. It does not follow from that, however, either that our descriptions are unrelated to the world or that we should deny existence to anything simply because our knowledge or perception are limited. (…). Checkland is also right that we can never know definitely or prove conclusively the existence of systems. Again, however, this does not prove the converse, that they do not exist. We can move beyond the crude empiricist ontological criterion that to be is to be perceived, instead adopt the critical realist view that causal efficacy is the proper criterion for existence.* ***In other words, if some structure or system can be shown to have causal effects on the world, then, whether we can perceive it or not, it can be said, putatively, to exist***". (Mingers, 2000a).

Hirschheimer et al: "*If one takes the position that concepts shape the world that we experience (i.e. interpretivism), then no real comparison is possible. If concepts come first, a comparison of the conceptual models with the real world is self-confirming:* ***'experience only confirms what the concept teaches****' is a well-known dictum from Hegel that sums up an essential insight of the interpretivist position. Radical structuralists will insist that systems thinking is the ideological vehicle by which the dominant elite will seek to rationalize and legitimize primarily those designs that do not threaten their privileges and vested interests. The comparisons are phony, because no attempt is made to broaden the discourse and use elaborate checks and balances against self-delusion or 'cooking the data'. The emancipatory potential of SSM is lost for want of critical reflections of the connection between social institutional boundary conditions of systems development and epistemology - the validity of the premises and ideas on which design solutions are based".*(Hirschheim et al., 1995)

Ledington and Ledington: "*The conceptual model is built entirely from a root definition and structured according to logic.* ***Why should some version of this model exist in***

reality? *Indeed, what is the mechanism by which such a model causes a version of itself to exist? The question really harks back to the hard systems approach in which the concern is to express a model that describes some aspect of the situation. (…) Clearly some relationship between the situation and the model must be seen as pertinent, or there would be no sensible reason to create the model. Therefore, one of the questions being addressed in the use of the model is to what extent there is a likeness between the model and the situation; that is, to what extent the situation can be conceptualized in terms of the elements expressed in the conceptual model".*(Ledington & Ledington, 1999)

Let us know try to formulate the main ideas of that fictitious discussion above. SSM, anchoring mostly at the Interpretive or Social Relativism strand never introduced an ontology. At first because, the birth and the evolution of the methodology has been at odds with hard systems approach (OR and even cybernetics) on a basis of an initial –and structural to the methodology- denial. Systems are not out there. We construct activity systems in our effort to *make sense of something* which for some reason we perceive as a problem. But in that way the methodology accepts at least implicitly, a reality that can be either traced or constructed by groups of people interested in it, that is, **O**ntology is not rejected. Furthermore natural systems are left to ontological thinking not only because they exist in materialistic terms but mainly because any way of thinking about them does not intervene with them and especially does not alter them. But instead, social systems belong to another category. They are different because the way we intervene as we learn about them, changes them. It actually changes both the system and the facilitators of change and those affected by it. Therefore there can be only "systems of inquiry" through which meaning is attributed to what we perceive to be systemic reality. Should we calmly speak of The Health System in natural language fashion, then, SSM asserts us that there is no really such system out there. What really exists, perhaps, are conceptual models that we use without paying much attention in separating the object from the name of the object. SSM builds on that separation and prescribes the conceptualization of Human Activity Systems as epistemological devices for (i) Action Research as Problem Making Sense process that could eventually lead to strategic requirements (or even application requirements) and (ii) Learning as the ultimate purpose of the methodology , a kind of ***raison d'être*** for it as a systemic thinking methodology. What Ledington et al suggest as

the “pertinent relations” between the model and the situation modelled by it together with the Hegelian remark ***“experience only confirms what the concept teaches”*** describe perhaps a Trojan horse in the introduction of an ontology in the SS Methodology as Studer et al (Studer et al., 1998) define it. Because in the absence (as SSM dictates) of an “archetypal system” or “a reference system” then no comparison is feasible at the first iteration of the model since there is nothing to inform “out there”. Should someone suggest that comparisons are made between consecutive conceptual models produced from the model’s iterations (everyone against everyone), then this leaves us with the question of comparison wide open to the question of how this is a valid procedure of sense making and not, for example, the outcome of the social and political nexus that is context for the modelling. It is the need to compare that may bring an SSM ontology augmented (with small o-letter). One last comment: when a depicting of models happens in the fashion of Burell-Morgan, then two things are to be remembered: (a) as we travel from one point of the axis farthest to the opposite direction the question of feasibility rises: can we really go that far? Or, perhaps, the existence of our other axis creates **a gravitational dark hole** that forces all quadrants to exist near the center, close to where the axes cross? What is an epistemology half? And (b) both models suggest an orthogonality between order and subjectivity (positive or negative) and thus a kind of independence between them as notions. That being said, we accept that Checkland’s epistemology does not inform us about the corresponding Order and vice versa. Then we may say that if Checkland assumes a certain epistemology and someone else builds the symmetric ontology device they may found themselves as mirrors against order. If such a symmetry exists in that sense, an isomorphic function may be found between the epistemological and the ontological topoi.

In a nutshell: if there is (as Checkland says) an autopoietic epistemological project through which we process learning to become behavior and that to emerge as social system perception which in turn informs a “holon” (see Figure 42) through which we move to the next iteration, then this device is ontological (or can become) in the sense of Bunge’s definition.

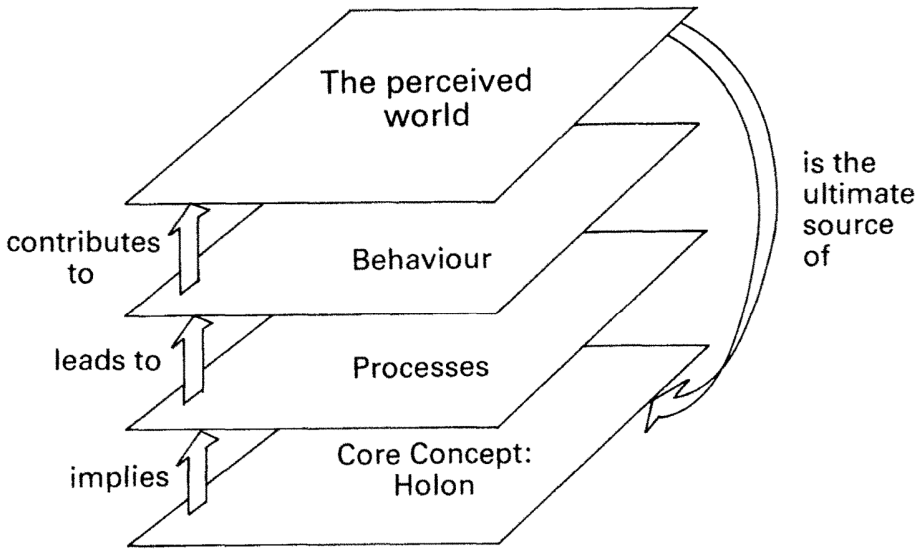


FIG. 1. *A coherent epistemology for systems thinking.*[9]

Figure 42 Checkland's model of "autopoietic epistemology"

In the next paragraph we further elaborate on a possibility of an SSM informed with an ontology.

4.4 A path of accommodation: an SSM-friendly ontology driven conceptual modelling (ODCM)

We are now at a point to discuss an accommodation between two different approaches. Can ontology, **as an explicit specification of a shared conceptualization,** due to the quest of explicitness and standardization that are internal in its making, bridge the gap to a "theasis" of the world provided by SSM (and epistemological strand in general) as the creation of systemic inquiry? Can we build an ontology that models the learning process of the LUMAS model? In this latter case, how can learning about learning be incorporated in an ontology thinking of the domain? And how level thinking of the systemic inquiry fits in?

Ontology modelling, in the case of smart city inquiry through a systemic fashion, is also an attempt to represent social relations, perceived, conceived and be part of (lived) in a space representation in a Lefebvrian mode.

Following Jurisica et al (2004) a "static ontology" that consists of hierarchical entities, set of attributes and relationships to other entities, even at a Domain (or Top) level is not suitable to grasp the complexity of the case in an Urban context. For example a static ontology where CATWOE stakeholders and notions may be presented as the top entities, then hierarchically arranged to appear in all levels of the inquiry may not suffice to explain much. At first because such an ontology will become too soon very complex for the stakeholders to evaluate or to even understand. Secondly because and despite increasing complexity it will remain far less complex of the universe of discourse that presumably tries to explain. Therefore an urban static ontology no matter how wonderfully sculptured is doomed to be sooner or later obsolete: the urban surprises by the novelty it can produce, in an explosion-implosion manner that leaves "ontological artifacts" empty of meaning not very far of the future. A number of static ontologies are built: to name a few, SOFIA, SCRIBE or NOW. Komninos et al are providing their own. But they also state the problem mentioned above clearly: "*the number of classes (size of ontology) that the application contains is related to the range of urban problems that can be addressed. Narrow applications having some classes tend to be very focused on specific problems and operations (…) On the other hand, wide applications possessing many classes can address more complex urban problems*". Therefore, the size of the ontology emerges as a problem concerning the quality of the results of such ontology. Another major problem in constructing a static ontology is the absence of change through time, that is, how time intervenes in the social relations that the ontology depicts.

Needless to say, none of the above-mentioned ontologies take into account the Worlds of other Urban Discourses that affect the urban context under consideration. The making of the urban is not local, but perhaps more global than one can anticipate.

Following the path of Jurisica et al (Jurisica, Mylopoulos, & Yu, 2004) we advance to consider what they call "social ontologies": "*A social ontology covers social settings, organizational structures or shifting networks of alliances and interdependencies. Traditionally social ontologies have been characterized in terms of concepts such as actor, position, role, authority, commitment etc.*". Not surprisingly they state that "*in a social context, the exploration and consideration of alternatives need to be done from the viewpoint of all stakeholders*", a point well in alignment with the need for considering

alternative Worldviews and Root Definitions anchored to different Conceptual Models in the SSM tradition.

One way to think of an accommodation between the epistemology of SSM and the need for an ontological type of classification lies at the heart of the Methodology. By being a methodology of Action research and Learning that iteratively revisits context and stakeholders of that context, SSM brings no clarity to the way it thinks about context per se. For example, the way we describe the Action Research in Chapter 5: includes the creation of networks of "belonging": One reason for that is to reveal urban space as a production of the interconnection of people, ideas, machines and nature but also of history trajectories that insist and therefore as a social construct (which reflects the epistemological base of the inquiry). But the second reason is, through this network exercise, to produce the Stakeholders of the problem area and the agency that comes with it. As, in each of the iterations, the context of the problem is revisited so does the relations between the Stakeholders. The result of the interplay between the context and the actors is the emergence of new learning to which new agency also corresponds. Therefore, our socially constructed reality bears a **weak, but still ontological dimension**: it is the reality of social relations made possible through learning interpretation and accumulation. If something is out there then it must, at least be social relations. An actor-network is an example of continuously assembled and disassembled relations as, in a Lefebvrian mode, conceived space (the space of ideas, strategy and abstract images) changes the way of everyday life. A change that is "*really real"*. Because of that change, those networks are forced to re-branch either willingly or unwillingly. That re-branching at the lower level initiates new battling and negotiation that through the mediators of spatial practice travel to upper spatial levels and reach conceived space. Therefore, an SSM friendly ontology may well be based on the concepts it uses to describe the models of it. Such an attempt, following the work of Gaspoz and Wand, is presented in Chapter 6.

Another way to accommodate SSM with an ontology may be thought as follows: Instead of trying to simulate World through the usage of concepts that allegedly proximate the Urban that is "out there", an SSM-friendly ontology (or a conceptual classification schema if "ontology" sounds an improper used word and in the case that names are

important for learning) should not limit itself to the inquiry process prescribed by SSM. Such an ontology should describe not only concepts of the Methodology (as for example the CATWOE elements or the learning ones that arise from the use of it) but also concepts built on the Urban theory that augments the Methodology. In that sense is at the same time dynamic (changes as iterations continue), intentional and social since the elements of the Methodology act and are enacted in the canvass of urban context. Because if for example someone talks of Stakeholders as in the CATWOE, one should remember that the Methodology itself is consisting of Analyses 2 and 3, that is analysis of the political and the social relations that bind the Stakeholders to particular Worldviews and justify the selection of certain (and not others) Transformations. If that is the situation we are dealing with then concepts of the SSM should be dealt as classes and/or properties of the ontology of the urban context under consideration. Further to that, notions of the Methodology as the Worldview or Political and Social Analysis are addressed through the part of Urban theory ontology. This split is also helpful in separating People's concepts (who are the Stakeholders?) from ideas concepts (what are the views of the Stakeholders?). The separation creates a domain of activities and ideas that interact to generate meaning within and of the domain. (see (Jelassi & Foroughi, 1989)).Therefore an initial representation of the ontology is as below:

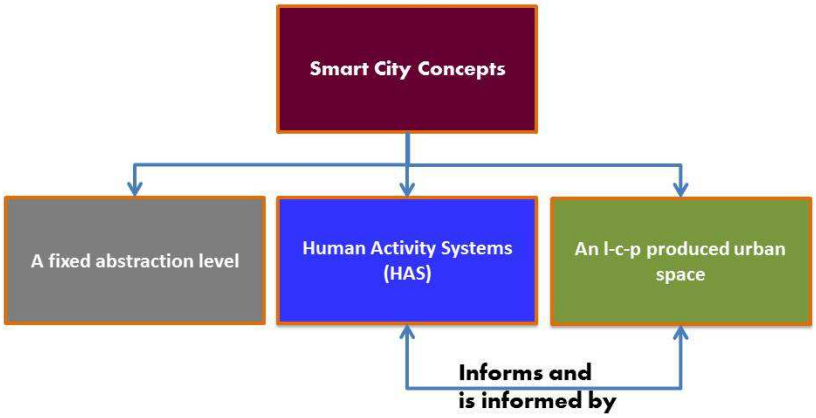


Figure 43 An SSM type I ontology

Another important issue to deal with is that of “abstraction level”. Since the ontology we are sketching here is an ontology of the way our learning of the domain “smart city” is built, we need to organize a compatible angle view between the classes of the Methodology and the classes of theory: since classes in the Methodology are dealing with activities of people participating in the Methodology, the level of the systems (ie level-0, 1 ,…, n) need to be within a similar range of abstraction or , if deliberatively not the same case is selected, we need to explain why for example we choose to entrain different levels. The choosing of the Lefebvrian ideas of space production as a trialectic of “lived experience”, “perceived space or Spatial practice” and “conceived space or representations of space” (an l-c-p space) is helpful because one can accordingly correspond the most abstract level (say G, for Global) to the conceived space, the least abstract level to the “lived experience” space, denoted by P and what lies in the between to a Medium or Mixed level of Spatial practice. On the left-hand side of the figure above, Human Activity Systems, a Level-0 system should contribute to the conceived Space: the abstraction of both should be equivalent. Stakeholders of a Level-0 system for example should be able to conceive the space produced by their activities as being explained by correspondingly abstract ideas at the theory level. If for example a system at level-0 is “Economy of the city” then the theory class of “conceived space” should be inhabited of a theory for economy (perhaps a growth theory or a trade theory). The theory is needed when an Action research mode in the methodology part decides the activities which comprise the system. It also dictates who the Stakeholders are: could be those that represent capital, labor or technology the way the theory describes. Activities and theoretical artifacts that serve lower abstraction levels are doing so by some degree of proper specialization. The discussion also suggests that a nested hierarchy can also be applied. An l-c-p space may be seen as having different degrees of abstraction ranging from Global (the highest level) to P (the lowest one) but still the P abstraction of it, is higher than any used in a lived experience space or even a conceived space if considered at a lower level of the ontology. To better present the discussion we refer to Table 15:

Table 15 Abstraction levels and correspondence to Human Activity Systems and l-c-p space

Abstraction Level	Human Activity Systems Level	Theory artifact
Highest	0	Global (an l-c-p space)
Mixed/Medium	1	Lefebvre's notions of "markets of spaces" as independently produced and acting: lived experience as "ways of living", a spatial practice space as networks shaped by demand and supply of resources and finally conceived space seen as policies or strategies attached to less complex activity systems
Lowest	n	All of theory notions presented in previous level stem from the interconnection of actions and meanings at a lower level. Private is the level "least collective", almost at the individual's plane: it is probably the plane of theorizing individual learning or micro economic theory. It is also the plane that spatial practice first appears –we therefore seek behaviors (as learning artifacts) or envision Services as a streamline of Actions. Finally we conceive a Global level as Policies are taken form and worldviews are been shaped.

Such an SSM-friendly ontology should describe the concepts and ideas, states and actions, worldviews, learning streams and environmental constraints for each stakeholder. A draft of that ontology is further discussed in Chapter 6.

4.5 A recap

Until now we have dedicated Chapter 3: and especially paragraph 3.3 to the foundations of the approach. Systems thinking and a special stream of it, has been selected to address the smart city notion. The rationale of the selection as presented in chapter 3 holds three major arguments. (1) That "smart city" is a wicked-problem and a complexity one (2) that systems thinking is a suitable way to deal with smart city as a way of addressing the complexity of it and (3) smart city is a socially constructed urban space. Based on the

characteristics of the problem, a specific strand of systems thinking has been selected to address it, namely Soft Systems Methodology.

A missing link concerning "smartness" has been detected: that of an urban context, a theory that could incorporate smart city as an urban context. Denying a techno-scientific approach we have selected the Lefebvrian ideas as more suitable to augment systems thinking: it was also a departure from grand level theories and the choice of meso-theories that prevailed in our decision to employ Lefebvrian ideas. That does not mean that SSM cannot be anchored or work with other Urban theories. What we are advising against though is to let it by itself, without any context specific theoretical binding. If the Methodology answers to "How can we act and think", which is a much needed approach, then Urban Theory answers to "Why we think and act that way", providing us, therefore, with the "*raison d'etre*" of our intervention. There is no such thing as a neutral or optimal intervention. Instead, we think, any effort to a smart city path is a preferential and a learning one.

Soft systems Methodology lends itself to the Social Constructivism paradigm as we have shown in chapter 4. But that may be not an obstacle to embody an ontology of social relations as the ones embedded in the CATWOE formulation or in a more complex case by achieving an ontology of the How and the Why as an ontology of people and ideas of people.

In Chapters 5 and 6 to follow we present an "instantiation" of the foundations. We move (in chapter 5) to the sketching of SSM for the smart city following the processes of it in Level-0 and Level-1 systems of human activity. That perhaps, we hope, will bring clarity to the theory of it as presented in Chapter 3. But of course this "instantiation" is not an application to a specific city. And cannot, of that reason deep into details or reaches a level where for example domain requirements may be elicited.

In Chapter 6 we present the accommodation of SSM with an ontology. Still the analysis remains at a meta-level.

Chapter 5: Applying SSM to Smart City Domain

5.1 Introduction

The aim of this chapter is to implement Soft Systems Methodology as the selected systems thinking approach in disentangling the notion of smart city. By implementing we do not mean that the Methodology has been practiced in a specific Urban context, in a specific city so as to present and reflect on the results achieved on the field. It is rather a "simulation" of it with the usage of "fictitious" or "laboratory" concepts. We employ the theory of the methodology as described in paragraph 3.3 by drafting layers of systemic inquiry, Human Activity Systems specific to Urban context representation, CATWOE definitions, Root Definitions and Conceptual Models of it. We also provide a collection of rich pictures to describe aspects of the Methodology and the Urban as well.

In presenting an Urban theory (that we thought as) needed for the anchoring of the smartness notion in an Urban context, we have considered the Lefebvrian production of space, that is that Urban space is socially constructed[29]. But as Lefebvre had foreseen some 50 years ago Urban had gradually attracted intellectual forces from numerous fields, though not yet an "episteme" in itself, in the attempt to investigate both the Urban itself but also the way we learn about it.

What is the Urban Context is today an ongoing debate (see Brenner and Schmid in (Brenner & Schmid, 2015)) and for the sake of simplicity we are using one of the broad epistemological devices (namely "Thesis 2") through which we clarify concepts later used in the SSM Conceptual Models

Thesis 2 states

"*The urban is a process, not a universal form, settlement type or bounded unit*"

Thesis 2 is elaborated via three major arguments:

(1) There is not a universal "form" of the Urban. Therefore, Urban cannot be thought as a "container" since this "container" itself is "*dynamically and historically evolving and variegated. It is materialized within built environment and socio-spatial arrangements*".

[29] It is also true that urban studies have been a major issue inside sociological studies throughout the 20th century and scholars such as Weber, Lefebvre or Chicago school ones as Park and Wirth or Frankfurt school are examples of it.

Therefore the Urban is (and has always been) a "Virtual Artifact" and in today's world technology creates new layers of virtual activity, where new, iconic representations of space are possible: digital networks or in the fashion of Saskia Sassen "digital formations" are playing not only the role that transportation played once in earlier phases of the urban context development (creating new and previously unimagined economies of scale) but also through the reordering of trade, financial and production networks become agents of the change that transcends all facets of Urban.

(2) "*Second the urban can no longer be understood as a settled 'type' (…). In such a conceptualization, urban configurations must be conceived not as discrete settlement types, but as dynamic, relationally evolving force fields of socio-spatial restructuring*".

(3) "*Third the Urban can no longer be understood as a bounded spatial unit*" and "*Conceptualizations of the urban as a bounded spatial unit must thus be superseded by approaches that investigate how urban configurations are churned and remade across the uneven landscapes of* worldwide *capitalist development".*

(Old) Geography is dead. Long live the New Geography. City boundaries cannot be thought as static. City geography is expanded and should be realized as being part of networks of numerous kinds as the City expands to the World and is infiltrated by the World.

Therefore, the Urban context of the City Designer is:

a. Geographical as described above

b. Virtual as also is described above (in argument 1 and as technology drives change)

c. Socially constructed (or as Lefebvre would argue: street based). The identity, the culture, the safety, the transport, the clash of gangs or classes for rights to the city etc. comprise the dimension of the social and political contestation and participation and finally

d. Both bearer and changer of a Production Mode (the economy considered as both within realm of spatial capital accumulation and migration flows or as a partner in international trade and financial networks).

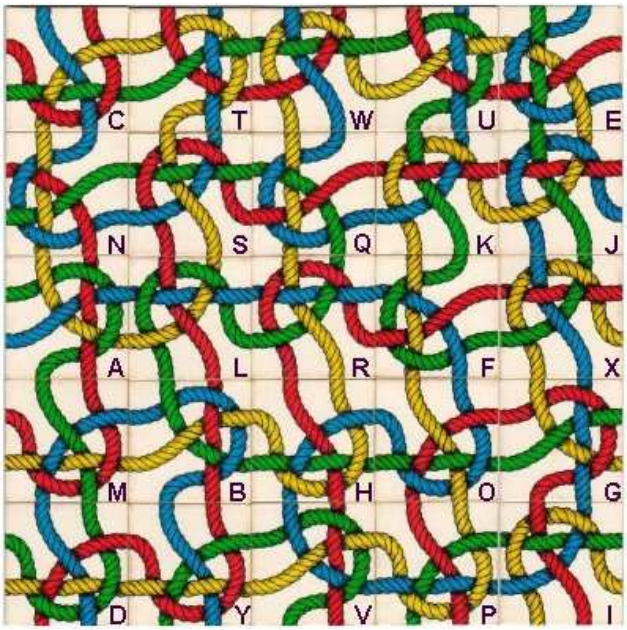


Figure 44 A knot

Smart city notion is in the previous context more than an ill-defined problem; **it is probably today an ill-defined problem of tomorrow**. The effort to break the problem is an effort to solve the tangle. **To deal with it one should try to start a dialogue between what has not yet become and that, which it may be**. In search for a land to stand on we call Soft Systems Methodology (SSM) because of its unique characteristic not assume a clear and single worldview in a systemic fashion that tries to model and later quantify what is out there but it rather seeks the path to analyze a set of complex worldviews through systemic inquiry. To quote the founder of the Soft Systems Methodology, Peter Checkland ***"SSM is an action-oriented process of inquiry into problematical situations in the everyday world; users learn their way from finding out about the situation to defining/taking action to improve it. The learning emerges via an organized process in which the real situation is explored, using as intellectual devices - which serve to provide structure to discussion - models of purposeful activity built to encapsulate pure, stated worldviews."*** in (Reynolds & Holowell, 2010).

The extra effort here is to construct the smart city notion, using Human Activity Systems as the intellectual devices not only to structure discussion but also to embrace and accumulate learning coming out of it.

The usual SSM Mode 2 fashion is used here by the City Designer to structure thinking and is described below as Steps 1 and 2 of conducting systemic inquiry:

1. The City Designer needs to identify the levels of systemic analysis. These levels actually define the perception of the City Designer and mostly reveal initial preferences of her action. The levels of analysis, namely 0,1,2 ..to n, where n is a choice of the City Designer, start with the most macroscopic view at level-0 and then consider lesser macroscopic views until reaches the level where human activity systems resemble or converge to be systems of activities realized by the least collective stakeholders –that is a level of individuals or "small collectives" such as "household" or "small firm". We will, from now on call that level as level-n and is the level to be last considered in the first round of the analysis. For the sake of simplicity we will also consider throughout this dissertation that the designer starts at **level-0**, identifies an initial collection of Wider Systems (this is the most abstract level), then moves to **level-1** by reducing the level of abstraction to a more "problem –specific" view. This, more specific view at level-1, within the urban context could be a level of city concepts (eg Transport, Energy …), which, as they intertwine, produce activities captured as systemic at the upper level (therefore an emergent identity for level-0 systems appears). It is also recognition that Urban Systems of level-0 are inherent or embedded to the systems of level-1 but are more specialized and structured when defined in the urban context. Transport inherits identities of Economy. Imagining and naming such Systems, at level-1 reveals more of the City Designer's intention to act, as these systems, in a SSM context are the "what" level. Finally, the City Designer reaches **Level-n.** Systems in level-n are, as pointed above, comprised of activities of actual actors, beneficiaries or wounded by the setup of the city designer. This is the most micro-level of our analysis. Needless to say, levels of analysis and systemic activities may be different between different Action Researchers. Eventually, what the City Designer designs in that step is nothing but an initiation. Several rounds of restarting and redrawing based on the initial step -and a lot of maturity- may be needed before the City Designer moves to step 2 of this inquiry. So, during Step 1, City Designer is (a) deciding the levels of abstraction

and forms initial systemic abstractions based on activities concerned and (b) selects the Stakeholders for each level of the inquiry and (c) brings forward a Root Definition and a description of the Worldview so as those can be used as learning benchmarks during the process.

2. Should the City Designer wish to understand the state of things she needs to perform a next step: that of a bottom-up procedure, symmetrical to the one prescribed in step 1. **The main effort in this second step is to check the assumptions of her own Root Definition and the Conceptual Model that resulted in the first round.** Starting at the level which concludes step 1, the City Designer needs to address different Root Definitions that are produced by different Stakeholders. It is also the stage to create a public awareness of the process through which these stakeholders become known as such and their objectives are publicly announced and debated. not only the true existence of individuals, households, firms, competitors, institutions, social formations or whatever else he thinks to be the stakeholders of the urban context. By taking over this role the City Designer is also becoming a broker of interests and therefore a publicly known negotiation procedure is a prerequisite for the continuation of the process. The bargaining procedure will result in the capability of the City Designer to compare the results of the step 1 (the learning produced and the initial model) with results coming out at the reconsideration or bargaining phase. Of course, it is the role of the City Designer to monitor the process at every stage.

Steps 1 and 2 will either converge in a few rounds or diverge quickly in which case a need for reexamination of the initial step 1 assumptions should be employed. Both steps 1 and 2 are used to provide an "accommodation" of interests and a convergence to a common sense making of the area perceived problematic.

One should bear in mind that:

a. The scope of Steps 1 and 2 are to finalize a common understanding of the state of things and the goals to pursue during, as a matter of fact, of any problem under consideration, with special case being that of defining the notion of smart city. Steps 1 and 2 fall precisely in SS Methodology, since do not prescribe a certain

solution but instead a systemic way of defining the problem itself. The usage of SS Methodology is combined (see paragraph 3.3) with many other methods to achieve better results. Such a combination of methods is advisable.

b. Level-0 Systems of systems is the most abstract plane of examination. The way the City Designer chooses systems reveal preferences and preferences are socially constructed. That is, the choice of the City Designer reflects the current state of the urbanization both as historical formation and as futuristic envisionment. It also reveals the state of power, the paradigm in place for economy, the environment and the rights to the urban context. **In SSM realm, level-0 is the most abstract level of analysis and is the level that corresponds to the "conceived space" of the Lefebvrian triad.**

c. Throughout the construction suggested by steps 1 and 2 implies an inheritance identity between the systems in level **0, 1 and n**: systems identified at levels after level-0are nothing but "sub-formations" of systems at level-0 which are identified as such because of our need to grasp the wholeness while pursuing a certain purpose or objective. In that context Transport may be a system of level-1, but one should understand it as a system which activities may be traced in every system in level-0. That said, we understand Transport to be a subsystem of the Economy (with an Objective aligned to the Wider System of Economy ie its own objective at its own systemic level cannot contradict the objective of the Economy system). But it is also a subsystem of the system of technology or of the system of social and political activity. Finally, when exploring systems at level-n, the City Designer should be able to identify human activity systems within, for example, the transport activities system: these activities at level-n produce social relations (work habits or leisure habits to name a few create networks of travelers within the city or within the city and other cities create the need of Transport Activities either from the supply or from the demand side). The inheritance identity that links systemic activities at different levels can also be defined as a trajectory of Objectives, forming paths from level-0 systems to level-n ones (as understood by the City Designer). During the step 2 of the bargaining procedure the City Designer seeks to maintain that identity inheritance after the consultation with the

stakeholders. These objective trajectories are the grid holding the negotiation process of step 2.

5.2 A System of Systems representation

Within a SSM realm, The City Designer, as we have described her earlier, has a worldview of the urban context in place. We have represented the urban context with a vector of dimensions in paragraph 5.1. Following a SSM the Designer seeks to analyze the current urban context and probably to identify the emergence of smartness as a result of this analysis. ***In our case the entity that is to be transformed via some transformation process (say T) of smartness is the Urban Context and the outcome of this transformation to be Smart City notion***.

The City Designer chooses the level-0 Systems: given the urban context those wider systems reveal a representation of power: it is the level where the decisions are made in order to fulfill the greater objectives of the City Designer. For example the City Designer understands three level-0 systems: The Economy System, The Technology System and the Social-Political system. The Designer needs to understand the following:

1. The structure of each system at the level of analysis
2. The way these activity systems interact and how this interaction is transferred within each system
3. The way its own urban context competes to other (rival or complimentary) urban contexts in the terms the City Designer is interested in.

Reaching a mature point in this understanding, the City Designer will be able to make public for each system the change in Strategic Objectives which emerge as learning is accumulated through the process. The City Designer may create images of these three Systems using different tools, despite where these tools are to be found. That level of soft systemic analysis aims to reveal the power level, the decision level and the level where

the Initial Objectives are improvised. It is , according to Checkland ((P. Checkland, 2000) the "Why" level.

But our designer does not only need to ask "Why". The Designer needs also to know the "What" level, or in SSM terms the level in which the transformation process will be implemented. The P of the phrase "Do P by Q to achieve R" in SSM terminology happens in that level of Systems of Systems defined as level-1. Therefore level-1 is the level of action. Level-1 is:

(a) A meso-level in terms of abstraction. Activities are more "concrete" abstractions as compared to level-0 activities.

(b) A level where new objectives (purposes) are served by different networks of stakeholders (compared with corresponding objectives and networks ay level-0)

The process may continue, but in finite steps to reach level-n systemic activity. A bottom-up process will guide to the formation of level-n objectives -as perceived by Stakeholders- and to the examination how can be aligned with level-0 strategic objectives. This is a criterion (from the City Designers view) of the successful outcome of the Methodology.

A description of the Systems at level-0 will enlighten the methodology but also will provide with the first hints of deviating from it. As pointed earlier, to think in terms of our Wider Systems, the following should be addressed:

- First, there is the need to describe the structure of the system, define a way to think of the boundary and try to emulate major "esoteric" relationships
- Second, relationships between the systems should be established, at an abstract level.

Throughout this chapter we will call upon our understanding of SSM as a methodology to resolve ill-defined problems and the Lefebvrian ideas on the urban space presented in paragraph 2.5 in effort to address "smartness" in the city as a learning process that stems out of Human Activities Systems. As we have already described earlier in this chapter, the representation of the urban as a system of systems is pursued in the SSM layered thinking of an observer, ie the City Designer, by suggesting the following hierarchy of Wider Systems- SubSystems of the Wider Systems- and finally Systems of human activities.

Table 16 Levels of systemic inquiry in an SSM fashion

Observer	Answers to	Level in the hierarchy	Human Activity System
The City Designer	Why?	Level-0 (the wider level)	EconS, the Urban Economy (any financial, trade or other economic transaction, human activities)
	Why?	Level-0 (the wider level)	TechS, the Urban Technology as a collection of human activities bearing **innovation** (in methods, organization and machines) **or mediating change** (between the other two wider systems, namely the Urban Economy System and the Urban Social and Political System) **or modifing time and space relation** in the urban context).
	Why?	Level-0 (the wider level)	SoPoS, the Social and Political System activities of the urban context as flows of current urban activity or stocks of more permanent activities.
	What?	Level-1 (subsystems of level-0)	Transport, Safety, Energy, Culture,Environment, Social Welfare, Government as systems of human activities **servicing both the policies** of the Level-0 (or the why level) and **the actions and meanings** of level-n systems.
	How?	Level-n (subsystems of level-1)	ie households or communities of households, firms, group of firms, markets, spaces, digital formations, the general public or specific groups of social or political alliances, government authorities or hybrid organizations combining the previous entities: all of them acting both as actors and customers.

As Checkland points out in (P. Checkland, 2000) systems thinking entails thinking in layers defined by an observer. Thus, if the City Designer is the observer, in an effort to describe human activity systems in an urban wide scale, she declares economy-type, technology-type and sosciopolitical-type activities to complete the wider level layer[30]. These are surface systems, observed at the sea level-0, in the sense that as the waves are shaped by the wind, earthquakes or under sea volcanos transferring energy, the systems at level-0 are shaped by forces at lower levels and present themselves as "battled aggregations" due to these forces, with emerging properties not to be found in lower levels.

[30] Note that the City Designer rests itself as a fictitious entity that can ascribe life to those systems while at the same time belongs to them; and that is perhaps the purest form of modelling.

As the City Designer unfolds the battled aggregation, steps in the level-1 systems that are suggested in the table. In a SSM based lexicography those systems are the layer of any attempted Transformation (in the sense that the level-0 systems are the layer to ask or answer "why", then the "what" rests at the next lower level. Then again the next lower level is that of "how', to do things. Needless to say that all of these layers are pure concepts of a common sense ability and not actual, ontological formations. In P.Checkland's words *"it might be decided also to model at the wider system level or to expand some of the individual activities in the initial model by making them sources of further root definitions*" ((P. Checkland, 2000).

To further demonstrate the methodology a number of systems were named as systems of level-1, considered as a collection of the following Human Activities and more specifically: **Transport, Safety**, **Energy Culture, Environment, Social Welfare, Government**. A detailed description of those HAS are to be found in paragraph 5.7

Finally the third level in the layered thinking (named as level-n) can be described as the Stakeholders (or the Agents) level, where collective or individual stakeholders of the city act and perform roles that actually create, as is later explained, the activities traceable at the upper systemic layers. So for example, if the City Designer needs to understand and label the Transport Human Activities, he should analyze activities of individuals and collectives such as

- households or communities of households,
- firms or group of firms,
- markets,
- spaces (roads, squares, buildings etc),
- digital formations (social media groups, digitally connected people),
- the general public
- specific groups of social or political alliances (unions or political parties),
- government authorities
- Hybrid organizations in which the previous entities are combined.

All of them appearing as both actors and customers create activities such as:

- Moving into the urban space from point A to point B
- Trade of goods or services or ideas

- Creation of innovation in Transport (in the form of application/method…)
- The claiming of rights regarding transport within the city center

And more.

Therefore, when a firm moves products from source to sink, is an activity in the level-n layer, as when a technology firm produces a mobile application to provide a GPS positioning for those products and as an activist group calls for a free transport within the city center. All three activities come under the Transport label because they share the purpose of achieving a transportation objective. A Firm transfers products and probably uses an optimization algorithm for that purpose. A Technology Firm may create an algorithm to be used by a transportation or an energy Firm. Finally, the activist group claims for a right that is bound to transport activity. Although activities of the Technological Firm and the Activist group are not Transport activities per se they clearly create an impact on it either for the demand or for the supply side. These stakeholders participate, through their activities in shaping something composite, namely the Transport System or the Transport Service; they do so as Moving activities occur in the urban space and technology is utilized to achieve an optimization of these moving activities and finally as they are claiming a specific right in the everyday life of the city. These activities reflect and create a conceived space of economic, technological and sociopolitical dimension of the transport system of level-1. They also may reflect and change the *Worldview* those stakeholders embrace, towards their living environment. What is not obvious is that, as these activities are aggregated in a negotiated or battled way, a level-1 systems thinking becomes possible. Transport at level-1 is a battled aggregation of Moving, of utilizing technology and of rights claiming. It is that aggregation (conflict, negotiation or battle), of level-n activities, that forms new activities at level-1; we will call them Services. Thus, **Transport is Services,** in that sense. Let us identify some of those: regulations in the form of light traffic, parking or pedestrian zones and the denial of moving on certain space and/or time are an example of those services and an emergent property of level-1 systems: *you cannot have a regulation of light traffic at the stakeholders level, for example there is no meaning in saying that traffic lights regulate households or firms*. Networks of alliances are another example of a Transport system activity. These alliances are due to proximity reasons, and proximity is thought as

a measure of closeness in trade or social relationships, the power grid or the production networks. A market of any kind is a network of alliances build by activities that are purposefully combined. It is through the construction of those alliances that Transport activities combined with the other systemic activities create for example economic activities. The most prominent example of how Transport activities created economy activities is the creation of the banking system in Europe as early as the Middle Ages.

The City Designer is, therefore faced with a need to a three-fold representation of Human Activities Systems, concerning all three levels of the Urban. Soft Systems Methodology will be applied to achieve a conceptual model for each of the Systems described in the table above: the idea behind this is that the City Designer (who inhabits in Level-0, ie "owns" the urban and wants to transform it to "smart urban", therefore is the Owner in the CATWOE acronym) should satisfy the *claims and meanings of "Customers"* that also inhabit the urban. These *claims and meanings* are born in the lower layer, the level-n (no matter how big that n could be: one can identify 4, 5 or more layers for the analysis). What we just named "claims" either vanish in the appearance of new ones or, can, at a certain time, become **"Actions"** of some kind and stream their way to upper levels of systems as aggregations in alliance or in conflict. So, **Actions** encapsulate both a production of claims and a response to goals, beliefs or needs and an attribution of meaning that are present in the networks of the urban context. **Actions are aggregated and coordinated** resulting in the creation of new and the abandonment of existing networks. Those new networks surface the urban context and they are understood as systems (of systems) perceived as such by emergent properties not to be found in other networks or in the Customers that constitute the networks themselves. An example of such a perceived system in the Urban context is the system of transport: a city is a travel in space for a myriad of reasons concerning both the Habitat and the Habiting[31] , to quote Lefebvre here, therefore is a constant negotiation of claims concerning how the Habitat and the Habiting are achieved. That negotiation uses purposes, beliefs and needs and a process of comparing different paths and suboptimal solutions, through a learning process

[31] Habitat in Lefebvrian mode is "imposed from above as the application of a homogeneous global and quantitative space, a requirement that 'lived experience' allow itself to be enclosed in boxes, cages, or 'dwelling machines'" while "essence, foundation and meaning are supplied by habiting" which "should no longer be approached as a residue, as a trace or result of so-called superior levels" ((Lefebvre, 2003)

and a network of people, machines and methods to achieve travelling in the city space. Thus, this network that achieves transportation throughout the city is in common language perceived as "a system" described by its ability to move people and products and ideas, an ability that emerges and is perceived to be an emergent property of the Transport System. The specific network of resources is only the Actors part in the CATWOE: actors are members of a wider network of people, goods, services or ideas that are actually reply to the demand for a transport service. The activities of transport demand (either met or not) and of transport supply (via resources such as car, rail or bus or feet) comprise a Human Activity System which we conveniently call Transport System. Because Actors and Customers in the Transport system are also easily identified as disjoint networks having specific roles or seeking specific goals or both we tend to think the transport system in a System of Systems fashion and particularly **as resource based subsystems** (ie the bus drivers, the taxi drivers, the metro system, the roads or the ports or the government authorities coordinating it etc.).

So far we have sketched how a streaming of Actions, in level-n systems create (as a constant negotiation between Aggregation and Conflict) and become the vehicle of new network formations, who in turn take life of their own. These anew networks, we will call ***Services*** to fully acknowledge the fact that they are perceived as such through the process of aggregation and conflict. It is these networks that Lefebvre refers to as "Spatial Practice". Furthermore, the way they are engineered and re-engineered create the need to treat them as Human Activities Systems that change themselves as the day turns into the night in the urban context. The above is well represented in Figure 45 and in Figure 46[32].

[32] Accesed on May 7th, 2017 from http://senseable.mit.edu/urban-exposures/

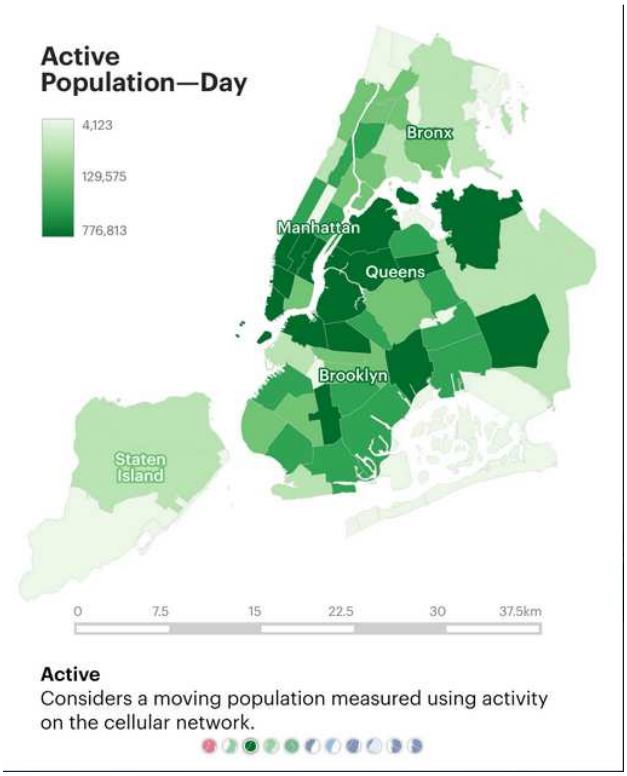


Figure 45 Day transport activity as traced by mobile phone

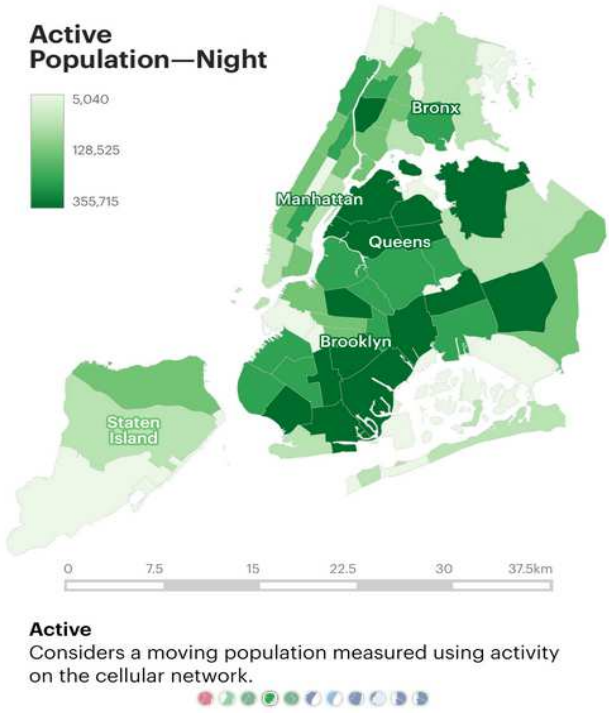


Figure 46 Night transport activity as traced by mobile phone

As figures above suggest, the Transport system is not a collection of lines of buses or trains only: it is actually an activity system that uses those resources to achieve a unification of space. That system relies on other activity systems as for example the energy activity system and is constrained by them also.

To conclude the discussion, concerning how "systems of systems" are to be perceived we reach the final level of aggregation. As Services are further aggregated or coordinated, they result in a level-0 human activity system: these are for example the economy, the technology and the sociopolitical systems conceived as such by the City Designer (the Owner in a CATWOE fashion) but also from both the Actors and Customers. This last aggregation informs every previous one, to bare an economic, a technological and a sociopolitical dimension or in a vice versa mode that every system of systems, less wider than level-0 systems, is reflecting eg a situation in the labor market or in the capital markets, a grid of power in the political sphere, an ideology status and, last but not least, a technology encapsulation.

"*According to Alexander's "A New Theory of Urban Design" it is not possible to examine the city (or its part) without an inherent personal imposition.*

We understand the city from our own cognitive models, influenced by our culture. The environment teaches us a sense of intuition; we learn to cross roads, navigate traffic, look and identify practical way-finding mechanisms. Our interpretations are learned by experiencing.

Therefore any analysis is unique to an individual – while there may be consistent overlaps – perception of context is derived from experience"[33].

The rest of the chapter will follow an SSM approach for systems in layers 0 and 1 by building Root Definitions for a selection of Human Activity Systems and drawing conceptual models for each of those definitions. Effort is made to create a de facto inheritance between the layered Human Activity Systems so that activities in the wider level to decompose to activities in the lower level. Furthermore, as activities are decomposed, the LUMAS model architecture should be sustained because the Transformation towards smartness is a learning activity for all participants of the

[33] As found in https://petejmitchell.wordpress.com/2013/04/14/early-analysis/

CATWOE and as information flows within the acknowledged systems and between them, learning is produced, as change, from status i to status j, is comprehended by stakeholders.

5.3 The Economy System (EconS):

The City Designer is interested in the system in different ways. For example the EconS of the city is part of a nation-wide or a region-wide economy and the way this relationship is realized is of a great importance for the designer. The EconS also belongs to a network or affected by a network of other urban EconS with which trade partnerships or competition may exist. The specialization of the EconS, is both a result of a historical development of city itself and the accumulation of capital in the never ending process of spatial fixes of capital according to Harvey (for a thorough discussion see (Jessop, 2006)). More importantly, financial mobility of capital which looks for anchors in space may also be of relevance in the examining of the EconS. The City Designer should also be aware of the particular Urban Context the EconS is operating in terms of Social System. For illustration purposes we presume that our City Designer has a preference to represent the EconS of the City as having (a) a specific growth function with endogenous learning (see models of Romer on Endogenous Technological Change, (Romer, 1990) and (Romer, 1994)) (b) that growth function has a specific geographical domain defined by a gravity function in trade terms (see for example (Anderson, 2011)) as trade terms are of particular importance since they reveal at the same time historical binds, societal preferences in goods and services and shed light to the specialization of economy. Finally (c) the Human Activity System of EconS is financialized: every activity that belongs to this system can be represented in money terms.

To begin with the City Designer needs a **Root Definition** of the EconS system in own urban context. One should bear in mind that such a definition is not something rigid or definite but really a tool of understanding and communicating ideas. It is an initial Root Definition having the purpose of setting an Agenda of the participative discussion among the Stakeholders but also of initializing the selection of those Stakeholders. The abstraction level of EconS corresponds to what in the l-c-p triad of the Lefebvrian space we call “the conceived space”. Therefore it is the space where learning is about the

ideological preferences, the production mode and the power of grid between stakeholders. It is also the most abstract among the levels. Perhaps, our neoclassical City Designer comes with the following:

Root Definition:

"An urban economy system, is a Human Activities System that is bounded in geography terms as a result of a gravity like function and follows a growth equation (eg of the Cobb-Douglas type[34])". Furthermore an urban economy system is:

1. Bounded with the help of gravity like function that redefines the geography of the urban to be *something more* than the city core. Depending on the definition of the gravity function economic activity takes place in an open and well penetrated space but for which a boundary can be constructed to declare the tripartition of the geography space: the urban vs the other (similar) urban versus the non-urban.
2. A map of the networks of Trade activity to and from this bounded area towards other urban or non-urban areas may then be easier to identify. Trade is one way to declare a relation in an inter-urban space.
3. A network of people, firms and institutions or any hybrid formation of them together with government authorities that act and re-act to create preferential hubs and networks of relations are emerging as nodes of the network with the purpose of achieving goals such as the best distribution of products and services, increasing of productivity and specialization of the labor and finally creating new fixes of capital formation.
4. Finally, a system in which every activity is monetized in numismatic terms no matter how this is defined (dollars, assets or even bit coins).

In a Soft Systems S Methodology the City Designer moves to identify the PQR formation in the root definition "Do P by Q to achieve R". This step will further bring in to light the tropos (the way of, the way of being, feeling acting and so forth) of the Designer.

For example the City Designer will analyze the urban economy system in order to understand the inter-urban representation in geography terms, to design snapshots of the

[34] $Y=AL^{\beta}K^{\alpha}$ where Y is total production, L,K labor and Capital inputs , A denotes total factor productivity and α, β are output elasticities.

trade activity of it in different time frames, to design a network of people, firms or institutions that are acting within its spatial boundary and finally to understand the impact of finance processes that affect the urban economy.

To build a knowledge base of the Urban System as described previously the City Designer needs to create Conceptual Models through which a learning process will begin to evolve.

Because of the creation of such models, a guided transformation of the "urban economy as system" will initiate. ***The transformation of the Urban to something that we may call "smart urban" is what is meant to be achieved through this process. The will of the stakeholders is the other important feature in this transformation process: a bargaining between the City Designer and the Stakeholders is core element of the methodology. Only when this bargaining is evolving a learning curve can be achieved in the smartness land.***

The City Designer now moves to identify the CATWOE elements of the SSM. What is important to note here, (and to every other Conceptual Model concerning other systems of activities) is that Stakeholders are being produced as the process is unfolding. That endogeneity of Stakeholders is a needed step towards the social learning the method is bound to. This kind of a repeated identification of Stakeholders reflects both the learning accumulated during the process but also the fact that social bargaining may alter the Stakeholders positions and understanding of the problem. Context is then accommodated through the reinvention of Stakeholders and the methodology achieves a double-loop learning status through this. Because CATWOE elements are part of the methodological approach, rethinking about them starts a rethinking about the methodology itself. Therefore, whatever is sketched below as Customers or Actors can be altered during the iteration.

Customers: the stakeholders of the urban context (for example the firms located, the different government authorities, communities of people that are interested, firms that may want to locate in the urban or multinational firms to expand their networks etc.)

Actors: same as customers: they are interchangeable in the sense that the City Designer uses resources within the urban context that are also customers of any change.

Transformation: in the process of learning creation concerning the urban economy that will eventually lead the City Designer and the urban stakeholders to converge or to at least to align in their objective concerning a "common sense making" interpretation of the urban economy.

Worldview: actually in plural, because the Owner, the Actors and the Customers all come with different Worldviews that need to be accommodated.

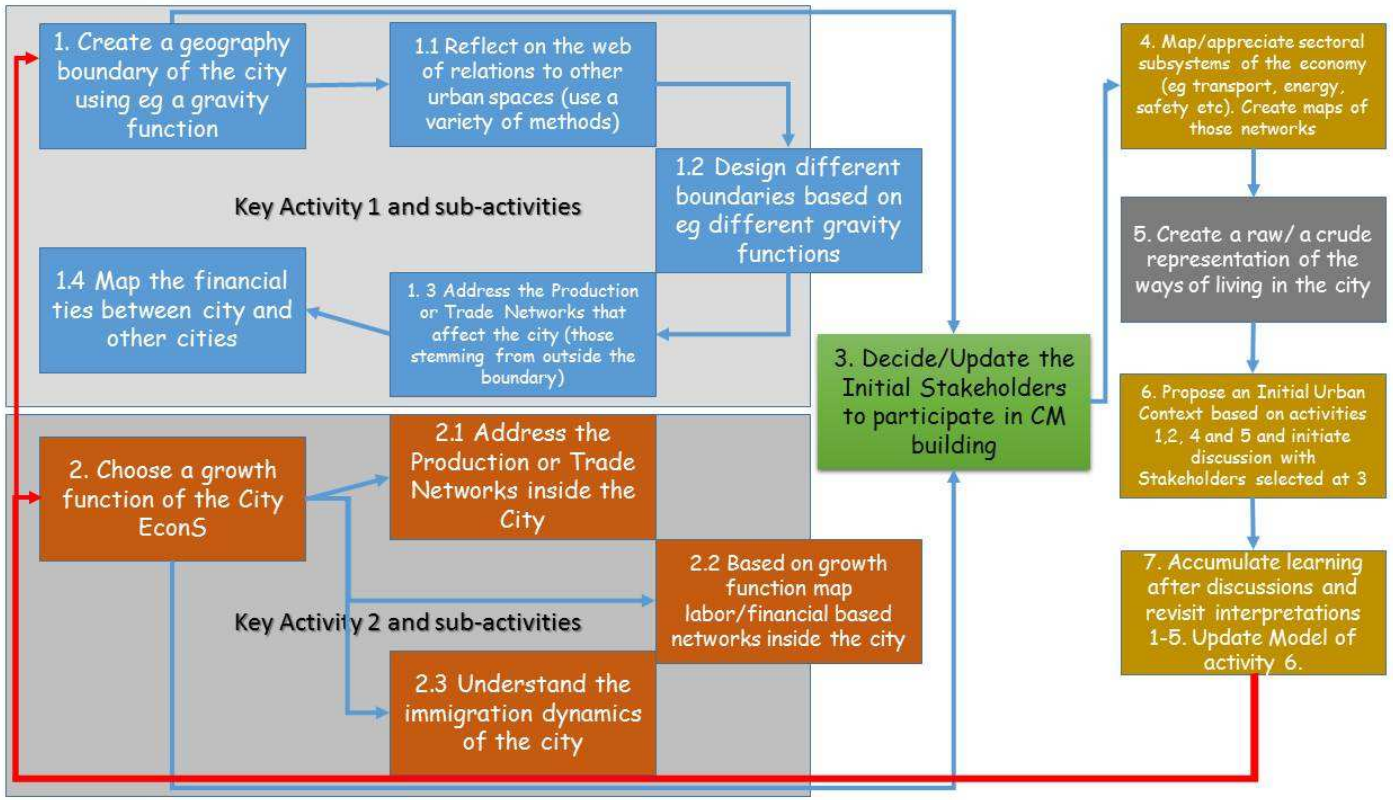
Owner: The role of Owner is, throughout this dissertation claimed by the City Designer. In a way, the fictitious character of the Designer can now be defined in more clarity: if something that designer can be is the Owner in the CATWOE, a role prescribed to be the initiator, the one that in Weberian fashion instantiates the neutral administration principle. And while to play the role of Owner the City Designer may need to acquire incredible scientific or power properties through the collection of those from different available sources, remains the bearer of the Role. He, alone, as the owner of the transformation process may at any time change or stop the process.

Environment: because the way we see the smart city notion, ie as a transformation via learning of the urban economic system the environment is both anthropogenic and natural. A learning process can have people and peoples' ideas, attributes and tastes as constraints but at the same time learning is bounded by "physical" (eg natural, environmental etc) constraints such the resources available or the magnitude of the problem. For example a City Designer may not be able to infer knowledge on the trade activity of the city but at the same time may be forced to move resources to tackle with a time specific and urgent problem or find himself trapped in a CO_2 battle between the poor that consume wood to heat and other societal classes that seek a "clean air" agenda.

The Conceptual Model

The Model in Figure 47 is an example of creating an initial model to be used as a guideline rather than a prescription of some kind. The ideas in the model are those previously presented but now take the form of activities as they are thought by the City Designer. These activities are:

Figure 47 A Conceptual Model for structuring thinking about Economy as a Human Activity System



To recap:

The City Designer needs to understand how the human activity system of the Urban Economy relates to the urban context. To do this she needs to acquire learning of how the urban of interest relates to other urbanities close or far away. Therefore, the City Designer needs to construct a representation network of the **world urban under her own preferences**. But not only that in a static way: more and more this network should be able to represent change in structure and information on the forces shaping it. To this end mapping a network of trade in an interurban fashion reveals something about the competition but also the history ties of the city. The second of the collective or Learning Activities is to create a model of growth that is city-specific. The collection of these activities combines, among others, the understanding and representations of production networks, financial networks or immigration flows to the city. Those activities are nothing but an attempt of conceived representation of the city in inner-out world dimension. Activity 3 is the production of Stakeholders activity. While activities 1 and 2 are closely related to the Worldview of the City Designer, activity 3 is the picking of the Stakeholders that supposedly have a stake in this Worldview. It is also a changer of the game in consequent steps. Activities 4 to 7 are now activities where Stakeholders participate with an initial objective to address the issue of appreciating the level-1 subsystems, the subsystems of interest. Further to that, as activity 5 states, the identification of "ways of living" is a crude way to develop an understanding the social underpinnings of those systems that have been identified at activity 4.

5.4 Technology System (TechS)

The Technology System (TechS) is seen as the result of pooling flows of innovations, ideas and a culture of cooperation. In our view TechS **is a system of networked activities** with nodes being people or firms or any form of organization that is bearer of innovation and arcs connecting nodes declare density, cohesion and centralization in the network. TechS, is a Human Activity System anchored in the Urban context. An activity to belong to this network system needs not to be financialized as in the economy sense. Examples of such activity are collective leadership in organizations, open source communities or knowledge communities and as Bach and Stark in (Bach & Stark, 2005)

state: "*From social structures and knowledge networks we thus get at cognitive social structures and cognitive knowledge networks (**who** knows whom or what). The cognitive perceptions of the members of a knowledge community taken individually may be incomplete or inaccurate, but together they form a transitive memory system that shares domains of knowledge. (…) communities of knowledge can be not only identified, but also created*".

Root Definition:

"The City Designer understands the Urban Technology System, as a Human Activity System that:

i. Creates innovation in methods, organization and machines
ii. Mediates change between the Urban Economy System and the Urban Social and Political System
iii. Modifies time and space relation of the urban context"

The City Designer now moves to identify the CATWOE elements of the SSM for the TechS.

Customers: as for the EconS, the stakeholders of the urban context (for example the firms located , the different government authorities, communities of people that are interested, firms that may want to locate in the urban or multinational firms to expand their networks etc) are again present as clients/wounded/beneficiaries. Because of the nature of the TechS, *firms, individuals and institutional bodies that are "Technology specific"* ie their prime or one of their prime businesses is the production of Technology in the sense it was defined in the Root Definition plus the fact that these agents locate themselves or have significant interests embedded in the urban context under consideration are of particular importance here. To tell the difference, a milk company located in the city uses technology (as method, organization or machines) and is definitely a customer but more importantly firms that produce the technology used by the milk company are forming a network of actors providing technologies throughout the urban context. Those companies are to be defined both as actors and bearers of transformation.

Actors: The firms, individuals and institutions that form the network of innovation and specific technologies. While the City Designer can orchestrate the EconS via methods of administrative regulation, intervention in finance, capital and labor markets or by exercising trade policies the same orchestration in the TechS may prove less possible because of the different nature, form and properties of the TechS network.

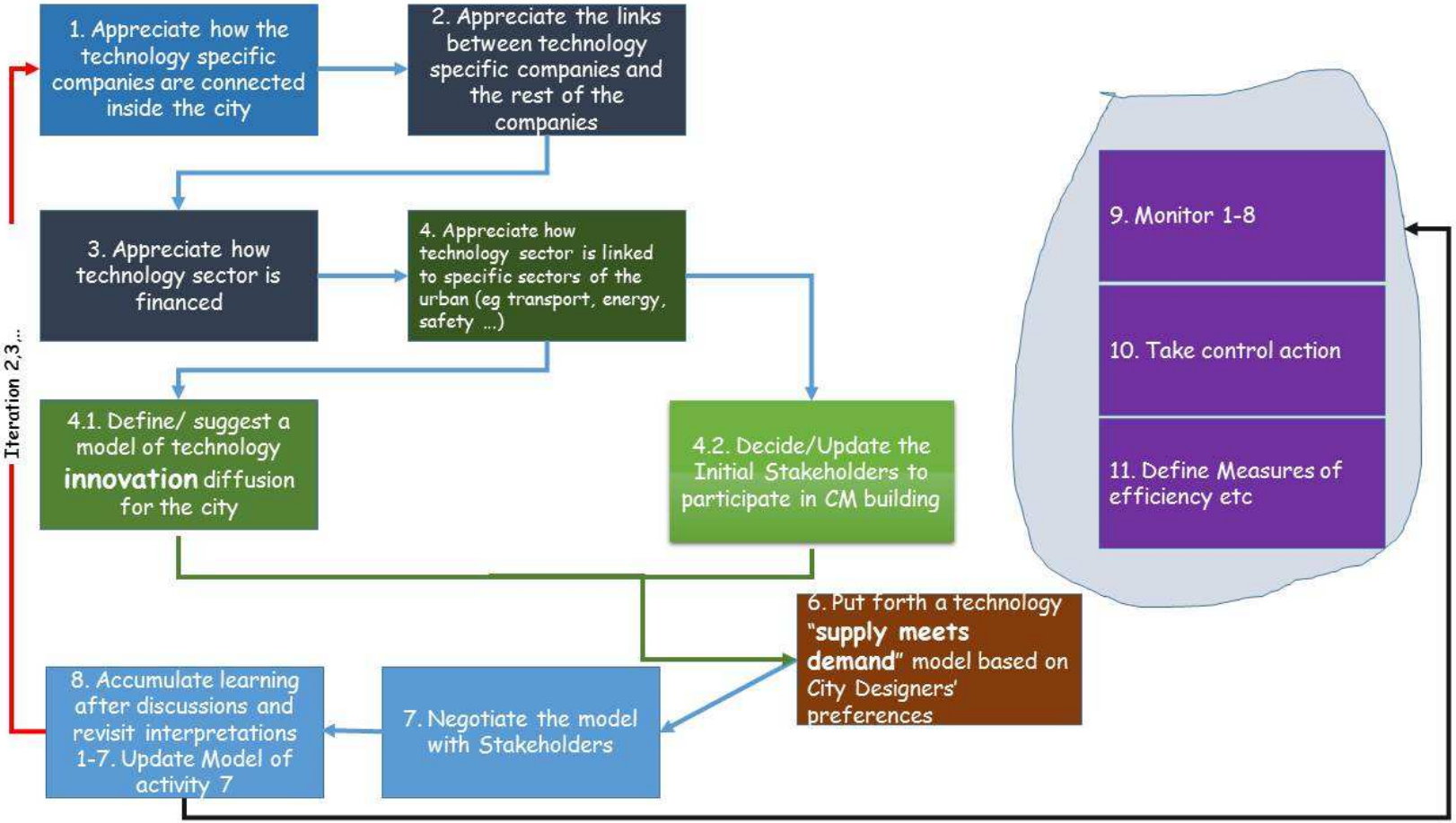
Transformation: a process T through which city is to become "smart city" for which all three conditions of the Root Definition are met when an entity of the urban is informed with the process. So for example if a subsystem X of the urban is turned into XT (via process T) then someone expects XT to be innovative in at least one recognizable way and to mirror a change in an economic or social way within the urban context and to have an impact both in the time and spatial formation of the urban. For example, if X is the subsystem of Safety any change to carry the smartness label ("smart safety") needs to simultaneously achieve innovation, reduce inequality and increase community ties.

Worldview: actually in plural, because the Owner, the Actors and the Customers all come with different Worldviews that need to be accommodated.

Owner: The City Designer

Environment: The Economy and the Social and Political systems of the moment.

Figure 48 Technology as Conceptual Model



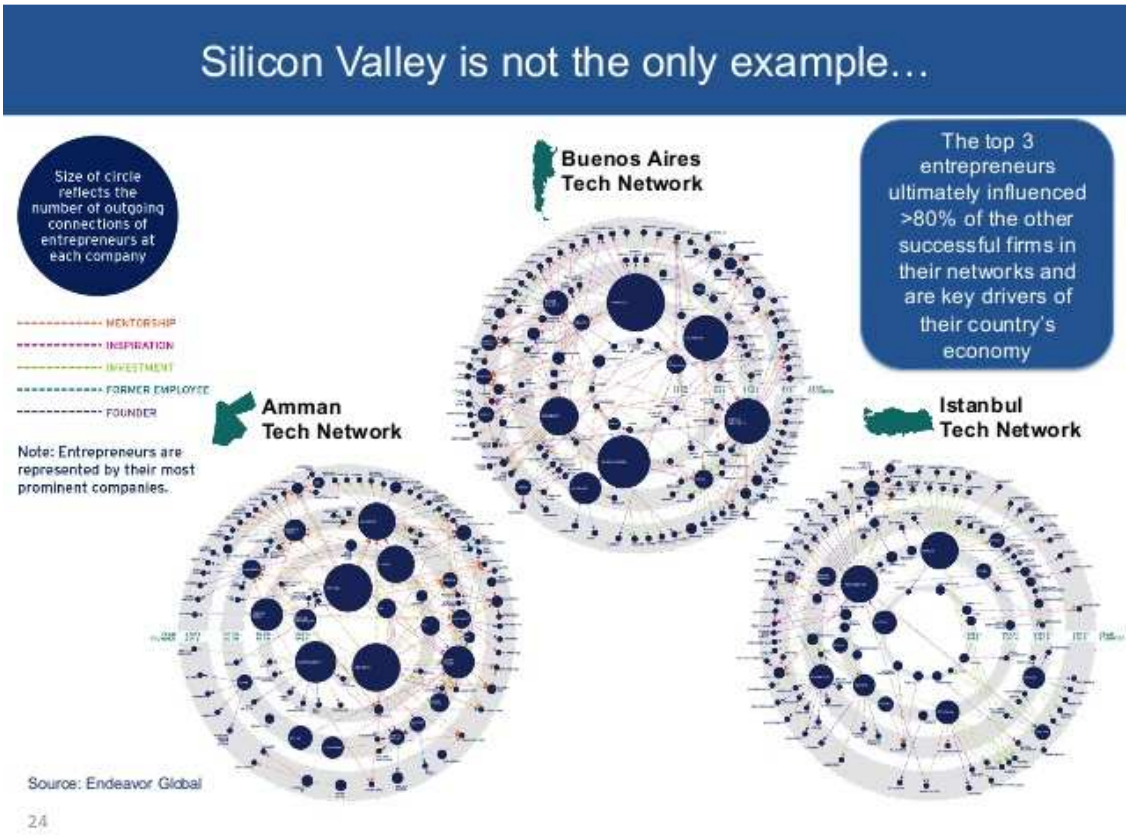


Figure 49 Tech Network representation for three different cities (taken from http://www.slideshare.net/NOAHAdvisors/ig-expansion-noah13-london)

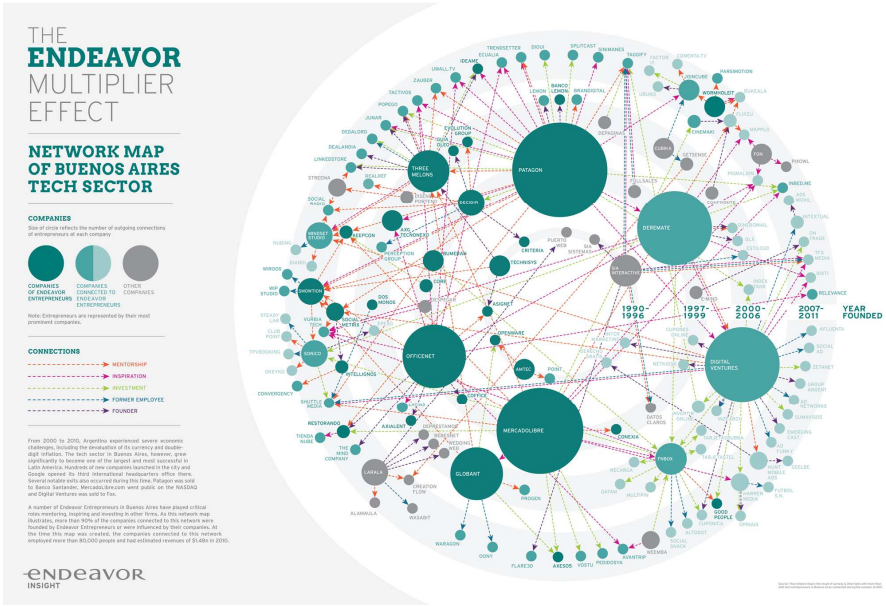


Figure 50 http://visual.ly/endeavor-multiplier-effect

Modelling Urban TechS

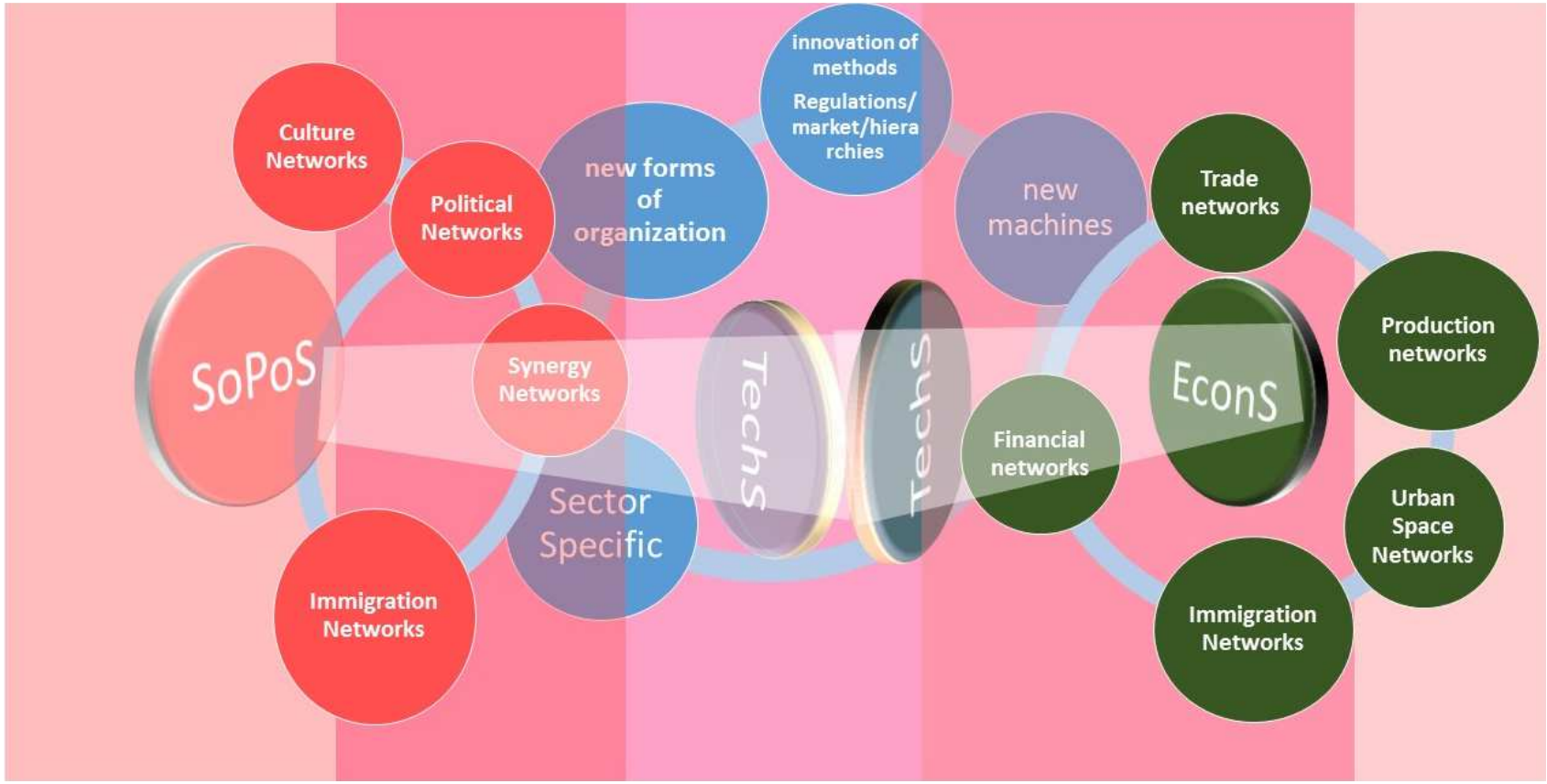


Figure 51 Technology as mediator

5.5 The SocioPolitical System (SoPoS)

The City Designer understands the functioning of the Social and Political System (as Level-0 System) as emergent and constructed after human actions stemming from individual, cultural and even historical beliefs at a global level (in the sense Lefebvre uses Global). To form a Root Definition, the City Designer needs to understand phenomena emergent only in and because of the current urban phase while at the same time he needs to be able to foresee or at least hint a near future development. It needs to do so because within the SoPoS the greater difficulty lies in understanding by design or by quantifying. Discussing the SoPoS Human Activity System one can identify all the concepts of the EconS and the TechS systems: human relations can be "monetized" or come into existence because of network belonging. But one cannot easily attribute activities as only being part of EconS (therefore "economy-only" activities) or of TechS ("technology-only: activities) and then perhaps to understand activities of SoPoS as a residue: what is not economy or technology, is then of some Social or Political meaning. Doing the attribution of Social or Political meaning to activities is more of a fine art than of a fine science. Furthermore, the correspondence of activities to each of the systems is getting harsher when examined in space and time of the urban configurations because what it may rest as a residue behavior at one temporal-spatial configuration may turn to become a driving force in another one.

So, the way the City Designer will write down a root definition of the SoPoS, not only reveals the way of thinking, the preferences, the overall life standing in terms of philosophy, history or else: it also changes the path to a new urban configuration that in future will be labeled as "smart city" configuration. To further examine the SoPoS as a Human Activity System, the City Designer proposes the following:

Root Definition:

"Within the urban context, any human activity that cannot be directly subsumed as an EconS or TechS activity, but still relates to them in a strong or a weak manner, is considered to belong to the Social and Political System activities of the urban context. Those activities are

a. Either "***flows"*** forming temporary "thin air" networks (and present themselves vividly when streets erupt, communities of any kind form and dissolve, culture

artifacts emerge such as buildings, fashion trends, gangs claiming the city, iconic figures that capture the daily life of city or even flows of immigrants, tourists and rumors

b. Or ***"stocks"*** , by forming liquid networks (less temporary but not solid) such as social networks (both virtual and non-virtual), political affiliations or hubs of "synergistic networks" that combine social an poilitical relations.

Given the Root definition the City Designer will

Do P1: "analyze the SoPoS using a spatial representation of urban social activities coming up with a map of ***"flows"***

By Q2: "create a live map of the city that arrests those flows"

To achieve a construction of the urban configuration

Do P2: "map networks of social and/or political affiliation" by Q2: "comparing against the maps produced in step P1, Q1" to achieve an understanding of how the "flows" are moving to different **"stocks"**

Finally do P3: "examine how maps from previous steps compare with representations of EconS and TechS" by Q3 "identifying hubs that accumulate activities of all three systems" to achieve an understanding of the interaction of all Level-0 systems.

To further describe the activities involved:

1. Design a map of social networks located in the urban context
2. Design a map of political networks that can affect decisions
3. Design possible hubs of "synergistic networks"
4. Design "flows" inside the above networks
5. Identify "bridges" or "important paths" or "weak neighborhoods" in those networks

The CATWOE for SoPoS.

Customers: are again the stakeholders of the urban but this time seen as agents (social or political ones) ie the poor, the immigrants, the middle class, the elites, the pubic audience, the women or men, the Unions, the political clubs.

Actors: The Customers as described above are also the Actors in the Social and Political system.

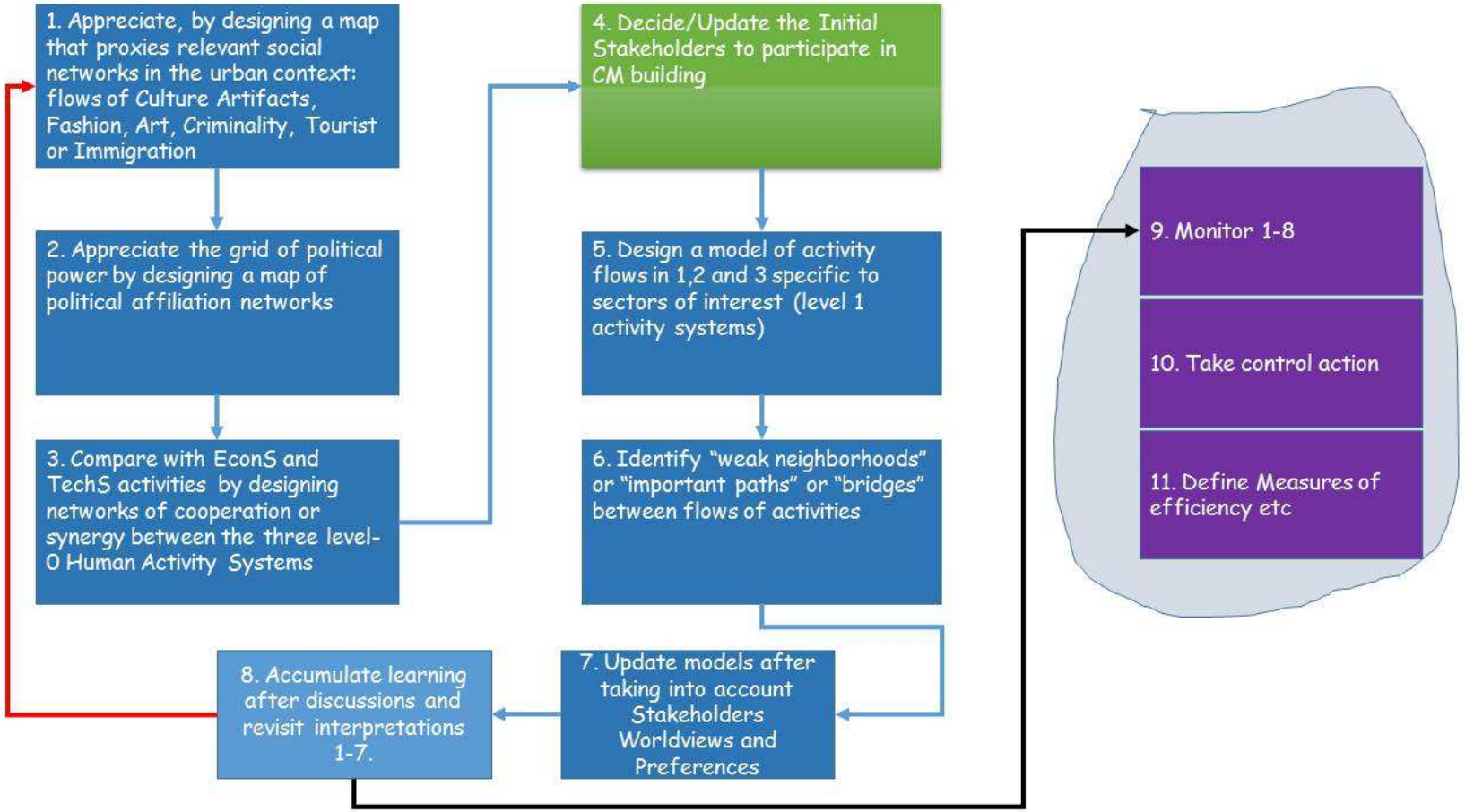
Transformation: *"the creation of a common Knowledge concerning the self-awareness of the urban"*

Worldview: actually in plural, because the Owner, the Actors and the Customers all come with different Worldviews that need to be accommodated.

Owner: The City Designer

Environment: defined as what lies in EconS and TechS as activities and also the physical/geographical constraints.

Figure 52 Social-Political Activity System as Conceptual Model



5.6 Building an initial model combining all Zero Level systems

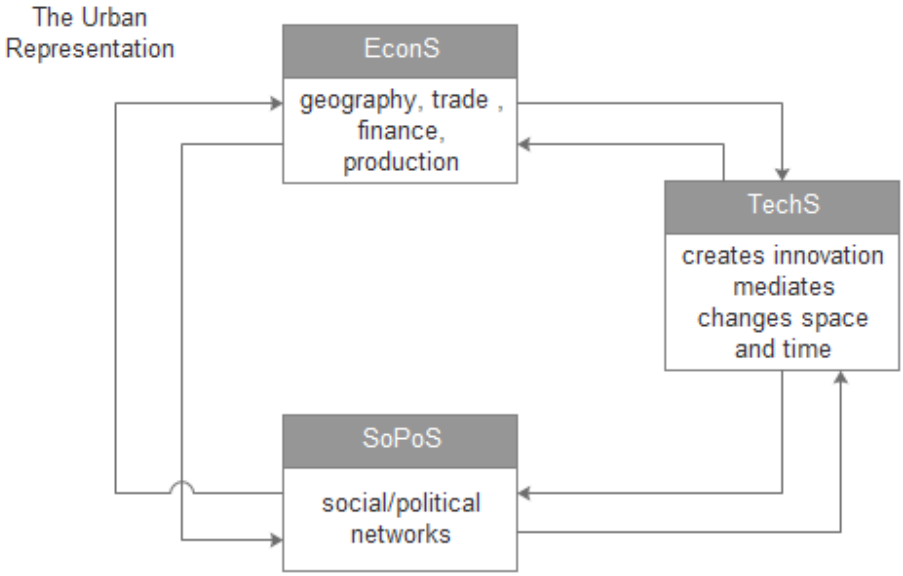
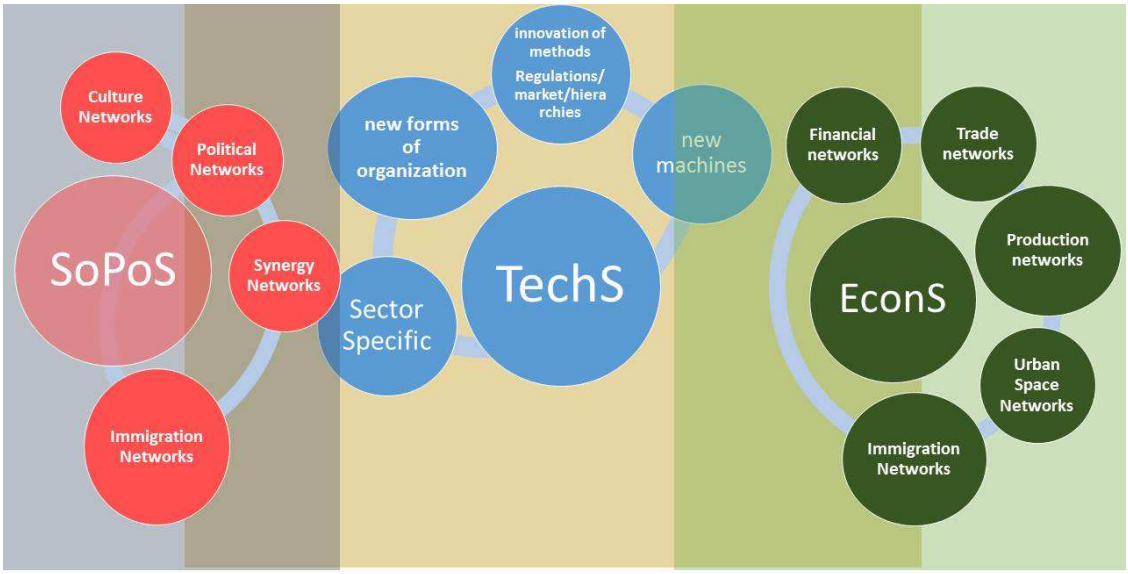


Figure 53 The interplay of systems at level-0



5.7 Building models for Level-1 systems

We now move to describe the next layer of Systems, that we have called Level-1 systems. An important reminder at this point: what we are seeking is not systems that have an ontological nature and can be traced "out there" as a result of our methodology. Instead we are designing Human Activities Systems with identified purposes, which will guide our effort to describe the problem of city to be transformed to smart city. Furthermore, the systems we discuss are not primary based (that they do not correspond to existing organizational boundaries already known to us). They are rather issue based, meaning that the boundaries of them cross well known configurations of established city entities. In agreement with Soft Systems Methodology, Level-1 is the layer of Transformation. Here lives the Transformation (T) through which a city will eventually be understood as smart city. For clarification reasons, we present the seven (7) HAS that were chosen as the level-1 systems. Although choosing them is an **act of designing**, it is not completely arbitrary. Reasoning for the choosing and a small description of each system follows below:

1. **Transport:** by that we do not mean what is perhaps commonly referred to as "systems" of public or private means and resources of transportation. Buses, cabs or rail and planes, or even drones are resources used to achieve something else: the unification of space and the exchange of human activities that request the proximity among those to achieve them. In historical terms, Transport, is at the root of the city genesis because, as the activities of transport were technologically augmented and economically feasible and socio-politically demanded, the economies of scale they have produced by constantly achieving greater degrees economies of scale resulted in the accumulation of social, political, economy and technology factors that created and exploded the city. *Everything in the city uses Transport*.
2. **Energy:** here again we do not refer to electrical companies providing energy. We envisage the city as the great consumer, through a myriad of activities, one of them could be transport, which need energy to be pursued. A Transport activity claims energy to achieve its purposes, but so does the pursuing of safety activity or of a cultural activity. Transformation towards a smart city could be the city

sustaining a better equilibrium between production and consumption of energy based on smarter usage or sustainable production. But again, *everything in the city uses Energy, any activity has an Energy footprint*.

3. **Environment:** recent studies suggest cities to be the big pollutants in the World. By consuming energy and through traffic congestions a non-sustainable environment is created affecting air, water and sewage management and eventually living conditions and health. On the other hand climate change is also imported from other cities or areas in the world in the form of pollution, extreme weather conditions that stretch the ability of the city to answer them. **All City activities do have a carbon print**, thus consuming a resource from a common Environment: again, *everything in the city "uses" Environment*.
4. **Safety:** we let Jane Jacobs in "The death and life of great American cities" (Jacobs, 1961) describe the System Safety. First "*the first thing to understand is that the pubic peace-the sidewalk and the street peace- of cities is not kept primarily by the police, necessary as police are. It is kept primarily by an intricate, almost unconscious, network of voluntary controls and standards among the people themselves and enforced by the people themselves"*. Safety is increased when eyes are upon streets, "*eyes belonging to those we might call the natural proprietors of the street"* and when the sidewalk (meaning the public space) has users continuously "*both to add to the number of effective eyes on the street and to induce the people in buildings along the street to watch the sidewalks in sufficient numbers"*. To achieve safety, says Jane Jacobs, fill the streets with small or less small enterprises and public places that are used all day and night because safety "*is a complex order…composed of movement and change (…) the ballet of the good city sidewalk never repeats itself from place to place and in any one place is always replete with new improvisations"*. So, safety is , in that manner known as Culture enforcement, aided by Good Governance and a free exercise of economic and sociopolitical activities on the level of street. Again, *everything in the city uses Safety, produced by human activities projection on the roads of city.*

5. **Culture:** historical patterns that persist such as trade flows or memories of previous eras, new fashions, streets that erupt, tourists that flood the city, immigrants that do not disappear, iconic figures like pop stars or businessmen or artists or activists, the power distribution and the social networks, all contribute and shape a thing we refer to as Culture. Perhaps we attribute to these activities the shaping and emergence of beliefs, roles and norms that, in a SSM fashion, can be used to achieve common learning and understanding. Each one of our activities inside the city can be explained or traced back, deep into a clash of ways of living. Again, *everything in the city uses Culture as concurrently creates and re-creates it.*
6. **Social Welfare:** may be approached as a Human Activity System that is comprised of the set of activities through which a certain level of life quality is maintained throughout the City. These include activities concerning Health or Insurance ones, anti-exclusion activities or, in general, activities that increase the Social Capital inside the city.
7. **Governance:** A Government activities system is thought to achieve (and represented by) a number of activities (building on the seven hypotheses model of Justus Uitermark, in (Uitermark, 2005)) that identify and generate learning about
    i. Activities of other Human Activity Systems (as for example the previously described ones)
    ii. Activities of different levels systems (as for example Wider Ones or narrower ones)
    iii. Self-reflecting activities based on activities described in (i) and (ii)
    iv. Activities of applicability and transferability of learning achieved through (i to iii) to different situations of the Urban context by the creation of institutions or the adaptation of resources to facilitate different objectives
    v. Activities of alleviating the Stakeholders participation and through that the re-creating activities as in (iv).

    The Governance Human Activity System as described above has a number of capabilities that Linders (Linders, 2012) describe as Framing (corresponds to i,ii), Sponsoring (activities iv), Mobilizing (activities v), Monitoring (all activities but

especially activities under iii) and Last Resort Providing. Or as Siugzdiniene et al (Šiugždinienė, Gaulė, & Rauleckas) define "*Due to the complexity and uncertainty of the environment that governments face today and the multiplicity and complexity of societal goals, public governance (not just government) is needed to cope with contingencies, both looking at the whole system and ongoing interactions between actors and contexts, as well as greater capacity to envisage, adjust and innovate. This may be defined as "being smart". Public governance refers to the creation and implementation of activities backed by the shared goals of Society*".

By suggesting the above human activity systems as the level-1 systems, all of them being Systems of Systems, we have implicitly suggested that the servicing the city needs in that layer needs to think interactions between those activities. Everything in the city connects and disconnects, every level of the Lefebvrian triad informs and is being informed as depicted in Figure 54:

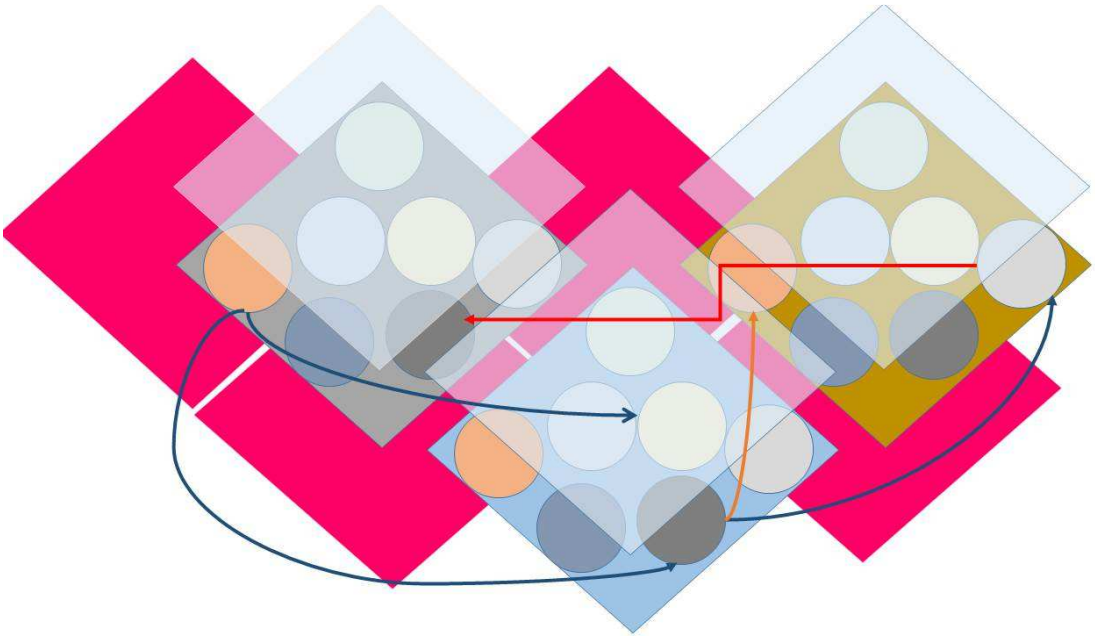
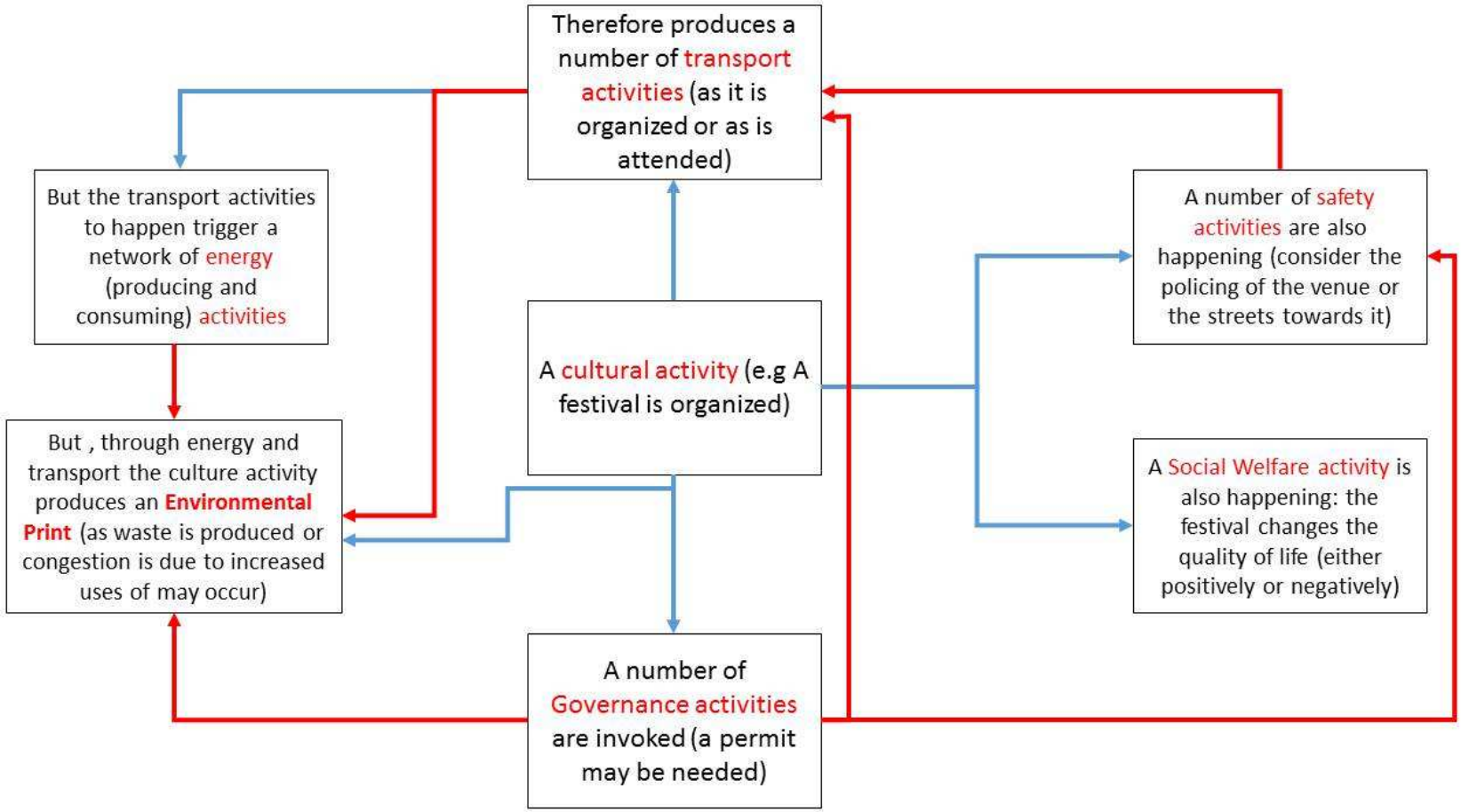


Figure 54 The Lefebvrian Triad: the lived space (terracotta colored), the perceived space (the circles represent perceived Human Activity Systems), and the conceived space (sky colored). Arrows represent possible ways of systems interconnections. Breaking the conceived space into separate squares, that correspond to squares in the perceived level, depicts the idea that Human Activity Systems may present themselves in all lower or upper level systemic layers based on the needs of the inquiry. Therefore if circles represent Human Activity Systems in level-1, then those systems have a correspondence to level-0 systems. Transport can be conceived through economy or technology lens.

Figure 55 Everything connects (a blue arrow indicates an activity is created as a direct result of the activity studied, a red arrow indicates activities stemming out as second or higher order activities produced because of the activities triggered to achieve.



Following the Soft Systems Methodology, we now proceed to create a conceptual model for the Transport system.

SSM starts usually with a Rich Picture. The City Designer may create a number of Rich Pictures to reveal aspects of the perceived problem. For example Rich Picture 1 the city space as compared to other city spaces

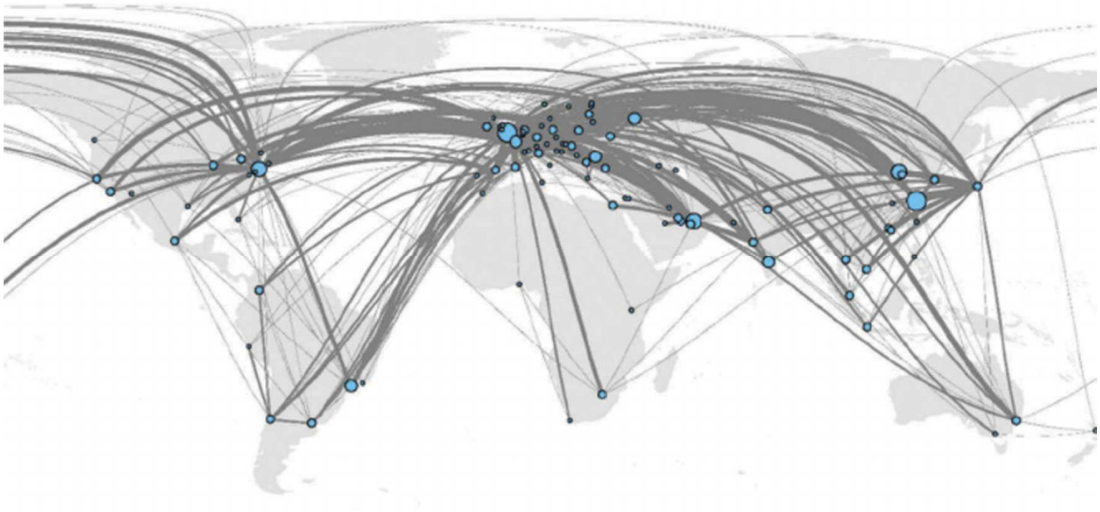
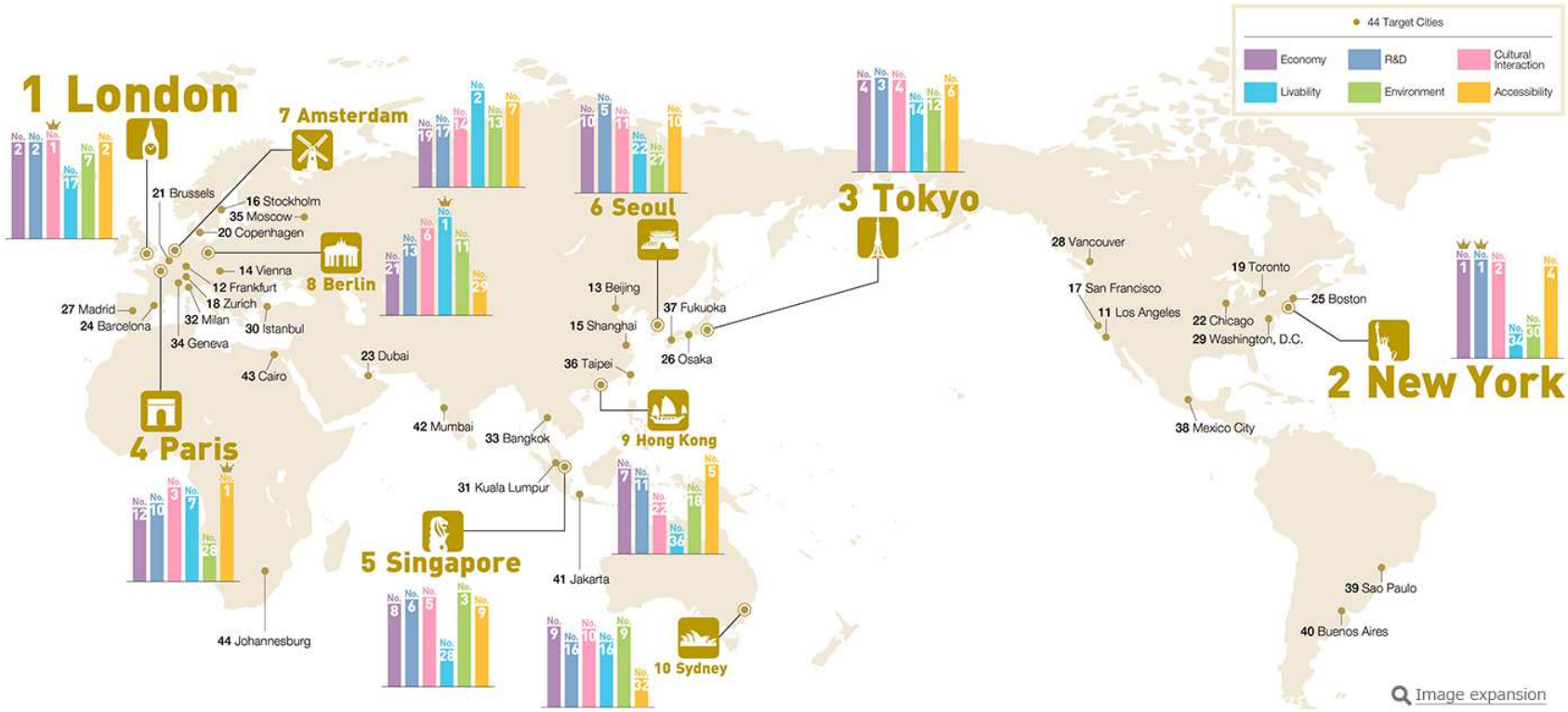


Figure 56 Connections of Urban Spaces, source: (Wall & Stavropoulos, 2016))

Figure 57 Rich Picture 2: A map of a city

Figure 58 An Urban competition map source: Global power city index 2017[35] of Mori Memorial Foundation



[35] http://mori-m-foundation.or.jp/english/ius2/gpci2/index.shtml accessed June 2018. "Global Power City Index 2017 Summary" uses figures and charts to clearly introduce a city's power through the lens of 6 functions (Economy, R&D, Cultural Interaction, Livability, Environment, Accessibility) covered in the Function-Specific Ranking, as well as through the viewpoint of 5 urban actors (Manager, Researcher, Artist, Visitor, Resident) in the Actor-Specific Ranking".

Following Lefebvre (see page 133 in (Lefebvre, 2003)) we formulate a root definition as:
Root Definition: "Transport is a Human Activity System, owned by the City Designer, operated at level-1 systems (services) to achieve freedom and sustainability within the city and between the city and other cities so as every place and every event at the level of Actions (the level-n, the stakeholders level) or at the Level-0 (the level of policies) can inform and receive information in order that demand and supply for transport are at equilibrium (supply meets the demand)".
The root definition follows Wilson (as in (Wilson, 2001) rules:

1. The transformation process is represented in the RD ("achieve freedom and sustainability of movement")
2. CATWOE is well embedded in the RD with the City Designer to be the Owner, Actors and Customers to be those that produce supply and demand for transport services, T is to "achieve freedom and sustainability within the city and between the city and other cities" and although W is hinted only, it is represented as the CD is perceiving transformation as free flow of information and with a sustainability clause in mind.
3. In Wilson's terms the root definition is in the generic form "An O-owned system, operated by A, to do X by Y (transform) in order to satisfy requirements of C, within the constraints of E". But because the process of achieving it is through the LUMAS model learning is added to depict how the CATWOE is informed in every succession, in every round of the process.
4. Finally one can deploy the Conceptual Model for the Transport system as a System of Systems (SoS) by understanding Owner, Customer and Actors to act purposefully within different activity systems. The initial admittance of the City Designer as a unique entity leaves us here with the "existence" of systems only for Actors and Customers.

So the generic representation of the Conceptual Model the CD is facing could be as below:

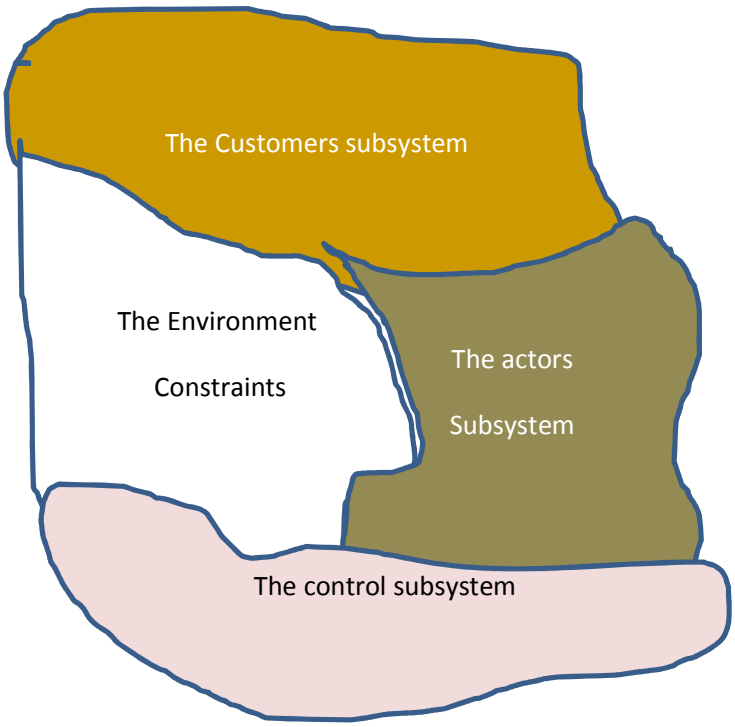


Figure 59 The transport activity system (the city designer's view)

We move now towards creating a Conceptual Model for the Transport system.

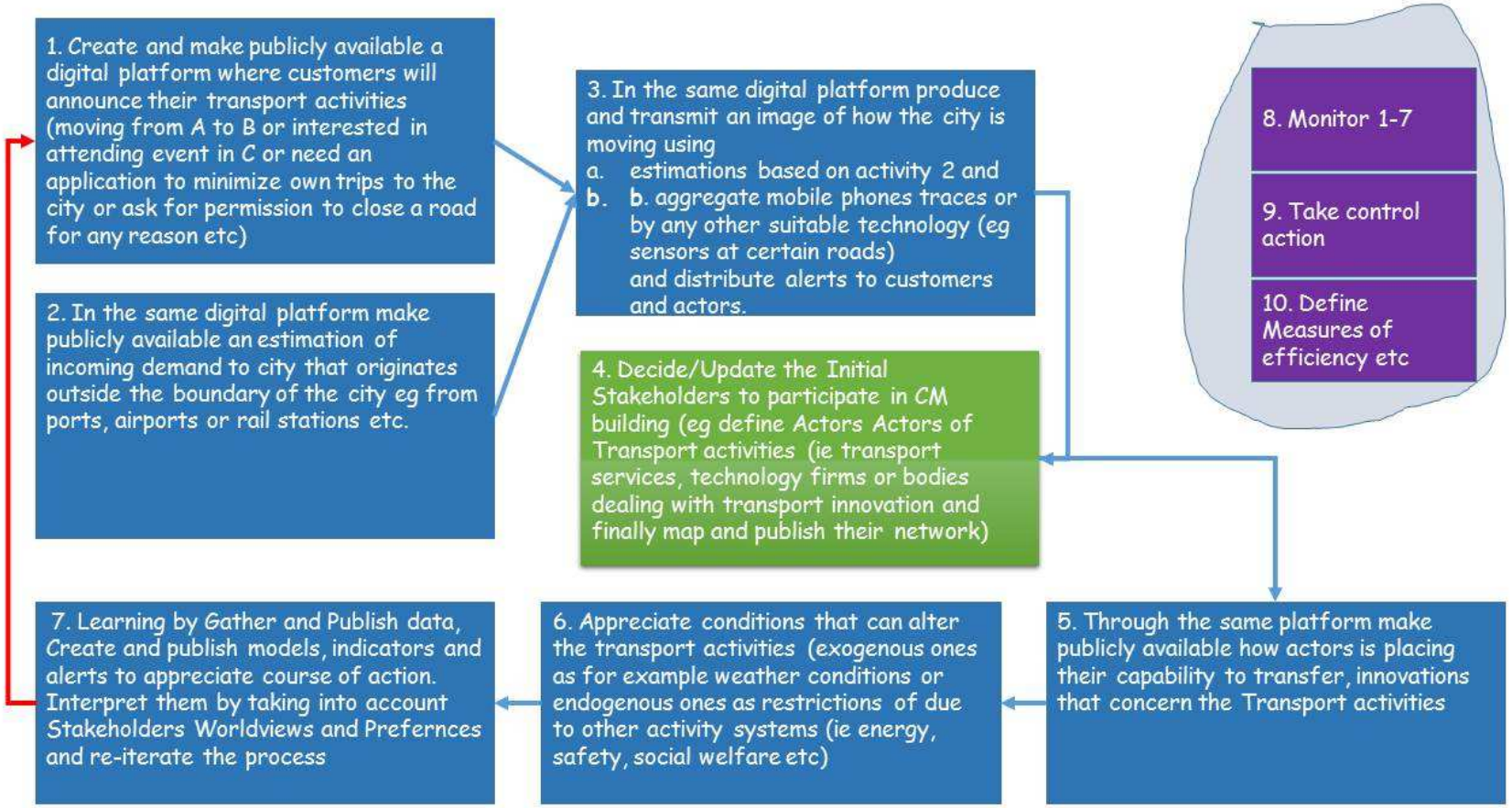
The City designer needs to create a digital space/platform where people freely announce their own demand for "transport activities". The purpose served by that is the acquisition of learning on how transport activities are born, negotiated against other activities (probably cannibalized by them) and finally become the demand for transport.

a_1	Create and make publicly available a digital platform where customers will announce their transport activities (moving from A to B or interested in attending event in C or need an application to minimize own trips to the city or ask for permission to close a road for any reason etc)
The demand for transport	
a_2	In the same digital platform make publicly available an estimation of incoming demand to city that originates outside the boundary of the city eg from ports, airports or rail stations etc.
The demand for transport	

a_3	In the same digital platform produce an independent and live transmitted image of how the city is moving using aggregate mobile phones traces or by any other suitable technology (eg sensors at certain roads) and distribute alerts to customers and actors.
The demand for transport	
a_4	Define the Actors of Transport activities (ie transport services, technology firms or bodies dealing with transport innovation and finally map and publish their network).
The supply for transport	
a_5	Through the same platform make publicly available how actors is placing their capability to transfer, how they make innovations concerning the Transport activities.
The supply for transport	
a_6	Appreciate conditions that can alter the transport activities (exogenous ones as for example weather conditions or endogenous ones as restrictions of due to other activity systems (ie energy, safety, social welfare etc)
constraints	
a_7	Gather and Publish data, Create and publish models, indicators and alerts to appreciate course of action. Re iterate procedure after augmenting with learning
learning	
$a_{8,9,10}$	Monitor processes 1 to 7 Take control action Define criteria (for efficiency, efficacy and effectiveness)
learning	

So the Conceptual Model can be visualized as follows:

Figure 60 The conceptual model for a domain action research on the transport activity system



The conceptual model set in figure above is a model that tries to identify Customers level requirements, that start as activities in the level-n systems but then aggregate at a next level (level-1) and emerge as aggregations in that level. “Going to work” is a transport demand activity that is generated at the lowest systemic levels as Actions of the type “Going to work” are achieved.

The City Designer needs to identify the Stakeholders that are appropriate to the level. Because transport activity (as all activities in the level) is affecting everyone both at the individual and the collective level (ie the student and the University), choosing the participants in the SSM initial round is quite important for the purposes of valid representation and effectiveness of the Action Research. Following the Lefebvrian triad, level-1, is level of Spatial Practice, a level that is informed by the “lived experience” level but also from the “conceived space”. Therefore the selection of Stakeholders, by the City Designer, reveals preferences and a grid of power. It is in that sense a political action that inscribes the “conceived-space” formalism to the “spatial-practice” daily routine. Transport activity serves purposes not transparent to its Owner, Customers or Actors. That is, by picking stakeholders A and B, instead of X and Y, the activities are changed, the preferences differ and the data gathered reveal the differences in choice.

Thinking in terms of the “lived experience”, City Designer, considers “transport activity” to emerge as, in the “lived-experience” level “ways of living” are creating “actions of mobility”. A certain way of living could be that of a working person who

1. Goes to work (sometime within a time frame)
2. Returns from work
3. Visits places for pleasure or for another purpose
4. Just hangs around

But the “way of living” for a transport company could be somewhat different, for example:

1. Transfers goods, people or a hybrid of it
2. Manages actors that perform the transfer
3. Manages material resources (cars, parts, petrol, suppliers)
4. Complies to standards or respond to changes
5. Uses technology of the field

These are just two examples concerning "ways of living", that happen in the "lived experience" space, which at the same time, as they happen and evolve, utilize resources and create, by repetition, the path to an abstraction (ie an imagery of transport as an Economy, Technology or SocioPolitical subsystem) to the "conceived-space".

In the simplest approach, the City Designer may use an (initial) crude aggregation of the Stakeholders at level-n, to imagine the appropriate level of aggregation of its Stakeholders at level-1. If, at level-n of the systemic inquiry stakeholders are "individuals, households, small companies, neighborhood or markets" then an aggregation at level-n could be "firms or networks of firms, networks of specific firms (ie firms that produce transport driven technology, innovation species either public, as universities or private as tourism industry ones), specific groups of social alliances (that have an interest in transport activity systems) such as metropolitan areas that receive the activity at day or at night, or neighborhoods affected etc and governmental bodies that affect (ie there actors) of aspects of transport regulation. The art of stakeholders' picking can be a tedious algebra on behalf of the Owner.

We move now to the activities $\mathbf{a_1}$ to $\mathbf{a_7}$ as presented in the conceptual model above. Needless to say we perform a domain and Mode 2 implementation. The conceptual model presented here is not an instance of the methodology for a particular city, but rather a visual initiation of it.

Activity $\mathbf{a_1}$ calls for the designing and implementing of digital platform that captures the demand for transport activity. By setting an agenda for demand knowledge digitization, the City Designer increases the level of learning capability. Interested stakeholders may participate in the designing of such a platform. The purpose is that, when the platform goes live, demand will be transparent to everyone, thus resulting in better formalization of the transport activities (by examining patterns not previously available) and –hopefully- to better decisions, which will embrace a very different learning status. Learning capability would also increase in case of an intertwining of transport activities with activities stemming out from different systems of inquiry. Let us consider for a moment (despite not being our main effort here) the following situation: a strike in Mass Media Transportation announced to the platform will result in a change of the transport activity, since someone expects the demand for the road to increase. That creates an

uneven opportunity: those without access to car are unable to exercise their rights to the city and markets could also suffer an asymmetrical hit. Change in demand should be reflected and scenarios dealing with it should be in place. The need of a theory (as the one provided by the Lefebvrian triad) could now be useful to cut clear on how these asymmetrical shocks should me ameliorated. It could also provide the ground of a participative and democratic decision made.

Activity $\mathbf{a_2}$ asks the question "Was there a consideration for the demand of Transport to be added by non-population?" Activity $\mathbf{a_3}$ is an activity after activity that succeeds activities $\mathbf{a_2}$ **and** $\mathbf{a_2}$ and it is learning through interpretation activity because it can now uses the accumulation of learning that emerged from the previous activities. The interpretation learning stage may also be used as a self-reflecting stage among those that are Customers or Actors of the activities 1-3 (and that is possible to happen in almost real time).

Achieving activities 1 to 3 reveals also of who the Stakeholders should be: Actors such as "transport services" or "transport resources", "technology firms" (especially dealing with transport demands), energy stakeholders or governmental bodies or authorities of competence. Activity $\mathbf{a_5}$ concerns the supply of transport and the Actors involved with it. Finally activities $\mathbf{a_6}$ **to** $\mathbf{a_7}$ are contributing to learning accumulation while those of $\mathbf{a_8}$ **to** $\mathbf{a_{10}}$ are the monitor and control activities of the process.

Up to now we used an (near to) SSM mode 2 description of the Owner's path to setup the Method and define the Stakeholders (Customers and Actors) that will become part of the learning and common sense making of the Human Activity System "transport activity". The second and consequent stages of interaction will be not only refine the top-down approach but also embed in the situation with the Root Definitions that the Customers and Actors (the stakeholders) will bring forth. And also their Worldviews. It is now apparent why the introduction of a theory is needed together with the methodology. Worldviews is something that affects the methodology but is formed and utilized independently of it. It is also of a need to use relevant to the situation Worldviews (not general theories of everything) and the l-c-p model of Henri Lefebvre is a valid candidate. The l-c-p will tell us about the meaning attributed to the situation and perhaps the position of the stakeholder to the grid of power. It is through the trialectic of l-c-p that

meaning attributed, enlightens the preferences of the different networks. The initial "digitization platform" could be eradicated and ultimately be replaced by the enrichment of learning as the iterative process continues. When the activity model is settled (*if is settled*) then it trickles down to the design of information systems according to the following generic schema, due to (P. Checkland & Scholes, 1990):

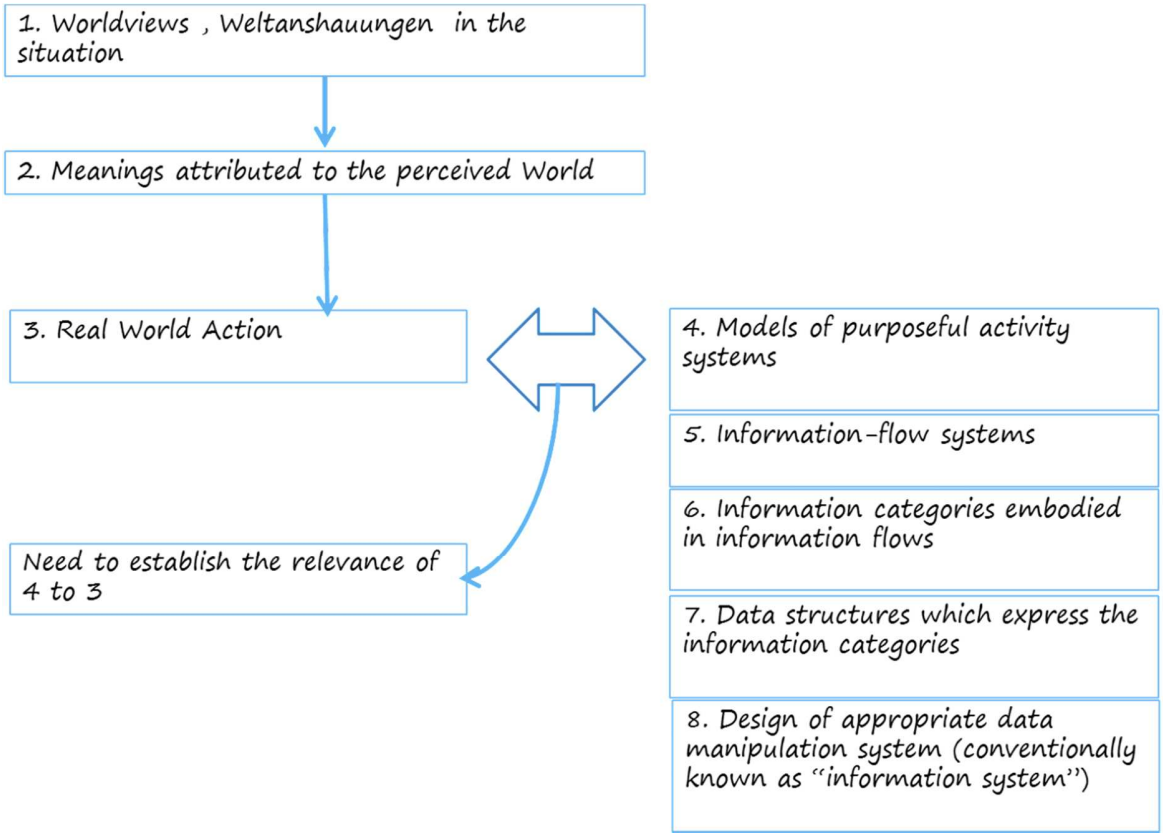


Figure 61 The links from worldviews to data source:(P. Checkland & Scholes, 1990)

The conceptual model includes a learning activity as an **endogenous activity**. Learning occurs as different rounds of the model is played, as proposed in (P. Checkland & Holwell, 1997)[36] that is, not only as data gathered or pattern detected or game changes are understood at the start of every new round, but also as a result of the demand and supply activities realized and imagined in an almost concurrent way. Networking among customers, actors and the city designer facilitates the endogeneity of the learning activity and also enables the transition of that learning and the consequent status of informed

[36] See page 106 in (P. Checkland & Holwell, 1997) "Information, Systems and Information Systems"

decisions and actions. What lies out of the scope of this dissertation is the symmetry and the completeness of the learning achieved.

5.8 A recap

This chapter has been a kind of a rehearsal. Using the foundations of Chapter 3 we have moved to the instantiation of SSM by producing some, crude, systems thinking about smart city notion. First we have used layered thinking. We improvised levels of activity (three levels of which we offered examples of human activity systems for level-0 and level-1). It is a top-down approach, with the City Designer to be the Owner of it: he or she is the Owner of the Vision and the decision maker of the activity levels abstraction as well as the Human Activity Systems that are seen in these levels. It is the City Designer who decides on the selection of Initial Stakeholders that calls to participate. It is the City Designer who initiates, updates and finally has a stopping rule in the process of Methodology.

Further to that and as we have examined the different systems we have declared something that brings some novelty in SS Methodology.

(a) Stakeholders are endogenous to the process. Despite the City Designer identifies them at the start of the process, he may change decision at a later cycle to match Stakeholders to the learning produced about the area perceived problematic. He might also do so in response to the fact that, during the process, network affiliation of the Stakeholders may alter as they re-interpret their social relation belonging under the light of this new learning. Thus, Stakeholders networks may appear, disappear or change more or less to reflect the dynamics of process itself.

(b) Interconnection happens both within levels of activity and between levels. An activity system reflects of social relations and as such may be the cause of others and itself become affected by others. Dealing with that is an intriguing part of the process. One cannot loosely refer to “Transport Activity System” thinking rails and buses and airports and other resources. One should think of, for example, “people go to work” , “or people go to leisure activities” as Transport Activities stemming out from everyday lives and constrained as other Economic activities battle them (for example a shortage of financing for new resources or “being

unemployed" as a labor labelled "activity" rearranges the spatial part of the activity). If "owing of a car" is part of a hegemonic ideology through which space is conceived, then Transport Activities are likely to be more car oriented , thus more congestion builders and energy consumers.

(c) Learning is produced during an SSM cycle as:

i. A result of Difference. As the networks of Stakeholders evolve (grow, shrink or re-assembled) this results in a difference in belonging that can be evaluated.

ii. The networks change reflects an outcome of learning: as people re-configure their own social relations to achieve something of purpose (therefore through an activity promising the change) to which new meaning is attributed, new emergent properties may surface in the level of systemic activity. Those should also be incorporated in the SSM cycle.

Chapter 5 thinks technology as a mediation activity system, through which Economy could become SocioPolitical activities or the other way around or both. In Chapter 6 we rethink about that mediation with the help of Activity Theory of learning.

Hopefully, this chapter has clarified another issue: thinking in terms of "domain concepts" (as smart energy or smart transport or smart governance) that are fixed around an IT infrastructure or an institutionalized one apart from revealing a certain commitment to ideas and relationships can be very unproductive in realizing the dynamics of the Urban context as they are constantly rearranging. This is elaborated from a different point of view in Chapter 6.

Chapter 6: Applying Ontologies to Smart City Domain

6.1 Introduction

This chapter builds on the notion of accommodating Soft Systems Methodology with ontological thinking (as presented in paragraph 4.4). To this end two approaches are deployed. Paragraph 6.2 discusses an "SSM-friendly" ontology building on the work of Gaspoz and Wand ((Gaspoz & Wand, 2012) by further elaborating the generic schema they have produced with new classes of activities (such as Policies, Services and Actions) that correspond to different levels of the systemic thinking. In addition to the generic schema, a vocabulary and visualization are provided. Paragraph 6.3 incorporates the idea of an ontological separation between whatever falls under the Stakeholders label (or under the "How?" label) and whatever falls under other aspects of the SSM model such as political analysis, social analysis and Worldviews presented as a Theory of the Urban classified according to the Lefebvrian ideas of Space production. It is the "why" part of the ontology. Finally the abstraction level has also been taxonomized.

6.2 An SSM-friendly ontology

In an article of 2012 Gaspoz and Wand (Gaspoz & Wand, 2012) are dealing with the issue of Negotiation between Stakeholders so as consensus is reached. The authors identify negotiation as an ill-defined situation and they quote Braun et al (Braun et al., 2006) who note that "*real-life negotiation problems are typically ill-defined, information is not equally distributed among the participants, the participants have only partial knowledge about their counterparts and communication is often ambiguous or imprecise*". One the main issue during a negotiation is the lack of a shared view as what the domain of the problem is. Therefore, the authors propose the usage of ontology as "*a visual representation of the problem knowledge in the form of ontologies will improve the stakeholders' performance and support them in learning and understanding the problem domain. In order to represent the whole problem domain, we apply merging, mapping and refining transformations to these ontologies*". They proceed in designing a generic schema of an ontology based on SSM concepts and they do so by acknowledging the fact that SSM does not use any formality in the representation of the conceptual models but, they nevertheless proceed in the designing of one because "*nothing restricts us in using*

our previously defined domain ontology to support the representation of the problem". They propose the generic (not problem specific) ontology of to help the negotiation activity between elements of the CATWOE of Figure 62.

Although perhaps this is despite Checkland's own view of SSM being of "epistemological" species, and because we treat ontology not as a philosophical but as Noy and McGuiness plainly put it (Noy & McGuinness, 2001) "*The Artificial-Intelligence literature contains many definitions of an ontology; many of these contradict one another. For the purposes of this guide an ontology is a formal explicit description of concepts in a domain of discourse (classes (sometimes called concepts)), properties of each concept describing various features and attributes of the concept (slots (sometimes called roles or properties)), and restrictions on slots (facets (sometimes called role restrictions)). An ontology together with a set of individual instances of classes constitutes a knowledge base. In reality, there is a fine line where the ontology ends and the knowledge base begins*"[37]. A thorough discussion on the SSM's avoidance of the ontology term, is also provided by Zhu in (Zhu, 2009).

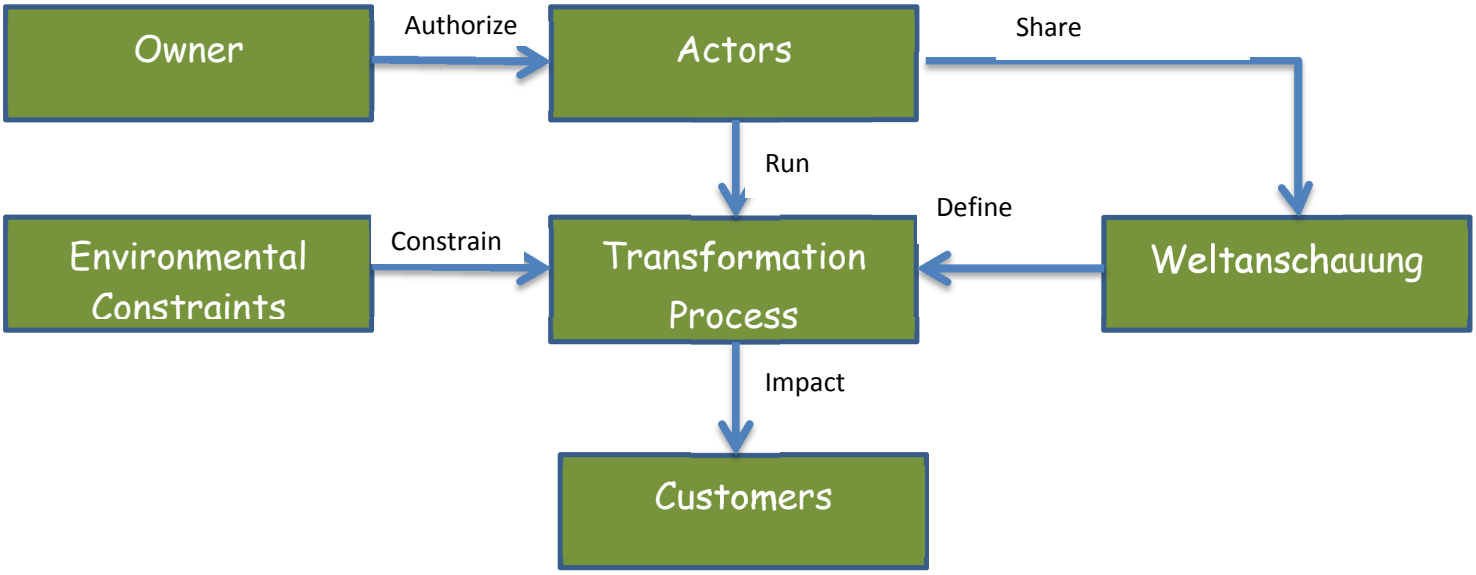


Figure 62 Gaspoz-Wand ontology for SSM

[37] As found in http://protege.stanford.edu/publications/ontology_development/ontology101-noy-mcguinness.html (accessed June 10th, 2017)

Following the path of Gaspoz and Wand and in an attempt to accommodate SSM with an ontology based formalization (as discussed in paragraph 4.4) we proceed with an elaboration of Gaspoz and Wand's generic ontology as follows[38]:

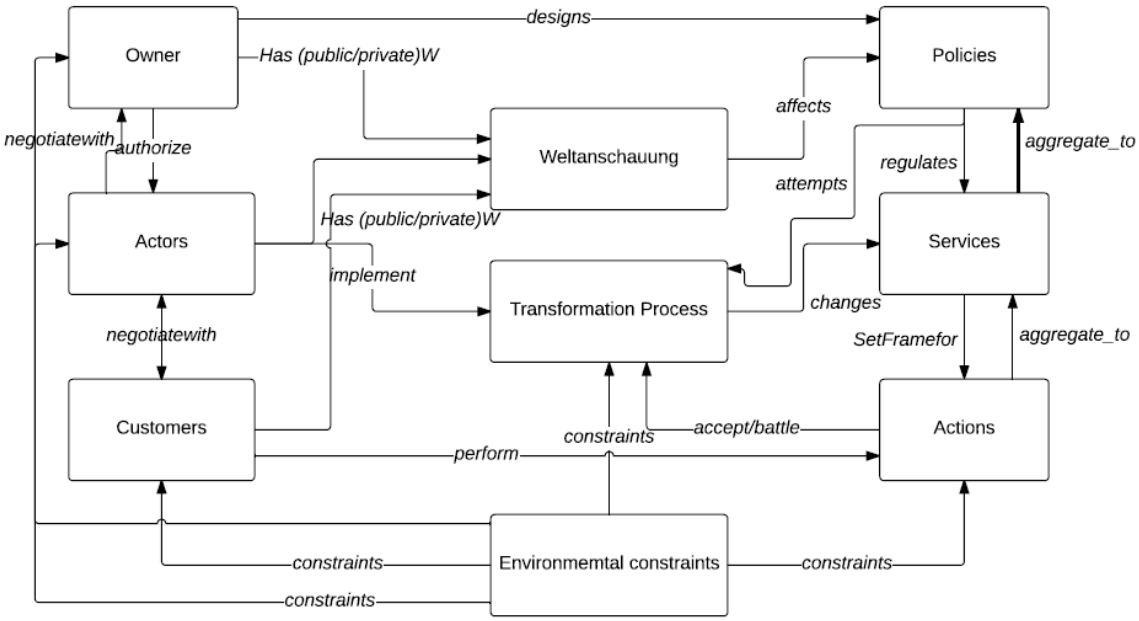


Figure 63 An SSM friendly ontology artifact

In this way we bind SSM with an ontology that combines all the elements of the CATWOE as Classes augmented by the systemic conceptualization of layers of systems are always present in the methodology. Policies, Services and Actions are treated as Classes in an attempt to catch the way the elements of CATWOE interact with other Human Activity Systems resulting in the emergence of Policies or Services (as explained in paragraph 5.2).

A vocabulary of the above Figure 62 is presented in the table below:

Table 17 A vocabulary of a classification scheme

Class Name	Description
Customers	As in CATWOE
Actors	As in CATWOE
Transformation Proccess	As in CATWOE
Weltanschauung	As in CATWOE
Owner	As in CATWOE
Environmental Constraints	As in CATWOE

[38] Needless to say that ontologies dealing with certain aspects of the urban or even smart city are not in shortage. See perhaps http://opensensingcity.emse.fr/scans/ontologies

Policies	Human Activities System at a higher abstraction level. A policy can be a regulation mechanism or the network that produces that regulation. A regulation can be as broad as “economic policy” or “a network of economy agents” belonging to a higher level of abstraction.
Services	Networks that emerge, as Actions stream their way to greater complexity either on the demand side or the supply side presenting themselves as Human Activities Systems relevant to the urban phenomenon (transport, safety, governance etc)
Actions	Encapsulate a production of claims and meanings as a response to objectives, beliefs or needs that are present in the networks of the urban context.
Object Properties (relationships between Classes)	Description
Has (public/or private) W	Owner, Actors and Customers are possessing a certain Worldview, which more or less specific and also changes after a Transformation period is complete (therefore there is no direct impact on it during it).
designs	The Owner only has the privilege of designing. A rather simplified view as earlier explained.
affects	A Weltanschauung property and implicitly the way via which Actors and Customers intervene in the formation of Policies.
attempts	Policies are the means of Transformation Process. A bouquet of Policies creates the intended or not intended Transformation Processes.
implement	Actors implement a Transformation Process
regulates	Policies property referring to the idea of setting a compulsory situation or statement that in theory no one can escape.
authorize	Owner authorizes Actors to implement Transformation Process.
changes	A transformation process results in changing the Services networks or SoS that they align to the Policies mandate.
Negotiates with	A formal or semiformal negotiation
Aggregate_to/sum_to	Combining networks of simpler elements to networks of more abstract ones.
Accept/battle	An informal/everyday decision making
setFramefor	A knowledge of the action environment
perform	Customers turn claims into Actions
constraints	All exogenous types of constraints

The same representation is also available with the usage of Vowl in protégé

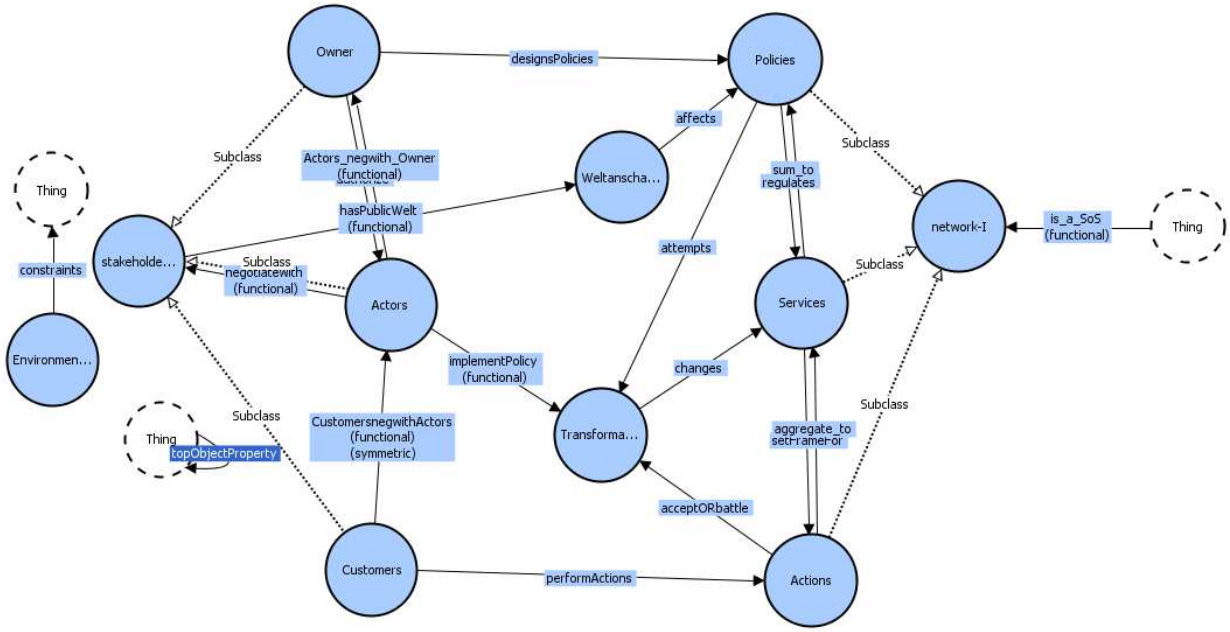


Figure 64 An ontology representation in Protégé

6.3 A SSM type I ontology

The other way to augment the SSM with an SSM-friendly ontology is what we have called the Weak Ontology of Social Relations. An ontology that corresponds to the SSM concepts on one hand and Urban theory (the Lefebvrian triad of Space production) on the other. If joint together they, hopefully, reveal how an implicit use of theory (hidden through Worldviews of different abstraction levels) may direct our actions in the intervention of problematic area. Also, how learning produced in that process of systemic inquiry is informed through comparison and preference of our historically created theory. And, since learning that stems out of an SSM inquiry is seen as both an interpretation and accumulation of Stakeholders' changing anticipation of the problem area, of how the interaction between the Stakeholders changes the theoretical approach at use. The Stakeholders moving positions should be interpreted both as a result from and resulting to learning interpretation and accumulation. But what lies as the changing force is the

Difference. Difference that is due to a constant renegotiation and battling, thus yielding a change to the networks of belonging, ie the Social Relations.

We are sketching such an ontology by first creating an elaboration of concepts at the right hand side of Figure 43.

The hermeneutic of that ontology may be described as follows: "a smart city concept at a fixed abstraction level is a triad of the abstraction level, a Human Activity System and an Urban theory". Both the HAS and Urban theory concepts correspond to the abstraction level. For example a Highest abstraction level means that both activities and theoretical concepts are dealt at an increased abstraction that should be clearly stated in their design. For example at a highest level of abstraction one should perhaps expect a Human Activity System as those at Level-0 of previous chapter and theory concepts that are suffice to explain the selection of HAS. If for example Economy or Technology is the HAS of choice then an Urban theory concept is expected to deal with the relation of Space to the selected HAS at the fixed level of abstraction. In our case a Production Mode or a growth function or a Theory of technology should be expected. In one sentence: "**a smart city concept should be analyzed at a specific (a priori fixed) level of abstraction with the use of a Human Activity System that corresponds to the level and a theory of space that serves both the level and the concepts of the activity System**".

If H, M and L are the fixed levels of abstraction then:

SC_concept is a ((H, HAS_h, lcp_h), (M, HAS_m, lcp_m), (L, HAS_l, lcp_l))

which builds on the idea of layering of SSM. A sketching of the ontology is presented in Figure 65:

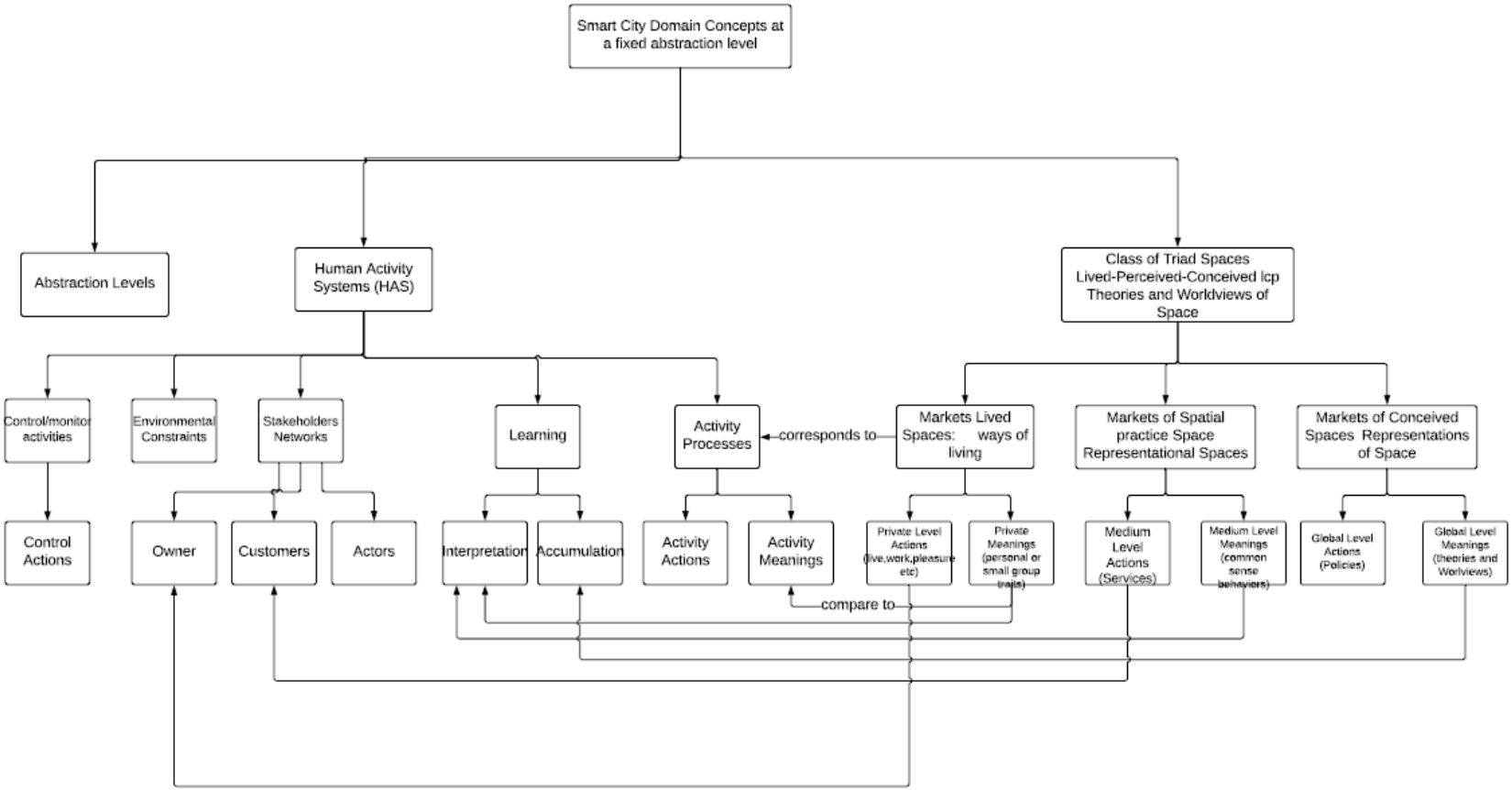


Figure 65 A more detailed SSM type I ontology

Let us give some insight to ontology sketching of Figure 65. For example if we consider the Highest abstraction level of it, and require a Human Activity System which we name "Economy", a theory concept at that level could be for example "a theory of growth" (in a neoclasical style this theory would adopt a context of Capital, Labour and exogenous Technology at the simplest form). Such a selection of theory should inform phenomena at of "markets of lived spaces", "markets of Spatial practice" and finally "markets of conceived space". That means that it could explain, for example, "preferences to work" as a way of living that includes work, or "congestion in the city" (as a spatial practice paradigm), or pesent a path to understanding the "hegemonic ideas" that through it shape the urban context. That is not an ubearably complex thing. Economic theories heve been involved with all three aspects mentioned above. To further explain the functioning of such a scheme let us employ the notion of an algoritmh: think, as a metaphor, for a moment the l-c-p space as an algoritmh processing theories, whose inputs are theories (at the Private, Mixed and Global Lefebvrian level) and the outpout is an imaginary of space (which again is a theory construct). If input-theories describe a Social relations representation(s) in an Urban context then the output is not a really real Urban Space: it is a product of "thinking about it". A quite simpler way to see this is: "as we produce images based on the Social relations produced by the interaction of our "way of living", "spatial practice" and "general ideas" we come up with a general concept we call Urban.The produced Urban context is a conceptual space, modelling our Social Relations which perhaps is the only really real thing out there".

As we move to further decompose classes of theories we adopt a common bifurcation for all markets of spaces. This bifurcation suggests that a Market of Space (either *l* or *c* or *p*) is produced as (theories of) Actions entrain (theories of) Meanings at a lower level of classification.

The theories part of the ontology should be thought as a historical evolution of the Activity Systems part of the ontology. Because it is there due to the development of knowledge it is the refenece framework of any activity that may form part of an Action Research inquiry into an area that is problematic. It informs it and then is expecting to be informed by it. At the lower levels, Actions and Meanings are used to interpret and

accumulate learning at the HAS part. In the absence of an initial representation no learning can be validated or accumulated.

We may also think that emergence of the Stakeholders as the process initiates reflects the Owner's preferences both at the systemic level and the theory level.

The same is true if we consider Technology as a smart city enabler (as the story telling of the literature goes). As only a part of the representation of Social relations that form the Urban context, a Human activity system called "Technology" is no island. It may mediates change in the Space it inhabits but that change is both dictated by previous and current configurations in that space but also of imaginary future ones of people assembled in networks of material means and abstract ideas.

In this chapter we have attempted to present in a more detailed fashion, ideas if augmenting Soft Systems Methodology with what we have named "a friendly ontology". As SSM is epistemological and constructivistic in nature we have avoided to present an ontology based on specific urban context concepts (as many papers implicitly or otherwise suggest in the literature). SSM calls for Action Research and Learning and the usage of it to dientangle smartness cannot be something else. Therefore our "ontology driven" effort to augment the methodology has moved towards the "ontologizing" of concepts of the methodology. An attempt that is already made by Gaspoz and Wand. We have added to Caspoz and Wand's generic schema concepts that enhance the CATWOE elements of ontology. Policies, Services or Actions are "entities" that correspond the Worldview or Transformation. They, hopefully, explain them in a better way.

Beyond our attempt to create a generic schema based on CATWOE elements we have also produced another type of approach (we have called type I ontology for SSM). That second attempt is again based on the same principle of building "*an explicit specification of a conceptualization"*: this time we have included in the specification (a) the meaning of abstraction level (b) the C,A and O and E elements of CATWOE blended with the type of Activity under consideration and a Learning concept , declared as interpretation and accumulation and (c) concepts of an Urban theory in an effort to present Worldview and Political and Social Analysis of the Methodology seperately. In that way we have incorporated both the Why level and the How level of the methodology. Needless to say that both of these efforts are very primitive in a maturity axis.

6.4 A recap

In this chapter we have asked ourselves on the possibility of augmenting SSM methodology with an ontology bearing in mind (a) that SSM is epistemological (deals with the learning of a situation or about a situation) and (b) that SSM should be combined in the case of smart city with an Urban theory. In that path we have developed two rather complementary ontology artifacts. The first is allowing us to elaborate on the negotiation taken place between the Stakeholders during an SSM cycle. This may combined with conseptual models that arise from SSM and in that way at least create a common understanding of the notions under negotiation. The second approach merges into one ontological artifact the abstraction levels of the discusion, the people making the discussion and their representations that influence that discussion. It is an idea still premature but perhaps fertile.

We will now move (at Chapter 7) to using the language of learning in a unification attempt.

Chapter 7: A learning process -A unified approach

7.1 Introduction

In "Information, Systems and Information Systems" (P. Checkland & Holwell, 1997), Checkland and Holwell offer a description (visually provided in Figure 66) of the relation between technology and theory. The main argument is that any field that uses technology will ultimately phase a lag of theory as thinking seems to depend on or follow the advances of technology.

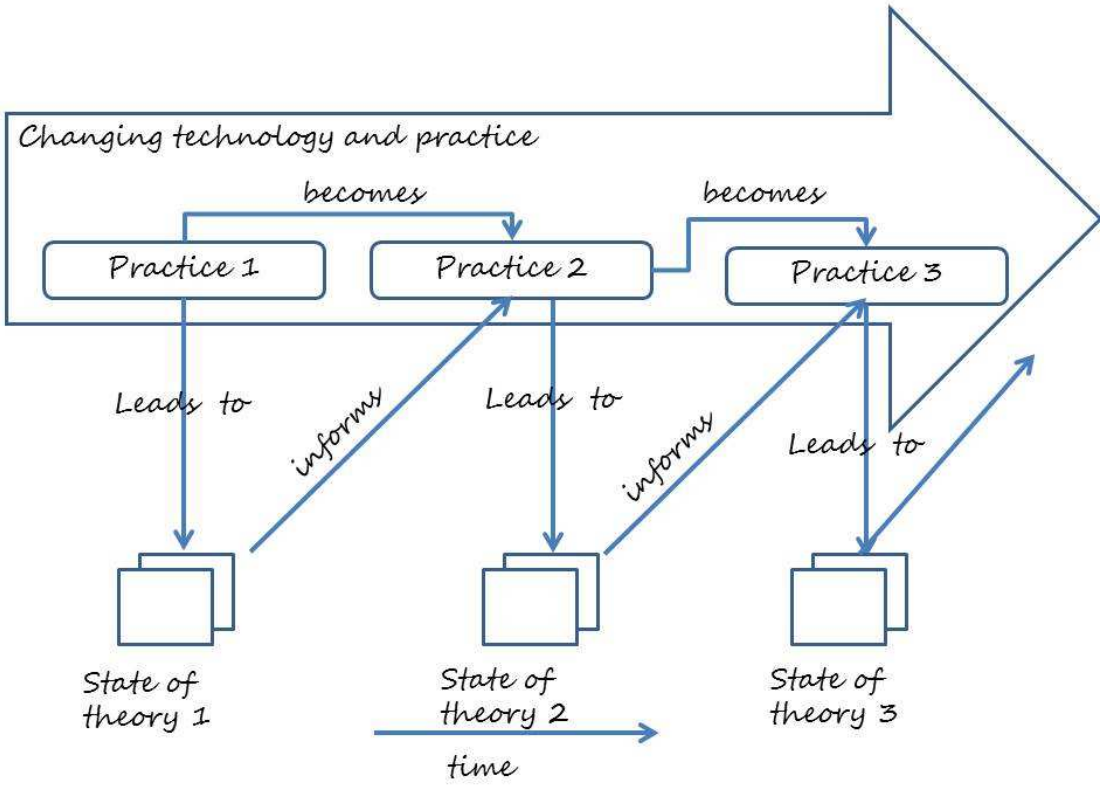


Figure 66 Checkland's conceptual model of technology-theory relation source:(P. Checkland & Holwell, 1997)

They argue "*But where technology is developing very rapidly new practical possibilities will be found and developed by users whenever and wherever the new possibilities are found to be useful; they will not wait for the relevant theory!*" Let us pause here to refer to another argument in the same book (p.47 ibid) where the authors present the difference in the view of the world of Soft, Interpretive approach as found in the thought of Vickers

as he was seeking an explanation, a theory, for understanding the human activity to be a trajectory of different possible paths or courses of activity which they are forming the space (the mix) of the available choices; these possible courses "*are themselves generated by the previous history of the system itself and its interactions with its environment. Finally, the actions taken in the mix of courses to be followed are perceived as relationship maintaining (or eluding) rather than as striving to achieve goals*".

If someone rethinks those two major arguments he may identify a primitive prototype of a learning theory: the interplay between technology and practice is nothing but an analogy the way learning emerges as difference is understood by the learning subject. A "*practice leads to theory which informs and changes the practice to a new one*" is a cycle of learning via the awareness of Difference. A more abstract version of the cycle could then be "**as a *subject* of learning understands Difference in possible arrangements or configurations of *objects* (of any kind: practices, beliefs, alliances or visions of a different future) then starts to changes its own relation in the configuration to adapt to the new conditions. It does so by updating its neighborhood of belonging in the network of the Social Relations that is part of**". Updating social relations means creating new, changing or abolishing existing and maintaining an awareness of the possibility to change them again. The way the new path is travelled is based on a Framework of Ideas (what is Theory in the argument above) and the competition the actor phases to achieve this new configuration (so, the Practice corresponds to the space of possible states the actor can found himself). Three terms are important here: the activity of the learning subject to adopt a new possible arrangement (for reasons coming from inside or outside environment of the activity system), the change in relationships to achieve the activity and because of the activity and the awareness that whatever the result it may again change in a second step. Learning occurs as, during the above process of changing a possible configuration, the subject (a) uses a framework of ideas of which is bearer, as belonging to a network of social relations that is historically evolved, to judge the new condition (an interpretation is used therefore) (b) observes the way that this contextual process has been mediated (tools and signs of the mediation are part of the accumulation of learning) and (c) hopefully, uses and distributes learning by making

sense of how the context itself has changed through the learning process of (a) and (b) (a double loop learning).

Presenting the previous learning arguments based on ideas of SSM, brings forth the idea that as a learning methodology SSM can be blended with two major learning theories, namely the Activity Theory and the Connectivism Theory. We will further elaborate our approach by presenting the way learning in an SSM cycle fits to above mentioned theories of learning (through a coupling of ideas that stems from SSM approach to intervention and are embedded in its culture and similar notions of the learning theories) and through that ***the way smart city may eventually emerge, as learning produced in the course of an SSM type intervention that informs the Urban context*** (which we have chosen to describe through a lived-conceived-perceived Lefebvrian triad). Although we do not fully articulate on the learning theories themselves, still some of our understanding on this chapter reflects notions of them (and wherever is necessary we refer to them in an ad hoc manner).

7.2 SSM is about learning

Attempting an understanding of the problematic area "smart city notion" SSM was called in, as a systemic thinking approach, suitable for the examination of a situation identified to be a wicked problem. But Soft Systems Methodology is not only a systems approach. The founding fathers of SSM have already pointed out that as a Mode 2 approach is employed (ie thinking about the process itself as the process evolves) the methodology becomes a learning tool; it yields learning in every round of the iterative process. This iterative process between the problem understanding and conceptualization and what may finally emerge as a feasible solution to it (even though such a feasible solution may lie somewhere between wishful thinking and any partial specification that can facilitate stakeholders' different worldviews) is explained by Checkland and Holwell in "Information, Systems and Information Systems"(P. Checkland & Holwell, 1997) as a learning process both at an individual level (a least collective one) and at a social level (or a most collective one). They have also elaborated a "*process organizational model (POM)*" that grasps the accumulation and interpretation of learning through the lens of an

organization that is built around processes (of learning). We revisit these arguments in brief before we explore the coupling noticed above.

Following the description of the authors, learning at individual level is a process through which the individual, as subject of learning, assembles and reassembles his ideas about a selective part of the world she is interested in. We are not here interested for the reasons that stimulate such a behavior. Neither we declare that the minimalistic nature of description may cover all possibilities; although we think that the generalization (or as said elsewhere: the abstraction level) suits a common sense level. Therefore the "selectively perceived world" activity is a feedback between some standards already known to the individual and perhaps an externally induced need to re-address those standards so as to cover new possibilities (opportunities or threats or other). The individual enters the process by attributing new meaning or making judgments about the standards until she reaches the stage of forming an intention (which again re-informs meaning and judgements) that is locally and perhaps temporally "finalized" and causes a kind of action. The description is better explained in the picture below:

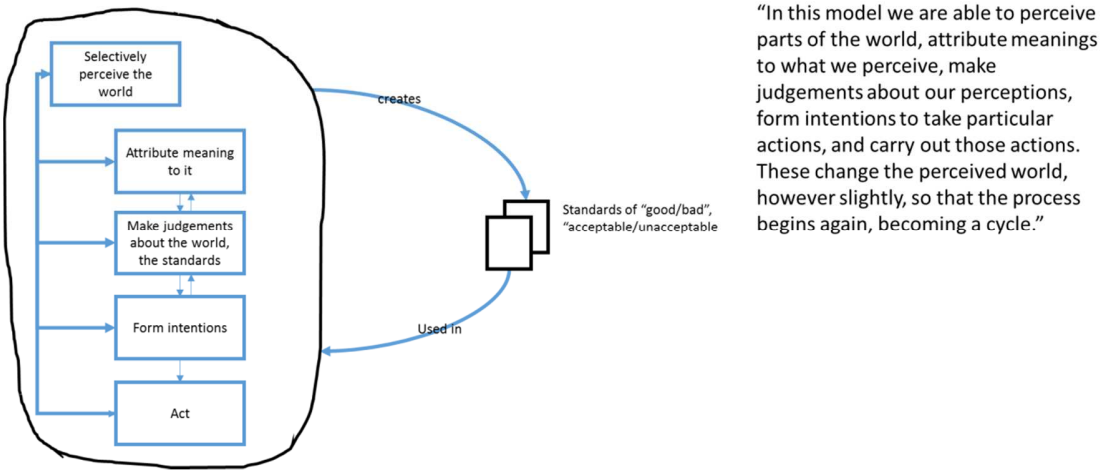


Figure 67 Learning at the level of active human agent Adopted from Chekland and Holwell

There are two important points here. One, "*we always selectively perceive parts of the world, as a result of our interests and previous history*",(P. Checkland & Holwell, 1997) that is history is important since even our interests (the other part of the "and" clause) is the ones already formed (therefore are part of that history). Secondly "*the act of attributing meaning and making judgements implies the existence of standards against*

which comparisons can be made (…). Finally, the source of the standards, for which there is normally no ultimate authority, can only be the previous history of the very process we are describing, and the standards will themselves change over time as new experience accumulates". That means accumulation of learning changes standards which we use for comparing and decision. Here again history matters, now as the path of configurations or states of the process we are dealing with. Finally and for reasons that will later on the chapter become clear we provide an adaptation of the above process as a triangle as follows:

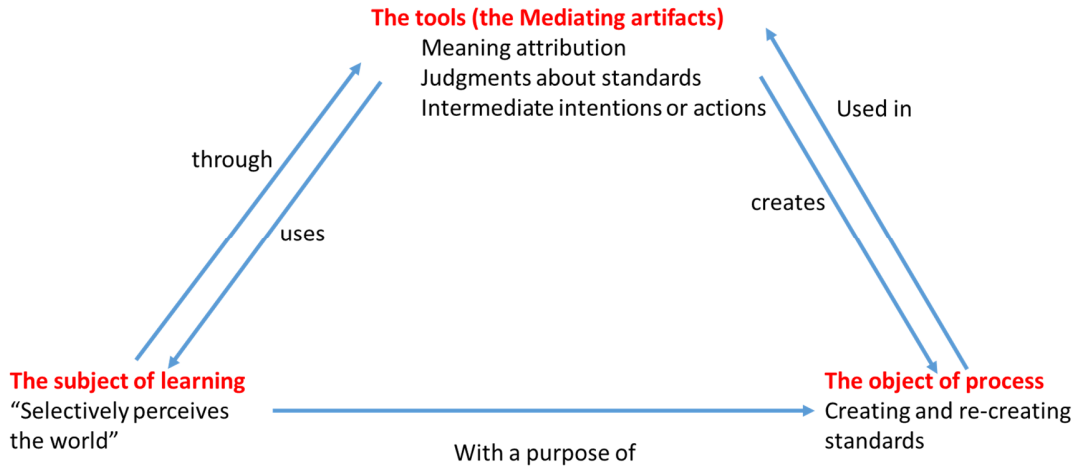


Figure 68 The individual learning as n Subject-Mediation-Purpose schema

The reading of the triangle is "a subject that selectively perceives the world uses the mediation of tools such as 'meaning attribution or judgement about the standards', but also 'intermediate intentions or actions' in the course of achieving the purpose of updating the standards of her world. During the process, standards in place are used to create the mediating artifacts through which the subject changes her perception of the world".

But of course, since "smart city" has been identified as a problem of social relations, the learning view should expand itself to deal of how learning is achieved as social process (the most collective levels). Checkland and Holwell in (P. Checkland & Holwell, 1997) provide a general description of their model of learning as social process.

As they state "*Although each human being retains at least the potential selectively to perceive and interpret the world in their own unique way, running the risk of being regarded as 'weird', the norm for a social animal with sophisticated language is that our*

perceptions of the world, our meaning attributions and our judgments of it will all be strongly conditioned by our exchanges with others (…) This means that we can assume that while fig 4.3[39] *continues to apply to the individual, the social situation will be that much of the process will be carried out inter-subjectively in discourse-which is the word we adopt here to cover all communication, verbal or written (…) the pursue of which is to affect the thinking and actions of at least one other party".* The description is depicted in figure below:

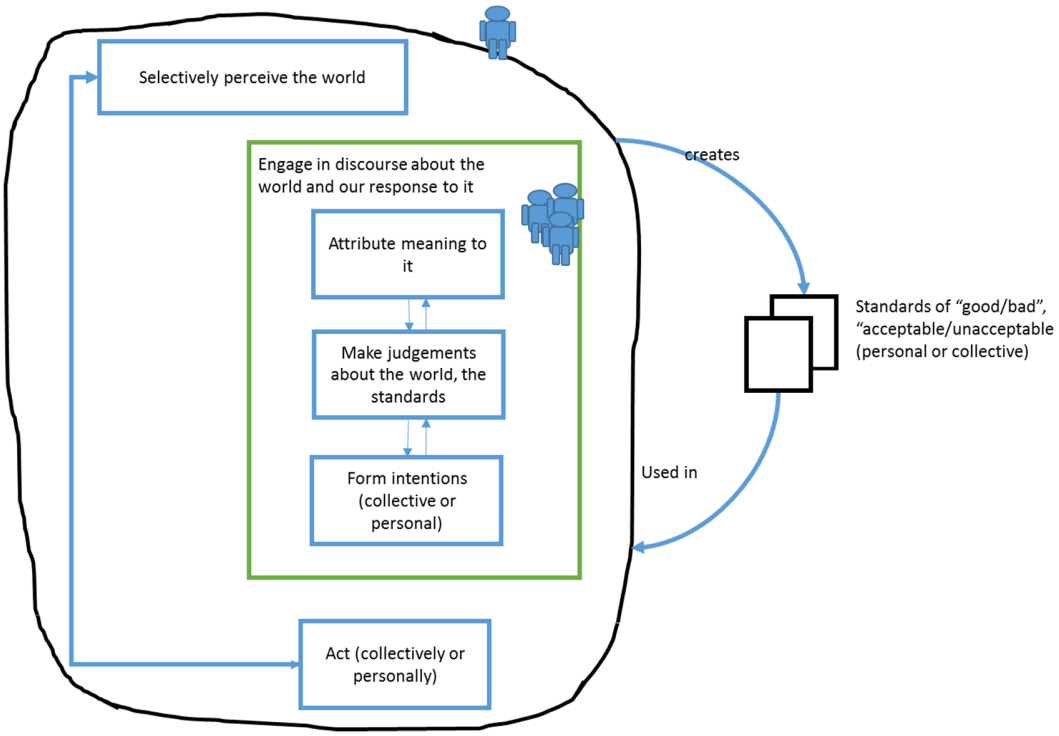


Figure 69 Learning as social process, human agents in the world (adapted)

Finally Checkland and Holwell provide a model of how this theoretical schema of learning becomes a process organization model or the intertwining of "processes of organizational meanings".

We are again moving to providing a simplified view that encapsulates both the social process model of learning and the model of "processes of organizational meanings" as in Figure 70:

[39] Fig 4.3 is Figure 67

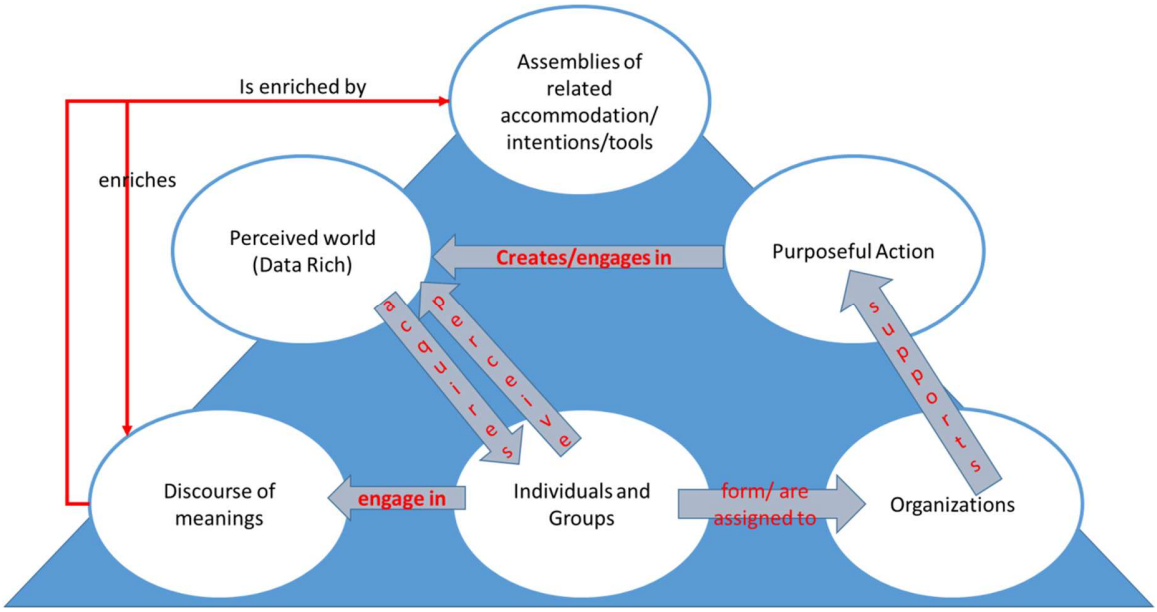


Figure 70 A model of learning as social process, the case of organization (adaptation of POM, as in (P. Checkland & Holwell, 1997)).

The model's description can be as simple as "Purposeful action as engaged in the understanding of the world is changing or creating that understanding using assemblies or networks of related accommodations or tools in general that help the formation of intentions and the carrying of actions through which the discourse of meaning is also enriched. The cycle closes as these processes lead to the creation of organizations which ultimately support the processes from which they have been created." By adopting the previous argument one identify a learning space that uses learning as the mechanism of self-awareness and preservation against both an internal and an external environment. Therefore the Urban re-invents itself as a learning space or a space that processes are informed by what may be labelled under "learning".

Until now we have presented the way SSM models learning that is produced during a process of intervention (as the process model of Figure 70). We have also provided a specific ("triangular") visualization of both the individual level learning and the social level learning. That was a purposeful action. Because those triangular visualizations correspond to the triangles of learning constructed by Vygotsky[40] as reformulated and used today by Activity Theory of Learning. For a thorough introduction to the theory one

[40] Lev Vygotsky , A Russian psychologist deemed as the father of Cultural-Historical Activity Theory (CHAT) (1896-1934).

may consult (Yamagata-Lynch, 2010) or (Engeström, 2001) . For the purpose of coupling SSM with the Activity Theory we are using here the notion of a Vygotsky triangle along with its common reformulation as depicted in Figure 71.Vygotsky (considered to be the founder, or 1st generation of Activity Theory) introduced the meaning of "mediated action" or as Engestrom writes "*This idea was crystallized in Vygotsky's (1978, p. 40) famous triangular model in which the conditioned direct connection between stimulus (S) and response (R) was transcended by 'a complex, mediated act'*".

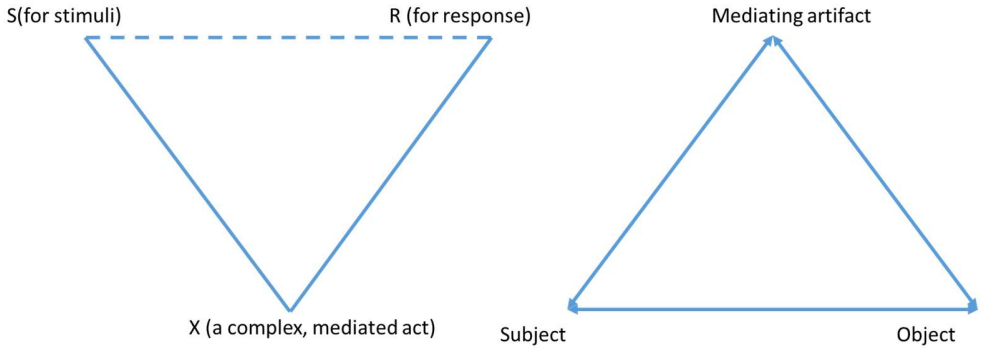


Figure 71 Left is Vygotsky's model of mediated act and right its common reformulation

The idea of mediation intervenes between Stimuli and Response and inserts the social environment in the individual's learning process. The **Subject** is the individual or groups of individual involved in the activity. The **Object** is the goal or the motive of the activity (ie the purpose of it) and the **Mediating artifact** (sometimes referred to as **Tool**) includes the social others, prior knowledge or any kind of artifacts that act as the resources for the subject's activity. The triangle relationship breaks a direct Stimuli-Response formation suggesting that mediation due to social factors takes place. As Yamagata-Lynch (Yamagata-Lynch, 2010) notes "*Human activity is a process that involves artifacts that act as technical tools and signs that act as psychological tools available in the social environment and this process contributes to the formation of individual consciousness within an evolving environment*". The Mediated Artifact as a cultural artifact cancels the dichotomy of individual versus society that may lead to supremacy of what dictates or subsumes the other. In systems thinking terms it resembles the notion of causality flowing in every direction as parts of the system interact to provide an emergence of a property in an upper layer and as upper parts create constraints on the possible states that

can be attained by lower ones. Vygotsky's triangle has further developed by 2nd generation activity theorists to engulf learning beyond the individual level. This resulted in the model of Figure 72.

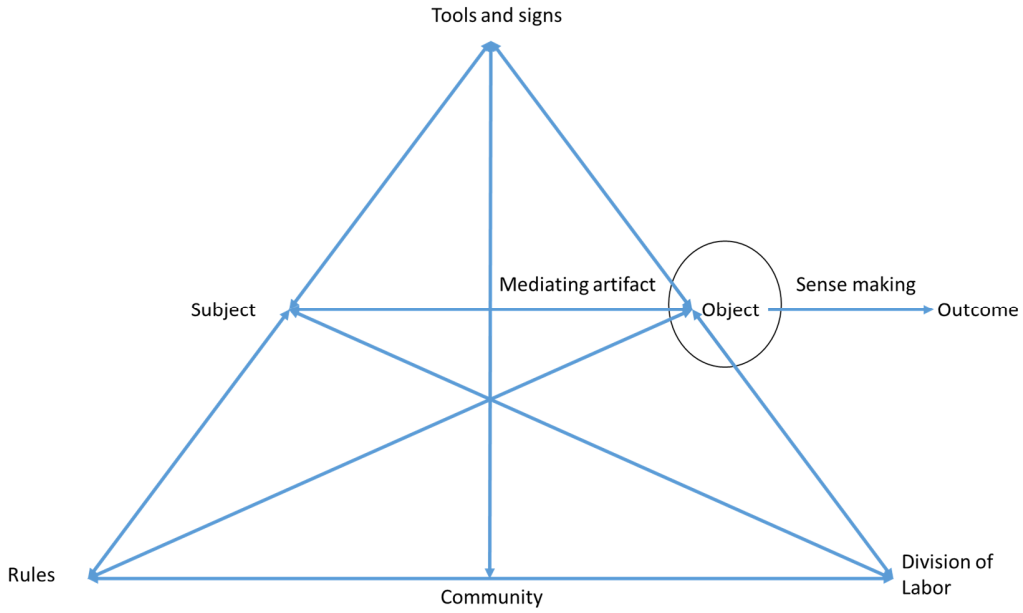


Figure 72 The structure of a human activity system (Engerstrom)

As subject, tools and object remain as defined previously

Rules are any formal or informal regulations that in a varying degree can affect how the activity takes place.

Community is the social group that the subject belongs to while engaged in the activity and

Division of Labor refers to how the tasks are shared among the community.

We have already described a triangle of SSM learning in Figure 68 and in Figure 70. In figure below we create a correspondence in terms of CATWOE and the Social learning triangle of Activity Theory. We believe that there is an analogy between the way SSM and Activity Theory situate learning in an activity system and that bringing them together enhances the understanding of learning and through that provides insight to the notion of smart city.

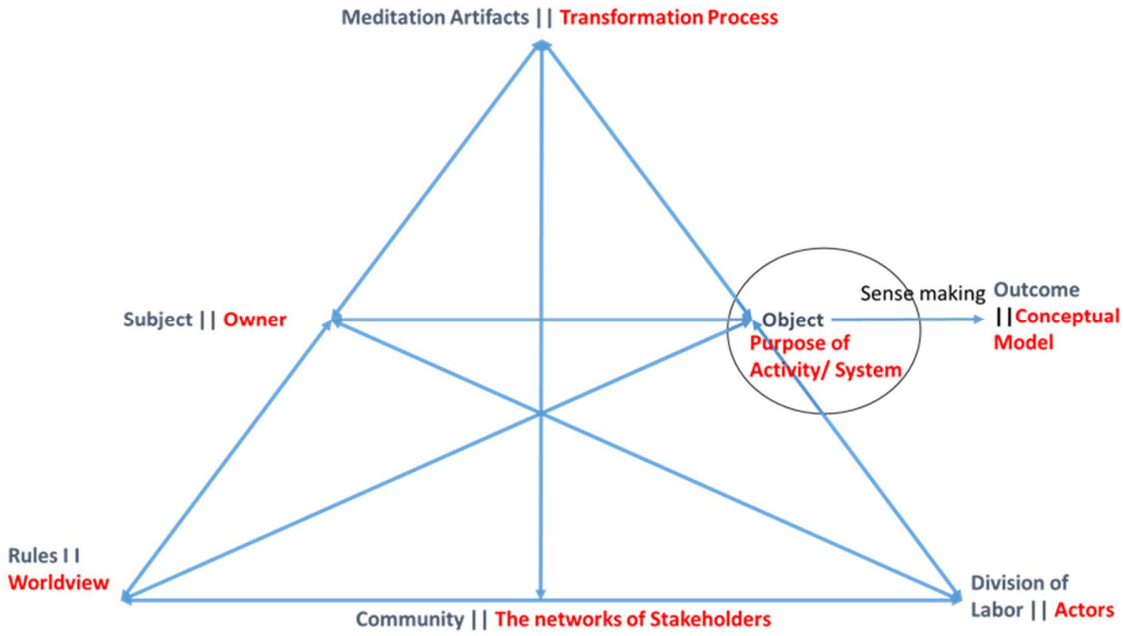


Figure 73 Analogy and enhancement How the SSM elements couple with Activity Theory notions

The figure above is a scheme of correspondence between SSM elements of CATWOE (in red color) and the Activity Theory notions of learning (in blue color). This scheme is thought as:

(1) The Meditation artifacts are tools or instruments either concrete or mental or symbolic that are used in an SSM cycle. In terms of an SSM learning language they constitute the "attribution of meanings" or "the judgments" or "the intentions formed" or "the actions declared or undertaken". They can also be "visions of history" or "visions of the future" as the Stakeholders of the problem area are "selectively perceive the problem". Mediation artifacts are also interpreted through the use of the specific context: they are Urban specific and they can be both of the lived, the conceived or the perceived moments of space as in the Lefebvrian triad. They can also be ontologies like the ones we use to augment SSM with in Chapter 6: if they are they serve the classification of the processes that are used in the negotiation of the SSM cycle.

(2) The Subject is, in our case the Owner of the cycle, who we have named the City Designer.

(3) The Object corresponds to the Objective of the Activity under consideration, the purpose root in "purposeful Human Activity Systems" notion.

(4) The Community is, the networks of the Stakeholders for the Activity (Customers, Actors and the Owner). It could well be networks of historical ties or paths; but also networks of belonging. Change in the interpretation of historical networks or in current networks of belonging mirrors a difference in learning, therefore can be a measure of learning differentiation during an SSM cycle.

(5) The Division of Labor describes the role of Actors enacted with the Transformation: in an SSM mode the activities described in the Conceptual model have always an Actor dimension involved. Actors also mediate and can be thought as a Mediation Artifact. But what is of interest here is the Division of Labor in Actors, how they interact and what this tells us about the power grid or the production mode.

(6) Rules are closer to the Worldview notion of SSM (and the root definitions coming out of them). Rules in Activity Theory context can be more informal and activity binding than Worldview. Still Rules mirror a Worldview on their own. Monitor-control subsystem of SSM may also be thought as being part of Rules.

Finally, the outcome of the AT model is matched with the Conceptual Model of SSM. An accommodation of different Worldviews seen as a Conceptual model, corresponds to an outcome that embodies learning.

From an Urban perspective, there is also an analogy between the Lefebvrian notions of Representational Spaces (the lived experience), Representations of Space (the conceived space of ideology and production mode) and Spatial Practice (in Lefebvre's word "***Social space contains a great diversity of objects, both natural and social, including the networks and pathways which facilitate the exchange of material things and information****").* The analogy depicted in figure below provides an argument in favor of the case of unification of approaches through a learning device of knowledge:

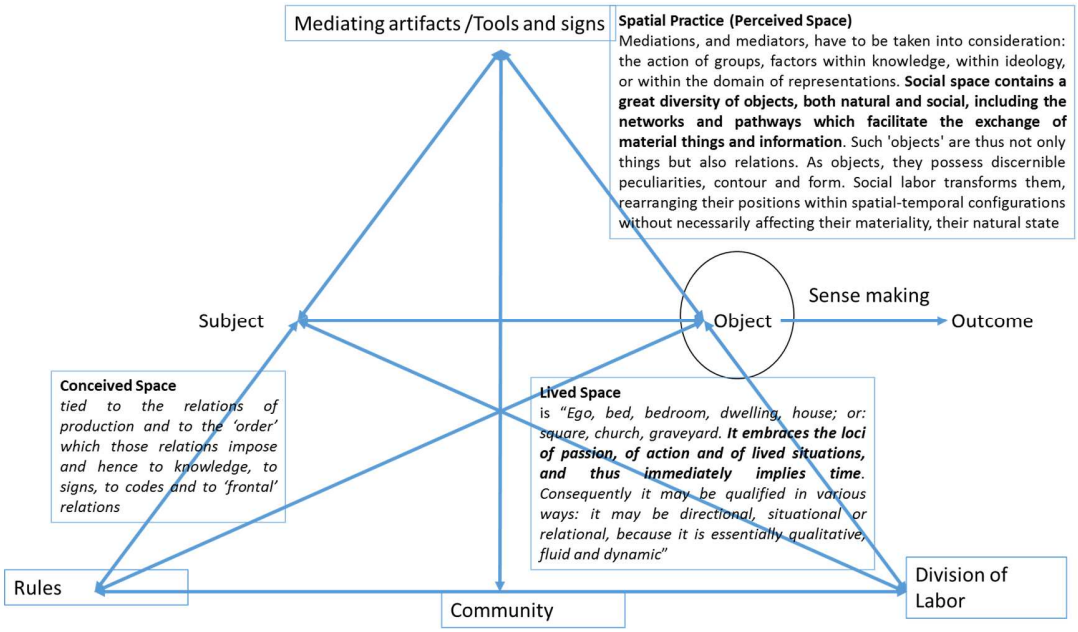


Figure 74 The Lefebvrian triad as learning process

An Action Research Methodology (how to deal with a wicked-problem), an Urban theory (how we are informed of the Context specific to the problem) are coupled with a learning artifact to disentangle the intertwining factors that we may eventually label or trace as "smart city" producers. As one can deduct from Figure 73 and Figure 74 Networks of Stakeholders produced through the Cycle of SSM re-enter the cycle with differentiated worldviews. As the cycle continues learning is accumulated and interpreted through:

(a) The process of creation and update of mediation artifacts
(b) Knowledge of network belonging and the evolution of that belonging
(c) The Ontologies and the Conceptual Models produced as both intermediate but also as more "finalized" outcomes
(d) The Urban theory used variations
(e) The organizations (either formalized or not) and the Information Systems that support the processes
(f) The political and the social behavior understanding (selectively)

It is now more than obvious (see also Table 18 of paragraph 7.3) for a concise presentation of how SSM couples with Urban theory and learning) that our wicked problem has evolved from a widespread definitional battle (of the type "smart city is…")

to a new speak of "our learning about smart city" is constructed as intervention for the sense making of the problem through an SSM cycle, coupled with a specific Urban theory and augmented with notions crafted by Activity Theory takes place. We move to more arguments on how learning constructs knowledge about smartness and perhaps creates systems that emerge because of it in the next paragraph.

7.3 Mathesipolis means "a polis of learning"

In paragraph 3.2.4 we have identified "smart city" as a wicked problem of a very special kind, namely as one that involves future in the definition of it. In particular, we have stated smart city to be a problem described as "*an urban context of today, not been satisfactory in our own eyes for a lot of different and conflicting reasons is hoped to be transformed to something visionary and futuristic which we agree to call the smart city*". Moreover we have attempted some formalism in the way future has entered the discussion by defining that ""*In a future time t_n when we look back at time t_0 we can identify a transformation process, say T, that eventually has modified an urban context at time t_0 to what is perceived to be the urban time at current time t_n*". Although nothing is at hand from the above argument (neither the urban context at present nor the transformation to a future something) what the argument reveals is that our knowing about smart city would always be a tradeoff between memory and imagination. Memory as a space of realized in past-present configurations about the notion: history of paths travelled or possible today's interpretations about the Urban context. "Urban is…" type ones. Imagination as a space of possible states not yet realized but as products of intentional coupling of existing ones (ie belonging to the memory space) or due to serendipity. In a way the relation between such a memory-imagination axis can be used to replicate the problem-solution dichotomy. Because "problem" situates in the land of memory while solution may belong to either memory or imagination: it may a rearrangement based in paths travelled before (known to us) or a new emergence, not previously realized. Therefore, smart city problem could well fit in the latter. We seek a path to future.

But what is actually depicted here is a path between a past-present configuration of the situation perceived problematic and a of a future one that is improved in the following

sense: the participants (i.e. the stakeholders of the process define "a space of the problem" (each of them a different one, but perhaps overlapping with the others), which they present as a past-present configuration based on their own perception of reality. At least at the initial stage, as they seek a solution to the problem, they, implicitly most of the times, move to a futuristic re-configuration by imagining, through the means of a purposeful imagination, a situation that serves or is closer to their purposes. But as they think about the future, either in light or in shadow, they change the past-present configuration they started with and they think about. **In that initial round something new has already been produced: learning, either intended or unintended, as syneidesis of the difference between the past-present configuration and of a purposefully imagined re-configuration of the future. But the achievement of the future envisioned re-configuration, demands change** to occur at the past-present one. Then the return to past-present configuration is both a reassessment of it and the start of a re-configuration of it so that this new past-present configuration will alleviate the path towards the envisioned future one. What happens in the next round of the same process is a new imaginary of the future that can be quite different from the initial one.

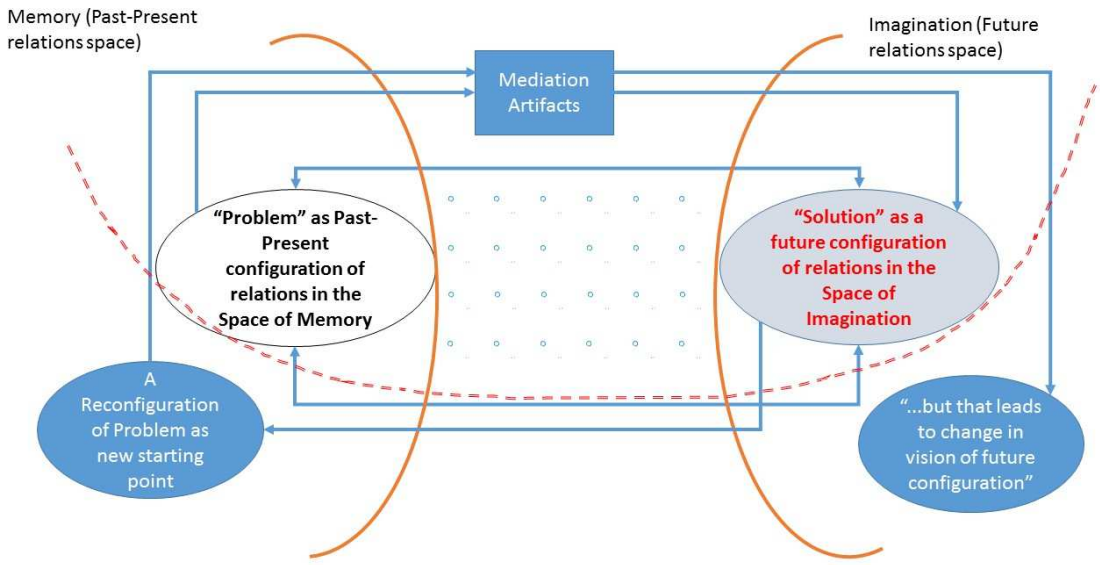


Figure 75 Learning at an individual level (a simple model) or the level of the simplest stakeholders' organization (or in terms of SS Methodology the level-n stakeholders).

Two constraints of the procedure are always present; one can be labeled as an objective one, prohibiting the reconfiguration of the past-present (due to natural systemic constraints or social systemic events as the emergence of a Black Swan[41]) and the other can be labeled under the subjective one, since the stakeholder (owner of the change) has actually changed the network of social relations during the process and has been changed himself. That is the meaning of learning achieved: an awareness of the new configuration achieved (in the case it is not achieved learning also occurs). One should also observe that no rationality of any kind is expected in this path of reconfiguration. Figure 77 below is a complete analogy of the "technology-theory" representation of Figure 66 and is only referring to the path of re-configuration.

What is above the dotted line in Figure 75 is the first round of the iterative process. The second round –below the dotted line- depicts in terms of the LUMAS model of the SSM the learning that is produced as reflection over the situation and gives birth to a new potential arrangement that is thought to become closer to the initial vision of the future. But if such a potential is feasible then it has already created the possibility for a new imaginary thus of a different possible future. This is because, of either an incompatibility between this new arrangement and the old perception of future or because of a new understanding (knowledge) that allows for the initial vision to change for something more desirable.

As the steps continue with successive iterations, learning is (a) accumulated, (b) being interpreted, (c) distributed and (d) lost but these states should not be thought as successive but rather as the following schema:

[41] An extreme event outside our expectations

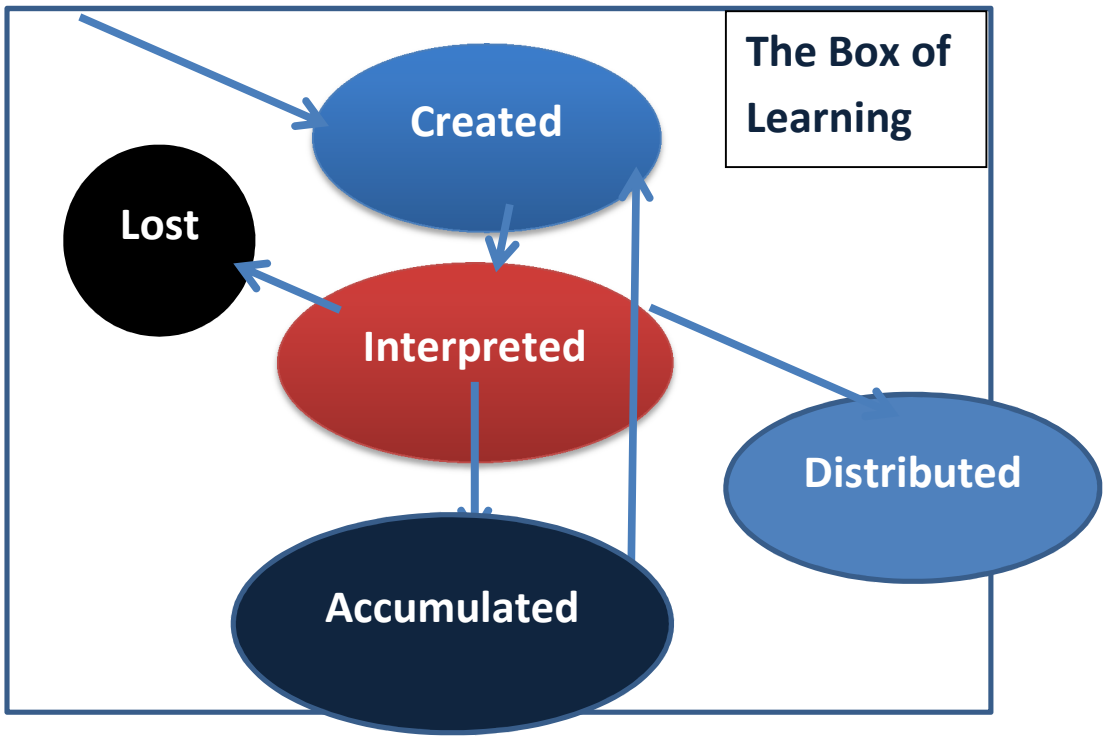


Figure 76 learning II

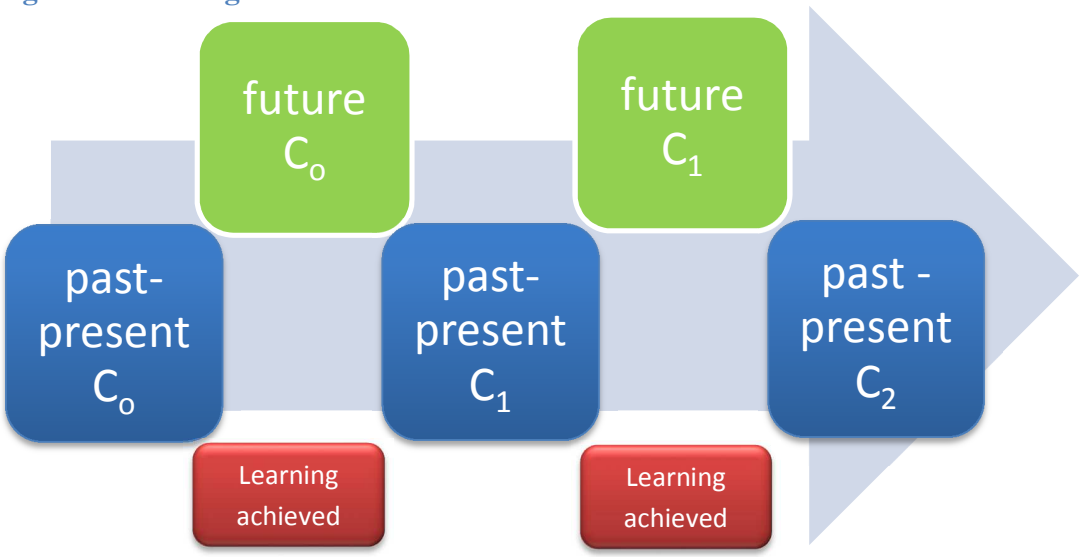


Figure 77 learning as time path: is the learning analogy for Figure 66

Learning emerges as the Transformation between an initial configuration and a re-configuration of it, thought as an interpolation point on the road to a future image purposefully built, reveals itself. Needless to say, that this is not a fixed scenario, but an open one as Transformation is attempted or even rehearsed ie battled, negotiated or achieved and facilitated between the stakeholders both within the levels of the systemic

inquiry and between the levels (intra and inter). So, Transformation is not a function (in input-output mode) but rather a ***Difference of reconfigurations that can be traced in a posteriori manner*** (i.e. after they have eventually been realized).

We have so far presented a case of how learning occurs during an attempted construction of an imagined re-configuration. It is the case that learning creates a bridge between memory and imagination.

We move now to a different understanding of learning. That of Learning in every systemic level: Learning happens at every level of the systems thinking model of SSM. A part of that learning is as we have already pointed out in Chapter 5, is the "production of the Stakeholders during the SSM cycle. Stakeholders (who they are, how they behave) are themselves learning, emerging as the process initiates and continues and accumulated by both the Owner of the process and themselves. In Table 18 we present possible accumulation stages of Learning as SSM cycle happens. Then we go on with a paradigm of how learning is produced (and may be accumulated) by using Transport Human Activity.

Table 18 HAS, stakeholders and learning achievement

Systems at level	Stakeholders of systemic level	An Urban Theory	A Learning aggregation
Level-0: the wider level, where human activity subsystems of economy, technology and the SocioPolitical relations as Human Activity Systems	Of Abstract level as representing capital, labor, human capital, social activity or political institutions or more concrete level ones such as financial institutions, members of the Forbes 100, labor unions or social media or political institutions	**Global level G** According to Lefebvre is the level associated with what is referred to as *institutional space* (along with its corollary, institutional urbanism). This assumes, if not a system of systems of explicit action, at least some form of systematized action (or "concerted" actions that are conducted systemically)	Political analysis and Social analysis through an Urban theory. Learning as reflecting on learning. Emergence of Systems having learning properties.
Level-1: "Sectors" of the Urban (for example the 7 subsystems identified as Transport, Energy, Safety, Social Welfare, Governance	The markets, the streets, the squares, the unions, the communities, local or global companies, government bodies or authorities	**The M level** According to Lefebvre "this includes anything associated with level M, namely, institutions, organizations and urban "agents" (important people, local leaders)". M is the level of means but can never be an end. It is where, between G and P clashes are actually taking shape. M is the plane of systems that the battle when generality attempts to cease peculiarity or the global attempts to absorb the local.	SSM Model of learning (CATWOE+iterative process+Conceptual Models) coupled with an Activity Theory Model. Learning as a process of network belonging re-assemblage
Level-n: Households, Firms,…	Me and You, Households, small firms, local collectives	**Private level P** of the urban or the level of habiting. For Lefebvre P is not only locus of "minor" economic or sociological agents or cannot only be perceived in a micro-macro bifurcation. Is in itself a source of foundation, functionality and transfunctionality. It is the locus of everyday life.	Learning by observing or by doing or by anticipating or by suffering. Also learning through socialization.

As individuals construct trajectories of learning, they create, in a spontaneous fashion, streams of reconfigurations that are created by and create again, “learning” (of every kind: by design, by observation, by doing, by historical accumulation or by exogenous sources). These streams of learning are forming new relationships and as some of the new processes, directed by learning, become dense and complex they organize themselves to more permanent entities, we fashionably call organizations. To this systemic level, stakeholders should be thought not in the form of individuals (eg household, firms or hybrid formations of the two) but as collective entities in the form of sectors, or markets of specific products or services, or as forms of government (around the learning presented at this level as regulation).

Take for example the transport activity systems at levels 1 and n. An individual (that is a stakeholder of level-n) may want to move from home to work. How she does that (in a given context of the Urban) is based on previous learning about it (accumulated learning), on the possible routes, obstacles on the road or preferences of any kind on the new learning she creates (interpretation) as examines alternatives (either because she is forced to do or chose to do) and the ability to change previous learning (or lose some also) by accumulating new one. And of course, by the ability to transfer part of that learning to others.

But that is at the n-level, the level of least collectiveness.

In an SSM fashion, there is an upper systemic level where the individual behaviors of moving are taking the form of a new Human Activity for example the Transport activity: it is now an activity produced by the collective stakeholders of the level-n. CATWOE elements may now form and present themselves as broad as Markets, local or global companies of any kind, neighborhoods or communities with specific need for transport, or governance bodies responsible for the regulation bind with activity or even regulating parts of the activity. Tourists or international travelers can also be part of the Transport Activities System. So, activity at that level (transport activity) may take the form of “congestion”, or “pedestrian areas” or “cargo shipping inside the urban”, or “pedestrian areas, parks and squares” etc. Activity is no longer “I go to work” but becomes “moving people, products or services in an urban context”. In this sense mapping of movement by tracing mobile phones may give an explanation of the anticipated Transport Activity (as

in Figure 45 and in Figure 46). But these data present a past-present configuration of the Transport Activity (although a quite accurate one). It will tell us nothing for what to expect that will happen tomorrow and thus how perhaps to reorganize the allocation of resources (metro, buses or other) to achieve functioning. A future-forward configuration could be achieved if stakeholders of any kind could make their own future configuration known. It is for this reason that a platform (a digital one) that allows movers to declare intentions to move or organizers of events to geographically spot their events and administrators to reallocate and publish their reallocation of resources, could be in use. Because despite the spontaneous features of organization of human activities into systems, social systems, change the organizing rules of their context. If we adopt a supply-demand (or sender-receiver) schema of learning then such a platform with CATWOE-stakeholders, adopting a model of learning and iterative processes of Conceptual Models until feasibility is agreed we have actually substantiated a market of learning, where supply meets demand. Through such an informed and informing platform, which is also perhaps co-evolutionized by Owner, Actors and Customers the box of learning is becoming possible also for subsystems of level-1.

Smartness then is the existence of a learning process described above as a feasible way to answer our initial concerns of smart city being the label to a wicked problem and especially a wicked problem of the future.

Suppose now that an SSM type intervention in an Urban context as the one described in Chapter 5. The Owner (the City Designer), as enabler of the intervention, constructs a layered representation of that Urban context as Human Activity Systems and initially decides on who the Stakeholders are. She, the City Designer, holds a specific Worldview of how the Urban context is produced. A worldview that facilitates her thinking of "what the smart city is". As the cycle moves a change in the Urban context has already occurred as the City Designer is now informed both about how others perceive the Urban context and perhaps she has a better understanding of tensions or conflicts that may be produced if she chooses to act in a specific way. We call this process, at that point, L1 informed

(following the definitions of Bateson (see (Bateson, 1972) and (Tosey, 2006)[42])). Such an Urban context, acquires, as SSM cycles become dense and organized instead of sporadic, insights to the Urban context that allows changes (deliberative or not) to all the Stakeholders involved. Such a change creates activities L1 informed that interact. Those interactions can be depicted as belonging to networks change and as the rebranching of networks takes place change is propelled to all elements of the network: the ideas, the rules, the mediating artifacts. The discourse of Urban context becomes something new, we call "an L1 Urban Context".

While Bateson (also Argyris and Schön[43] in (Argyris & Schön, 1978)) argue that L2 learning or "a double loop learning" occurs when we think about the process of learning, such an L2 may be quite close and inseparable from L1. Instead, suggesting that L1 Urban Context has achieved the "awareness/learning of belonging to a network" may be the cause of new Activities based on the emergence of learning. Then and echoing the Connectivism theory of learning we should turn to how learning in networks (ie learning that reside beyond ourselves, in nodes of networks we belong to) may alter L1 Urban context to a new Urban context which following the flux of ideas presented in this chapter we call "Mathesipolis" (the learning city), a word combined by the Greek word "mathesis" (μάθησις) which means learning and "polis" for city. We provide in the next paragraph a recap on the notion.

---

[42] From whom we reproduce the following table

Learning 0	..is characterized by specificity of response, which – right or wrong - is not subject to correction.
Learning I	...is change in specificity of response by correction of errors of choice within a set of alternatives
Learning II	...is change in the process of Learning I , e.g. a corrective change in the set of alternatives from which choice is made, or it is a change in how the sequence of experience is punctuated
Learning III	...is change in the process of Learning II , e.g. a corrective change in the system of sets of alternatives from which choice is made.
Learning IV	`...would be change in Learning III , but probably does not occur in any adult living organism on this earth.'

[43] "O-II learning systems require conditions under which mistaken assumptions can be reformulated, incongruities reconciled, incompatibilities resolved, vagueness specified, untestable notions made testable, scattered information brought together into meaningful patterns, and previously withheld information surfaced"

7.4 A recap

Mathesipolis, as introduced in this chapter is a construct of a learning model based on the SSM cycle, the Activity Theory of Learning and an Urban context theory. As we have stated earlier in paragraph 7.2 the wicked problem of "smart city" "has evolved from a widespread definitional battle (of the type "smart city is…") to a new speak of "**our learning about smart city" is constructed as intervention for the sense making of the problem through an SSM cycle, coupled with a specific Urban theory and augmented with notions crafted by Activity Theory takes place**".

SSM well facilitates such an approach (together with political and social analysis as the two-stream version of it). The SSM model of learning is also well aligned with the learning model of Activity Theory, providing us with further insights with the use of notions such as "mediation artifacts" and "division of labor". Our selection of Urban theory is also aligned with both SSM and AT notions providing a discourse insight that is compatible. Mathesipolis is therefore:

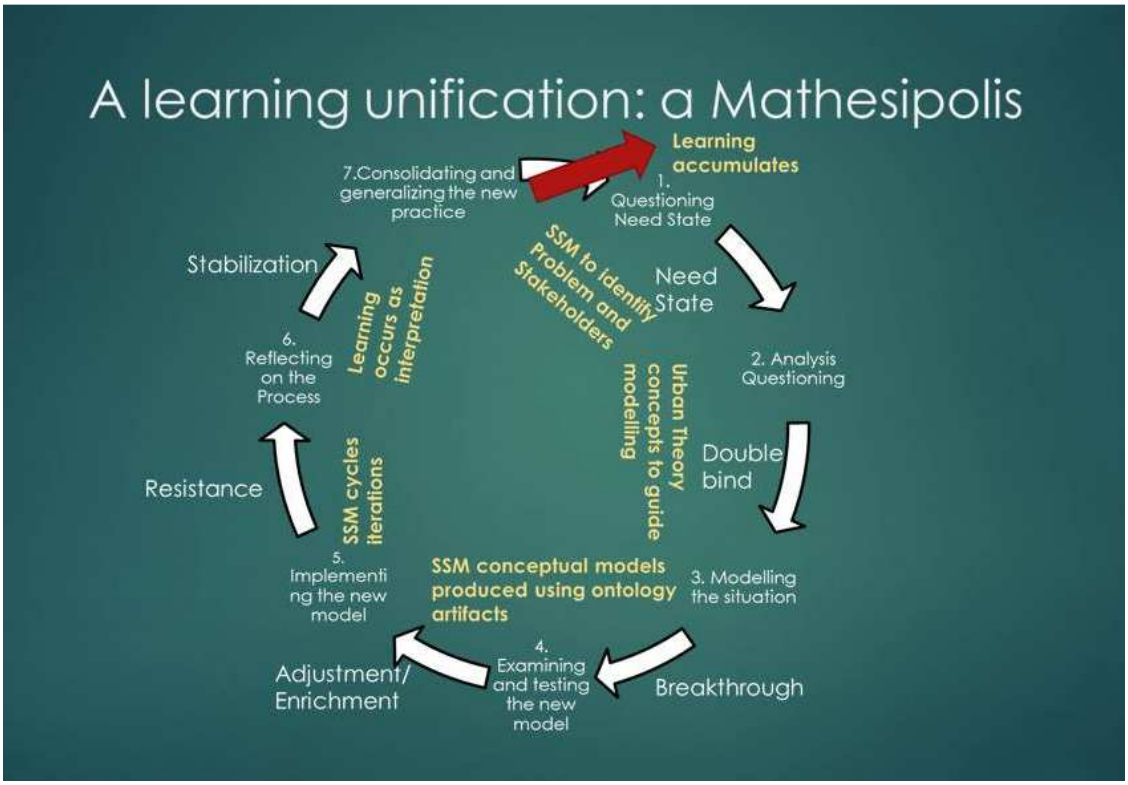


Figure 78 Sequence of learning actions in an expansive learning cycle adapted from (source:(Engeström & Sannino, 2010))

(1) A process of constructing our learning about the Urban context. It does so in a systemic way (via a SSM cycle). It does that by bridging past-present to future configurations: our learning will eventually create a path to an envisioned future.

(2) A systemic representation as layered Human Activity Systems where learning is also achieved in layers and becomes emergent property for each of the layers (that do not preclude that there are other emergent properties).

(3) An L1 Urban context. Perhaps an L2 Urban context (based on the interactions of L1 parts) may appear on a later stage. It may be represented as the model of (Engeström & Sannino, 2010) presented in Figure 78.

Mathesipolis achieves (up to a degree) what Habermas describes as "communicative learning"; that is, an understanding of what others mean (involves feelings, intentions, values and moral issues).

Chapter 8: Reflections and discussion

8.1 Review: motivation and research objectives

The path towards an inquiry and acquisition of learning for the smart city notion that has been sought throughout this dissertation can be summarized as follows:

"An area perceived problematic" has recently emerged (at least for more than 25 years now) both as an academic field or discipline and as an established trend within the context of urban action. People in the academia, in bigger and lesser corporations but also in government (state or local) and international organizations (like the UN or the EU) have declared a wide and rising interest in "smartness" as an urban notion. Thus, the area has been literally constructed by a diversity of different networks of people (as the ones described above). The set of those networks constitute only a few of the networks that may have an interest in the discussion. They both form a Universe of Stakeholders. Some of those Stakeholders can be thought (probably all of them at a lesser or bigger point) as the Customers (profiting or wounded by) of the development and the attempts to implement the notion. Some of them may also appear on smartness stage as the Actors: those who carry the systemic activity of change, those that will eventually will institutionalize change pursued. Finally, there is an entity (or should we rather, echoing the discussion of epistemology versus ontology tracking, speak of "a process") which we have, conveniently, called Owner. For reasons of simplicity only and throughout the discussion in this dissertation, Owner has been thought as an "abstraction of simplicity". Owner is unique to its role of deciding both the inquiry exelixis and the stopping rule of the process of systemic inquiry. Therefore, a "top-down" approach has been considered. But also, the need of a "participative" approach made an early appearance as needed if the notion had to be properly addressed. And a methodology that could handle those and other aspects also had been explored.

Before we continue with the rationale, the struggles and the path of the analysis chosen a much-needed parenthesis of describing the field is, we think, a must:

As noted, the emergence of smart city notion, has given rise to a new urban domain of thinking. Many of those that have dealt with the issue provided description of that domain but also of the range of the domain. So, after 25 years of ideas production and thousands of articles later, smart city is primarily

- An “Eldorado” of ICTization of core city functions (ranging from the simplest form of complaint receiving and following to the most complicated form of governance in municipality level).
- A new phase or episode in the transformation of capitalism in a spatial dimension- but not only. This is probably where the work of Richard Florida on Creative Cities most eloquently defines the unfolding of this new episode from the perspective of the enthusiast of such a development. Implicitly, many of the attempts to describe smartness reify this new concreteness of capitalism.
- A new governance/management or marketing agenda by those “governing” the city or having the power to invoke change for it. An increasing number of cities are setting forth such and very similar agendas of smartness. As Hollands puts it nicely “Please, rise the smart city” (Hollands, 2008).

But, according to the aforementioned prescriptions of smartness, smart city is far less if even at all:

- “an Urban context”- “a device of thinking about the urban”- “a contribution of some kind to the production of Space”. City and the Urban are treated as a tautology, as synonyms. And furthermore they are an implicit “container” of this new episode; the unfolding of the episode “smart city” seems to happen independently and atop the historical evolution of the city or the Urban context. Needless to say, a theory of the Urban is consequently missing. City or Urban exist **O**ntologically. After all we are all living in it with a possibility of 50%. How cannot exist? That Urban could be an interplay between a historical existence of something (that means a hermeneutical schema is needed here) and a new construction alongside is not addressed. Are we really in a need of a theory of the Urban? How about a “new epistemology” of it?
- A “holon” produced, as Systems of Systems representing Human Activity, are interacting to produce the Urban context. As it is pointed out in paragraph 1.2 “City and therefore anything that relates to it (as smart) is a “geography of systems” and itself appears in today’s capitalistic phase as the battleground of networks of economic activities, social and political actions and technology mediations. To render **smart city** as a concept within the lexicon of the systems thinking becomes a necessity as the smartness vocabulary defines new areas of spreading”. Following the

"are" and the "are nots" of smartness mantra, the perception of it as "a wicked problem" do surfaces but is rarely further analyzed. A minority of the articles address the issue, the "area smart city as problematic" as a Complex-Pluralist or Complex-Coercive area in terms of the complexity and of the Participants. Furthermore, Preferences of the Participants versus complexity as a tool to understand the power distribution or the social context that underlie the problem is also missing. To this end a specific stream of systems thinking has been employed in our attempt to view the notion from a holistic point of view and avoid the trap of ICT solutionism.

- A Learning evolution battleground among the stakeholders of it. The way action (any kind of action) is contributing to learning as we project todays "as-is" to tomorrow's "wanna-be" is also in shortage. Seen as a Social System (of systems), actually produced as such through the systems thinking inquiry, smart city is itself a learning episode in the Urban development. A Mathesipolis that is producing and being reproduced as learning networks within it accumulate and interpret disposable learning that concerns and affects the Urban context.

These three points were our motivation turned into objectives road for this dissertation. Figure 3 tells the story as a workflow: view holistically by employing a Soft Systems Methodology, understand the domain concepts by using an ontological approach of the SSM and with the choice of an Urban theory, identify the subjects and the participants of the SSM cycle and finally blend those in a learning unification scheme. The approach thus moved considerably away from mainstream roads.

8.2 Contribution: the road that was least travelled

Understanding the state of affairs as such, this dissertation has sought a different path to address the issue. The artifact constructed (at least attempted-constructed) is an epistemological device comprising of:

1. **A Soft Systems approach and specifically a Soft Systems Methodology**: systemicity in the Urban context cannot be "systems persistent" or produced by "concrete systems". Urban is the context of social systems, and as such, systemicity may be fruitful when applied to the inquiry, to the way we live-conceive-perceive it. If, in our view at least, Urban is more processes in co-evolution and less entities in

rigidity, then such an approach may be more flexible in dealing with the dynamics of fluid and thin-air networks changed by and changing the Urban space. The methodology chosen (SSM) to that end can also be fruitful to another. Apart from being used as a "problem-solving" and "common sense making" of the area, can also increase our learning capability. As meaning attribution surfaces during the methodology cycle, learning is produced both intra and inter stakeholders shifts and reconfigurations of mind, imagery and negotiative power to name only a few. Learning is then interpreted (compared to reference frameworks of ideas, values but also hopes and fears) but also accumulated. Stakeholders' pattern of thinking, we have claimed, is in itself the cornerstone of smartness. Smartness emerges as learning occurs and that is not merely a technological learning or a factual learning. Is mostly an understanding of the differentiation in the social relations (and that includes in the Lefebvrian Urbanity: the production mode, the regeneration mode and the mode of the labor regeneration) concerning the issue at stake. SSM targets a problem having in mind to create an accommodation of conflicting interests as learning about the problem (single loop) and learning about the learning itself (double loop).

2. **A theory of the Urban**. This is part of the ontological description of the device, of the artifact of our thinking (see chapter 5). Why an Urban theory? Why the choice of Lefebvrian one? To quote an old systems thinking saying "it takes complexity to deal with complexity". Resting on a Methodology alone, a systems thinking methodology, no matter how insightfully chosen, is (i) an acceptance of a singularity of the kind "the world is or can only be systemically described" and (ii) an acknowledgement that the exercise of smartness can ignore representations of the Urban and their implications towards our understanding of it. Further to that, an understanding of the Urban through the lens of the Lefebvrian triad of lived-perceived-conceived contains the micro, meso and macro levels of thinking that our common sense uses when dealing with an understanding of Urban space. This levelling is quite similar of the levelling that SSM is based on. In a way, if the systemic part is suited to describe the ongoing intervention and the agents of it, the theory part of the device (tries to) conceptualize "die Weltanschauungen" of those participating in the intervention plane. Actions in the intervention plane not only create learning about the

issue but they constantly inform and are informed in the theory plane: a way of living reflects a mode of production and a change in learning, a new accumulation that never existed before as result of the SSM cycle, drives a new transformation in production mode or social relations which will in turn re-inform the way of living. In a meta-level, the Theory Part of the artifact plays the role of a reference framework against which meaning is attributed and learning is achieved. It is also an answer to a critique very often addressed to SSM and SSM based methodologies. How is the Analysis 2 and Analysis 3 blend in the model? Social and Political Analysis cannot be a trivial part of it. By encapsulating the specific theory, as the theory needed, we do not only prescribe some theoretical underpinnings to the SSM methodology. We clearly and not accidentally call for a binding that forces SSM to the neo-humanist tradition (as in Hirscheimm et al). Together with the acceptance that an ontological thinking is possible the Domain of Smartness ranges from (1) Action to (2) Thinking about Action to (3) Learning and finally to the theorizing of the three as a lived-perceived-conceived schema. One can also think that the "root definition" in the SSM typology is connected with the methodology part and the "Conceptual Model" with the theory part.

3. **A learning based unified approach**, based on SSM cycle, the selected Urban theory and the selection of Activity Theory of learning, led the "smart city" to the Mathesipolis approach. Mathesipolis is an Urban context informed with learning in the process of making. It is the Stakeholders of Human Activities Systems, self-organized or directed ones, binding to SSM cycles of learning that achieve communicative learning or empathy. Does it have structures in place? The fact is that processes that are institutionalized are then treated as structures. Where is learning accumulated? In networks of all kinds: people, mediation artifacts, in lived-conceived-perceived ontologies.

Those points epitomize the thinking presented in this dissertation about "smart city". We move to the next paragraph to reflect on that and possible developments.

8.3 Reflections and Self-reflections

Travelling a road outside the mainstream network should not be followed of any kind of arrogance of exceptionalism. It does not guarantee either a success story or the promise of memorable achievement. It certainly does not mean that other roads are not possible or more fruitful. It is a decision that based on preferences (and as such is a road of learning) and reflects the researcher's own state as the process evolves. Having acknowledged that, what lies ahead is also of some concern. What is the future of building further to this (however small) contribution? The worst case scenario may be that the road may prove (sooner or later) to be a dead end. The collective mind is perhaps both dominant and right to follow a different path. But then again, if not a complete dead end, it may be a specialized bifurcation. If that is the case then some value may arise from it. The beautiful scenario would be that of a continuation through a "grounded effort": theory, as is the artifact presented in this dissertation, needs to be coupled with specificity. It is only then it can begin either to adapt and continue live or to prove non-fertile and forgotten. Specificity could for example follow two strands:

a. Focusing in particular and well bounded Urban contexts and further elaborating on the aspects of the artifact (the kind of Chapters 5 and 6, but with Urban context of, say Athens-Greece where Stakeholders are named to be such and such and they participate in an SSM cycle).
b. Or, by selecting specific Cities and common specific deployment of SSM cycles and reflect on the learning produced and distributed in networks of Stakeholders, reaching out for data rich such networks and base to the resulted outcomes for further elaboration.

Both of them are roads of progress.

A final remark is attributed to the way this dissertation has evolved over (not consecutive) periods of time that ranged for about 3 years. Paul Mason's article in Guardian[44] has been one of the first inspirations, especially the lines concluding it "*Smart cities represent a genuine and potentially massive new market for the private sector, breathing economic life into the old structures and patterns of cities. But if faced with somnolent and uninformed local governments, the results are going to be chaotic and*

[44] See footnote 3

unwieldy systems, and an erosion of democracy. If the movement is to generate a new vigour and vision, city governments must stop being patsies to the IT giants and start to think, from first principles, what technology would look like if it served the people". Then a mind map with domain concepts based on the experience of the field (for example the work of Neirotti et al in (Neirotti et al., 2014)). Angelidou in ((Angelidou, 2015) has provided us with the first hint that urban has been always shaped by technology and most importantly that despite cities development reflects changes in production mode or social relations as formulated under geography (spatial constraints) nothing deterred the appearance and spreading of utopian views of the city through the lens of science , technology or industry.

Therefore, the first bibliographic research focused on articles on this new utopia: smart city as a keyword in title or abstract and through a number of resources as Scholar, Scopus or WebofScience, articles available through publishing houses and libraries as well as a number of researchers that provided us with some of their publications (no matter used or not in our bibliography). Almost immediately a second path: that of Urban planning or Studies. Interestingly enough the major work on smart cities bibliography have been completed by the end of the first semester of the first year. While search in Urban studies has continued and spanned the entire three years. System thinking research (other than SSM) has conducted in years 1 and 2 while research on SSM has occupied time in all three years. Ontology and Learning has been researched at years 2 and 3 respectively. Needless to say, that not all articles considered had eventually been downloaded and not all articles downloaded have been used as referential material.

The selection of articles and the path travelled is all about preferences of the author. The way of thinking over a search of what is actually "out there", the search for the grid of power and social relations or finally learning as an emerging urban property as social relations are forming networks are all part of the way the author understands the urban context at least.

At the end of this journey we feel that the most proper way to reflect on the journey itself is by reevaluating the verse of the poet:

Ithaka gave you the marvelous journey.
Without her you would not have set out.

She has nothing left to give you now.
And if you find her poor, Ithaka won't have fooled you.
Wise as you will have become, so full of experience,
you will have understood by then what these Ithakas mean[45].

[45] Cavafy, Ithaca (C.P. Cavafy, Collected Poems. Translated by Edmund Keeley and Philip Sherrard. Edited by George Savidis. Revised Edition. Princeton University Press, 1992) Accessed from http://www.cavafy.com/poems/content.asp?id=74

Bibliography

Alba, E., Chicano, F., & Luque, G. (2017). *Smart Cities*: Springer.

Albino, V., Berardi, U., & Dangelico, R. M. (2015). Smart Cities: Definitions, Dimensions, Performance, and Initiatives. *Journal of Urban Technology, 22*(1), 3-21. doi:10.1080/10630732.2014.942092

Anderson, J. E. (2011). The Gravity Model.

Angelidou, M. (2015). Smart cities: A conjuncture of four forces. *Cities, 47*, 95-106. doi:10.1016/j.cities.2015.05.004

Angelidou, M. (2017). The role of smart city characteristics in the plans of fifteen cities. *Journal of Urban Technology, 24*(4), 3-28.

Anthopoulos, L. G., & Vakali, A. (2012). Urban planning and smart cities: interrelations and reciprocities *The Future Internet* (pp. 178-189): Springer.

Argyris, C., & Schön, D. A. (1978). *Organizational learning: a theory of action perspective*: Addison-Wesley Pub. Co.

Bach, J., & Stark, D. (2005). Recombinant technology and new geographies of association. *Digital formations: IT and new architectures in the global realm*, 37-53.

Bateson, G. (1972). The logical categories of learning and communication. *Steps to an Ecology of Mind*, 279-308.

Berry, B. J. L. (1964). Cities as Systems within Systems of Cities. *Papers in Regional Science, 13*(1), 147-163. doi:10.1111/j.1435-5597.1964.tb01283.x

Bertalanffy, L. v. (1973). *General system theory : foundations, development, applications*. Harmondsworth: Penguin.

Boardman, J., & Sauser, B. (2006, 2006). *System of Systems-the meaning of of*.

Borst, P., Akkermans, H., & Top, J. (1997). Engineering ontologies. *International journal of human-computer studies, 46*(2-3), 365-406.

Braun, P., Brzostowski, J., Kersten, G., Kim, J. B., Kowalczyk, R., Strecker, S., & Vahidov, R. (2006). E-negotiation systems and software agents: Methods, models, and applications *Intelligent decision-making support systems* (pp. 271-300): Springer.

Brenner, N. (2009). What is critical urban theory? *City, 13*(2-3), 198-207. doi:10.1080/13604810902996466

Brenner, N., & Schmid, C. (2015). Towards a new epistemology of the urban? *City, 19*(2-3), 151-182. doi:10.1080/13604813.2015.1014712

Brocklesby, J. (2007). The theoretical underpinnings of soft systems methodology—comparing the work of Geoffrey Vickers and Humberto Maturana. *Systems Research and Behavioral Science, 24*(2), 157-168.

Bunge, M. (1979). Treatise on Basic Philosophy, Vol. 3, Ontology 1 : The Furniture of the World. *Tijdschrift Voor Filosofie, 41*(1), 155-156.

Burrell, G., & Morgan, G. (1979). *Sociological paradigms and organisational analysis : elements of the sociology of corporate life*. London: Heinemann.

Cadenas, H., & Arnold, M. (2015). The Autopoiesis of Social Systems and its criticisms. *Constructivist Foundations, 10*(2), 169-176.
Caragliu, A., Del Bo, C., & Nijkamp, P. (2011). Smart Cities in Europe. *Journal of Urban Technology, 18*(2), 65-82. doi:10.1080/10630732.2011.601117
Castells, M. (1983). The city and the grassroots: A cross-cultural theory of urban social movements. Berkeley. *Cal./Los Angeles: University of California Press*.
Checkland, P. (1983). OR and the systems movement: mappings and conflicts. *Journal of the operational research society, 34*(8), 661-675.
Checkland, P. (2000). Soft Systems Methodology: A Thirty Year Retrospective. *Systems Research and Behavioral Science, 17*, 11-58.
Checkland, P. (2000). Soft systems methodology: a thirty year retrospective. *Systems Research and Behavioral Science, 17*, S11-S58.
Checkland, P. (2011). Autobiographical retrospectives: Learning your way to 'action to improve' – the development of soft systems thinking and soft systems methodology. *International Journal of General Systems, 40*(05), 487-512. doi:10.1080/03081079.2011.571437
Checkland, P. (2012). Four conditions for serious systems thinking and action. *Systems Research and Behavioral Science, 29*(5), 465-469.
Checkland, P., & Holwell, S. (1997). *Information, Systems and Information Systems : Making Sense of the Field*: Wiley.
Checkland, P., & Holwell, S. (1998). Action Research: Its Nature and Validity. *Systemic Practice and Action Research, 11*(1), 9-21. doi:10.1023/a:1022908820784
Checkland, P., & Poulter, J. (2010). Soft Systems Methodology. In M. Reynolds & S. Holwell (Eds.), *Systems Approaches to Managing Change: A Practical Guide* (pp. 191-242). London: Springer London.
Checkland, P., & Scholes, J. (1990). *Soft systems methodology in action*: John Wiley \& Sons, Inc.
Checkland, P. B. (1972). Towards a systems-based methodology for real-world problem solving. *Journal of Systems Engineering, 3*(2), 87-116.
Checkland, P. B. (1980). The systems movement and the "failure" of management science. *Cybernetics and Systems, 11*(4), 317-324.
Chourabi, H., Nam, T., Walker, S., Gil-Garcia, J. R., Mellouli, S., Nahon, K., . . . Scholl, H. J. (2012). Understanding Smart Cities: An Integrative Framework. 2289-2297. doi:10.1109/hicss.2012.615
Cocchia, A. (2014). Smart and digital city: A systematic literature review *Smart city* (pp. 13-43): Springer.
Dameri, R. P. (2013). Searching for smart city definition: a comprehensive proposal. *International Journal of Computers & Technology, 11*(5), 2544-2551.
Dauber, D., Fink, G., & Yolles, M. (2012). A Configuration Model of Organizational Culture. *SAGE Open, 2*, 215824401244148. doi:10.1177/2158244012441482

Dirks, S., & Keeling, M. (2010). A Vision of Smarter Cities: How cities can lead the way into. *Ministry of Science, Technology and Innovation Aras 1-7, Blok C4 & C5, Kompleks C, Pusat Pentadbiran Kerajaan Persekutuan, 62662 Putrajaya, Wilayah Persekutuan. T+:(603) 8885 8000*.

Durán-Sánchez, A., de la Cruz del Río-Rama, M., Sereno-Ramírez, A., & Bredis, K. (2017). Sustainability and Quality of Life in Smart Cities: Analysis of Scientific Production. 159-181. doi:10.1007/978-3-319-40895-8_12

Easterbrook, S. (2014). *From Computational Thinking to Systems Thinking*. Paper presented at the Proc. ICT4S. Atlantis Press. http://www.atlantis-press.com/php/download_paper.php?id=13446

Engeström, Y. (2001). Expansive learning at work: Toward an activity theoretical reconceptualization. *Journal of education and work, 14*(1), 133-156.

Engeström, Y., & Sannino, A. (2010). Studies of expansive learning: Foundations, findings and future challenges. *Educational research review, 5*(1), 1-24.

Fernández-Güell, J.-M., Guzmán-Araña, S., Collado-Lara, M., & Fernández-Añez, V. (2016). *How to Incorporate Urban Complexity, Diversity and Intelligence into Smart Cities Initiatives.* Paper presented at the International Conference on Smart Cities.

Florida, R. (2014). *The rise of the creative class–revisited: Revised and expanded*: Basic Books (AZ).

Foerster, H. v. (1960). On self-organizing systems and their environments. *Self-organizing systems*, 31-50.

Fonseca, F., & Martin, J. (2007). Learning the differences between ontologies and conceptual schemas through ontology-driven information systems. *Journal of the Association for Information Systems, 8*(2), 129.

François, C. (1999). Systemics and cybernetics in a historical perspective. *Systems Research and Behavioral Science, 16*(3), 203.

Gaspoz, C., & Wand, Y. (2012, 2012/01//). *Using Ontologies and Soft Systems Methodology to Provide Multi-user Support in Problem Structuring*.

Georgiou, I. (2015). Unravelling soft systems methodology. *International Journal of Economics and Business Research, 9*, 415. doi:10.1504/IJEBR.2015.069680

Giffinger, R., Meijers, E., Fertner, C., Kramar, H., Kalasek, R., & Pichler-Milanović, N. (2007). *Smart cities: Ranking of European medium-sized cities*: Centre of Regional Science, Vienna University of.

Gruber, T. R. (1995). Toward principles for the design of ontologies used for knowledge sharing? *International journal of human-computer studies, 43*(5-6), 907-928.

Guarino, N. (1995). Formal ontology, conceptual analysis and knowledge representation. *International journal of human-computer studies, 43*(5-6), 625-640.

Guarino, N. (1998). *Formal ontology in information systems: Proceedings of the first international conference (FOIS'98), June 6-8, Trento, Italy* (Vol. 46): IOS press.

Guarino, N., Oberle, D., & Staab, S. (2009). What is an ontology? *Handbook on ontologies* (pp. 1-17): Springer.
Hall, P. (2000). Creative cities and economic development. *Urban studies, 37*(4), 639-649.
Hall, R. E., Bowerman, B., Braverman, J., Taylor, J., Todosow, H., & Von Wimmersperg, U. (2000). *The vision of a smart city*.
Hanafizadeh, P., & Mehrabioun, M. (2017). Application of SSM in tackling problematical situations from academicians' viewpoints. *Systemic Practice and Action Research*, 1-42.
Harrison, C., & Donnelly, I. A. (2011). *A theory of smart cities.* Paper presented at the Proceedings of the 55th Annual Meeting of the ISSS-2011, Hull, UK.
Harrison, C., Eckman, B., Hamilton, R., Hartswick, P., Kalagnanam, J., Paraszczak, J., & Williams, P. (2010). Foundations for Smarter Cities. *IBM Journal of Research and Development, 54*(4), 1-16. doi:10.1147/JRD.2010.2048257
Heynen, N. C., Kaika, M., & Swyngedouw, E. (2006). *In the Nature of Cities: Urban Political Ecology and the Politics of Urban Metabolism* (Vol. 3): Taylor & Francis.
Hirschheim, R., Klein, H. K., & Lyytinen, K. (1995). *Information systems development and data modeling: conceptual and philosophical foundations*: Cambridge University Press.
Hollands, R. G. (2008). Will the real smart city please stand up? Intelligent, progressive or entrepreneurial? *City, 12*(3), 303-320.
Holwell, S. (2000). Soft systems methodology: other voices. *Systemic Practice and Action Research, 13*(6), 773-797.
Houghton, L., & Ledington, P. W. (2002). The evolution of confusion: Soft Systems Methodology and social theory revisited. *Australasian Journal of Information Systems, 9*(2).
Hunt, D., Rogers, C., & Cavada, M. (2014). Smart Cities: Contradicting Definitions and Unclear Measures. f004. doi:10.3390/wsf-4-f004
Jackson, M. C. (2003). *Systems thinking: creative holism for managers*. Chichester, West Sussex ; Hoboken, N.J: John Wiley & Sons.
Jacobs, J. (1961). The death and life of great American cities. *New-York, NY: Vintage*.
Jantsch, E. (1980). *The Self-Organizing Universe: Scientific and Human Implications of the Emerging Paradigm of Evolution*: Pergamon Press.
Jelassi, M. T., & Foroughi, A. (1989). Negotiation support systems: An overview of design issues and existing software. *Decision Support Systems, 5*(2), 167-181.
Jessop, B. (2006). *Spatial fixes, temporal fixes and spatio-temporal fixes*: na.
Jurisica, I., Mylopoulos, J., & Yu, E. (2004). Ontologies for knowledge management: an information systems perspective. *Knowledge and Information systems, 6*(4), 380-401.

Kamalipour, H., & Peimani, N. (2015). Assemblage Thinking and the City: Implications for Urban Studies. *Current Urban Studies, 3*(04), 402.
Klir, J., & Valach, M. (1967). Cybernetic modelling.
Kock, N. e. (2007). *Information systems action research An Applied View of Emerging Concepts and Methods*: Springer.
Komninos, N., Bratsas, C., Kakderi, C., & Tsarchopoulos, P. (2015). Smart city ontologies: Improving the effectiveness of smart city applications. *Journal of Smart Cities, 1*(1). doi:10.18063/jsc.2015.01.001
Lamp, J. (1998, 1998). *Using Petri Nets to Model Weltanschauung Alternatives in Soft Systems Methodology*.
Ledington, P., & Ledington, J. (1999). The problem of comparison in soft systems methodology. *Systems Research and Behavioral Science, 16*(4), 329.
Lefebvre, H. (1991). *The production of space / Henri Lefebvre ; translated by Donald Nicholson-Smith*. Oxford, OX, UK ; Cambridge, Mass., USA: Blackwell.
Lefebvre, H. (2003). *The Urvan Revolution*: University Minnesota Press.
Lewin, K. (1948). *Resolving social conflicts: selected papers on group dynamics [1935-1946]* (Vol. 1): Harper.
Linders, D. (2012). From e-government to we-government: Defining a typology for citizen coproduction in the age of social media. *Government Information Quarterly, 29*(4), 446-454.
Luhmann, N. (1986). The autopoiesis of social systems.
March, H., & Ribera-Fumaz, R. (2016). Smart contradictions: The politics of making Barcelona a Self-sufficient city. *European Urban and Regional Studies, 23*(4), 816-830.
Maturana, H. R., & Varela, F. J. (1987). *The tree of knowledge: The biological roots of human understanding*: New Science Library/Shambhala Publications.
Maturana, H. R., & Varela, F. J. (1991). *Autopoiesis and cognition: The realization of the living* (Vol. 42): Springer Science & Business Media.
McFarlane, C. (2011). Assemblage and critical urbanism. *City, 15*(2), 204-224.
McGuirk, P. (2012). Geographies of urban politics: pathways, intersections, interventions. *Geographical Research, 50*(3), 256-268.
McLoughlin, J. B., & Webster, J. N. (1970). Cybernetic and General-System Approaches to Urban and Regional Research: A Review of the Literature. *Environment and Planning A: Economy and Space, 2*(4), 369-408. doi:10.1068/a020369
Meijer, A., & Bolivar, M. P. R. (2015). Governing the smart city: a review of the literature on smart urban governance. *International Review of Administrative Sciences*. doi:10.1177/0020852314564308
Merton, R. K. (1949). *On sociological theories of the middle range [1949]*: na.
Midgley, G. (2006). Systems thinking for evaluation. *Systems Concepts in Evaluation: An Expert Anthology. B. Williams and I. Imam. Point Reyes CA, USA Edgepress*, 11-34.

Miller, J. G. (1978). *Living systems*: McGraw-Hill.
Mingers, J. (2000a). An idea ahead of its time: the history and development of soft systems methodology. *Systemic Practice and Action Research, 13*(6), 733-755.
Mingers, J. (2000b). Variety is the spice of life: combining soft and hard OR/MS methods. *International Transactions in Operational Research, 7*(6), 673-691.
Mingers, J., & Taylor, S. (1992). The Use of Soft Systems Methodology in Practice. *The Journal of the Operational Research Society, 43*(4), 321-332. doi:10.2307/2583155
Mingers, J., & White, L. (2010). A review of the recent contribution of systems thinking to operational research and management science. *European Journal of Operational Research, 207*(3), 1147-1161. doi:10.1016/j.ejor.2009.12.019
Mora, L., Bolici, R., & Deakin, M. (2017). The First Two Decades of Smart-City Research: A Bibliometric Analysis. *Journal of Urban Technology, 24*(1), 3-27. doi:10.1080/10630732.2017.1285123
Murphy, N., & Stoeger, W. R. (2007). *Evolution and emergence: Systems, organisms, persons*: Oxford University Press on Demand.
Nam, T., & Pardo, T. A. (2011). Conceptualizing smart city with dimensions of technology, people, and institutions. 282. doi:10.1145/2037556.2037602
Neirotti, P., De Marco, A., Cagliano, A. C., Mangano, G., & Scorrano, F. (2014). Current trends in Smart City initiatives: Some stylised facts. *Cities, 38*, 25-36. doi:10.1016/j.cities.2013.12.010
Nguyen, V. (2011). *Ontologies and information systems: A literature survey*. Retrieved from
Noy, N. F., & McGuinness, D. L. (2001). Ontology development 101: A guide to creating your first ontology: Stanford knowledge systems laboratory technical report KSL-01-05 and Stanford medical informatics technical report SMI-2001-0880, Stanford, CA.
Ojo, A., Dzhusupova, Z., & Curry, E. (2016). Exploring the Nature of the Smart Cities Research Landscape. 23-47. doi:10.1007/978-3-319-17620-8_2
Ostroff, S. (2000). Systems Theories: Toward a Meta-Perspective.
Partridge, H. L. (2004). Developing a human perspective to the digital divide in the'smart city'.
Peffers, K., Tuunanen, T., Rothenberger, M. A., & Chatterjee, S. (2008). A Design Science Research Methodology for Information Systems Research. *Journal of Management Information Systems, 24*(3), 45-77.
Pouloudi, A., & Whitley, E. A. (1997). Stakeholder identification in inter-organizational systems: gaining insights for drug use management systems. *European journal of information systems, 6*(1), 1-14.
Pugalis, L. (2009). *A conceptual and analytical framework for interpreting the spatiality of social life.* Paper presented at the FORUM Ejournal.

Reynolds, M., & Holowell, S., eds. (2010). *Systems Approaches to manging change: A practical guide*: Springer.
Ricciardi, F., & Za, S. (2015). Smart City Research as an Interdisciplinary Crossroads: A Challenge for Management and Organization Studies. *5*, 163-171. doi:10.1007/978-3-319-09450-2_14
Rios, P. (2012). *Creating" The Smart City".* Google Scholar database.
Rittel, H. W., & Webber, M. M. (1973). Dilemmas in a general theory of planning. *Policy sciences, 4*, 155–169.
Romer, P. M. (1990). Endogenous technological change. *Journal of political Economy, 98*(5, Part 2), S71-S102.
Romer, P. M. (1994). The origins of endogenous growth. *Journal of Economic Perspectives, 8*(1), 3-22.
Sadi, T., Wilberg, J., Tommelein, I. D., & Lindemann, U. (2016). Supporting the design of competitive organizations by a domain-specific application framework for the viable system model. *Journal of Modern Project Management, 4*(2), 96-103.
Scott, B. (2004). Second-order cybernetics: an historical introduction. *Kybernetes, 33*(9/10), 1365-1378.
Senge, P. M. (2006). *The fifth discipline : the art and practice of the learning organization*. New York: Doubleday/Currency.
Šiugždinienė, J., Gaulė, E., & Rauleckas, R. In search of smart public governance: the case of Lithuania. *International Review of Administrative Sciences, 0*(0), 0020852317707814. doi:10.1177/0020852317707814
Studer, R., Benjamins, V. R., & Fensel, D. (1998). Knowledge engineering: principles and methods. *Data & knowledge engineering, 25*(1-2), 161-197.
Su, K., Li, J., & Fu, H. (2011). *Smart city and the applications.* Paper presented at the Electronics, Communications and Control (ICECC), 2011 International Conference on.
Torlak, N. G., & Müceldili, B. (2014). Soft Systems Methodology in Action: The Example of a Private Hospital. *Systemic Practice and Action Research, 27*, 325-361. doi:10.1007/s11213-013-9290-z
Tosey, P. (2006). Bateson's levels of learning: a framework for transformative learning?
Tsolakis, N., & Anthopoulos, L. (2015). Eco-cities: An integrated system dynamics framework and a concise research taxonomy. *Sustainable Cities and Society, 17*, 1-14. doi:10.1016/j.scs.2015.03.002
Tsoukas, H., & Hatch, M. J. (2001). Complex thinking, complex practice: The case for a narrative approach to organizational complexity. *Human relations, 54*(8), 979-1013.
Uitermark, J. (2005). The genesis and evolution of urban policy: a confrontation of regulationist and governmentality approaches. *Political Geography, 24*(2), 137-163.

Verdonck, M., Gailly, F., de Cesare, S., & Poels, G. (2015). Ontology-driven conceptual modeling: A systematic literature mapping and review. *Applied Ontology, 10*(3-4), 197-227.
Viitanen, J., & Kingston, R. (2014). Smart cities and green growth: outsourcing democratic and environmental resilience to the global technology sector. *Environment and Planning A, 46*(4), 803-819. doi:10.1068/a46242
Wang, W., Liu, W., & Mingers, J. (2015). A systemic method for organisational stakeholder identification and analysis using Soft Systems Methodology (SSM). *European Journal of Operational Research, 246*(2), 562-574. doi:10.1016/j.ejor.2015.05.014
Washburn, D., & Sindhu, U. (2009). Helping CIOs understand "smart city" initiatives. *Growth, 17*, 2.
Wiener, N. (1961). *Cybernetics or Control and Communication in the Animal and the Machine* (Vol. 25): MIT press.
Wiener, N. (1988). *The human use of human beings: Cybernetics and society*: Perseus Books Group.
Williams, B., & Imam, I. (2007). *Systems concepts in evaluation: an expert anthology*. Point Reyes, CA: EdgePress of Inverness.
Wilson, B. (2001). *Soft systems methodology: conceptual model building and its contribution*. Chichester ; New York: Wiley.
Yamagata-Lynch, L. C. (2010). *Activity systems analysis methods: Understanding complex learning environments*: Springer Science & Business Media.
Yu, E. (1997). *Towards Modelling and Reasoning Support for Early phase Requirements Engineering.* Paper presented at the 3rd IEEE International Symposium on Requirements Engineering, RE'97, Washington D.C., USA.
Zelený, M., & Hufford, K. D. (1992). The application of autopoiesis in systems analysis: Are autopoietic systems also social systems? *International Journal of General System, 21*(2), 145-160.
Zhu, Z. (2009). OR without ontology: A pragmatist critique of SSM. *OR51 Keynote Papers. The OR Society: England*, 90-112.
Zygiaris, S. (2013). Smart city reference model: Assisting planners to conceptualize the building of smart city innovation ecosystems. *Journal of the Knowledge Economy, 4*(2), 217-231.