

# Modeling and Simulation of New Territories Projects Using *Agencements* Theory, Mereological Principles and Simplicial Complex Tool

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## Abstract

*Space is a matter of distance between social objects. The following article is based on the “agencement” concept seen as a framework to formalize new projects territories. The area of research is PARIS-SACLAY Campus, which views the sitting of a world science cluster. The agencements are modeled by means of mereology and simplicial complexes. Its objective is to offer new decision-making tools to urban actors.*

## 1. Introduction

Since *distance* is an existing problem between social objects, space is an issue to which societies are faced. Therefore, space topic can be viewed as management of the constraints generated by distance and that may hinder social objects interaction. A city design is an instance of solving the problem of distance. Similarly, information technologies may partly be answers to some of the problems related to distance, wherever interaction between social objects is required. Between the two extremes that are the boundary marking of the enclosed space (infinite distance) and ubiquity (overcome distance), half-way situations can be treated by the appliance the two main methods (fig.1): copresence (distance cancelled by co-localisation) and mobility (physical displacement to connect two distant realities) - not including telecommunication which consists in communication from a distance as well as immaterial information transfer.

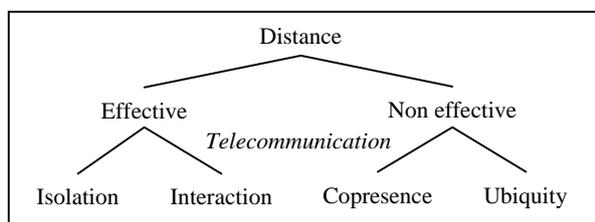


Figure 1. Types of spatial relations between two social phenomena (inspired by Levy [1]).

However, a potential space where distance is partially abolished is not solely consequent to the use

of information technology as a technology of distance, but it is also due to the way this very distance is viewed. Lévy and Lussaud [2] oppose two assessment methods to measure distance: topographical versus topological - which are embodied into the territory/network opposition that constitutes the recurrent theme of the present article. We do know topographical metrics (territories, locations, countries) that are linked to the State territory model and to the metaphysics of identity and substance. Inversely, topological metrics convey space designs where distances are discontinuous, deficient and transitional (impermanent) and where multiplicity of active elements in unstable interaction prevails, and therefore does connexity.

Some philosophers tried to conceive such a topology of multiplicity in relation to a high spatial concern: Michel Foucault in his criticism about space conceived an area of “disciplinary” apparatus [3]; Gilles Deleuze in his approach of “arrangement” thought as multiplicity generating de-territorialization and re-territorialization processes [4]; Peter Sloterdijk and his concepts of spheres: “foam” or “envelope” - as opposed to rooting, enhancing speed urban stimulations, air de-territorialization and figure of pluralities of spaces such as “anthropogene islands” or “anthrospheres”[5]. Among sociologists, Giddens [6] stressed space and time dissociation in modern societies. Modernity breaks the bond between social activity and its localisation in some peculiar contexts of presence: social systems delocalization characterizes the extraction of social relations from the local context of interaction and their reorganization in indefinite space-time contexts. Information technologies reinforce the dismantling of space compared to place in favour of an unlocalized capacity, a *wandering power*, which authorizes a multitude of changes. These permanent changes support the blossoming of a “Risk society”. It also requires the development of mechanisms based on trust.

Lastly, let us mention the work of Michel Callon and Bruno Latour on the Actor-Network Theory

(ANT). Their analysis takes into account the actors as well as the objects (or agency of “nonhumans” actants) and the discourses [7]. The ANT assumes that what makes the social is “association”, the formation of “collectives” and all the relations and mediations which make them hold together. These relations are established by an operation of “translation” or chains of translations (successive transformations) by which actors (individual or collective) are defined as spokespersons (or delegate actors), translate the will of collectives and also try to enroll new actors. In this way, the social is understood as being an effect caused by the successive interactions of heterogeneous agents, i.e. of the actor-network. The relative stability of an actor-network results from the strength of the relations and the mediations which make hold together heterogeneous collectives composed of actors, objects and discourse (but also of its size or length). But it can constantly collapse if some agents are withdrawn from the network.

In spite of these theoretical breakthroughs, the representation of these structures is difficult. In a first part we will define the concept of *agencement*. Then we will illustrate its application based on a concrete case of cluster - the project of the *Paris-Saclay Campus Project*. Finally, we will present formal tools allowing the modeling and the simulation of territorial *agencements*.

## 2. Definition of *agencements*

Our assumption is that the concept of *agencement* is generic enough to promote the idea that the interaction between social objects does not depend on metaphysics of unity (territorialized space around a central force of power) or substance (perdurant identity of entities in interaction). Conversely, it depends on a *movement*, a multiplicity which comprises many heterogeneous terms and which establishes connections, relations between them, through dimensions which are themselves heterogeneous. The *agencement* is what makes it possible to flee, by delocalization, any territory (or identity, or on substance), for the benefit of movement (and of becoming). This conceptualization synthesizes the work of Foucault, Deleuze and Latour that we gather under the term “Theory of the *Agencements*”<sup>1</sup>. Its

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<sup>1</sup> In [4], Foucault translator proposes to translate « *agencement* » by « *assemblage* » in English whereas in [7] the same notion is translated by “arrangement”. But [8] keeps the term “*agencement*”: An actor, said Callon and Koray, “is made up of human bodies but also of prostheses, tools, equipment, technical devices, algorithms, etc’. – in other words is made up of an *agencement*”. An *agencement* is thus an *assemblage*, arrangement, configuration or lay-out. We retain the French ‘*agencement*’ because it does not have a passive connotation the term ‘*assemblage*’ has in English.

objective is to offer new decision-making tools to urban actors.

Foucault defines an apparatus following: “What I’m trying to single out with this term is, first and foremost, a thoroughly heterogeneous set of consisting of discourses, institutions, architectural forms, regulatory decisions, laws, administrative measures, scientific statements, philosophical, moral, and philanthropic propositions – in short, the said as much as the unsaid. Such are the elements of the apparatus. The apparatus itself is the network that can be established between these elements (...) By the term “apparatus” I mean a kind of a formation, so to speak, that at a given historical moment has as its major function the response to an urgency. The apparatus therefore has a dominant strategic function (...) I said that the nature of an apparatus is essentially strategic, which means that we are speaking about a certain manipulation of relations of forces, either so as to develop them in a particular direction, or to block them, to stabilize them, and to utilize them. The apparatus is thus always inscribed into a play of power, but it is also always linked to certain limits of knowledge that arise from it and, to an equal degree, condition it. The apparatus is precisely this: a set of strategies of the relations of forces supporting, and supported by, certain types of knowledge” [3, 194-96].

Contrary to Foucault who seeks through the figure of the apparatus to make the idea of structure more dynamic (in structuralism sense), while preserving however the assumption of a certain homogeneity of the elements which are connected, Deleuze will build the differential of the forces which are embodied in *agencements* starting from an assumption of radical heterogeneity of their components. “Structures are linked to conditions of homogeneity, but assemblages are not (...) What is an assemblage? It is a multiplicity which is made up of many heterogeneous terms and which establishes liaisons, relations between them (...) Thus, the assemblage’s only unity is that of *co-functioning*” [4].

Latour pushes these intuitions to the limit in the Actor-Network Theory [7]. Here, an active entity (an agent or actant) is defined neither by itself (identity, essence) nor by its relations (its network). This apparent paradox is possible because the question of the actors and their network is always *empirically* untied, during trials in which agents, and *mediations* on which they rely on, operate *translations* enabling them at the same time (or not) to enter in relation, and to be defined as acting individual and collective entities. The dynamic “mediation-translation-trial” associates (according to dimensions which are themselves heterogeneous) and stabilizes an initial

plurality of heterogeneous entities according to three main steps.

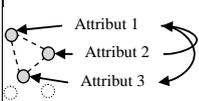
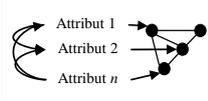
| Heterogeneous entities  | Hybrid Collectives or Networks   | Society or Envelope  |
|---|--|--|
| Points without attributes, "empties" entities (or social vacuity state)           | Points made up of the intersection of "free floating" qualities "plugable" with empty entities | <i>Agencement</i> associating attributes, translated and stabilized, appearing to emanate from the (full) entities |
|  |               |                                   |

Figure 2. The movement of an *agencement*

By radicalizing the idea that any materials, attributes or types of bonds can belong to an actor-network - human as well as nonhuman (according to the principle of Generalized Symmetry), Latour and Callon give an account of any phenomenon as a progressive aggregation of a plurality of "heterogeneous entities". This aggregation is able to stabilize itself during a trajectory, and thus forms a "whole" of associated heterogeneous elements. At the beginning of the situation of analysis (fig. 2, first column), agents are empty. Gradually, their own action and the action of the other agents equip them with heterogeneous and not inter-connected attributes (middle column). Through mediations and translations, entities get themselves associated into situations where they are defined by the modifications (translation) they realized on each quality that defines them. Simultaneously, actors are definable only starting from some lists of relations or attributes which very distant from what we can image actors are (right column). In short, heterogeneous entities *agencements* should ideally been visualized *simultaneously* starting from their activity and their relations. However, if one starts from agent, one will note the immediate metamorphoses of his identity. And if one starts from his attributes - "structure" - those will be permanently modified by his activity. The necessity of presenting these two movements *simultaneously* leads to a formal difficulty that we will try to solve in the section 4. Now we introduce the case study.

### 3. The Paris-Saclay Campus and VSB projects as *agencements*

"Grand Paris" is a project aiming at transforming Paris and its suburbs into a large world and European metropolis of XXIst century. It will cost approximately 20 billion euros in investments, according to the

government's calculations. It will place the *Ile-de-France* area in the leading bunch of the first five world-cities, along with New York, London, Tokyo, Shanghai and Hong Kong. In relation to the "Grand Paris" projects, an Operation of National Interest (OIN) plans the creation of the "Plateau de Saclay" Campus as a territory with high scientific and technological potential. It will be a pole of research and innovation of world rank, similar to the Silicon Valley. This project will benefit from an exceptional investment of a billion euros. This investment has been made possible by the National Loan, for a total cost estimated at three billion euros. This initiative implies the moving of some research institutes from their current territories to Saclay. In connection with this initiative which implies moving research institutes currently installed in their territories to Saclay, local politicians from territorial collectivities separating Saclay from the capital imagined in their turn to gather their efforts to form a territory baptized "Scientific Valley of the Bièvre" (VSB), complementary to "Paris-Saclay" cluster which they wish to promote within the political dynamics of "Grand Paris".

This economical context offers the opportunity to study two projects of new territories, both competitive and complementary. In [9], we analyzed in detail and from a comparative point of view the descriptive categories mobilized by their concerned promoters to expose these two projects, with a particular stress on the VSB. We studied many documents available on "Grand Paris" project, the prefiguration document of the project of the Saclay cluster (nov. 2008), and finally the documents produced by the conferences "Assises of the VBS" (in particular the 4th one held on June 2010). The analysis made it possible to apprehend the on-surface attributes characterizing the two *agencements*. To go beyond this first analysis, we use the concept of "Heterotopia" (space) proposed by Foucault in a text entitled *Of Other Spaces* (1967) ([http://foucault.info/documents/heterotopia/foucault\\_heterotopia.en.html](http://foucault.info/documents/heterotopia/foucault_heterotopia.en.html)). We asserted the idea that heterotopias precede *agencements* such as we defined them in section 2. Indeed, unlike the Utopias, the Heterotopias are existing places but which, as predicted by the *agencements* theory, are performative arrangements of heterogeneous entities. These are spaces of otherness, which are neither here nor there, that are simultaneously physical and mental.

The principal limit of our study was due to the nature of our data: data resulting from the projects communication documents tend to erase the movement of association of the entities involved in the *agencement* of the projects of new territories. A second test of the Theory of the *Agencements* was therefore

elaborated by using the Google™ search engine and starting from key words relate to the projects headings, scientific disciplines, political actors and organizations. The ranking offered by Google™ enable the analyst to identify the multitude of actions (and discourses) which express existing modes that are at the origin of the heterogeneous attributes which will be able, in a second time, to become the attributes (or list of relations) of the agents involved in the studied *agencement*. We analyzed five results pages in the surrounding of the terms related to the projects. Hereafter we find the extract of a request.

Pole majeur en recherche et technologies de la santee en Ile de France, la VSB propose aux portes de Paris, un véritable...

la science et la recherche représentent une composante forte du paysage urbain et de son identité

profitez de la dynamique de la *Vallée scientifique de la bièvre*

de la **Vallée Scientifique de la Bièvre** (VSB), la **Chambre de commerce et d'industrie de Paris** a développé un **programme ambitieux** visant à **renforcer son attractivité et son développement économique**

La conférence territoriale de la *Vallée scientifique de la Bièvre* organise ses 4es Assises le jeudi 17 juin dans les locaux de l'université Paris Sud

video Les assises de la *vallée scientifique de la Bièvre* à Fontenay-aux-Roses - Jeudi 17 juin 2010 ...

Nortel active le réseau "Rubis" de la Vallée scientifique de la Bièvre

13 mai 2004 ... L'équipementier canadien Nortel a activement collaboré au déploiement du Réseau métropolitain haut débit de la Vallée scientifique et ...

Table 1. Extract from Google™ search « Vallée Scientifique de la Bièvre » (30/04/2011)

The preceding table shows the links between attributes (generated by actions) and agents. Some attributes are relatively awaited, others less. Even if it is only an extract of the complete result of the request carried out on Google™, one already sees certain variety of the attributes and relations. The attributes common to several agents connect these agents and potentially modify the form of the attributes (structure and dynamics).

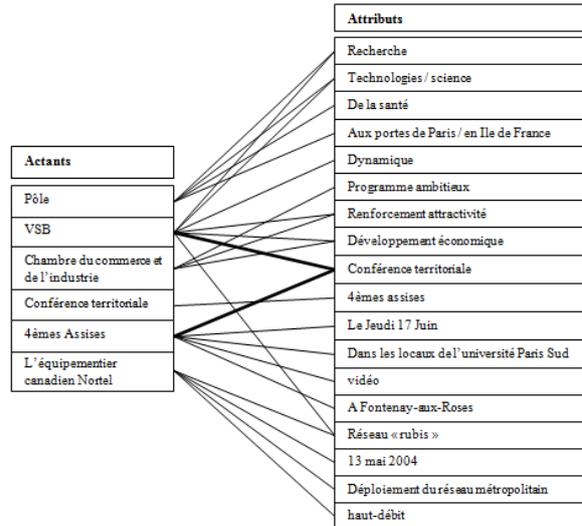


Figure 3. Table of actants / attributes

Let us take the instance of the agent “4<sup>th</sup> conferences”. Its attributes are: the date on which it took place (“June 17th, 2010”), the city in which it took place (“Fontenay-Aux-Roses”), the building in which it took place (“buildings of the Paris university”), its organizer (“Territorial Conference”) and the objects produced on the subject (“video”). Another example is the Agent “VSB” that has been filled by: some macro-fields (“technology” and “research”), some objectives (“reinforcement of attractiveness” and “economic development”), the involved technology (“network ruby”), its characteristics (“dynamics”, “extending on 2 departments”) and its authorities (“territorial conference”). Both clusters formed by “4<sup>th</sup> assises” and “VSB” (filled by their attributes) present a common attribute: “territorial conference” (relations are in bold in the preceding table). Therefore it exists a strong bond between the “4<sup>th</sup> assises” and the “VBS” through the “territorial conference”.

The problem, as we can see from this example, is the insufficiency of the binary relation which is at the base of the graph theory when representing the forming dynamics of an *agencement*. It is necessary indeed to go through n relations themselves multiple dimensions, and thus to use new mathematical methods generalizing the graphs concept, in parallel to hypergraphs. In the following section, we present the formalism of the simplicial complex, which we adapted to modeling and simulation of urban *agencements*. In mathematics, a simplicial complex is a topological space of a particular kind, constructed by "gluing together" points, line segments, triangles, and their n-dimensional counterparts.

#### 4. Modeling and simulation of territorial projects using simplicial complexes

An *agencement*, contrary to the binary relations usually described in the graph theory, is defined by a large volume of the elements which enter in composition (non-binary relations). The heterogeneous entities form a “system” because their links are based on some relations of dependences, which are themselves heterogeneous. Also, mereology (the “science of parts” in philosophy and mathematical logic) is useful to treat parts and the wholes they form [10]. For lack of room, we will not develop this point here, and we will focus on the way of using the technique of the simplicial complexes to follow and show *agencements* such as the “Paris-Saclay” Campus project.

We look for an algebraic approach for the representation of collections (structures) of heterogeneous elements (ingredients) and heterogeneous relations (connections and dependencies), but also for the representation of movements and possible pathways (dynamics). This approach should also allow considering the construction of a territorial *agencements* description tool for the modeling and simulation of cities.

The simplicial approach (Fig. 5) appears as an interesting mathematical theory. Particularly developed by [11][12], this framework provides a formalism of spatial representation of knowledge based on the Q-analysis (i.e. the representation and analysis of binary relations introduced by Atkin in 1977 [13]) and algebraic topology. This technique has been used, among others, for: research in urban planning, social network analysis, knowledge representation, content analysis, design or, more generally, systems analysis. Its application to territorial *agencements* allows a representation in a geometric form (Fig. 4 from the bottom to the top):

- The heterogeneous ingredients as “vertices” (parts);
- The combination or coordination of these entities within active entities in a “simplex” (micro wholes);
- The combination or coordination of these active entities in a territorial *agencement* as a “simplicial complex” (macro wholes);
- The territorial construction reality as “paths”.

Mathematically speaking, a simplicial complex is a set of simplices and faces (Fig.5a) and each simplex is an object represented by a collection of attributes or entities to which it is associated/ connected in a particular dimension (Fig.5b).

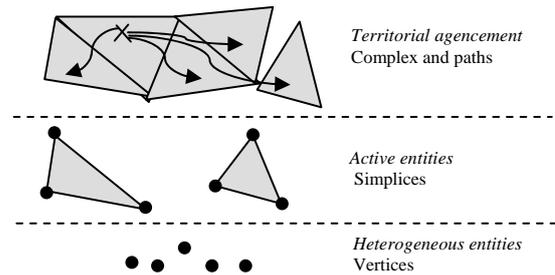


Figure 4. Abstraction levels in a territorial *agencement* model

In our work, each simplex is an active entity emerging from social, cognitive, mechanical, etc. relationships between the involved elements. These connections between entities and between simplices form a “path of connectedness” or “polygonal chain” (Fig.5e). Each elementary step of the chain corresponds to an elementary transformation; the complete chain represents the composition of elementary transformations, then the global transformation. So, we capture a territorial *agencement* as an area of possible changes. The complexity of one active entity (ie. the profusion of attributes and their relations within one active entity) can be analyzed as a complex node revealing a need to simplify this part of the territorial situation. In the same way, the lack of connection between two actives entities (two simplices) can be analyzed as a structural hole or break of connexity (Fig. 5f) revealing a potential opportunity within the studied territorial situation (ie. the possibility of imagining an entity or technical support that could cover the hole and, thus, link the active entities).

Such a graph is built in two stages: the network description (structure/“backcloth” [11]) with vertices and scores, and the description of dynamics (“traffic” [11]) which is specific to that network. The structure remains abstract but the traffic is a computational research (Legrand [12] indicates some calculations: measure of the degree of intersection between alternatives, measure of the similarity between several connected simplices that are involved in the sequence length, etc.). The topology of the structure and the characteristics of each of its vertices affect the traffic. Johnson [11] goes further by offering the distinction of different relationships between a given pair of points or set of points (Fig.5c). The result is a hypergraph that generalizes the concept of a relation between two things to relations between many things. Johnson gives an example of a hats network whose relations may be related to style or cost. It then defines two binary relations and Rstyle Rcost. This is a key point for the

representation of territorial *agencements* in which relationships are of various kinds. Johnson's work also provides an interesting look on the inclusion of the time issue in the emergence of such a structure (Fig.5g), "Simplices provide a way of defining multilevel structure. This relates to system time measured by the formation of simplices as system events" [11]. We can therefore consider following the emergence of an *agencement* and its trajectory step by step.

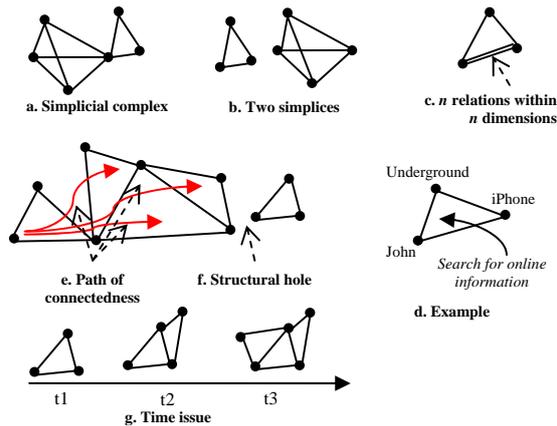


Figure 5. Main notions of the simplicial approach

If we take again our previous Google™ query (table 1 and figure 3), and apply the simplicial approach we note (in mathematical terms) that "4th assises" and "VSB" form two simplices with a common vertex (that could have been  $n$  common vertices or faces). All agents, attributes and relations form a simplicial complex (fig. 6).

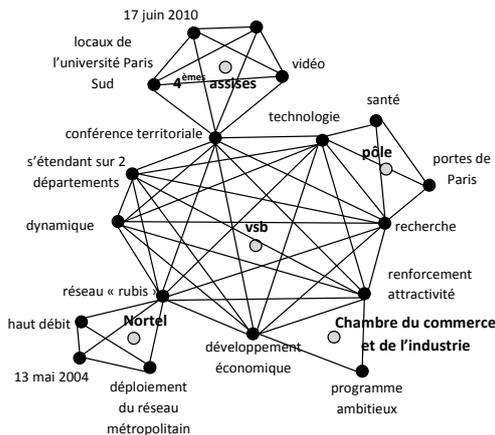


Figure 6. Simplicial complex of our Google™ query

## 5. Conclusion

This approach clearly presents mathematical and mereological intuitions. It relies on a strong principle of connectivity. The simplicial formalism is a rich and expressive formalism, which is a prerequisite for its use in the context of territorial, city or cluster modeling and simulation. Thus, we hypothesize that the combination of the simplicial complex technique and the mereological principles [10] allows the representation of space as heterogeneous network. The co-operation of heterogeneous configurations of entities in nested and interconnected mereological spaces gives rise to a territorial *agencement*. We propose to represent it through a hypergraph [11]. This overall structure provides access to various scenarios of "impermanent meta-organization" (or heterogeneous network) which are identified through the trajectories calculated by the connectedness principle within simplicial complexes. In short, vast urban projects, as well as "cities in action or in movement", can be modeled as hypergraphs in order to offer to urban actors' new decision-making tools.

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