Technological cities’ networks: The city of Baghdad as a model

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Abstract. Contemporary cities today are heading towards technological development and intelligence and are attempting to meet the needs of the population according to the best standards. This has led to the evolution of these cities from being simple to complex cities that display the level of intelligence of the city and urban development. Many levels and smart wired and wireless networks have emerged while building contemporary technological cities, this divides each city into several levels, starting from the infrastructure to all the physical city components and elements. These levels are linked to all urban buildings and spaces, and new methods are constantly being developed to facilitate technological presence. This study provides an extrapolation of the most important levels necessary for the establishment and application of technology according to the network system of the GIS program. This has been used to identify the most important networks that can be activated to transform the city of Baghdad into a technologically advanced city. The study is directed towards identifying the basic levels that contribute to building the technological network of a city that can be applied or accepted by the local community. This is done by identifying the capabilities and determining the most important standards that are required for their existence. Network elements, the links between them, and the number of nodes, that comprise a single network, are the factors required for establishing technological cities.

1. Introduction

Research has been conducted to assess the work in cities and to identify the factors that the city depends on to ensure the availability of basic requirements. The technological dimension is an important factor that determines the rate of development of cities and measures the extent of progress. The increase in technological networks within a city is a clear evidence of development. A United Nations initiative was launched in 2005 under the Habitat for Cities and Their Prosperity Program, to coordinate the work of international organisations to define new technological advanced ways for cities to function. This includes the increase in availability of smart, digital, ideal, electronic, and other locations, across the cities. Integrated studies are required to determine the percentage of performance has emerged. Recent studies have identified many indicators that can be used to determine the technological advancement of a city. This study aims to determine the basic technological levels of a city that can be utilised to build technological link networks and increase their efficiency. It has been assumed that it is possible to build more than one technological level by identifying multiple networks for a specific area in the technological development process. Studies have identified comprehensive standards that determine the levels of technological cities across the world. A descriptive analytical approach has been followed to extrapolate the most important indicators of these standards. A questionnaire has been used to identify the important formations in society and their orientation towards the technological dimension. The Al-Jadriya area in Baghdad was chosen for this study, based on the framework available in the area to transition towards technological development. The research was divided into several axes. The first axis includes analysing relevant existing literature that provides indicators to determine the level of technological development of cities and the potential for their transformation into smart cities. The second axis involves activating the role of the society and a questionnaire to identify the important
formations within the study area. The third axis is associated with the analysis of the expected connectivity networks for the Al-Jadriya area.

2. The smart scale in technological cities: The possibility of achieving technological advancement in contemporary cities is linked with the presence of many pre-requisites and specific standards that determine the existence of technology [1]. The International Organization for Standardization (ISO) has identified standards for technological cities by analysing existing developed infrastructure, as this is the base for the existence of a technological dimension. Furthermore, it has evaluated some of the basic requirements and elements of technologically advanced cities and other cities that have relied on technology revolution in renewing their basic joints. These include the following: Simplification Standardisation, Specification, Suitability for use [2]. The concept of the scale is linked to the first level that defines the basic characteristics of the city, while the second level measures the city’s performance and the presence of pillars related to the two levels. These pillars include, housing, economy, government, environment, and quality of life which implies, health, education, safety, and social justice, and other foundations. In the ideal situation, these are established. However, this may be difficult to achieve due to the change and diversity in the nature of cities [3]. Therefore, levels can be defined to divide the city’s performance measurement, which are in line with change and development. These measures include, performance measure, smart maturity scale, regional interaction scale, local interaction, open government scale, interconnectedness scale, and electronic readiness scale [4]. The standards established by international organisations and the competent authorities to determine the quality of life in cities may differ, but the criteria for city performance and determining the level of characteristics is important as it may indicate the ability to offer a better standard of living [5]. These cities may not be able to meet the challenges of life and the changes in the thought process of the society. This study attempts to identify a holistic measure that considers all these elements and characteristics to determine the rate of success or failure of cities in the process of transformation.

2.1 Technological city levels

The technological transformation process requires the existence of a number of fixed measures to determine the locations of development and areas that would be able to accommodate the transformation process through the existence of mechanisms to build the digital base. Based on the studies of these levels, an attempt can be made to develop the levels with a time link for the transformation requirements [6]. According to the World Mobile Communications Organization, a technological revolution will be seen between 2018 and 2025 wherein the basic networks for smart transportation within these cities will be established. Furthermore, the 5G network, which aims to provide the highest level of data and the highest speed of technical services through cellular technology, will be made available as it is expected that there will be approximately 80 billion Internet devices around the world [7]. The technological transformation is divided into three parts, the first stage is the short-term stage, the second stage is the medium-term stage, and the third and final stage is the long-term stage. Yes, as for determining the basic levels of the city and planning the periods of time required for the transition to a technological network system, it includes many elements that require transformation, but the basic elements and levels can be determined to prepare a comprehensive scheme for the process at a global and commercial scale, as has been seen in the case of Catania, a small city in South Italy.

A technological transformation and a semantic model has been created based on the stages of transformation and the city data. The entire process took approximately 20 years from the beginning of the emergence of technology services seen in 1991 [8]. City levels that were established and developed were as follows:

2.1.1 The level of virtual networks

The default level is associated with the level of the first transformation, which includes the idea of creating a technological city and includes the basic plans and designs for the city’s launch towards the use of technology. Therefore, any scheme, even at the initial stages, should involve building the default level, and the steps and elements can be modified as required. Subsequent levels are based on the needs
of each level. The default level involves creating initial plans, designs, and networks to develop any formation in the city [9].

2.1.2 The level of digital networks

Building a digital level in the city requires the existence of fixed and wireless communication networks such as, high-speed networks, terrestrial optical fibre and submarine cables, communication through satellites, digital broadcasting, data centres, communications centres, and digital and smart device technologies. These components form the primary base for transformation. Digital education platforms are a means to pave the way to create holistic knowledge of all the basics of this level within the city. The digital network transformation process for government buildings and basic community services can be launched, and a comprehensive database is organised for each building. Within each area, these buildings can be linked, and a digital base can be established. The process of building the digital level includes additional steps, and till these are completed in a comprehensive manner, it is considered as a part of the medium-term stage. These additional steps are represented by b [7].

2.1.3 Infrastructure and services

The technological infrastructure requires the existence of the basic installation of the first digital base and linking all city services to the level of infrastructure. This is required to organise the work at this level and determine the mechanisms to implement the level of infrastructure across all joints. This work connects the infrastructure from the middle stage to the long-term stage [10].

2.1.4 Mobility level and mobility

The emergence of fast and intelligent means of transport and the different nomenclature for transportation means is a natural phenomenon in the rapid development of technology. These means of transportation depend on the presence of digital networks, communication networks, and satellite connections, to accurately determine the path and ensure safety of the path. To install systems that enable electronic reservations for passengers without the intervention or interaction between individuals, evolved technology is required. Furthermore, this increases transport efficiency and improves the level of movement and traffic safety [11].

2.1.5 Blocks, building, and open spaces

The process of converting regular buildings into technological buildings includes two paths. The first depends on establishing a digital base for the building, the users, and beneficiaries, and the electronic records have to be updated for the existing records from their presence inside the city, and the second depends on the development of the building techniques itself, therefore, the result is a technologically advanced building at the digital level [12]. Special networks for buildings can be established, and each building is considered to be at the short-term stage of completing the creation of the private network with the database related to the building’s information. More than a single building can be linked within these networks. The process of linking buildings is a part of the intermediate stage. The open spaces within the city have an important role of providing psychological comfort to the residents and are therefore an essential part of the city’s development, provided that these green spaces include a number of trees and a number of paths and walkways that are used to move between residential neighbourhoods or even within a complex [13]. With the increase in technological development, green spaces have become an absolute necessity and act as a means of entertainment for residents. their lives Safer, provided that the size of green spaces commensurate with the number of users or the number of residents of the same area through the basic services provided by the community through the presence of children's playgrounds and a sports field and the most basic criteria that can be adopted for green spaces that are technologically transformable are [8]. After verifying the transformation at all these levels and the connection with technology paths, smart technology can be developed.

2.1.6 The level of smart networks

By developing technology or updating the existing technologies by introducing rapid and artificial intelligence characteristics, and combining these levels with smart management [14], it is possible to create a comprehensive smart path for the other paths, that is, the digital path and the default path. However, the period to access the smart path includes all the paragraphs, indicators, and elements of
levels in the city within the digital path and the default path. Therefore, it is the longest period and is within the long-term stages. It is linked to the obstacles and the society's ability to deal and adapt to the new technology [15]. To create a holistic smart city, all elements, qualities, and components, within the cities must be focused on and should be integrated technically [11].

Previous studies have shown the existence of a number of levels within cities which can be used to transform them into technologically advanced cities and to measure the possibilities of transformation towards technological development. These five levels as identified, can be used to measure the development process of any site or area within the city by identifying the challenges in the transformation process. The five main levels of the region and the inclusion of details of each level with an identification of the challenges and the possibility of verification and achievement, which can be applied to strategic projects as well as challenges and difficulties as well as their connection to the five main levels of the city. This includes the infrastructure and services as well as the paths of movement, construction, and lastly the smart level, and can be used to define a matrix to measure the development process as shown in Table (1).

| N  | Level                  | Site  | Completion rate | Challenges |
|----|------------------------|-------|-----------------|------------|
| 1  | The hypothetical level |       |                 |            |
| 2  | Digital level          |       |                 |            |
| 3  | Infrastructure level   |       |                 |            |
| 4  | Movement level         |       |                 |            |
| 5  | Level of blocks        |       |                 |            |
| 6  | Smart level            |       |                 |            |

3. Questionnaire

Previous studies have established the most important points that are included in the process of building smart cities, and a special questionnaire has been designed for a specific area in the city of Baghdad. This has been used to garner the opinion of the community and the residents, as the society has to accept the process of technological transformation and the most important places that the community wishes to develop have to be identified.

3.1 Preparing the questionnaire

To ensure that the information is accurate and build indicators with dimensions closer to reality, the task indicators for the study area were identified. The questionnaire has been customised for the Al-Jadriya area in Baghdad. This area has been selected as the study site based on the capabilities available in this area and the possibility of practical application. The area has shops and the following localities, 911 - 913 - 915 - 919-921-923. The responses of users and residents were related to indicators regarding the community's need to clarify the degree of importance of each indicator and its use within the area.

3.2 Questionnaire results

The results of the questionnaire are as in Table 2.

3.3 Conclusions

The results of the questionnaire have helped to define the category of society, and the importance and priority of elements that directly serve the community.
| N | Specified places | Development mechanisms | Not important | Of little importance | Average importance | Useful | Important |
|---|-----------------|------------------------|---------------|---------------------|--------------------|--------|----------|
|   |                 |                        | N % | N % | N % | N % | N % | N % |
| 1 | Government buildings | Building a comprehensive digital base | -   | -   | -   | -   | -   | 83  |
| 2 | Schools          | Digital connectivity for schools and homes | -   | -   | -   | -   | 2.4 | 81  |
| 3 | Health Centre   | Update data in digital form to users and direct link with the rest of the competent departments | -   | -   | -   | -   | -   | 83  |
| 4 | Hotels           | Installing intelligent sensing mechanisms | -   | -   | 3.6 | 3.6 | 19  | 18.1|
| 5 | Malls            | Modernising the link between malls and adding intelligence sensors for shopping | -   | -   | 28  | 28  | 33  | 33  |
| 6 | Restaurants      | Adding smart and fast customer service in providing orders and providing meals quickly, | -   | -   | 20  | 20  | 46  | 46  |
| 7 | Open green areas | Providing green areas with internet and electronic community | -   | -   | -   | -   | 3.6 | 80  |
| 8 | Markets          | Development into super brands with fast and smart services | -   | -   | 1   | 1   | 35  | 35  |
| 9 | Smart express services | Inclusion of mass smart transportation | -   | -   | -   | -   | 1   | 1   |

Table 2. Analysis of the results
Table 3. Sequence of the most important sites in the Al-Jadriya area based on the responses.

| N  | Sites               | The ratio (%) |
|----|---------------------|---------------|
| 1  | Government buildings - health centres | 100           |
| 2  | Smart express services | 98.8         |
| 3  | Schools             | 97.6          |
| 4  | Open green areas    | 96.4          |
| 5  | Markets             | 55.4          |
| 6  | Hotels              | 18.1          |
| 7  | Restaurants         | 7.2           |
| 8  | Malls               | 6.0           |

The table shows the sequence of importance, which was launched from health centers, government buildings, movement paths, transportation services, schools, open green areas, markets, hotels, and restaurants, down to malls, which society considered less important than the rest of the elements and components.

4. practical application
Verification at the third level depends on the application of one of the dimensions of technology, which is by using the analytical program of geographical information system (GIS). This is characterised by high capabilities that help in identifying the most important areas that can be developed and choosing the correct ones through the information base determined by the researcher in the framework of the program. This information base can be used to identify the important urban formations in the Al-Jadriya area, which should be prioritised during the network construction process. Important elements were identified in circles within different shapes, and each shape and its category were defined with an explanation of the network path proposed by the program with lines and direction. These have been depicted in colour, that explains the proposed network connection process between the elements of the urban formation in the Al-Jadriya area.

![Figure 1](image_url)  
Figure 1. Study area within the GIS program.

4.1 The study area
The Al-Jadriya area was chosen based on the capabilities available in this area and the possibility of practical application. The area was represented by the following localities, locality 911-913-915-919-921-923, as shown in Figure (2), which is a peninsula area surrounded by a river. Administratively, this area is affiliated with the Karrada district and includes several broad, straight, and intersecting streets that have numerous trees and orchards. It is located within a circle of latitude 33,17,17N, and a circle of longitude 44,23,35E [16]. It contains some important places that offer the basis of advanced technology, including the Central Bank of Iraq and some important banks and hotels in the region as well as a distinguished riverine enclosure. This can help in the development of river technology mechanisms that contribute to the development of the region. The presence of open green areas, as well as some scientific and
research centres that contribute to the development of this field, including the Baghdad University Complex, the Ministry of Science and Technology, and some important research centres, are factors that contribute to the development process. With the existence of digital, virtual, or smart networks, they provide a basic base for the development of the region. The questionnaire supports research to create an information base that is parallel to the research work.

![Figure 2. Al-Jadriya stores using the GIS programme](image)

4.2 Application of indicators
Based on previous research, important data and criteria have been identified, and they provide an important information base for the development of the Al-Jadriya area. This further clarifies that the transformation process stems from the existence of a hypothetical design base that can be used to transform the area into a contemporary area. This is followed by the transition to the digital level that establishes a comprehensive digital base and creates a digital network for the buildings within the area and is linked to the rest of the formations, such as, buildings, open spaces, and movement paths, in the area.

4.3 Interconnection networks analysis in the program
The results of the questionnaire indicated that the institutional dimension is considered to have a more important role while technologically developing the Al-Jadriya area. This implies that the government buildings have to be developed first followed by the areas in the rest of the city. For this purpose, the important buildings in the area have to be identified. Subsequently, the type of networks is proposed based on the process of connecting the requisite buildings within the specified levels for the formation of the Al-Jadriya area. The program links a group of buildings within a single digital network. This digital network provides the ability to:

- Share programmes and data
- Share resources
- Ensure central control
- Use email
- The possibility of running a software on the network
- The possibility of continuing the various operating systems within the scope of the specified buildings

Based on the program deemed appropriate for the area, a Metropolitan Area Network (MAN) is established. This is a network at the city level and consists of a group of smaller networks that merge with each other to form a city network or an integrated area, that is, a comprehensive network. The network has been defined as a set of paths linked with each other in a certain way through rapid technological transfer and it follows specific criteria related to the technological dimension. These are designed to simulate the work of the brain in the biological situation and depend on the presence of inputs and outputs to establish an interaction between them. These networks are known as neural networks, which are interconnected networks of different topological forms depending on the intersection of paths and the number of nodes within the network [17]. The degree of complexity of these networks depends on the number of buildings that are within the network space and within one level. This is divided into, complex and simple formation networks. The difference is established by increasing the number of points of intersection in the paths of
networks, and these intersections load digital data within network paths [17]. Bus: means a straight line, Annular, Star: This has a pivot device connecting the name of the Hub and is a picture of a group of network shapes that are formed on the basis of the number of nodes and the connection paths between the components [18]. Figure (3) shows the network shapes that result from the interconnection processes within a single plane. These shapes are known as industrial neural network forms and their complexity varies according to the number of paths and the number of intersections [19].

![Figure 3. Network designs, source forms [20]](image)

4.4 Linkage networks
The networks linking the specific levels of the Al-Jadriya area are explained as follows:

- The first level (the level of government buildings) includes the neural network for connecting governmental and institutional buildings in the Al-Jadriya area, as illustrated in Figure (4). This represents the first network of buildings. The specific paths and intersection points within the network space can be seen.

- The network connection of health centres is shown in Figure (5). This shows that the number of points identified as buildings within the network space is less those at the first level as seen in Figure (4). Therefore, the network configuration at this level is different. Between the level of government buildings and the level of the health dimension depends on determining the number of buildings and determining the number of points of intersection between the network and the number of paths formed from the network connection.

- The next stage is at the level of transportation and the main traffic path. Figure (6) illustrates the traffic paths that are digital and require modern technology.

- The smart transportation path that serves this area is a fast path that begins at the Baghdad University intersection till the two-storey bridge yard, provided that the middle carrot is used and the modern suspended transport lines are used, and public transport cabins are invested and developed into express transportation entrances. Figure shows the transport path in the region (Figure 7).

- The school network is shown in Figure (8). The formation of this network differs from that of the institutional and health dimension network. This is largely because the number of buildings at this level are lesser, thereby implying that there are lesser intersections and paths allocated to connect the buildings within the network space.

- The network for the open spaces has to be taken into consideration as it is one of the main factors that influences and promotes familiarity and social communication. These green spaces also have an impact on the health of the individuals. 10,000 square meters to achieve social communication within the acceptable distances for social distancing.
that must be preserved within the presence of the phenomenon of epidemics and their spread during the gatherings. Therefore, large green areas were selected for this study, as shown in Figure (9). These areas are necessary elements for development and it is important to link them through a digital or virtual network that can contribute and support social interaction and provide a more comfortable environment for users. The proposed network is shown in Figure (9). This network is similar to that at the institutional level as the number of points is the same, however, a mesh formation is observed due to the connection process between open areas.

Figure (10) shows the entertainment network which is characterised by a large number of buildings within the recreational level space for the Al-Jadriya area. This is reflected in the depth of the network formation required at this level.

![Figure 4](image1.png)

**Figure 4.** The network of connecting technological paths for government buildings, in the Al-Jadriya area.

![Figure 5](image2.png)

**Figure 5.** Network linking in health centres using the GIS programme.

![Figure 6](image3.png)

**Figure 6.** The network level of the traffic paths in the Al-Jadriya using the GIS programme.
4.5 Analysis of the networking results
It is an evident that there is a stark difference in the formation of networks for each level of the specific buildings within the Al-Jadriya area. This difference arises due to the difference in the number of buildings within the same level space, and thus the number of intersection points resulting from the connection of paths between them differs and this is reflected in the number of paths. Therefore, neural networks have been formed here with different configurations. This study defines, each network and its type, the number of buildings, the number of paths, and the number of points of intersection between one network. The same can be seen in Table (4), and the networks into complex neural networks and simple neural networks according to mentioned above.
### Table 4. Analysis of the network configuration of the levels in the Al-Jadriya region (prepared by the researcher)

| Asymptote lattice                      | The number of points of intersection | Number of tracks | The number of anchor points within the network | Network type        | the level                        |
|----------------------------------------|--------------------------------------|------------------|-----------------------------------------------|---------------------|---------------------------------|
| asymptote lattice                      | 14                                   | 84               | 14                                            | government buildings| health centres and clinics      |
| Tree network                           | 12                                   | 84               | 12                                            | complex neural network| Traffic and streets              |
| Fully connected network and nodes      | -                                    | -                | -                                             | simple neural network| Rapid transmission line         |
| Bus network                            | 9                                    | 45               | 9                                             | simple neural network| Schools                         |
| Tree network                           | 14                                   | 112              | 14                                            | complex neural network| Open spaces                     |
| Fully connected network                | 44                                   | 246              | 44                                            | complex neural network| Entertainment places            |
5. Conclusions
The following conclusions can be drawn:
1. Previous studies have identified numerous basic indicators to determine a measure of the degree of intelligence of cities and their association with technology.
2. Networks can be established at different levels linking the urban formations of any region.
3. These levels can be used as a database for the community to know the opinion of the users who deals with technology within the city formations.
4. The complexity ratios of technological networks in cities may differ according to the percentage of use of the network elements themselves.
5. The components of the network differ due to the difference in the number of link paths within the network and also the difference in the number of nodes that make up the network, and this depends on the size of the network linking to the assigned level.
6. The more networks within city levels, the greater is the city’s efficiency and the degree of its technological development.
7. Providing access to comprehensive connectivity for all city networks contributes towards attaining the smart level because of the comprehensiveness of the database for all city elements.
8. Neural networks, which are interconnected networks of different topological forms, depend on the intersection of paths and the number of nodes within the network.
9. It is possible to work with the three basic levels while developing any city from the default level, to the digital level and the smart level.

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