

Architecture as system: Study of housing systems evolution

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Abstract

Understanding architecture via the concept of system came after numerous, rapid and different developments upon all aspects of architecture, especially since the last third of past century till the present day.

Some theories characterized architecture as the complex whole that based on the different relationships and interrelationships with different sciences, besides of the multiplicity and independency of internal components, it should be assigned into the world of integrated system.

This study attempts to explain the phenomenon of architecture through the concept of (system), in order to include both its cognitive (the subject) - which is potential, and realistic presence (the object) -which is explicit. This study tries to explore both sides of the concept, in order to understand the architectural system -in one hand and determining its components -in the other hand.

To find out how these systems which have been developed via some housing projects, as an integrated system; comprised by secondary sub-systems with clear limits, within the total system of the housing architecture. This study follows the inductive and descriptive approach as a methodology, depending on the related literatures and applied available theories in housing projects during different periods of time.

The study aims to identify the systems and levels, set to reach a comprehensive understanding of the architectural system in general, and the evolutions of housing systems, in particular, benefiting from the rapid developments of this architectural style (Housing), which have been seen in many various levels too.

Key words: System approach, systems and complexity, architectural system, housing, housing systems.

Introduction

Architecture is considered as one of the main tributaries of civilization, and form one of its physical components. Therefore, some describes architecture as representing the progress of civilization through holding its characteristics and representing the spirit of the

time. While other described architecture initially as (civilization) itself, where it has been demonstrated and evaluated by architecture. (Robinson et al., 1991). Undoubtedly, the production of human idea includes components such as (cultural components), is described as a set of characteristics may also be shared with

other properties such as (change, creativity, continuity, generation, etc).

What brings these characteristics in a particular and specific framework is the concept of (system), as an integral whole. This includes components linked together by mutual relations, -in one side-, and other relations with the (whole), -in the other side-.

Thus, the research problem is identified by the lack of scientific view to assigning the architecture through the concept of (system). According to this, the research aims to determine the overall system of architecture –in general-, and housing systems -in particular-, through the integration of its internal systems. To achieve this, the research hypothesis formed as the understanding of ”system” concept, which will contribute significantly in exploring the complex nature of architecture. In addition to this, the identification of the secondary systems (partial), and their integrations will contribute also in determining the overall nature of the comprehensive system of architecture.

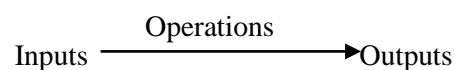
This study will follow the descriptive methodology based on inductive procedure approach, to prove the validity of hypothesis in one hand-, then to reach the main objective of the study in the other hand.

System and System Thinking

“System” is a collection of parts or components, which interdependence between them leads to form (the complex whole), or (a unity of the complex whole). As this (whole) is composed of parts and elements linked by relationships. These

linkages and its mechanisms shall make the models however they are (closed), or (opened).

The main part of the general systems theory (GST), insist on strict operations that support certain models. Each model is an expression of one thing; that helps to understanding the other things. This approach is trying to help thinking about exploring the general laws. Although these laws may be placed on an irregular basis, but helps in the initial understanding. So the system is (a whole), which can be treated as a whole too, with special unity. And also to claims that this unity includes operations, and has inputs and outputs too. Inputs came from the outside of the system, once entry into the system and its operations, become a part of that system as shown in the equation below:



The equation indicates that there are linkages too. The presence of outputs in the system is an indication of the (direction-oriented goals), which are directing the whole towards it. As well as the existence of operations, will form an index to possess the behavioural characteristics. In order the system appears in such form, all linkages and moral characteristics should work accordingly (Handler et al., 1970).

Thus, it is necessary that the outputs will be correspondent to their targets. If not, the Feedback on all parts of the equation must be chosen, to complete the process according to the goals of the system. Thus the idea of the system will be completed at last.

System approach as a tool in managing the complexity

Recently, things has become fragmented, and divided into separate and secondary principles. This helped us doubtlessly to imagine how things have been weaved.

Assigning the world of the system, concepts of mutual relations and different levels of description from accurate to moderate and then to macro levels have been evoked. This is contrary to what exists in the reductionist approach, (which take into account the institutional and structural components only). So according to Moschella et al. (2012), system approach keywords are:

- Levels of description,
- The recipient role,
- The overlapping principles and,
- Evolution.

The system approach links between (systematic thought) and the (functional thought), where function is the dominant characteristic of things in general. Thus the building functions and their components are the way to how they work.

System approach thinking, and architecture

In modern science, in contrary to the Greek conception, (Bertalanffy, 1968) assigned, that (dynamic interactions) appears to be the central problem in all fields of reality. Its general principles are to be defined by (system theory) (Vibaek et al., 2011).

In this regard (Handler) said that to see architecture as a system – means to see the architectural process in an objective framework, and the architect as (Analyzer/Designer), required to know and diagnose system procedure with their properties.

This leads not only to emphasize the problem in deep, but to provide a good ability in (Generalization), where, without this ability, the architect become a tool in isolate within the set of operations (Rasul et al., 2003a)

Thus, it is possible to look at architecture as a (Wholeness), includes many and varied parts (Systems), interact with each other in the dynamic linkages, seeking to form an integrated composition within multiple integrated configurations, and the nature of these systems oscillating between (physical) and Others (non-physical), according to certain rules.

Due to this concept, architecture is an integrated and comprehensive system constantly seeking to create balances between these systems, and so as to achieve its structure, and its final form, and then emphasizing on its (entity, consistency and stability), within this frame.

Accordingly, the factor that act in distinguishing an architect among the others, is his (her) understanding about the architectural design as a process, in the (implicit system), and how to be used in another (explicit system). Here (creativity), lies as a framework to show these systems. (Rasul et al., 2003a). This vision requires first, the knowledge with this system, and then the ability to perceive its relationships, -in the second place- and then, build a new vision - new system image - to the system as whole. As result, the system in an architectural context is seen always, representing a certain time, social situation, and stages of technology.

Architecture as System

Interpreting architecture through the concept of

system, is variable and renewable, it depends on codified systems constants. Human imagination goes beyond the physical presence of the place itself, and associated beyond it, his understanding for the limited space at a given time, but also the process of space configuration in the place architecture has been changed due to human perceptions variables and his interactions.

The variables derive its vitality from constants. Variables are the tangible material product in its various forms, and the constant is the codified system for producing the product. Between constant and variable activities, the human creativity activated according to his creative capacity. So, each cultural and societal environment has its characters which forms systems, mentioned above.

Constructing the architectural issues and its components shall be done, to achieve the goals in a given environment, to get -in the end- multiple properties as: (ideas, physical, optical and geometric), or rather, architecture designed to operate a certain behavior in the shade of a series of events and goals for the performance of a particular function and in a particular environment as well (Figure 1).

The concept emphasized that the system has been working in architecture, and including it, too. And it will be on the opposite side of (organic systems). As the output and processes that contribute in this creative acts, will enter within a particular system and mainly directed to achieve a known humanitarian goals. (Rasul et al., 2003b). So the equation formed as:

Tool - user - need = building - human – function

Thereupon, the buildings form a (system), with interrelated components (functionally), designed to achieve the certain goals. Thus the idea of (system) has entered into a way of thinking and the work of architect. And the architect should have a knowledge with these cognitive processes involved components and its details. He should also to develop goals related to these components on the one hand, and the overall goals of the architectural system - as a whole - on the other hand. This is via awareness and regular tests of the elements with the surrounding environment and the design problem too.

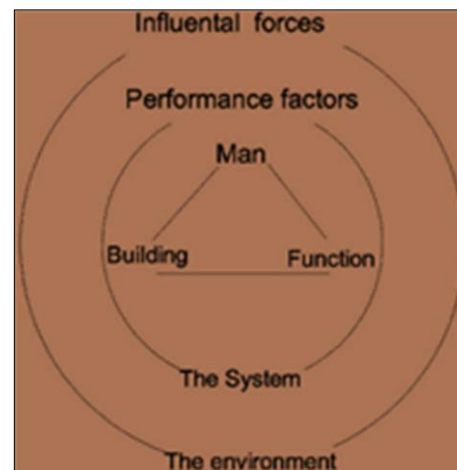


Figure 1: Architecture as a system. [From (Rasul et al., 2003 a)].

The Architectural System

Mies, (1990) expressed the state of architecture as a (system), and defined the role of (the subject) in govern the relationship between the (quantity) and (quality) and linked them to place - architecture as a state of place expression. Where it was considered that the (spatial quantity) represents what is personal, expressed by (openings, materials and other physical elements). But (quality), represents the system which deals with (the object). The system is the base for the process of putting this (quantity) with (quality- how-)

within that base to configure the image of the place. (Meiss et al., 1990).

Although the object in this area related to the building – as a system-, and then determine this system as (physical and technical aspects), within the building process, but it's in the same time formed - a major systems- in the architectural system, depending on the facts that there is no architecture without building or that the architecture always represents the building.

The importance of sub-systems is varied from one researcher to another. At a time that Handler (2003) emphasizes on the design process, Markus (1971) sees the effectiveness behavior take this position. While Angyal (1973) emphasizes on the human in his trilogy (human - the building - the environment), Broadbent (1973) gave this importance to the ecosystem. On the other hand, Ching (1979) confirms the spatial, structural, enclosure and circulation systems, while Rush and Ehrenkrantz (1989) confirms on structural systems. Rezouki (1996) agreed with them and confirmed the importance of two systems (material and form) evenly (Rasul et al., 2003c).

Human system has interrelated with the design system, and will form both extremes of (subject and object) dualism. How the subject deals with the object is the quality of system configuration. Thus we find out that, it is possible to treat them as a single unique system under the title of the (system of thought), whereas it also contains a human deal (designer) with the (design problem), in all its dimensions and relationships.

While the (object) configures as all systems outside the (human systems – Designer), where -

in architecture systems - determined as (Building, Form, and the external forces impacted on architecture, social, economic, technology, environment, etc).

Building process: (Design and construction) as a system

As Ulrich and Eppinger, determined that the system level of design phase includes:

“Definition of the product architecture and the decomposition of the product into subsystems and components. The final assembly scheme for the production is usually defined during this phase as well. The output of this process usually includes a geometric layout of the product, a functional specification of each subsystem, and a preliminary process flow diagram for the final assembly process” (Vibaek et al., 2011b).

Creating systems has always played an essential part in architectural works. By defining basic rules of the building process, the architect has been enabled to manage the structure and the architectural expression of the building.

Today, the world is facing new challenges; so new systems and new ways of perceiving systems needs to be developed to match an increasingly industrialized way of production. It is important not to see systems as limiting aspects but rather to see them as positive challenges in the creation of architecture. To ensure the architectural quality, new rules needs to be made to create a closer interaction between architecture and new means of production (Vibaek et al., 2011c).

Historically, the building as a system classified in to many types of system during its evolutions such as (The SfB system, bips and DBK – Danish

building Classification-, BSAB, IFC and STEP, Omni class/OCCS, etc) (Vibaek et al., 2011b). IBS (integrated building system) is another and important milestone in this approach, it forms a roadmap in the introduction of -Modular Coordination (MC). MC is a concept of coordination of dimensions and space, where buildings and components are dimensioned and positioned in a basic unit. The concept allows standardization in design and building components. It encourages participation from manufactures and assemblers to enter the market, thus reducing the price of IBS components.

Modular need to be adopted to cut down the waste in IBS. However the implementation of modular coordination requires better design planning (Mohd Idrus Din et al., 2012)

Housing

The concept of housing has developed with the evolution of development concept, and that the most important aim is human well-being and his prosperity. Housing no longer means, providing dwells with any qualities for human only, and not isolated with the structure of surroundings.

Today housing means integrity, product, sustainability and social life. Housing reflects the degree of complexity in design, attention, dignity, freedom and human's right to live in the framework of resources –actual and perceived- and economic activities. Due to their interrelationships, interacting and inter correlations, these influential forces acts as system and raising the degree of design complexity (Figure 2).

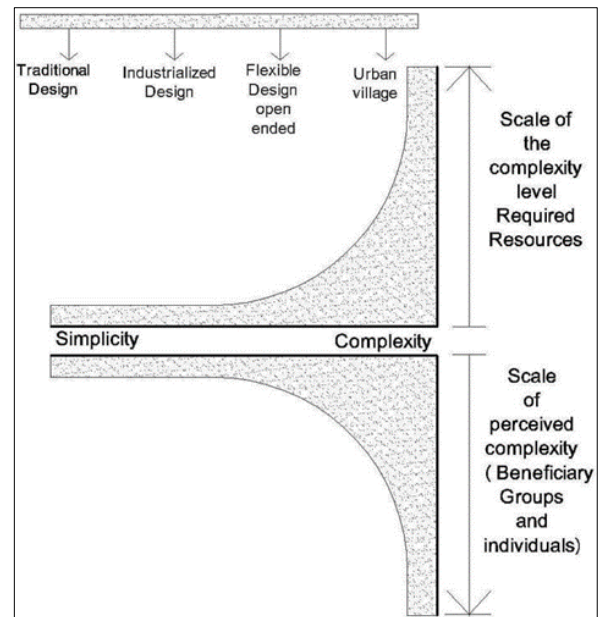


Figure 2: Architecture and the design complexity. [From Vibaek 2011b]

Habraken (1972) defined housing, as a complex set to achieve purposes that serve inhabitants, where interrelated variables overlapped, and influenced to each other. So, it considered as the field of conflicting forces (Habraken et al., 1972). Habraken (1972) emphasized that the housing form an issue, in which many variables overlapped, interrelated such as (social, cultural, economic and even political). Via integration between them, the ultimate goals of the entire housing process will achieved, creation a healthy, socially, and comfortable residential environment. He pointed out that the housing unit, must be a tool to achieve the requirements of the occupants and a means to represent them in the community.

Heidegger (1997) confirmed that the interactive relationship between man and his dwell is the basis of the housing process, the positive interaction that achieves the idea of housing (Hidegger et al., 1997).

Housing from the standpoint of (structuralism), indicates an internal structure similar to the structure of space and includes a number of diverse secondary places with varied characters, and linked to each other via paths, showing various events of daily life. Thus the house considered as a dwell's structure, and a system of meaningful activity (Despres et al., 1991). So, housing means more than providing dwells, and influenced by many various, interrelated forces, contributing in forming subsystems to the housing overall and complex system.

Housing Systems

Modern man, influenced by heredity and environment, can hardly imagine constructing a building in any other way, than producing small or medium sized components, and putting them together at the site. This is a fundamental reason why we are still building so irrationally around the world (Schömer et al., 1997).

Rapaport (1969) confirmed that, building the dwelling unit is only a building of the phenomenon of civilized space, and its shape influenced by cultural environment, which individual belongs to (Rapaport et al., 1969).

However, housing cannot be seen in isolated affected factors, and environment, it forms a permanent part of this environment. Organization of these parts – between each other and with the whole, formed the structure of the housing system.

After the Second World War different kinds of prefabricated building systems have been developed. The traditional methods in building monoliths are changed to building systems, which uses prefabricated elements. Today we have about

200- 300 types of frequently used prefabricated systems (Figure 3).



Figure 3: Housing as a system product prefabricated mass housing (Habracken, 1972).

A systems-oriented approach to housing conveys not only an understanding of its structural condition, but of the functional purpose of the system in which housing is embedded. For example, we can see housing as part of an ecosystem aimed at reducing energy consumption or as part of an industrialized system whose goal is to produce the maximum number of housing units at a minimal cost. The notion of a system is equally applicable to living beings, physical reality and abstract thinking.

In fact, systems-oriented thinking blurs the separation between these realms, between the natural and the artificial, and between the physical and the abstract (Ferguson et al., 1975). As a result, we see that the concept of system capable to cover various realms at various levels, (abstract, physical, ecology, society and organisms).

Case Studies

The first project: Van Eyck Orphanage

In the 1950's, Team X introduced concepts such as clustering, association and growth to overcome the notion of functionalism postulated by the

modern movement. These ideas were synthesized in the term of “**mat-building**” (Figure 4)

According to Smithson, “this concept of building is to epitomize the anonymous collective; where the functions come to enrich the fabric and the individual gains new freedoms of action through a new shuffled order, based on interconnection, close-knit patterns of association and possibilities for growth, diminution and change” (OIKODOMOS et al., 2011)

The clarity of the system’s idea through the definition of parts within the formation with its distinct characteristics and known targets also to overcome the abstract functionality which dominated in modernity of 20th century, besides of the continuous movement of blocks and residential units in all directions (without affecting on the design concept of the project), are indicating to growth or dynamic principle of architectural idea (open-ended system).

The project leads us to finding out that organic relations between all parts – with each other and with the whole- (internal – external and external – external) strengthened the concept of the system of residential complex project. Also the values derived are designing the project with open-ended system, which added more flexibility to the housing complex system.

The second project: HABRAKEN'S SUPPORTS

A support is the collective domain controlled by the community, whereas the in-fill is the private domain in command of the individual household. By ascribing a specific realm in the decision making process to the individual user - the infill -

he or she could participate in the creation of the dwelling (OIKODOMOS et al., 2011a).



Figure 4: “Mat building”- open ended system- by Team X (OIKODOMOS et al., 2011a).

Habraken’s method epitomizes the distinction between “**building systems**” and “**systems building**”. The former refers to “an assembly of building subsystems and components, and the rules for putting them together in a building”. The latter term, “systems building”, pertains to “the application of the systems approach to construction, normally resulting in the organization of programming, planning, design, financing, manufacturing, construction and evaluation of buildings under single, or highly coordinated, management into an efficient total process” (ibid). For example, it is possible to achieve better management by producing building components in a factory, whereas with systems building “the architect is not simply incorporating new technology; he is asking society to radically transform its economic organization, so as to provide shelter more efficiently”.

Habraken’s theory of (support and in-fill) is therefore an example of system's concept, applied to housing design. The new notion in this regard is public participation (Private-Public linkage) system in housing.

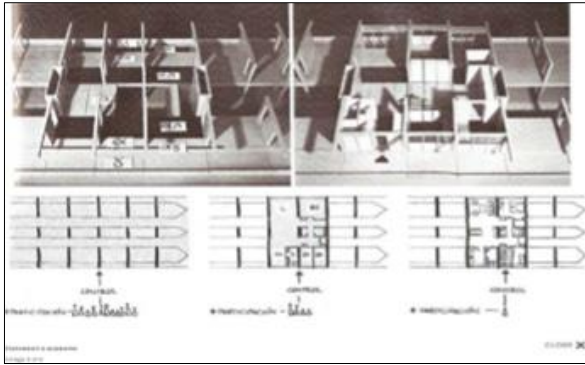


Figure 5: “Mass Housing project”. Support and infill theory by Habrakin (OIKODOMOS et al., 2011b).

The third project: Universal Design-Maison à Bordeaux, by Rem Koolhaas

The term “universal design” was coined by the late Ronald L. Mace, from the College of Design, North Carolina State University, USA. In 1988 he defined the term in the following way: “Universal design is an approach to design that incorporates products as well as building features which, to the greatest extent possible, can be used by everyone. Universal design is a simple concept, but one that requires a fundamental shift in thinking.

Traditionally, design has catered to averages, creating a world in which few people can actually thrive. Universal design strives to encompass the widest possible ranges of size, strength and capability, doing so without the need for adaptation or specialized design. The intent of universal design is to simplify life for everyone by making products, communications and the built environment usable by as many people as possible (OIKODOMOS et al., 2011b).

Thus, as argued above, UD is a design concept that recognizes, respects, values and attempts to accommodate the broadest possible spectrum of human ability in the design of all products, environments and information systems (Figure 6).

It requires sensitivity to and knowledge about people of all ages and abilities. Sometimes referred to as "life-span design" or "trans-generational design”, UD encompasses and goes beyond the accessible, adaptable and barrier-free design concepts of the past. It helps eliminate the need for special features and spaces.

The project (Maison à Bordeaux, by Rem Koolhaas), has the advantage of being wheelchair-friendly (Figure 6). It accommodates technical facilities for this purpose and reflects certain flexibility in use on its different levels (OIKODOMOS et al., 2011c).

So, universal design should incorporate design criteria (technical systems and wide ranges of peoples as users), that can be universally applied to new homes, preferably at minimal cost. Each design feature adds to the comfort and convenience of the home while supporting the changing needs of individuals and families at different stages of life. It allows more people to live independently.



Figure 6: ‘Maison à Bordeaux’ by Rem Koolhaas. (OIKODOMOS et al. 2011c).

The fourth project: The system of the system

This new approach (The system of systems approach) requires, engineering leadership, and a multidisciplinary approach to the integration of social and economic factors with physical infrastructure, and support a strong and dynamic resolution and tools used by a variety of stakeholders in order to make decisions based on performance and on the basis of the consequences (Mirmiran et al., 2015). Through this approach, issues of progress, sustainability and resilience can all be addressed systemically and logically. Within a "system of systems," it is logical to define terms of progress, and to weigh the impact that change in one system may have on the others. One of the projects that realize these concepts is Sulaimaniya Hill residential project. This project design by Al-Bayatti Bureau (2011) on the area

about 1257000 sq.m. Sulaimaniya Hills is not only a place where the people live, interact and work; it is the visible statement of civilization (Figure 7).

The design has to consider the complicated levels and the contour lines of the site through infrastructure design process. Furthermore, it's point of view, to create a contemporary neighborhood to serve as an important land mark not only in Sulaimaniya city but all over Iraq and Middle East.

To develop the given site as an urban designed settlement with all supplement facilities. These facilities with interrelated relationships for project inhabitants –in one hand- and for the city of Sulaimaniya –in the other hand- will form the sub-systems and added the complexity to the whole system of the project.



Figure 7: 'Site plan for Sulaimaniya Hills Housing project' – The system of system concept – (Al-Bayatti et al., 2011).

The fifth Project: The Cloud Path

Although known as the future approach in residential housing projects, but nowadays, becomes the common dominated approach related to the housing project that is for the land high-prices in the center of the cities. The urban forces within the large cities became the new challenge which contributed the architect's duty more and

more complex. The product also faced the new issues which effects on the overall systems of the architectural product. Housing as the most interrelated, inter-correlated and interacted domain with the more contemporary forces, is in continuous debate with these notions, So the new ideas has been arises within the housing projects continuously. The MAD bureau for architecture introduced the future vision for residential

architecture in the form of the high rise buildings, with the high-density population (Figure 8). This project (the cloud path) in Los-Anglos city, named as (urban village) too (Al-benaa et al., 2015). The project realizes the (Ma-Yan-Song) philosophy which relied on architecture to explore the relationships between architecture and nature. High-rise buildings are not new, but (MAD) developed his idea via the connection of the towers through bridges. That is the way to enable the habitants to move easily among towers without getting down to the ground levels. The towers also covered with planting, and contain balconies, and open green areas.

Thus, the project attempted to join all man made systems to the system of nature, including human and circulation system which added more complexity to the project. So, the evolution of system approach in housing developed in parallel with challenges faced to housing architecture and forces influenced, and contributed as systems interrelated with each other and with the whole system of housing. In the same time understanding these (systems), will contribute significantly in adding more values of complexity to the nature of housing architecture (**improving the study's hypothesis**).

Discussion

After results that derived from the theoretical part and project's presentation (briefed in Table1), the study will discuss these results as:

1) The complexity and the evolution of the housing concepts, needs to deal with the systems of housing as an integrated and interdependent relations which integrated with each other and



Figure 8: The Cloud Path (Urban village system) by MAD (Al-benaa magazine, et al. 2015).

constitute dynamic structures, within the deliberate and clear intentions.. Interacting with other systems in recent years, such as sustainability, which integrate not only with housing as multi-systems, but with technological and human system as a whole.

2) The impact of the system spreads to cover issues, rather than building engineering. Nowadays the system deals with the notion of people with special needs, and other, as flexibility, public participations and sustainability (Table 1). Therefore, because of its wide influences with contemporary urgent necessities, architecture becomes the systems of system and the degree of its complexity raised above its normal levels. So the architect's responsibilities became more and more complex too.

Table 1: The study results achieved in housing systems evolutions.

System evolutions	Systems related	Sub-system related	Values added	Levels of complexity
Building system	Structure-construction-	building components (Roofs-walls-openings-services-facades)	Engineering	Building components with each other and with the building as whole
Industrialized Architecture	Structure-building elements-assembling	Building elements	Mass production-Architecture as product	Off site-on site linkages
IBS	Building elements-space configuration	Building components-system of form-system of functions-Service system	Module-monolithic in form and interpretation	Internal-external linkages Integration between systems in different levels
Open-ended system	One unit with other units-public services	Building as a sub-system to the whole as a system	Flexibility-Individual multi choices	Internal-external, External-external linkages
Support and in-fill	building systems social system	Building components Technical and social infrastructure	Private-Public participation	Building systems-systems buildings
Universal Design	building systems Special needs	Building components Technical and social infrastructure	life-span design Bio-medical Physic-Social comfort and convenience	Internal-internal Internal-external fundamental shift in thinking
System of System	Building system Social and environmental systems	Building components- Envelop system landscaping	multidisciplinary approach change in one system may have on the others	social-economic-physical infrastructure – the system of the city-the nature
The cloud path-urban village	Building system-high technology system-environmental system-the structure of the city's system	Building components- Service systems-environmental system-circulation system (vertically and horizontally)	City center systems-sustainability-Social interactions.	Internal-internal-external-the city structure system-Social & environmental linkages

Conclusions

The conclusions of this study can be summarized in several points as follow:

- The concept of system used in a complex fields, at different levels. It is also used in analyzing and interpreting the architecture of housing. These analyses become a difficult subjects, due to its interfere with other systems, such as infrastructure services, social, economic and technological systems.
- Interpreting architecture through system is variable and renewable. It depends on codified systems constants (Ferguson et al., 1975). Human imagination goes beyond the physical presence of the place itself and associated beyond his understanding of the limited space at a given moment.
- The system is in a dynamic state constantly, and so for being understanding as concepts of interactions between multiple parts that make up the (Whole), among themselves –in one hand, and between themselves and the surrounding environment -in the other hand.
- Accordingly, looking at housing as a system -in planning and design - leads to understand the dynamic relations between elements (Physical and abstract), in addition to other elements of the surrounding environment (non-physical and vital), too.
- Evolution of housing system concepts from simple to its complex shape, which depended on the structural systems (building systems) in the beginnings, to new, improved and complex concepts –latterly-, included systems (influenced forces), surrounding the housing environment as

a whole. Which hold to deal with as a complex issue by specialists, but nowadays has become a necessity of planning and design affairs.

- The study's relevant to housing evolution systems do not preclude any other systems not addressed in this context, but at the same time it emphasizes the fact that, the process of the housing system's evolution is a continuous process, and its complexity will increase with the growing numbers of influenced forces and the nature of their complexity.

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