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Understanding urban complexity in the light of asymmetrical warfare

Topological systems and complex relationships for analyzing the space of urban conflict

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Beyond any metaphor, urban complexity is the strongest defensive weapon of a city that faces unpredictable challenges. This can be extremely well exampled through the analysis of the effective role of complexity in recent urban warfare. By representing complexity as a topological system of complex spatial relationships, this paper introduces a tool for analyzing this role in some recent conflicts, where complexity has proved to be a key agent, forcing modern and developed armies to change or adapt their tactics and strategies after being defeated by far less equipped forces, allied with the complex urban setting. This confirms the hypothesis of the importance of urban complexity in situations of incertitude and its ability to anticipate a wide range of futures. Urban planning history has always been closely linked to military strategy history. Although it is not well known, this link is still ever-present. Therefore, while we may think that war is no more than an extreme aspect of (uneven) social and economic conflicts, it can be used as a powerful instrument to understand urban behavior.

Keywords: urban complexity, asymmetrical warfare, topological systems, graph theory, urban self-organization

1. Introduction

This paper summarizes the methodology used in a more extensive study, which seeks to reinforce the link between representation of urban complexity and conflict in cities. Here, we propose to introduce a new language for the city, through modelling and representation of its complexity. This new language conceptualizes urbanity and other related areas, aiming to stress the importance of spatial connectivity. As a result, we will see how this connectivity reveals itself as a defining value in the complex functioning of a city.

Such representation of urban complexity allows us to sequence several urban battles. This way of reading the urban environment could also be useful for understanding urban behaviour in different phases. According to this regard, this new urban language can be transferred and applied, not only in description, but also in planning of any type of relationships that are already established or might occur in the city.
In this study we have analyzed urban warfare in three urban sceneries over the last twenty years. The first battle was in Mogadishu, during the intervention of the U.S. Special Forces (Task Force Ranger) against the urban militia of General Mohamed Farrah Aidid, on 3th October 1993. The second and third battle took place in the West Bank, during the Second Intifada, in April 2002, in the Palestinian cities of Nablus and Jenin, during the intervention of the Israeli Defense Forces against Palestinian militia (Amnesty International, 2002). We will not expose how each battle developed, since our focus is on the relevance of urban complexity during a conflict, and by extension, on the 'normal' functioning of the city, through topological representation of urban space.

2. Complexity and urban conflict

Foucault, quoting Moheau, claims that interventions on the environment lead to an alteration of the human species itself. Bases of population are altered with the implementation of a project aimed at the environment, including projects regarding both creation and destruction. In Jenin, the devastation led not only to the lossing of urban structure, but also to the breakdown of underlying societal structures rooted in the refugee camp. And that is how, according to Foucault, security and control mechanisms interfere on *the perpetual intrication of a geographical, climatic, and physical milieu with the human species* (Foucault, Michel, 1977-78).

From an (eco)systemic perspective, precisely complexity is the mechanism by which any evolving system protects itself against uncertainty and chance. It is imperative to point out that we refer to open systems that exchange flows of matter, energy and information with the environment. Accumulation processes, carried out through history, have produced a complex order in the cities. This complexity should be interpreted in informational terms, according to the classical model of Shannon and Weaver. An urban system is nothing more than a communicative system that consists of relationships. The multiplicity of relationships – opportunities to establish communications – increases as time progressively makes internal processes of spatial differentiation more complicates. This progressive differentiation involves the gradual conformation of a fuzzy structure as a basis of possible and effective relationships among multiple and diverse agents.
In other words, the adaptability of the system, this is to say, its ability to reach different states according to demands taken place in the system environment (broadly defined; including individual decisions of agents in this notion of the environment, whose interactions constitute the urban system itself) necessarily implies some kind of diffusion of the structure of power. A complex system is undoubtedly difficult to govern while it is equally difficult to comprehend it. Understanding and deciphering complexity of the system with self-organizing capacity is not a question of estimation capacity, but requires a sea change in viewpoint: it involves dealing with chance and probability and banishing any hint of certainty and assurance.

We are facing a fascinating paradox: the city refines its adaptive capacity through the same mechanism which hinders its government and planning - complexity. Therefore, it comes as no surprise that hegemonic power structures, afraid of uncertainty, have constantly tried to reduce complexity. Urban planning history is a story of complexity reduction mechanisms and it is always linked to imposition of superstructures of power upon the "unbearable" fragmentation or dispersal of implicit decision-making capacity in a mature city. The multiplicity of links and the complexity of the network they create, involve a wide range of possibilities and individual decisions. Ultimately, there is a certain idea of citizenship as an active and responsible insertion in a complex network of decision-making mechanisms. The imposition of hegemonic superstructures has appeared to be peaceful (Baron Haussmann´s Paris is the epitome of this model) but what we are really facing is a forceful infliction, whose legitimacy depends on the very legitimacy of the government. Similarly, under the pretext of functionalist efficiency or mass housing provision, behaviorist discourse has legitimized building of new peripheries or radical renewal of urban centers by demolishing complex, "resistant" (and unruly) consolidated urban structures. A military conflict is an extreme type of conflict. It is unsurprising that many armies have been traditionally avoiding urban settings. In a conventional war, symmetrically designed armies face each other in an open battlefield. When it comes to incorporating a city in a conflict, the siege or, if war techniques allow it, the urbicide, are more likely to occur.

In modern asymmetric conflicts at least one of the sides is organized in an equally diffuse hidden structure. The same informational mechanism that links citizens with urban complexity also links the apparently less organized side with the complexity of urban warfare setting. The same adaptive capacity of urban structure, faced with a situation of uncertainty, becomes a weapon of defense even against the most powerful enemy, especially if he ignores the complexity of the setting and acts as if he was faced with something banal. It is no coincidence that the defeat of U.S. troops in Mogadishu has much contributed to a strange (and again paradoxical) enrichment in urban studies.

We find it important to part from the analysis of these extreme conflicts, hoping to develop an urban analysis methodology that would allow us, in turn, to illustrate, both topologically and spatially, evolutionary processes triggered by conflict of any kind.

3. Topological representation of urban complexity during conflict

Reading the city through the prism of systems theory, developed by a German sociologist Niklas Luhmann, helps us understand that it actually is a complex open system that exchanges entropy with its environment (Luhmann, Niklas, 1984). When system functions normally, entropy flows are negative. In other words, the system gives out disorder to the environment, building increasingly complex structures.

In order to analyze three urban battles from the perspective of complexity, we will use two agents: system and environment. The first one will be identified with the system of each city, including its physical, energy and communicative [informational] elements. The environment is everything that remains outside the system. The system boundary is not stable and it depends on the system alterations caused by environment. We shall consider that boundaries are found in those points of the system where the influence of the environment is negligible.

We understand the city not only as an urban system, but also as individuality, since the city tends to maintain its identity beyond physical and energetic transformations that happen therein. This concept, called *persistence phenomenon* (Ruiz Sánchez, Javier, 2001), is key to understanding processes the city is undergoing during conflict. Therefore, in order to preserve its individuality, the city must maintain its identity beyond any action that occurs between its system and the environment (Wagensberg, Jorge, 2010).

3.1 Topological comprehension of urban warfare

The more links there are between the elements of the system, either through an increase in the number of elements or their relationships, the more complex urban space becomes. In urban systems that we have studied, we tried to show that the complexity of urban space is partly determined by the complexity of its network.

In this research, the representation of these battles is focused on the link between private and public space. The connectivity within each space and also between them, determines the course of the battle, its strategies, and consequently, control over the adversary and urban space.

It is important to understand that urban system is not only composed of physical, but also of social and sensory elements and urban militias themselves. In that sense both Palestinian and Somali militia operate within the same system, known militarily as 'swarm' (set of semi-autonomous or autonomous units that conduct convergent attacks against targets in a determined place) (Edwards, Sean J. A., 2000). Taking into account the topological relationship that keeps individuals in a "swarm", as well as the concept of complex urban system, we propose to analyze the spatial system of the city from a topological and relational point of view.

Building a topological representation of an urban warfare involves understanding the city through the connectivity and compactness. The importance of this relational field in a complex construction of the city is manifested in an extreme way when the uncertainty of a system and its elements is increased by environmental factors. In our case studies, this vast increase of uncertainty is caused by an external military incursion, whether by the U.S. Special Forces or by the Israel Defense Forces.

In order to represent these urban conflicts as relational fields, we will apply the graph theory – a theory of topological character – to the battle development, representing a city fragment as a graph.

As graph theory has many applications and a great development in the research of connected components, graphs, as a tool to assess the degree of connectivity of a system, are used quite excessively. We find this theory appealing, since it is easy to relate the connectivity of a graph with the connectivity of urban space by using topological abstraction. Given that we intend to assess the complexity of the system as a key for guerrilla action, we believe that understanding the connectivity is the appropriate approach to tackle the relational field of urban complexity, although we are aware that we can not encompass all aspects of urban complexity.

3.2 Construction of the urban system graph

A graph G is a pair of ordered sets [V, A], in which the elements of A are 2-element subsets of V. Elements of V are called vertices and those of A as edges. As we will see, graphs are diagrams with nodes and lines, where nodes are vertices and lines are edges connecting the corresponding vertices. If a and b are two vertices of G, and [a, b] is an edge, this is represented as a-b. One of the inherent characteristics of the vertices in a graph is the adjacency; two vertices, a and b, belonging to graph G are adjacent if a-b is an edge of the graph G. Similarly, two edges are adjacent if they have a common vertex. The degree of a vertex is the number of edges is the incident to it (Harary, Frank, 1969).

The creation of each graph follows the exhaustive research of three battles we analyze, Mogadishu, Nablus and Jenin. Narratives we drew from each battle, allowed us to understand that the link between public and private space relational fields was crucial for development of each conflict. Using these parameters, we have elaborated three graphs for each one of the cities.

The first graph represents a part of Wardhiigley neighborhood in Mogadishu, where the battle of October 1993 took place. The graph G is created from a set of vertices V, marked as v_i, that correspond to public space between two city blocks in each street section [see *Figure 1*]. A total of nine blocks are represented in the graph G. Each vertex of set V characterizes the space belonging to public road between each pair of blocks [$v_1, v_2, ..., v_{24}$]. Each vertex is adjacent to six others, i.e. the degree of each vertex is six. We have established this degree of connectivity isotropically, since each street section connects with two consecutive street sections within public space and to four perpendicular sections in both directions. We have designed the graph G' [see *Figure 1*], isomorphic to the graph G, to avoid a predetermined grid. It will serve us as a public space connectivity representation.

The second graph explains the microscopic scale of the battle. Using the graph G' as a starting point, we have extracted the subgraph G'', which consists of the set of vertices $V'' = (v_2'', v_5'', v_6'', v_9'', v_{12}'', v_{13}'', v_{16}'')$. This set represents public street sections, limited by two blocks [see *Figure 2*].

The subgraph G'', extracted from the graph G', shows connectivity of only few street sections. Nonetheless, this subgraph is used to describe the connectivity of public spaces with private spaces inside each city block. Therefore, we have introduced a new graph H, which consists of a set of vertices U. This graph represents spaces and internal connections of each building bounded by the set of vertices V''. For example, the graph H, which connects with the vertex v_9 of subgraph G'', represents a building with an access to the street section v_9, containing several private spaces connected within the sequence u_1, u_2, u_5, u_{10} and u_{11}. This sequence shows circulation area of a building [corridors, stairs, etc.], and other spaces, represented by vertices of degree one, whose role in the connectivity of interior is less important [see *Figure 2*].

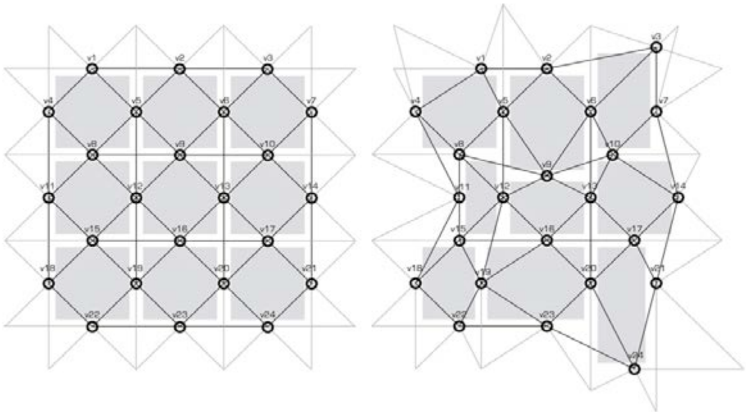

Figure 1. *Isomorphic graphs G and G': connectivity between streets of nine city blocks in Wardhiigley neighbourhood. [Source: the authors].*

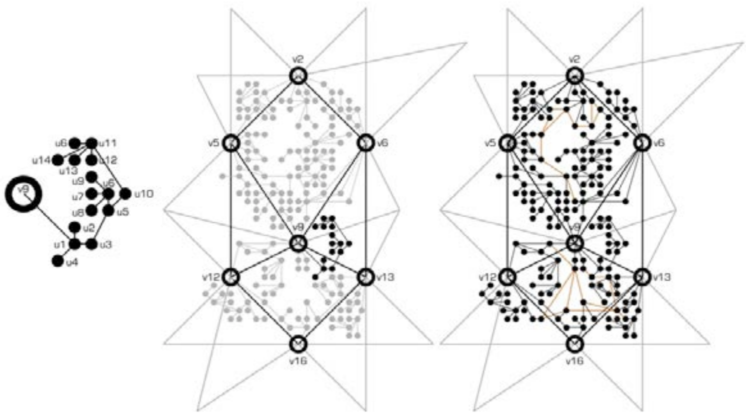

Figure 2. *Graph H and subgraph G'': connectivity between private and public space, two blocks. Conceptual model of two city blocks in Wardhiigley neighborhood. [Source: the authors].*

Finally, we introduce a type of edge that will convert the subgraph G'' in a multigraph[1]. All edges in the previous graphs were showing physical connectivity, i.e. the possibility of moving through public and private spaces. The type of edge introduced in this last graph refers to the visual relationship between interior spaces and vertices V''.

The subgraph G'' represents the underlying scenes of Mogadishu battle, in which both hiding capability, enhanced by good comprehension of public and private space, and situational aptitude of militia, were decisive for the course of the battle. This subgraph represents the space of insurgency.

[1] A graph that may have more than one edge between two vertices is called a *mulitgraph*.

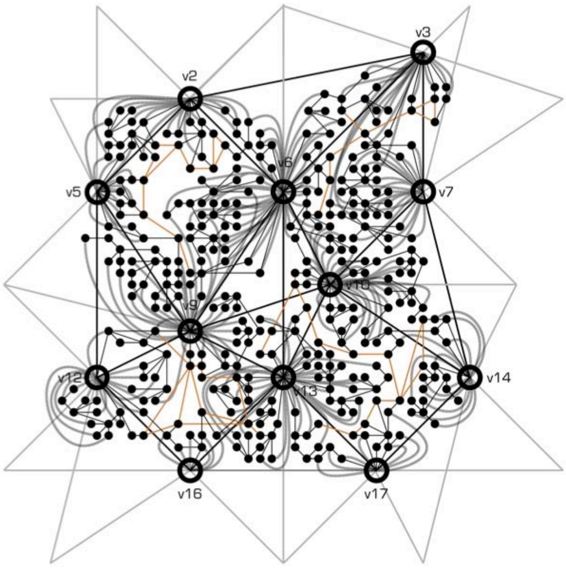

Figure 3. *Subgraph G": connectivity between streets of nine city blocks of Wardhiigley neighborhood, connectivity between private and public space and visual connectivity. [Source: the authors].*

Both spatial relationships and visual connections allow us to understand manoeuvres and spatial occupation during the battle of October 3, 1993, in the Somali capital. In case of Jenin and Nablus, we will reproduce this scheme through a couple of graphs that visualize two battles in which the militia have succumbed to counterinsurgency.

3.3 Topological representation of urban conflict.

After designing graphs of urban systems for three cities, we will represent the sequence of each battle. The subgraph *G"* allows us to understand how different adversaries occupied the space using its connectivity. *Figure 4* represents the advance of the U.S. Special Forces, which followed the isotropic grid of public space, while the Somali militia moved through all kinds of space, both public and private. The militia occupies the space in subgraph *G″* as a swarm, using the adjacencies between spaces, represented by black vertices in the graph [see *Figure 4*].

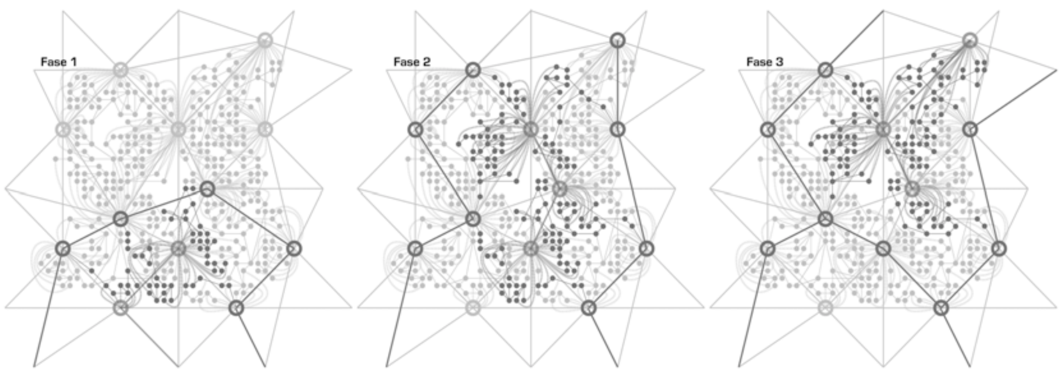

Figure 4. *Subgraph G″ showing the battle. The U.S. Army Raid and self-organization and redistribution of the Somali militia, phases 1, 2 and 3. [Source: the authors].*

These graphs, as well as the ones representing the battles of Nablus and Jenin, are used to highlight the importance that occupation through spatial connectivity has on the course of the battle. In that sense, it is understood that the richer the spatial relationships, the easier the self-organization of an urban system. The urban system, a mix of physical-energetic system and social or communication system can interconnect through the vicinity of its vertices, spatial grid and sensory grid. This organization is presented as a complex network, containing real and other possible relationships that are materialized under the threat of uncertainty.

It is important to understand that militia subsystem is a part of urban system. That is why the link established between connectivity of urban system and militia, allows militia to occupy space by self-organization. On the contrary, Special Forces failed to control some areas of public space. And here is where the debate on the importance of the profusion of relationships between public and private space begins.

By the use of graphs, the language of urban system allows us to understand the evolution of relational fields intertwined with that system. Graphs reveal the functioning of the social system, so they are a tool that models the urban system, a system that is characterized by overlapping physical, energy, and information structures.

4. Case studies

We mentioned earlier that the investigation was through examination of three urban battles. In this paper, we wanted to briefly expose a small part of the methodology. However, we also wanted to expose some of the peculiarities of complexity of those battles that we have stumbled upon throughout this research.

While in the first case study, the Battle of Mogadishu, the Somali militia, deeply rooted in the urban system, achieved to defeat foreign military incursion. In other two cases, the situation is reversed. In the case of Nablus, the Israeli Defense Forces managed to intervene in connectivity and the relational field of the urban system. To accomplish this, they had to override the existing system by the implementation of a new network. They opted for the use of a spatial connectivity strategy: avoiding public space and intervening in the city through private space. Therefore, they used tactics of 'walking through walls' of private homes and creating tunnels through Nablus (Weizman, Eyal, 2007). The implementation of a new system over the primary system caused its hypertrophy. The intruder took control over urban space and militia subsystem. In this study, this spatial control sequence is represented by a set of graphs, proving that one network can control another.

In the case of Jenin, the Israeli Defense Forces acted similarly. However, they discovered that the urban system of the city was closely linked to the military subsystem, so the resistance was very hard. Therefore, they proceeded with the destruction of the system, demolishing buildings and streets, which is known as the 'Jenin Urbicide' (Graham, Stephen, 2010). The Israeli army destroyed the structure of the urban system since its strategy of "walking through walls" was not complex enough to defeat the militia. Faced with the complexity of Jenin, the intruder has chosen the destruction and eradication of its relational field.

Reading the city as a system, as a complex relational field, allows us to discover and model the most relevant structures during a conflict. Furthermore, we understand that these structures and relational fields, currently not very common, can unveil new aptitudes of a complex city.

This new urban language – the topological representation of urban conflict – aims to highlight the importance of the complexity as a defining factor in the self-organization of the urban system and its physical and sensory elements. We understand that claiming the proliferation of connectivity and urban subsystems provides the city, forced into a state of uncertainty, an effective self-organization capacity.

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5. Acknowledgments

In conclusion, we have developed a tool for dynamic visualization of conflicts, based on design of space-topological graphs. This fact results in a new paradox: the graphs are not intended to represent the complexity as a static structural construct, but through its dynamic behavior because, ultimately, any action leading to self-organization of a system, is responsible for its evolution. The city is a system of both rivalry and mutual support. But the conflict of interests is at the base of the evolutionary nature of the urban system. Our hypothesis goes even further. Urban complexity remains a threatened value. Our contribution to its understanding claims this value: while offering tools for representing evolutionary processes, we advocate that uncertainty and chance should not be seen as the enemy to suppress but as a value to promote.