Intelligent Systems in Buildings

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Traditional Courtyard Houses in Baghdad as a Case Study

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To those who roam the depths of the seas and probe the depths of the universe...

To those who are looking for the secret of existence...

To my father and unit soul who instilled the roles of life in my heart...

To my wonderful mum, sisters, and brother...

To my twin soul who taught me how to appreciate knowledge, and life...

To my lovely daughter...

I dedicate my humble opinion.

Rand Agha
2019

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ABSTRACT

Intelligent systems (IS) are seen as a vital component in improving building performance. The research reported in this study explores the potential role of such systems in improving the performance of courtyard houses in Baghdad, Iraq. The Iraqi government's intention to refurbish those courtyard houses that possess significant historical architectural value was based on modifying the ambient social and environmental condition in order to protect the occupants. The benefits of IS are generally to: provide environmental and system controls, reduce running costs, improve operational effectiveness and energy efficiency, maintenance/building upkeep, reliability/dependability, and last but not least monitoring and observation. However, the majority of IS research and development has been on commercial and office buildings, and although there were applications in dwelling houses, their potential benefit for certain house types, for example courtyard houses, has not been well understood.

Against the background of the possible refurbishment of the courtyard house, the aim of this research is to explore the potential role of intelligent systems in improving the performance of a certain type of building in Baghdad, Iraq: the courtyard house. The main objectives of this research were to: (1) investigate the characteristics and features of the traditional courtyard house in Iraq, (2) investigate the meaning, nature and application of intelligent systems in buildings, (3) investigate the lifestyle of current users of traditional courtyard houses and how these buildings support their needs, (4) examine the potential role of IS in improving the performance of courtyard houses, and (5) make recommendations on the possible applications of IS to courtyard houses.

Various research methods and strategies were adopted to achieve the defined aim of this research. These methods include an extensive literature review in both the areas of the courtyard house and intelligent buildings, and a case study collected the data from two main sources: (1) semi-structured interviews with twenty five architects and twenty four occupants, and (2) a physical survey and observation of traditional courtyard houses in the Al-Kadhimiya historic area of Iraq. The qualitative method was used to analyze the data collection.

The findings from the study identified the following new themes which provide the basis for exploring the research question: (1) architectural value – a key feature through the passive system of the traditional courtyard house type in the Al-Kadhimiya, (2) limitation of space use – some spaces were not used, and the residents felt as if they were paralyzed at these times and (3) requirement for new systems in this type of house.

It is concluded that the key features of the traditional courtyard house are passive systems which support the lifestyle by achieving thermal comfort. Adding simple IS as applications which are integrated and wireless, with an actuator, will certainly help the residents enhance house performance in Al-Kadhimiya. This will be done by: developing the level of control over the environment, reducing the environmental challenges, decreasing the social struggles, and supporting the response to the environment.

This study contributes to the role of IS in enhancing the performance of traditional courtyard houses. For current users, these roles are achieved through three major steps: (1) the nature of IS in traditional courtyard houses; (2) the priority of systems; and (3) using the courtyard house as a container for intelligent systems. Future users are likely to have a different lifestyle and so the level of intelligence may change; thus, the potential need for IS might change too due to the type of intelligent system and its operation. A clean air recirculation module is one application to be used in the traditional courtyard house type in Al-Kadhimiya, which can be selected to enhance house performance.

ACKNOWLEDGMENTS

So this is where I construct my relational self. This book was borne out of my PhD study, which was a rollercoaster ride.

I would like to express heartfelt thanks to a number of people who made the research possible. The author wishes to express special gratitude to her husband, Dr Akram Al-Akkam; without his love, support, and encouragement, I would not have been able to complete my journey. I will forever understand the world in a different way and for that, I am eternally thankful. I also extend my thanks to my dearest mother and sisters, whose continuous support and encouragement assured me that I had done the right thing.

ABBREVIATIONS & ARABIC TERMINOLOGY

Abbreviations

Arch.	Architect interview.
BP	Building performance.
CH	Courtyard house.
HP	House performance.
IB	Intelligent building.
IBs	Intelligent buildings.
IS	Intelligent systems.
IT	Information technology.
Occ.	Occupant interview.
PH	Physical survey.
PH.CH	Physical survey of the traditional courtyard house in Al-Kadhimiya.
T.C.H	Traditional courtyard house.
T.C.H.T	Traditional courtyard house type.

Arabic terminology

Bad-Geer	Air-scoop.
Hash	The courtyard.
Iwan	The semi closed space.
Jam-khana	The winter family room on the ground floor.
Kafish-Kan	The mezzanine level between the ground and first floor.
Mamsha	The semi open space on the first floor.
Muqarnas	Decorative techniques in T.C.H.T which use brick and gypsum and other materials.
Neem sardab	The mezzanine level between the basement and ground level.
Sardab	The basement.
Shanasheel	A timber screen in each window on the first floor over the street.
Takhta-boosh	The space which looks towards the basement.

Tarma	The semi open space on the first floor.
Ursi	The family room.

CHAPTER ONE

GENERAL INTRODUCTION

1.1 Introduction

This chapter describes the context of the study by presenting the background of the research project and a brief explanation of the topic; it then highlights the definitions and key features used in the statement of the problems and study questions, as well as in the research aims, objectives, and scope; lastly, the research organization and chapter layout are described.

1.2 Background to the research

The author's interest in intelligent technology was growing day by day; the more she read about the subject, the more she recognized that there was more which needed to be known and learnt. The motivation for this research arose from the need to improve the performance of the traditional courtyard house, specifically concerning the problems linked with the disintegration in this type of house.

1.2.1 Iraq and refurbishing projects

Iraq is at the centre of the Middle East; Baghdad is its capital and lies more or less in the centre of the country. As a country, Iraq has seen considerable changes due to war and international sanctions, as well as environmental conditions. Certain social values and cultural standards have been altered, as have Iraq's architecture and cities in terms of their quality and quantity. As one of the largest Gulf countries, Iraq has many historical areas with historic architecture. The historic regions of Baghdad contain a type of house known as the courtyard house, whose land use has a high value. The historic regions which have this kind of house include cities or sub-city centres such as (old) Rasafa, Karkh, Al-Kadhimiya and Al-Adhamiya.

Despite the Iraqi political situation, the government aimed to refurbish the courtyard house (CH) in historical areas. The current government has made an effort to improve the infrastructure and housing stock of Baghdad. Ten years ago, the Iraqi state's cities report of 2006-2007 (SICR) referred to the typology of residential areas including courtyard houses which developed organically within Arabian culture. For the defence and improvement of the historical centre of Baghdad, the Baghdad Council, in cooperation with several consultant architectural offices (2007-2010), investigated the urban development of the historical area and architecture heritage around Al Rasheed Street. The study project titled "*Building Al Rasheed for the future*" uncovered several issues with historical areas. The study proposed to conserve this area includes using high technology like renewable energy for transportation. In the same year, the Municipality of Baghdad (2009) presented 12 investment opportunities for contemporary projects in Baghdad. Half of these projects are located in historical areas with courtyard houses; these are:

- Developing Haifa Street
- Developing Khlafaa Street
- Developing the Bab Al-Sheikh area
- Developing Al-Sheikh Omer Street
- Developing Khether al-Yas in the historical area of Karkh
- Developing the Al-Kadhimiya historical area in the sub-centre of Baghdad.

The project sought to refurbish examples of the traditional courtyard house type (T.C.H.T) that possessed significant historical architectural values, by modifying the ambient social and environment condition to protect the occupants. In this way, it is clear that the greatest strengths of traditional units with an interior courtyard are demonstrated at the level of the general fabric, and at the level of the individual unit, such as engaging conservation and rehabilitation. Perhaps the most important factor that makes the study area suited to this investigation is the presence of a government plan to refurbish courtyard house types. However, we must consider why this T.C.H.T needs improvement.

1.2.2 The need for improvement in traditional courtyard houses

The courtyard house represents a major type of building and it is often the central focus of the residence in terms of space and socialising, and as an environment. It is a secluded area that facilitates safety and privacy, but

also productivity. It responds to and interacts with all these aspects to determine the typical nature of the place. Thus, the courtyard in the world satisfies the essential requirement for shelter, and other needs such as privacy. The courtyard is one of the determining and organizing factors of a dwelling house, which involves various aspects.

However, the growing body of literature from many authors such as Ihsan Fethi (1976), Warren and Ihsan Fethi (1982), Al-Azawi (1984), Al-Qaisi (1984), Al-Rahmani (1986), Al- Jawadi (1986) Al- Al-Azawi (1996a, 1996b), UN-Habitat (2005, 2006-7), Al-Akkam (2013) and others have identified several existing problems in the T.C.H.T in Iraq. These are: (1) Functional problems such as modification of the residential type into commercial and government offices. (2) Economic problems, especially the lack of financial resources for maintenance or conservation. (3) Cultural problems such as loss of identity and cultural continuity because of the modernization process, which has mainly been influenced by technology and new materials and transformed living styles, the rejection of living in the traditional physical environment, mass migration, the decline of safety and security (issues such as crime, robbery, and terrorism), the prevalence of addiction, poverty and disorder, and breakdown in social organisation. (4) Structure and services problems: such as deteriorated structures, slums, lack of infrastructure maintenance, and neglect and decay. (5) Re- development problems: clearness schemes for civic centres, including the demolition of buildings and the defragmentation of historical areas.

Thus, the T.C.H.T has not had to adapt to changing needs because of the problems which have had a negative effect on the house's performance. As a result, the social aspect causes a number of challenges to lifestyle. This is the way of life related to the role of everyday different activities in terms of the relationship with places[1], spaces[2], and levels[3] during different times, and the possible changes in the need to respond to the appropriate thermal comfort. For these reasons, the T.C.H.T needs to be equipped to face these changing needs according to the awareness of the basic needs of the lifestyle of current and future users. However, intelligent technology could be used as a part of the refurbishment projects for this type of house to enhance their performance.

[1] It refers to a functional area such as the *ursi*.
[2] It refers to degree of enclosure such as with an *Iwan*.
[3] It includes different levels such as the *sardab*.

1.2.3 Information technology and performance

Information technology (IT) has increased the speed of information flow, which is considered a key aspect of improving intelligent buildings (IB), and the performance of different types of building as a result (CABA, 2014, p. 5).

Many researchers have attempted to identify IB such as Wong et al. (2005), Holden (2008), Chan et al. (2009), Alwaer and Croome (2010), Watson (2011), Wang et al. (2012), Zhou et al. (2014), and others. As a result, the operational definition relies on a designation of IB which is considered to be the ability of the building to use intelligent systems (IS) to monitor the information from the different environmental situations, and then to assess, and dynamically respond to changing needs that improve performance and result in improved occupancy and a comfortable living environment. Many researchers have attempted to identify and categorise the benefits and advantages of IB to enhance building performance. IB leads to the accomplishment of a type of building which has the optimum benefits in terms of performance socially, environmentally, and economically, such as through reduced running costs (Holden, 2008). Others have shown that the benefits of environmental control (CABA, 2002), control building systems (Alwaer and Clements-Croome, 2010, p. 800), enhance productivity, and provide safety and reliability (CIBSE, 2000). A number of researchers (Wong et al. 2005, Wong and Li 2006, Wong et al. 2008) have focused on better operational effectiveness and energy efficiency, enhanced user comfort, and better dependability. Research in the area of smart homes has confirmed the benefits of IS related to better health and less social isolation, improved household management for better decision-making (Courtney, 2008), activity/observation and monitoring physiological systems (Helal et al. 2005, Chan et al. 2009), maintaining building upkeep (Kroner, 1997, pp. 387-389) and others.

However, all IBs contain varying amounts of IS and the amount of these systems which have the function of controlling and responding. Therefore, we can introduce an intelligent system as a recognizable whole that has different applications linked in a systematic way. It can determine boundaries, the environment, and intent and has the capability to evolve. A system has the ability to communicate with other systems which can connect to the internet. The type of IS which must exist for a building to be seen as intelligent is difficult to define. Although buildings have some devices that deliver a type of automatic reaction to external change, they cannot always be seen as IBs. This is due to the problem of pinpointing when a building becomes “intelligent”; that is, knowing which technology

or systems add to the creation of a building's intelligence. To achieve the goal of an IB, we must consider how IS can enhance a building's performance.

1.2.4 Enhancement of building performance

Before discussing how to enhance building performance (BP) by using IT, we need a clear picture of what is meant by performance which was started in the humanities and social sciences and, following this development, also in the arts and sciences in general. In this case, it is considered to be the act of doing something successfully, or employing knowledge, as distinct from just having it or using it, or the way it functions or operates (AD, 2013, p. 17). Against the background of the wide context of architecture nowadays, the idea of performance is especially key and will continue to be so. This is due to the rise of the importance of the environment and our general surroundings. This should concern environmental quality for different aspects such as lighting, temperature, air flow, acoustics, humidity, water, and others (Hensel, 2013, pp.17-23).

At the beginning of the 1970s, Jenks and others pointed out that BP merges various meanings, which appeal to opposite faculties of the mind and the body, so that they interrelate and modify each other's (Jencks 1978, p. 132). At the beginning of the 21st century, Kolarevic and Malkawi (2005) stated that BP has an influence on a building's design, its processes and practices, by merging the difference between geometry and analysis, and between appearance and performance. Hensel (2013 p. 26) posited that BP stems mainly from the depth of the connection between form and function, and often coincides with the related art and science, or the relation between building and user(s). Kamara (2013) defined BP as

> "*the extent to which a building supports the immediate and changing needs of its users, and how its impact on society and the environment is optimised*."

The current research agrees with the last definition of BP: how far a building fulfils the current and future needs of its users, and its effect on society and the context in which it is used. Thus BP should improve the environmental status of a building. A key phase of developing the built environment is to create a way to promote building performance over as vast a range of environmental and energy criteria as possible (Agha, 2015). Alexander (1998) and Worthington (1998) pointed out that performance

equipment from building control manufacturers may specify a range of values for the aspects of building performance.

The designer is responsible for determining the precise needs of the building and ensuring that the equipment can be tailored to these requirements. These are: (1) Technical capability – energy, "*greenness*" of a building and solar gain, fabric and others; (2) The technological environment – flexible location and relocation of computing equipment and telephones, networks, and others; (3) Business and its processes – support for a rapidly changing work environment and open-plan to cellular divisions; and (4) User comfort – user ability to directly control his/her own micro environment.

Examples in the literature that have clarified how building performance could be enhanced include:

- Arkin and Paciuk (1997, pp. 471-479) considered the "*magnitude of systems integration,*" which means enhancing BP equal systems integration to improve the level of intelligence (see Section 4.3.3).
- Wong and Li's (2006) "*intelligent amenities quotient*" refers to enhancing BP and the equal classification of IS into categories as a means of improving the level of intelligence, which includes primary and secondary systems. Similarly, Frances Duffy, a world-renowned IB architect (cited in Kroner 1997, p. 383) suggests other classifications of IS as: office automation; advanced telecommunications; building automation; and creativeness to change.
- Many like Preiser and Schramm (2002) have conducted a "*user evaluation*" in an attempt to quantify the environment. In response to this, these authors developed the "*post-occupancy evaluation process model*" (POE) to reveal BP. They applied the POE process model to assess IBs in the multi-cultural context and proposed that the POE model might

  "*enhance building performance evaluation in intelligent buildings especially on a long-term, continuing basis*"

  as the assessment system permits the monitoring of the performance of novel high-tech approaches and their outcomes for a building's occupants, and the efficacy of these systems generally.
- Several studies have considered "*performance criteria*" as assessment methods of the level of intelligence in enhancing BP. In 2008 (p. 286) Wong et al. highlighted how the Multi-Criteria Decision-Making (MCDM) method has been suggested to resolve the difficulties in