Network Buildings: Definition and Assessment

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Abstract. The International Congress of Modern Architecture (CIAM), through the Athens Charter of 1933, strongly advocated the creation of open urban spaces as an essential principle of urban planning, referring to open spaces such as the city's lungs. It is certainly for this reason that several authors choose the green spaces and urban parks of cities as the fundamental open public spaces to integrate in the design of new cities and in the rehabilitation of the oldest or parts of these. However, in the older cities, namely in their older core cities, or in compact cities the physical limitations, to a certain extent, make the existence and creation of this type of urban public space unfeasible. Above all, in these cases, the increase in the attractiveness of the public space should focus on the morphology of buildings, particularly on the ground floor, as it is also defended by several authors. In this context, this paper is dedicated to the definition of a new concept of building - network building (of generalized application to isolated buildings or set of buildings), whose conceptual characteristics have taken into account criteria of polyvalence, flexibility, adaptability, durability, sustainability, permeability and aggregation of functions. The role played by these buildings establishes connections and promotes pedestrian mobility, the interconnection of places of conviviality or daily use of the public space. These buildings also contribute to the diversity of activities of work, leisure, culture and housing, generating vitality of the environment and qualification of the urban areas where they are inserted. In addition to the definition of the new concept, an empirical assessment based on the adaptation of the correspondence analysis to the discriminant analysis is made to classify, in relative terms, 37 buildings of the city of Lisbon of the last 70 years.

1. Introduction
This paper addresses the theme of urban public spaces having the buildings (or sets of buildings) as protagonists. It is understood that the city must be a place that provides the establishment of links, connecting several entities: people, private buildings, public buildings, public spaces and other places [1], but this paper does not deal with how people interact with urban public space, an issue that was already addressed by [2].

Today, cities present a depleted image with no social or physical references, resulting from the disconnected areas and globalizing architectures that fragment heterogeneity and propagate the lack of cohesion of the urban territory, obstructing connection systems and urban permeability [1]. Contemporary cities, in most cases, lack culturally representative places and spaces with vitality that promote greater permanence [1] and attractiveness, although there are some exceptions, such as older
core cities, as well stated by [3]: “in the historical centers the square, often characterized by buildings of historical and artistic value, has preserved its function as a physical place of aggregation, circulation and exchange”.

In addition to the square, the planning and design of urban parks (partly driven by the Athens Charter of 1933) are generally attractive public space and appear as a solution to new cities that have large areas of free space. However, the old cities are confronted with empty spaces that do not allow the implantation of this solution.

Aware of this problem, [4] and [5] attach great importance to the ground floor of buildings in order to increase the use and quality of life in the urban public space.

Another possible action is to explore the morphology of the buildings themselves in order to establish networked systems between neighbourhoods, buildings, streets, squares and other architectural and urban typologies, weakening the programmatic and functional imbalances of the cities, as well as the restoration of pedestrian flows. Thus, this paper proposes an exploratory approach on the creation and definition of a new concept – Network Buildings [1]. This is a study carried out within the framework of the PhD program already completed by the first author of this paper, which seeks to explore and develop a new look at the connection of spaces through architectural examples – Network Buildings – capable of generating and maintaining quality in certain areas of the urban fabric.

The objects of analysis are urban buildings (or sets of buildings) with differentiated uses and located in the city of Lisbon, built between 1945 and today. It is at the beginning of this time period that Portugal embraces the Modern Movement and that there are significant urban and architectural changes. These buildings are also classified, in relative terms, in the light of this new concept and based on some criteria that integrate architectural and urban aspects.

2. Historical context
The "historic" city model [6] corresponds to a representation of social and economic organization, that is, cities would have been founded to bring people together, to live and work together, to interact with less costs, translating in an agglomeration of people who organize in a space a complex social system, to which called "organic solidarity" [7]. However, understanding the cities as "living and mutant organs"; resulting from various historical, civilizational, social, and physical transformations that have taken place; have led [8] to make a critical portrayal of urbanity over time.

It is at the beginning of the twentieth century that the architecture of the Modern Movement, whose true rise only takes place after World War II, brings changes and innovation in the cities, as a consequence of the modification of the deep habits of the people who inhabited them. There is a significant change in the way of designing urban space, in the understanding of the living space and in the socioeconomic values of urban environments [1]. In this period, the free-standing blocks were the unit of the building system. Its spatial isolation was an obstacle to the permeability of the city, both by its length, by the junction with other blocks, by its repetition and by the quarters. However, some architects such as Gropius [9] and Le Corbusier reacted to this architectural and urban problematic of the Modern Movement, respectively with the Bauhaus School in Dessau (1925-26) and Villa Savoye (1929-30) in Poissy; designing modern buildings with principles of permeability and circulation assumed in design phase [1].

The International Congress of Modern Architecture (CIAM), through the Athens Charter, strongly advocated the creation of open urban spaces as an essential principle of urban planning, referring to open spaces such as the city's lungs [10]. It was probably this idea that motivated several architects to choose the green spaces and urban parks of cities as the open public spaces fundamental to integrate in
the design of new cities and in the rehabilitation of the oldest ones or parts of them (see e.g. [11], [12], [13] and [14]). The Charter of Athens, according to [1], also made an essential contribution to the contemporary cities, since it defined the functionality and structuring of modern urbanism, especially in Europe. The zoning of leisure areas, housing areas and green areas was determinant for the connection and structuring between the built spaces and the empty spaces of the urban network. A process of valorisation of the urban soil belonging to the public domain as a support for urban permeability and mobility took place; as well as the notion of neighbourhood unity, which motivated the action of pedestrian connection between housing, services and equipment [1]. Consequently, according to the same author, buildings have risen from the ground through structural elements such as pilotis, which allow permeability and transparency between free and built space. The study on the physical configuration of buildings with the use of urban land in a more systematized way was initiated and deepened by [15] and [16], relating the geometric shape with the surface of the urban soil. They emphasized the relationships between the morphological elements of the city, such as streets, built parcels and forms constructed in order to identify patterns of the use of space, which allowed assessing the physical structure of the city.

This new procedure of "making" city, creating a quarters system, allowed presenting a new image of the city (light and permeable), far from what was known until then (a labyrinthine and compact city with contiguous buildings, with dense and rigid facades). The increase in population density without loss of quality of the public space forced the city to become vertical and gain permeable spaces (see e.g. [17], [18] and [19]) and open to ground level, appealing to urban mobility. This change in the experience of the city was decisive for a more qualified way of life, totally different from what happened in the traditional city where the street predominated as the only distribution artery for pedestrians and vehicles and where the built elements were effluents and define those axes of communication in the distribution of urban flows.

However, according to [5] “The development of society and the attendant development of architectural ideals have created an urban architecture where meaningful close encounters between city and buildings and between people inside and out have disappeared almost automatically”. This idea is corroborate by [3] stating that: “the contemporary towns are progressively losing their connotation as spaces with precise functional characteristics, to become fluxes (of people, exchanges, relations, etc.), and are completely plunged into the development of a thick network of planetary communications, which make unnecessary and obsolete the traditional meeting spaces designed for various activities.” In fact, contemporary cities; due to its rapid growth, territorial expansion and population increase; are planned by disjointed areas, lacking qualified urban sense and the absence of connection and permeability systems, presenting with high fragmentation and heterogeneity in the urban fabric [1].

In addition, people continue to walk in public spaces (also in new cities). Furthermore, almost all cities (particularly the new ones) have stated policies to make public space pedestrian friendly, lively and safe. There is widespread awareness that it is healthy and energy efficient to walk, cycle and use public transport – which presupposes being able to walk comfortably and safely to and from transportation nodes. In short, lively, attractive and safe cities are on the public agenda” [5].

3. Definition of the Network Building concept

The Network Building concept, inspired by the Graphs Theory, is in all analogous to the concept of network communications, namely with regard to the notions of connection, communication, sharing and exchange.

This is an innovative concept, still in development, coined for the first time by [1] and who intends to relate ideas/notions with a new way of reading the buildings of a city.
In the current phase of the investigation, the Network Building can be defined as the whole building (or sets of buildings) that includes, in an integrated way, several characteristics (independent of cultural, economic or technological origin) that contribute to improve connection, communication, sharing and exchange between its users (or inhabitants) and the surrounding urban environment, regardless of whether its circulation or communication is horizontal or vertical. More concretely, the Network Building should:

- be a product of a harmony between the values of architecture and urbanism in concern of a more cohesive, more collective, more participative and efficient city;
- be a fundamental part in the communication and displacement of people and goods in the city, giving security and encouraging their journey;
- be original and context-appropriate;
- be legible and coherent from the formal point of view;
- be consistent between formal reading and use;
- be multifunctional in its uses and relate to the geomorphological context, respecting collective values and memories;
- be a generator of urban life;
- be identifiable and understandable to users;
- establish connections between road systems, urban spaces and buildings;
- establish permeability with the territory and surrounding space;
- establish relationships with the street.

This concept has as main objective to recover the street as "community stage" where people and goods flows [1].

For the set of characteristics mentioned above, the same author also identifies four distinct subtypes (not developed in this paper) of networked buildings:

- those that are attraction poles – buildings that congregate certain types of functions and that attract a significant number of people during a certain period of time;
- those that connect attraction poles – buildings that establish links, or through their permeability attract and allow the flow of people connecting the places of attraction or interest;
- those that generate poles of attraction – the building appears first and later the poles of attraction, the building requalifies the zone and promotes the attraction of people and uses to the surrounding/adjacent area;
- false network buildings – buildings that indicate crossings, a possible link between urban spaces but in reality are no more than insurmountable barriers.

The Network Buildings can thus be considered as "actors of urban transformation, determining the quality of urban life independent of its scale in the territory or physical dimension" [1].

4. Case Study: Lisbon

The city of Lisbon presents a heterogeneous and dense urban network, fruit of an enormous historical temporality, from the medieval period until the present time. The urban permeability in Lisbon was portrayed in intelligible ways and could be detected in the medieval labyrinthine mesh resulting from its constructions, sometimes through its defensive wall – Cerca Fernandina –, sometimes through the city gates, sometimes through the working-class villages and in urban planning [1]. That pedestrian and mixed urban permeability's are nothing more than streets that cross buildings or quarters, or roads...
that circulate under or between constructed masses [1]. These less common spaces of circulation were approached by [20], presenting a descriptive survey of some of these passages.

The fragmentation and dispersion of the city result largely from the implantation of buildings that are disconnected from the urban network or from the place where they are inserted, as well as from the misfit programs and the insufficient treatment of the surrounding public spaces [1].

According to the same author, some buildings in the city of Lisbon, in addition to their high speculative real estate value, are out of date from the place where they belong, that is, from the city network. They function as small autonomous cells, hermetic to their surroundings, which almost originate the creation of new small towns. They often arise due to security issues, power marking associated with exclusivity or also the exclusion factor. It is understood that the concept of inhabiting put into vogue by the Modern Movement is diluted. The house is inhabited and lived only in its interior not relating to the outer space that surrounds it. The Network Buildings appear in urban territory as spaces built by and for society, which uses and lives together the public and the private spaces.

Thus, in the Portuguese architectural context more precisely in the last seventy years, the search for innovative solutions of organization and construction of the building generated solutions that on the one hand would promote permeability and on the other hand would connect different attractive poles in the city.

As not all builders probably fulfil this function, an assessing methodology was used to classify these buildings.

4.1. Network Buildings assessment
In figure 1 the buildings that were submitted to the evaluation are located geographically and identified. They are described in detail in [1] in terms of their location, implantation plan, photographic documentation, authorship, project design or building dating, functionality, use and framing.

In accordance with the definition of Network Building given above, nine binary variables (yes or no) were used to express the concept (see table 1).

The assessment was carried out using a robust methodology – adaptation of Multiple Correspondence Analysis (MCA) to Discriminant Analysis (DA) – described in detail in [21, 22] and has already been applied to other knowledge domains, both for their simplicity and for the promising results obtained in these applications [23-28].

The variables in table 1 submitted to the analysis were coded [29] in order to constitute a complete disjunctive matrix (see table 2). In this phase, expert information, with a strong multidisciplinary component, plays a fundamental role in defining the importance that is assigned to each variable, in the number and limits of the classes in which the variables are divided. In this particular and exploratory case all variables are equally weighted and all divided into two classes. To this matrix were added two fictitious lines (see table 2), one that brings together the full characteristics of the Network Building (EdR); and another that brings together the full features of the Non-Networked Buildings (EdNR), which constitute the defining archetypes of the extremes of the arbitrary quality scale and which defines the discriminant axis. The coordinate of the projection of the individuals (the 37 buildings) on this scale constitutes the classification of these individuals as or not Network Buildings, that is, the quantitative representation of this quality.
Figure 1. Location of 37 buildings or sets of buildings submitted to analysis
Table 1. Variables used to assess the Network Buildings

| Main Domain                  | Variables       | Definition                                                                                                                                                                                                 |
|------------------------------|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| **Architecture**             | Function        | It translates the multipurpose feature, increasing the permanence and diversity of occupations within the building, making it more attractive and dynamic for users or inhabitants                                        |
|                              | Parking         | It added value for the functional organization of the urban space, as well as the way of approaching the user to the building, not neglecting the car                                                                 |
|                              | Ground Release  | It increases the permeability of the urban territory, contributing to a higher yield and use of it; this space can be converted into public areas or green zones with influence on the flows and stays of the users |
|                              | Multifunctional | It is related to the adaptability i.e. with the possibility of the building being reversible as to its use and making it more durable and temporarily more profitable                                               |
| **Urbanism**                 | Security        | It is a combination of physical and psychological factors; such as: open spaces, little winding spaces, illuminated spaces, pleasant and inviting places that encourage the journey and stay                         |
|                              | Pedestrian Access | It is related to aspects such as the adequacy of the pavement, climacteric protection, direct routes associated with spatial sequences, pleasantness of the pedestrian path, become more attractive |
| **Urbanism + Architecture**  | Permeability     | It is related to accessibility and pedestrian mobility, i.e. with physical and formal aspects of the building, with empty spaces, with release of the ground and with visual transparencies through materials; allowing connection between places and the shortening of distances |
|                              | Public Spaces    | It is related to the valorisation of the social and spatial relationship of the city, through the congregation of people to different activities in a space more protected and away from vandalism               |
|                              | Green Areas      | It is related to the connection between comfort, climate and social activities, valuing the place and complementing the architecture                                                                         |

Table 2. Complete disjunctive matrix with two archetypes EdR and EdNR.

| Building | Function | Ground Release | Green Areas |
|----------|----------|----------------|-------------|
|          | MUy      | UUn            | Yes | No | Yes | No |
| 1        | 1.0      | 0.0            | ... | ... | 0.0 | 1.0 |
| 2        | 1.0      | 0.0            | ... | ... | 0.0 | 1.0 |
| ...      | ...      | ...            | ... | ... | ... | ... |
| 36       | 0.0      | 1.0            | ... | ... | 0.0 | 1.0 |
| 37       | 1.0      | 0.0            | ... | ... | 1.0 | 0.0 |
| EdR      | 1.0      | 0.0            | ... | ... | 1.0 | 0.0 |
| EdNR     | 0.0      | 1.0            | ... | ... | 0.0 | 1.0 |
In practice, the data matrix of Table 2 is submitted to the MCA algorithm (EdR and EdNR lines as active and the rest as supplementary), through AnDad software version 7.1 [30] and [31], projecting the buildings in the discriminant axis that defines the arbitrary scale of classification of the Network Buildings, and whose extremes are given by the archetypes EdR and EdNR. The results obtained were rescaled on a scale of 0 to 10 and are showed in figure 2.

**Figure 2.** Results obtained (rescaled) by the methodology applied to buildings assessment

For the sake of clarity the results were divided into three groups (Figure 2) illustrated by an example of each group in Table 3. The group of twelve buildings that obtained higher ranks (9 and 10) meets the large majority of established criteria and may in fact be considered Network Buildings, that is, they promote the characteristics of the definition given above. The group of six buildings with smaller classifications (< 4.5) meet few of the criteria considered and are Not Network Buildings. The group of nineteen buildings that obtained ranks between 5 and 8, occupies an intermediate position.

**Table 3.** Example buildings of each group

| Building number | Name | State | Location | Photo | Level |
|-----------------|------|-------|----------|-------|-------|
| 26              | Edificado do Montepio Geral (Montepio Geral Buildings) | Designed between 1955 and 1957 | ![Photo](image) | ![Photo](image) | 9.0 |
| 10              | Quarteirão Antiga Fábrica União (Old Union Factory Quarter) | Rehabilitation and reconversion start in 1999 | ![Photo](image) | ![Photo](image) | 7.7 |
| 17              | Conjunto da Praça de Alvalade (Set of Alvalade Square) | Built in 1960 | ![Photo](image) | ![Photo](image) | 4.4 |

This assessment clearly demonstrates the existence of buildings that play a key role in the dynamics of cities and in the increase of the quality of urban life – Network Buildings, while other buildings do not promote these functions.
It is not intended that all buildings in the cities are Network Buildings, but only alert the various stakeholders and agents involved in the cities to the importance that these buildings have in increasing the attractiveness.

5. Conclusions
The creation and definition of the Network Building (isolated object or sets of buildings) concept, results from the integration between architecture and urbanism; through notions such as shape, function, permeability and connectivity. This concept intends to contribute to the construction and understanding of new centralities and better architectural and urban connections, translating into good urban living.

The Network Buildings will contribute to the reduction of commuting movements in the city stimulating pedestrian circulation, thanks to its versatility and functionality. In this way, it is believed that they are fundamental pieces for the revitalization and rehabilitation of part of the urban fabric, with connections and adding infrastructures, enabling a better quality of life for the residents of urban areas.

The interest and novelty of the results obtained is related to the classification of the urban buildings of the city of Lisbon, in relative terms, and the value they represent for the environment and for society where they belong. Its practical application is expressed in what will be understood to be better or worse Network Building or what is intended to be known as a possible hypothesis for the architect or designer to design a building with quality and urban utility.

As [32], cited by [33], refers the future of cities derives from their territorial wealth and culture, as well as from the capacity of their stakeholders (residents or users) to overcome difficulties and generate a new civilization, consequently to propose a new urban model, in a joint effort so that they can build a just community.

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