

# Intelligent Systems in Buildings



# Intelligent Systems in Buildings:

*Traditional Courtyard Houses  
in Baghdad as a Case Study*

By

Rand H.M. Agha

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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*



# TABLE OF CONTENTS

List of Figures.....	xii
List of Tables.....	xviii
Abstract .....	xix
Acknowledgments .....	xxi
Abbreviations & Arabic Terminology.....	xxii
Chapter One.....	1
General Introduction	
1.1 Introduction.....	1
1.2 Background to the research.....	1
1.2.1 Iraq and refurbishing projects.....	1
1.2.2 The need for improvement in traditional courtyard houses.....	2
1.2.3 Information technology and performance .....	4
1.2.4 Enhancement of building performance.....	5
1.3 Problem definition .....	8
1.4 Aim and objectives .....	10
1.5 Significance of the study.....	11
1.6 Scope and limitation .....	12
1.7 Structure.....	12
Chapter Two .....	16
Iraq	
2.1 Introduction.....	16
2.2 General view of Iraq .....	16
2.2.1 Climate .....	17
2.2.2 Infrastructure .....	20
2.2.3 Security .....	22
2.3 Al-Kadhimiya .....	22
2.3.1 Historical area .....	23
2.3.2 Refurbishment and development projects .....	26
2.4 Discussion .....	27
2.5 Summary .....	28

Chapter Three .....	29
Courtyard Houses	
3.1 Introduction.....	29
3.2 The traditional courtyard house type.....	29
3.2.1 The concept of traditional courtyard houses.....	29
3.2.2 Categories of traditional courtyard house.....	30
3.2.3 Components of traditional courtyard houses .....	36
3.2.4 The responsiveness of the traditional courtyard house.....	43
3.2.5 The traditional courtyard house in Iraq .....	53
3.3 Contemporary courtyard houses .....	56
3.4 Advantages and disadvantages of the traditional courtyard house .....	65
3.5 Summary .....	69
Chapter Four.....	71
Intelligent Building and Systems	
4.1 Introduction.....	71
4.2 Intelligent building .....	71
4.2.1 Intelligent building definition.....	71
4.2.2 The concept of intelligent building.....	76
4.2.3 Intelligent building as a container .....	77
4.2.4 The benefits of intelligent building .....	80
4.2.5 The potential of intelligent building in traditional courtyard houses .....	87
4.3 Intelligent systems .....	89
4.3.1 The concept of system intelligence .....	89
4.3.2 Types of intelligent systems .....	90
4.3.3 The relation between intelligent systems.....	94
4.3.4 The relation between intelligent system components .....	95
4.3.5 The operation of intelligent systems.....	97
4.3.6 The potential of intelligent system in the traditional courtyard house.....	99
4.4 Applications of intelligent systems .....	104
4.4.1 The possible applications of intelligent systems in building.....	104
4.4.2 The potential application of intelligent systems in the traditional courtyard house .....	110
4.5 Summary .....	112



Chapter Five .....	113
Methodology and Research Undertaken	
5.1 Introduction.....	113
5.2 The need for an appropriate methodological approach.....	113
5.2.1 General approach.....	114
5.2.2 Methodology considerations .....	121
5.3 Research design .....	128
5.3.1 Data collection method.....	128
5.3.2 Justification of research methods .....	134
5.4 Fieldwork .....	135
5.4.1 Field study phases .....	136
5.4.2 Research obstacles.....	141
5.4.3 Research ethics.....	144
5.5 Data analysis.....	145
5.6 Summary .....	146
Chapter Six.....	147
Architect Interviews	
6.1 Introduction.....	147
6.2 Semi structured interviews with architects in Iraq/ Baghdad.....	147
6.3 Iraqi architects' perspectives.....	148
6.3.1 Experience with courtyard houses.....	148
6.3.2 The main strategies that enhance user comfort in the traditional courtyard house .....	155
6.3.3 Adapting the traditional courtyard house .....	163
6.3.4 Development of the traditional courtyard house/active systems .....	165
6.3.5 Architects' miscellaneous comments .....	170
6.3.6 Additional aspects .....	172
6.4 The possible uses of intelligent systems in the traditional courtyard house in Iraq.....	174
6.5 Summary .....	180
Chapter Seven.....	181
Physical Survey and Visual Observations	
7.1 Introduction.....	181
7.2 Physical survey for the traditional courtyard house in Al-Kadhimiya.....	181
7.3 Description of the traditional courtyard house type in Al-Kadhimiya.....	183
7.3.1 House categories .....	183

7.3.2 Different neighbourhoods.....	190
7.4 The existing conditions of the traditional courtyard house in Al-Kadhimiya.....	234
7.5 Summary .....	237
Chapter Eight.....	238
Occupant Interviews	
8.1 Introduction.....	238
8.2 Semi structured interviews with occupants of the traditional courtyard house in Al-Kadhimiya .....	238
8.3 Occupants' perspective of the traditional courtyard house in Al-Kadhimiya.....	239
8.3.1 General review of the occupants .....	239
8.3.2 Everyday activities/places/times .....	241
8.3.3 Conflicts and challenges.....	247
8.3.4 Evaluation of existing environmental performance.....	257
8.3.5 Enhancing the environmental situation .....	267
8.3.6 Occupants' priorities and miscellaneous comments.....	272
8.3.7 Additional aspects .....	274
8.4 The everyday life of current users of the traditional courtyard house in Al-Kadhimiya .....	283
8.5 Summary .....	289
Chapter Nine.....	291
Research Findings and Discussion	
9.1 Introduction.....	291
9.2 Environmental control, challenges and social struggles of the traditional courtyard house in Al-Kadhimiya.....	291
9.2.1 Partial control of the built environment.....	291
9.2.2 Environmental challenges .....	315
9.2.3 Social struggles .....	325
9.2.4 Traditional courtyard house performance in the Al-Kadhimiya .....	330
9.3 Traditional courtyard houses and intelligent systems .....	336
9.3.1 The nature of intelligent systems in the courtyard house ....	336
9.3.2 The priority of intelligent systems in the courtyard house ..	340
9.3.3 The courtyard house as a container for intelligent systems .	347
9.3.4 Intelligent systems and house performance in the Al-Kadhimiya .....	348
9.4 Summary .....	353

Chapter Ten .....	354
Summary and Conclusion	
10.1 Introduction.....	354
10.2 General summary .....	355
10.3 Completion of aim and objectives .....	376
10.4 Contribution of knowledge .....	380
10.4.1 Partial control of the environment and passive systems in the traditional courtyard house .....	380
10.4.2 Partial control of the environment and lifestyle in the traditional courtyard house .....	382
10.4.3 Environmental challenges and house performance in the traditional courtyard house .....	383
10.4.4 Social struggles of living in the traditional courtyard house.....	385
10.4.5 The role of intelligent systems in the traditional courtyard house.....	386
10.5 Research limitations.....	387
10.6 Recommendations and further research .....	388
10.7 Concluding statement.....	390
References .....	391

## LIST OF FIGURES

Figure 1.1: Clarifies the main research questions of the study and their relationship to the main aim and objectives (Author) .....	11
Figure 1.2: Chapter breakdown, aims and the main issues discussed in each chapter within the three main parts of this research (Author)..	15
Figure 2.1: Location of Iraq and neighbouring regions (Google Maps)....	17
Figure 2.2: Baghdad has four historic areas, one of them is Al-Kadhimiya (JAU 2013) .....	23
Figure 2.3: The land of the Al-Kadhimiya historical area, here viewed from the air, has a high value (Google Earth, 2011) .....	24
Figure 2.4: The holy Shrine of Imam Musa Al-Kadhim, with golden domes (Author) .....	25
Figure 3.1: The compactness of the T.C.H.T in Al-Kadhimiya as a contiguous and amorphous mass of buildings separated at random by winding shapes and narrow gaps, viewed from the air (Google Earth, 2011) .....	31
Figure 3.2: Classification of the one-courtyard house in Al-Kadhimiya according to size (Author) .....	32
Figure 3.3: Example of the one courtyard in T.C.H.T in Al-Kadhimiya (Author) .....	33
Figure 3.4: Example of a two courtyard in T.C.H.T in Al-Kadhimiya (Author) .....	34
Figure 3.5: Example of a four courtyard in T.C.H.T in Al-Kadhimiya (Warren and Ihsan Fathi, 1982) .....	35
Figure 3.6: The kafish-kan as multipurpose rooms of the T.C.H.T in Al-Kadhimiya, (Author).....	37
Figure 3.7: The tarma as a transitional space of the T.C.H.T in Al-Kadhimiya (Author).....	39
Figure 3.8: The mamsha as a transitional space of the T.C.H.T in Al-Kadhimiya (Author).....	40
Figure 3.9: The <i>shanasheel</i> as a physical architectural element of the T.C.H.T in Al-Kadhimiya (Author).....	41
Figure 3.10: Wooden columns as a physical architectural element in the T.C.H.T in Al-Kadhimiya (Author).....	42
Figure 3.11: Brick ornaments in walls and ceilings in the T.C.H.T. in Baghdad/ Al-Kadhimiya (Author) .....	43

Figure 3.12: The vertical and horizontal movement in the house section during different seasons, to accomplish daily activities in the T.C.H.T in Al-Kadhimiya (Author) .....	49
Figure 3.13: Example of the urban fabric of the contemporary CH – West Ham, London (Goh, 2010, p.109).....	57
Figure 3.14: Example of a contemporary CH with a clear shape (Goh, 2010, pp.102-136).....	58
Figure 3.15: Example of the size of a contemporary CH – Ardler in Dundee (Goh, 2010, p.107).....	59
Figure 4.1: Some terminology related to IB (Author) .....	72
Figure 4.2: Types of IB as a container of IT (Author).....	78
Figure 4.3: Potential for the nature of IS in buildings that distinguish IB from non IB (Author).....	103
Figure 5.1: Appropriate approach for the study (Author).....	120
Figure 5.2: Checkpoints in the Al-Kadhimiya historical area (Author)...	143
Figure 5.3: The data analysis stages related with each chapter (Author) ...	145
Figure 6.1: The most beautiful architectural values of the old district in the Al-Kadhimiya historical area such as shade and shadow; and the close relations between neighbours (Author).....	159
Figure 6.2: The <i>shanasheel</i> is an element that responds environmentally, socially and aesthetically and is distinctive to the Al-Kadhimiya historical area (Author).....	161
Figure 6.3: Example of the first refurbishment projects in a T.C.H in Baghdad/ Al-Kadhimiya (Author) .....	173
Figure 6.4: The weakness of the T.C.H.T Kadhimiya (Author).....	177
Figure 6.5: The weaknesses (e.g. difficulty to control underground water in the <i>sardab</i> ) of the T.C.H.T that arise due to modernization (Author) .....	177
Figure 7.1: Refurbishing the T.C.H.T in Al-Kadhimiya for houses No. 1 and 4 (Author).....	191
Figure 7.2: Refurbishing a T.C.H in Al-Kadhimiya, house No. 1 (Author) .....	191
Figure 7.3: Different types of device added to the T.C.H.T in Al-Kadhimiya, house No. 1 (Author).....	192
Figure 7.4: High humidity affecting the walls of the <i>sardab</i> in the T.C.H.T in Al-Kadhimiya, house No. 4 (Author).....	193
Figure 7.5: Case study of houses No. 1 and 4 (Author’s drawing).....	194
Figure 7.6: Case study of house No. 2 (Author’s drawing) .....	197
Figure 7.7: Refurbishing the T.C.H.T in Al-Kadhimiya, house No. 2 (Author) .....	199

Figure 7.8: Different devices added to the T.C.H.T in Al-Kadhimiya, house No. 2 (Author) .....	200
Figure 7.9: Different devices added to the T.C.H.T in Al-Kadhimiya, house No. 3 (Author) .....	201
Figure 7.10: Case study of house No. 3 (Author's drawing) .....	202
Figure 7.11: Case study of house No. 5 (Author's drawing) .....	206
Figure 7.12: Refurbishing, and different devices added to the T.C.H.T in Al-Kadhimiya, house No. 5 (Author) .....	207
Figure 7.13: Case study of house No. 6 (Author's drawing) .....	209
Figure 7.14: Example of refurbishing and types of device in the T.C.H.T in Al-Kadhimiya, house 6 (Author) .....	210
Figure 7.15: Refurbishing of the T.C.H.T in Al-Kadhimiya, house 7 (Author) .....	211
Figure 7.16: Case study of house No. 7 (Author's drawing) .....	212
Figure 7.17: Example of refurbishing and types of device in the T.C.H.T in Al-Kadhimiya, case study 7 (Author) .....	215
Figure 7.18: Types of refurbishment in the T.C.H.T in Al-Kadhimiya, house No. 8 (Author) .....	216
Figure 7.19: Case study of house No. 8 (Author's drawing) .....	218
Figure 7.20: Case study of house No. 9 (Author's drawing) .....	220
Figure 7.21: Example of different devices in the T.C.H.T in Al-Kadhimiya, house No. 9 (Author).....	222
Figure 7.22: Changing the physical environment of a house, such as closing the courtyard with a fixed cover consisting of plastic sheets and iron beams (Author) .....	223
Figure 7.23: Case study of house No. 10 (Author's drawing) .....	224
Figure 7.24: Example of different devices in the T.C.H.T in Al-Kadhimiya, house No. 10 (Author).....	228
Figure 7.25: Case study of house No. 11 (Author's drawing) .....	229
Figure 7.26: Refurbishing, and types of device added to the T.C.H.T in Al-Kadhimiya, house No. 11 (Author) .....	231
Figure 7.27: The high humidity affects the ground floor; house No. 12 (Author) .....	232
Figure 7.28: Case study of house No. 12 (Author's drawing) .....	232
Figure 8.1: The occupants used the courtyard for eating and gathering in the T.C.H.T in Al Kadhimiya (Author) .....	243
Figure 8.2: Modification of the neem sardab to a living room used for family gatherings in the T.C.H.T. in Al-Kadhimiya (Author) .....	244
Figure 8.3: The occupants used different places and spaces to practise their hobbies (Author).....	246

Figure 8.4: The abandoned sardab as a result of the high humidity and odours in the T.C.H.T in Al-Kadhimiya (Author).....	246
Figure 8.5: Using the room on the second floor with a low ceiling of around 2.00m for sleeping in winter (Author).....	247
Figure 8.6: Using change over and a stabilizer to provide a stable electricity supply and to avoid power cuts (Author).....	249
Figure 8.7: Using the different devices for communication in the T.C.H.T. in Al-Kadhimiya (Author) .....	250
Figure 8.8: Gathering of dust in the T.C.H.T in Al-Kadhimiya (Author) ..	251
Figure 8.9: Types of refurbishment of the T.C.H.T – painting the walls every two years (Author) .....	253
Figure 8.10: Using a kerosene heater in winter creates a problem in the night (Author) .....	255
Figure 8.11: High humidity due to different causes leads to an unhealthy house (Author).....	258
Figure 8.12: The size of the courtyard slot in the T.C.H.T in Al-Kadhimiya making the environmental conditions hard to control (Author).....	260
Figure 8.13: The aesthetic of the T.C.H.T in Al-Kadhimiya was physiologically comfortable (Author).....	261
Figure 8.14: The uncomfortable time for the occupants in T.C.H.T in Al-Kadhimiya (Author) .....	262
Figure 8.15: The lack of maintenance of the T.C.H.T in Al-Kadhimiya led to an uncomfortable environment (Author).....	263
Figure 8.16: Adding different modern devices to avoid the harsh weather and enhance performance (Author).....	268
Figure 8.17: Different devices for improving the performance of the T.C.H.T in Al-Kadhimiya (Author) .....	269
Figure 8.18: The architectural appearance of the T.C.H.T in Al-Kadhimiya (Author) .....	273
Figure 8.19: Some T.C.H.Ts in Al-Kadhimiya had been abandoned by their original owners (Author) .....	275
Figure 8.20: Other T.C.H.Ts in the Al-Kadhimiya needed continual maintenance by the owners or tenants (Author).....	276
Figure 8.21: The continuing breakdown of the generator in the current house meant an unstable electricity supply and a lack of continuous heating or cooling in the house (Author) .....	277
Figure 8.22: Refurbishing the sardab of the T.C.H.T in Al-Kadhimiya by an Indian company (Author).....	279
Figure 8.23: The transformation of the Iwan as a semi closed space into a kitchen in the T.C.H.T (Author).....	280

Figure 8.24: Damage to the large part of the house with the big courtyard in Al-Kadhimiya (Author) .....	281
Figure 8.25: Special memories of the T.C.H.T in Al-Kadhimiya (Author) .....	282
Figure 9.1: Partial control of the built environment related to main issues in the T.C.H.T in Al-Kadhimiya historical area (Author).....	293
Figure 9.2: The shanasheel as architectural element, in the T.C.H.T in Al-Kadhimiya creates the passive system, which contributes to partial control of the environment (Author).....	295
Figure 9.3: The details create the passive systems, which contribute to partial control of the environments in the T.C.H.T in Al-Kadhimiya (Author) .....	297
Figure 9.4: Modification and adaptation through alterations caused by way of life in the T.C.H.T in the Al-Kadhimiya on a cold day to achieve partial control of the environment (Author).....	305
Figure 9.5: Modification and adaptation through alterations caused by way of life in the T.C.H.T in Al-Kadhimiya on harsh weather to achieve partial control of the environment (Author).....	306
Figure 9.6: Modification and adaptation through alterations caused by way of life in the T.C.H.T of Al-Kadhimiya on moderate days to achieve partial control of the environment by opening the windows for appropriate ventilation (Author) .....	307
Figure 9.7: Modification and adaptation linked to modern equipment, reflecting the lifestyle to achieve partial control of the environment in the T.C.H.T in Al-Kadhimiya (Author) .....	308
Figure 9.8: Mobility of the family through the vertical and horizontal movement in the T.C.H.T in Al-Kadhimiya during different seasons is a part of the lifestyle to achieve partial control of the environment (Author) .....	311
Figure 9.9: Environmental challenges explored as ten issues in the T.C.H.T in Al-Kadhimiya (Author).....	314
Figure 9.10: Increase of humidity on the ground level leads to environmental challenges for living in the T.C.H.T in Al-Kadhimiya (Author) .....	317
Figure 9.11: Lack of adequate space leads to environmental challenges through the difficulty of controlling the indoor environment quality when living in the T.C.H.T in Al-Kadhimiya, including increased humidity and odour level (Author) .....	319
Figure 9.12: An attempt to reduce the energy consumption in the T.C.H.T in Al-Kadhimiya, which contributed to environmental challenges (Author) .....	321



Figure 9.13: Using different resources for electricity supply inductors of environmental challenges in the T.C.H.T in Al-Kadhimiya (Author)..	322
Figure 9.14: The electricity was unstable in the T.C.H.T in Al-Kadhimiya as a result of the use of different sources, which is one of the environmental challenges (Author).....	323
Figure 9.15: Safety issue showing the potential fire hazard during the changes in the electricity supply current as an environmental challenge in the T.C.H.T in Al-Kadhimiya (Author) .....	324
Figure 9.16: Social struggles aligned with three issues in the T.C.H.T in Al-Kadhimiya (Author) .....	327
Figure 9.17: Belonging and nostalgia presented social struggles of living in the T.C.H.T. in Al-Kadhimiya (Author) .....	329
Figure 9.18: The multi-faceted relationship between the different issues and themes related to the first research question (Author).....	331
Figure 9.19: The interaction between the T.C.H.T in Al-Kadhimiya and IS as a base role of such systems to enhance the performance related to the second research question (Author).....	351
Figure 9.20: The level of intelligence in the T.C.H.T in Al-Kadhimiya for future users (Author).....	352

## LIST OF TABLES

Table 3.1: Summary of how the T.C.H.T responds to the environment with passive systems (Author) .....	47
Table 3.2: Summary of the features and characteristics of the CH, both traditional and contemporary (Author) .....	62
Table 3.3: Different issues in the courtyard house type discussed in the literature (Author) .....	69
Table 4.1: The what, why, when, and how of - different IB projects according to different types, CABA (2002A+B), Holden (2008) .....	85
Table 5.1: Research aim and objectives with relation to the selection methods (Author) .....	133
Table 5.2: Explanation of the field work including data (Author) .....	139
Table 6.1: Exploring the architects' experiences (Author) .....	150
Table 7.1: Relationship between the numbers of T.C.H.T with occupant interviewees in five neighbourhoods (Author) .....	184
Table 7.2: Comparison between the T.C.H.T as a case study (Author) ..	186
Table 8.1 Introduction to the twelve T.C. houses in Al-Kadhimiya (Author) .....	240
Table 9.1: Flexibility of different activities during the year related to the space, place, and level in the T.C.H.T in Al-Kadhimiya, as reflected in the lifestyle and desire to achieve partial control of the environment (Author) .....	303
Table 9.2: Comfortable times and levels within the T.C.H.T in Al-Kadhimiya (Author) .....	318
Table 9.3: IS by using different applications that could enhance the T.C.H.T's performance in the Al-Kadhimiya (Author) .....	345
Table 10.1: Answering the research questions (Author) .....	377
Table 10.2: Summary of objectives, research methods, and findings (Author) .....	378

## 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.

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# 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  
Ursi

The semi open space on the first floor.  
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 Khetter 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-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<sup>1</sup>, spaces<sup>2</sup>, and levels<sup>3</sup> 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.

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<sup>1</sup> It refers to a functional area such as the *ursi*.

<sup>2</sup> It refers to degree of enclosure such as with an *Iwan*.

<sup>3</sup> 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 21<sup>st</sup> 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