Technological Paths and Formation Levels in the Smart City

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Abstract. The emergence of diversity and difference in the formation of contemporary cities is a result of the different paths of the technological dimension used within the levels of urban formation. As a result, there are technology paths that differ in pattern according to their techniques and according to the nature of association with city formations that lead to the availability of many life facilities for the community. It works to regulate the motor level in the city, the physical formation level, the level of infrastructure and other levels whose coupling with the technological dimension has become an absolute necessity. The research aims to explore the diversity of the technological dimension according to the technical trends and possibilities it provides by identifying the technological paths that are associated with the levels of formation of the city. Therefore, the research hypothesis indicated that the link between the formation of cities and contemporary technology requires several systems and levels within which the different city formations develop. The research explores methods and patterns of formation that can comprehend the technological dimension of cities through facets and indicators related to methods to organize contemporary cities according to the technology dimension. The research provides a matrix of criteria to measure the performance of contemporary cities and the potential for transformation towards technological development by following one or a number of the extracted paths within several systems and levels. We concluded that the contemporary formation of technological cities linked with paths requires the presence of several systems and levels. Therefore, methods of forming and patterns to accommodate the technological dimension of contemporary cities are necessary to organize them based on the existence of systems of formation, levels, patterns, methods and elements, and combinations of these components. The research recommends the necessity to have strategies that support the process of transforming cities into technological cities through holistic programs that organize time to support innovation and creativity within city sectors in order to reach the smart cities platform.

1. Introduction
The concept of a path couples with the existence of a continuous longitudinal line associated with certain types of capabilities and elements. Therefore, the technological path is a path to direct the available technical systems, with their elements, to achieve a link between the starting point of the path to what is possible. The capabilities of this path, and what it achieves with the available technologies, is important [1]. When these paths or tracks link to the city’s system, their technologies organize in a manner commensurate with the city’s administration and its various formations. This organization reflects in the nature of the formation due to the proposals and solutions to face the problems that cities suffer from [2]. Hence, the nature of the paths will differ due to the different technologies that made up the path. The use of computers and advanced technology determines the type of pathway [3]. The research aims to explore the diversity of the technological dimension according to technical trends and the possibilities they provide by identifying the technological paths that are associated with the levels of formation in the city. The research utilizes the descriptive and the analytical approach to study the mechanisms that link each technological path to city levels based on the diversity and difference in the way cities are designed and shaped. These connecting mechanisms
lead to differences in the formal organization, spatial organization, and technological capabilities available for use today.

2. Technological pathway

2.1 The pattern of the smart path in contemporary cities

The smart path pattern in contemporary cities consists of the interaction of two components, namely the communication network and modern technology. The human mind represents the absolute ability to use smart technology. Artificial intelligence pathways rapidly transform traditional cities to cities that can balance various variables for rapid response to needs [1]. The smart city path consists of the merging of three forms of intelligence, which are the innovative, creative, and dominating intelligence of city society. It also requires institutional and societal intelligence. Moreover, it requires smart infrastructure and knowledge of smart use among segments of society.

With the availability of these three main intelligences, the launch of a smart path that is rapidly developing and transforming, at the same time, is achievable. This is so because the smart path is characterized by the speed of development and the speed of response to variables that increase the ability to develop according to need. [4] The smart path achieves a large proportion of potential outcomes for urban design and planning. Saving energy and the consumption of energy must achieve compatibility with the path of sustainability. The two tracks can be combined, with the development principle of providing for the needs of the population in the present and preserving the rights of future generations [5]. This relates to promoting the concept of a quality life as the presence of factors that help to achieve the best for society and the city, which will result in three basic indicators - Being Human Survival Index-An index of pleasure in a person’s life-Continuity index of human life

It can be noted that achieving quality of life indicators relates more to the existence of a smart path, as it is characterized by supporting the principles of sustainability on the one hand and supporting the mental development of human beings on the other hand, and this requires the achievement of many processes at the community level. We can define the smart path in a circular manner to enable smart technologies to regenerate and continue developing to meet needs and to develop oneself and infrastructures.

2.2 The Pattern of the Digital Path in Contemporary Cities

The digital path pattern in contemporary cities is one of the products of the era of technology and advanced research that has contributed to building a huge electronic computing system that works to collect the elements of the city within a huge database. It is responsible for all actions, taking appropriate decisions, and addressing sudden disasters, and this path is characterized by multiplicity and diversity, as there is the ability to link millions of people, regions, and information in one place. Furthermore, when determining the demand or need, the treatment process will determine the appropriate results and the appropriate decision. Therefore, the digital path needs to connect to a wide wireless digital network that is adequately prepared to absorb the necessary energy by directing web services and information conversion to the language of digital computing [6]. Some have defined the digital path as the process of digitizing the infrastructure to become more intelligent in order to improve the inter-space space. What results is a physical and virtual space for information, data, and services. [7] We note that there are several levels of the digital path, as it works on analysing the data in a different way in order to reach different results. It works to find the most efficient and least expensive solution with an increase in the quality ratio. Consequently, this is what the digital network works on as it provides possible solutions for the necessary requirements. As a result, this directs the path to be a smart path that relies on analysing evidence in various ways [8]. Here, it becomes clear to us that the digital path is one of the options that contribute to the development of the city and help to address errors and give the most useful and most appropriate solutions to the reality of the situation. The results it provides are more accurate than any provided by mechanical methods, alone.
2.3 The pattern of the virtual path in contemporary cities

The hypothetical concept is related to the virtual interactive environment within the space through merging systems, and this requires an advanced and modern computer device capable of formulating the required image of the surrounding space with high accuracy and similarity to reality [9]. Thereby, a different path pattern appeared in the curriculum, city formation, which is the hypothetical path that Sanguk Park defined, as the process of merging the actual basic formation of the city and the associated digital system with digital modelling of infrastructures. Thus, reliance is based on creating a virtual platform aimed at improving the reality of the situation and accelerating the link between city formations through virtual convergence devices [10]. In order to achieve the virtual path in its association with the formation of cities, a number of components must be available, including (network platform - physical layer - digital layer - data platform) and these components support the virtual simulation process. Here it becomes clear to us and is as if the city is taking shape. It has two parts: first is the realistic, physical part, and the second is the hypothetical part. Perhaps it has not been tested yet. It is about the mechanism of living in virtual reality. It requires the passage of time to achieve the integration of this unqualified reality with the population to start the process of living with the virtual organization of everything around. [10].

The hypothetical path is an imaginary path that depends on human needs. In reality, it does not exist, but it represents the possibility of rapid application and intelligent connection with all components [1]. In the city, there are two worlds: the basic physical world in the city and the virtual world that links to the digital worlds and networks that work with the virtual cloud system in order to analyse data and propose the most efficient solutions in organizing the city’s affairs as in Figure (1).

![Figure 1. The worlds in cities](image)

The virtual path is an imaginary path that works with a number of digital networks and cloud systems that analyse data and give efficient solutions in the face of the different conditions of the city. Moreover, the city consists of two worlds, a physical world, and a virtual world. The hypothetical path relates to all components of the physical world such as blocks, spaces, and movement paths and provides the comprehensive links within this world.

2.4 Levels of city organization

The presence of levels in the city can be more than one layer of analysis to deal with the city and five main layers can be identified in the city as shown in Figure (4), namely Digital level, Mass and physical level, Transportation level and mobility, The level of infrastructure and services, Virtual level.

The virtual level can be one of the levels of the contemporary city. It is connected to the digital level, an accurate database, and the presence of virtual reality devices in organizing its structure as it is the basis (base) of the city, provided that this is the last level that envisages the formation of the city in a renewed fashion. In order to support the development process, [11] this virtual level deals with two other levels in the organization of the city authority, namely the physical level and the digital level in order to organize the work in an integrated manner. The city dwellers as well as the energy sources,
the city outputs, and the daily needs that the city consumes from all sectors and these three levels are linked to one base as well as to digital and virtual programs [12]. Through these five levels, the elements of the city are divided into three main components: digital, physical, and virtual elements. These divisions define and distribute all the elements of the city into these three categories through which it is possible to determine the link of each element with a specific path and a specific technology that can work to develop this element. Consequently, it increases the efficiency of the work and services that it performs for the city, and Table (1) illustrates these divisions of the elements into three categories viz. physical, virtual, and digital. Here the elements link to the levels and paths specified for each element.

### Table 1. Dimensions and components of paths

| Physical indicators | Default indicators | Data          | City levels |
|---------------------|--------------------|---------------|-------------|
| Energy information  | General information| Classification information | Digital level |
| Environmental information | Private Information | | |
| Buildings           | Sensors            | Screensavers-simulation | Physical level |
| -Transportation     | Networks           | | |
| -Infrastructure     | Smart lines        | Virtual screens | Virtual level |
| Smart Buildings     | An intelligent     | Digital screens | |
| Smart transport media | benchmark          | | |
| Smart infrastructure |                    | | |

The division of the elements of the city contributes to reducing the efforts focused on developing one element without another. Through this division, it is possible to develop each element separately because of the element’s connection with the path devoted to development, which is commensurate with the nature of the services provided by the element and the nature of the development it needs. Thus, one can determine the technological path. This appropriately contributes to the acceleration of the development and construction process towards smarter and more sustainable cities.

### 2.5 Strategies of the Technological Pathways in Contemporary Cities

One of the most important steps to activate the work of technological paths in cities, whether smart, digital, or virtual is to define a strategy aimed at building an integrated plan to support these paths within cities. Such a plan has a number of environmentally friendly development programs in order to lay the foundation for a strong infrastructure to develop cities [13]. This includes the existence of specific timed programs that the city administration guarantees to implement within the specified period in order to ensure a sustainable and better future for people. Therefore, it is important to identify the most effective programs and strategies that cities must adopt to develop their structure, salutation and its general formation [5] and the most important of these strategies are Smart building technology strategy, Green Building Technology Strategy, Internet Technology Strategy, Smart Specialization Strategy.

The existence of strategies that support the city’s transformation process is nothing but comprehensive programs that organize time to support innovation and creativity within the city’s sectors to reach the smart cities platform. This important factor supports technology pathways in the city, as the transformation into a smart and sustainable city cannot take place without a clear program and priority to work within the city sectors.

### 2.6 Summary of the first axis

From the literature on multiple city paths, these paths differ in the connection of their components according to the technological dimension that they choose to organize administrative, economic, and social matters. Additionally, there are differences in the translation of the components of the city according to the optimal use of the path. This is shown in Table (2).


| Virtual City Path | Digital City Path | Smart City Path | Elements |
|-------------------|-------------------|-----------------|----------|
| A virtual world   | Digital networks consider the earth a virtual ground, as the city can be represented virtually, and all its parts are linked to virtual networks | A basic physical dimension associated with the administrative boundaries of the city and the physical borders | Earth |
| Cloud system that includes a complete database | Virtual infrastructures such as some elements of information and communication technology (software and telecommunications). The infrastructure of a digital city is represented only by information and communication technology | A smart city includes all types of infrastructure, whether physical, such as streets, bridges, buildings, broadband, railways, and others. | Infrastructure |
| Encrypted numbers and symbols linked to the database | In digital city, people are considered empowered and capable. | In a smart city, people are represented by all the individuals who live in the city, such as residents, workers, students, and tourists. | People |
| A comprehensive management system to control all components | With regards to the digital city, the government is geared towards E-government and e-governance because its main purpose is to improve the relationship between citizens and between citizens and the public administration through the network and the provision of electronic services. | Regarding the smart city, the government authorities are the local public administration, and the central and international public administration; institutions (such as the European Union). | Government |

3. Urban formation

3.1. Levels of technological configuration

Technology links to city levels through its technologies, components, and systems. Subsequently, these city levels differ from each other according to the nature of the formation and the degree of development. This axis is the most important level of technology in cities, which stems from the organizational basis of the city as a whole, represented by the infrastructure, as shown in Figure (2). What is required is the inclusion of digital technologies and information technologies within the base of the city in order to build a foundation for the rest of the levels. The second level is the transitional level, which defines the paths of transmission and movement by technology, where the programmed methods are used with smart imaging techniques, smart programming techniques, and rapid intelligent transportation techniques. The third level and most important level is the communicative level. Here, the management and governance of the city occurs by controlling the information for each person in the city’s database. This information includes administration, health, and education, and through it, it is possible to manage the city’s affairs and manage the file of the person who lives in the city. The
fourth level is the formative level that determines the possibility of forming the city in a sophisticated way and choosing advanced and smart construction methods. It involves the construction and design of open spaces and buildings by smart and advanced construction methods; however, this level cannot be implemented if the previous three levels are not implemented [2]. This is because a smart building cannot be controlled without a basic base as a means of control, and a smart open space cannot be built without a basic base for this space that provides protection and provides community services and thus becomes a centre for community turnout and influx [14].

| Fourth level | Smart formative level |
|--------------|----------------------|
| Third level  | Intelligent communicative level |
| Second level | Intelligent Transition Level |
| First level) Basic level) | Smart infrastructures |

Figure 2. Technology levels in the city and researcher preparation

The link between technology levels and city levels arises through the existence of a basic base, which is the base of smart infrastructure, meaning the establishment of a smart and developed database capable of assimilation, development, and comprehensiveness for all other levels. Therefore, technology levels are the basis for the emergence of a modern and sophisticated city.

3.2. Formation according to the regulations

The formation of cities today is linked to the existence of several networks. Each network is an integrated system that works directly to serve the general formation of the city and is linked directly to the rest of the networks and the rest of the systems in order for these networks to work in harmony, [15]. The application of the idea of the existence of networks in the formation of the city is a simplified method to organize. However, the connection of these networks to a distribution system may differ, depending on the nature of the city’s environment, geography, and even demography, as some types of systems result from it.

- A grid system with uniform distribution, known as (flat modulation system), which consists of sequential planes that are linked to each network directly after it [8].
- A network system with slanted distribution, known as (the slanting system), which consists of networks with oblique angles, where each network differs in its components. [16].
- Engineering networks system, known as (engineering formation system), in which a specific geometrical shape is chosen for the network, and this shape is repeated with the same specifications and measurements on all networks, and thus the connection and distribution process will be easier due to the specific ratios and similar measurements.
- The digital network system, known as the (digital modulation system), is one of the modern systems that works to build information networks for every urban network present in the city, and these networks are controlled through digital management and wireless networks. [2, 1]
- The virtual networks system, known as (the virtual configuration system) which works on building fake networks that support existing networks and work replaces one of the networks when damage or disasters occur, and this increases the protection of the city system in an innovative and new way [1].

Through the foregoing, we can notice that the existence of networks is a result of the process of dividing the city into levels. Each level is dealt with separately, after which these levels are linked to each other in order to organize work directly, and this may facilitate the work of network maintenance and increase its efficiency through its development. With modern systems, we must get to know these levels to know the proposed division mechanism.
3.3. Levels within the modulation methods

Despite the broad concept of levels in the city, a number of important levels will appear to us that show the nature of the formation of the city in a perspective or in 3D format. Through this perspective, we can understand the number of important parts and elements in the formation of the city. Additionally, through it we can explain the types of formation patterns in contemporary cities [11]. Some researchers have indicated that city levels are related to many of the basic elements that clarify the body and the general component of the city, which are as follows.

- The basic formation level: This level is an underground and invisible level because it relates to the infrastructure and works to establish a network and a service base for the entire city [11].
- The level of urban formation: This level shows the urban masses, their distribution, and the nature of the patterns that control the relationship between the mass components and the nature of the formation of sites in the city and the urban housing settlements. This level affects the nature of construction and development and thus determines the level of efficiency in the city [17].
- The level of spatial formation: This level relates to the spatial or spatial organization of the other elements and components of the city, such as traffic and communication crossings and places of service and social activities in the city.
- The level of movement formation: It defines the main and secondary movement paths in the city, through which all the elements of the city link according to the new formation. These paths may be yearly or central according to the nature of the division of the new formation of the city.
- The level of visual formation: This level relates to the possibility of visibility and visual perception of all components with the definition and clarity of the features of the components of the urban structure of the city. [15].
- Digital configuration level: This level is considered new in cities that have been associated with modern technology and the addition of wireless networks to its digital regulatory work at all levels in order to automatically control digital and smart simultaneously at all levels [1].

These levels determine the nature of the relationship and coordination between the traffic crossings networks, the urban construction networks, and the blocks. Additionally, the levels determine the controls of the typical dimensions between the mass distributions that can increase the efficiency of the urban planning process in coordination with the urban and architectural design decisions of the city. Efficiency of formation levels – flexibility of formation levels – comprehensiveness of formation levels for the city’s organizational process [11].

Achieving multiple levels in the city increases the efficiency of the organization process, which in turn contributes to achieving flexibility due to the ability to absorb change when needed in the future. This relates to the process of transformation into more efficient cities characterized by high technological capacity.

3.4. Division of city levels according to formation patterns

The concept of style in architecture in general relates to the method or type agreed upon by a group with certain characteristics that are similar in it [18]. The pattern may represent a model or symbol for a type, such as a way of distributing buildings within a specific space, or it may relate to methods of forming or organizing within characteristics specific to the city or to city architecture [19]. Furthermore with the emergence of the new generation of technology in the organization of cities, a new pattern of
distribution and formation appeared. This new pattern related to the concept of technology, so the pattern of smart formation or the pattern of technological formation of contemporary cities appeared [14]. This examines the style and characteristics of the elements of cities that link to the nature of the correct formation of cities on the one hand, and relate to the element of technology on the other hand. Here we must mention the possibility of generating different patterns according to the nature of the formation that appeared due to technology with different characteristics of these patterns due to the difference in distribution. Further, the type of technology it was associated with is different, and here we will mention the most important patterns that emerged after technology entered the process of shaping cities [15].

The single-core pattern, the multi-core formation pattern, the orthogonal smart formation pattern, the disconnected smart pattern, the changing smart pattern, the pattern of forming the peripheral frame. The presence of different types of patterns in the formation of cities indicates that diversity is one of the characteristics of the distinctive and creative formation. Undoubtedly there can be many and unlimited formations due to the possibility of integration and rapid formation that exists today, but it is important to know which style is better in use and can give better results upon application. Therefore, it is possible to rely on the experiences of other cities to find out the percentage of successes and failures that these formations generated. [17].

The formation pattern is a new way to define a specific picture or frame for the model to be designed within a specific area in the city. This model depends on a number of important elements in choosing the nature of the model and the nature of formation and organization.

3.5. Division of city levels according to formation elements

The formation of the city stems from the connection of many elements that are looking at achieving the aesthetics of the city and coordinating its urban spaces. A good design of the city considers all the elements and determinants for its formation; organization with measurements and; considerations indicating the preference in designing the urban spaces of the city. This aspect deals with the material elements and tangible determinants. In addition to this is the presence of intangible elements and determinants related to the cultural dimension of the city and highlighting the features of its formative identity [15]. The totality of the elements that make up the formation of the city determines the relationship between mass and space through a three-dimensional view. Since this relationship differs between cities, the differences appear clear between the character of European cities and Arab cities due to the different nature of the relationship between the elements and the determinants, and the most important elements that define this relationship are: Composition, Formal consistency, Fonts and colours, Proportion and proportion, Space void, Identity and cultural dimension. These elements are the basis of any urban configuration of cities, but the presence of technology and other determinants due to artificial intelligence have been able to introduce new elements associated with digital programming and intelligence as shown in Figure (3). These quickly respond to variables that the city may be exposed to because of an emergency or exposure to natural disasters or other emergencies [12]. Among the most important elements added to the formation of contemporary cities that are characterized by a technological dimension are: Elements of smart technologies, Self-control elements, Elements of automatic robots [13].

The merging of these elements with each other contributes to the rapid development of the capabilities of the cities to mix the initial elements of the city with the advanced elements of the result [1].
The elements of formation can be determined according to the components of the city, and the elements may differ between cities on the nature of the city component, the cultural dimension, and the identity of the city.

3.6. Summary of the second axis

The existence of the contemporary formation of technological cities requires several systems and levels within which the various city formations develop, and methods of formation and patterns capable of accommodating the technological dimension of contemporary cities may be proposed as shown in Table (3), which indicates the existence of systems of formation, levels, patterns, methods and elements. Furthermore, all these components have dimensions and indicators. They relate to the methods of organizing contemporary cities according to the technology dimension. Through previous studies.

**Table 3.** Formation levels, dimensions and indicators and researcher preparation.

| Measures | Pointers | Dimensions   |
|----------|----------|--------------|
| Organizing the city into networks | Regular grid system | Shaping systems |
| Dividing the city into networks with diagonal angles, depending on transmission lines and traffic routes | Grid system with slanted distribution | |
| Determine a specific style of geometric shapes to divide the city with specific proportions | Engineering networks system | |
| Preparing a digital formation system based | Digital network system | |
| Draw a fake network that supports the original city system | Virtual networks system | |
| Mass + space + movement + infrastructure | Technological formation | Formation levels |
| Smart network | Smart formation | |
| Smart interaction network | Communicative formation | |
| Smart traffic network | Transitional formation | |
| Smart infrastructure | Urban formation | Shaping methods |
| Spatial and spatial organization such as traffic | | |
| Traffic paths according to the nature of the formation of the specified network | Kinetic formation | |
| Visual perception of all components with clear features of the urban structure | Optical formation | |
| Building wireless networks linked to all levels of the | Digital modulation | |
| A single central distribution pattern | Mononuclear formation | Shaping patterns |
Table 3. continued

| Pattern | Description |
|---------|-------------|
| Distributing multiple nuclei in city areas | Multicore formation pattern |
| Defining orthogonal units linked to digital systems | Orthogonal smart formation pattern |
| Building a smart system within a specific region | Smart disconnected formation pattern |
| Random form patterns do not aim at a geometric shape. | Changing Smart Shaping Pattern |
| Perimeter frame for a specific area as a kind of closure | Contour shaping pattern |
| Add smart technologies and autonomous controls | Mass configuration |
| | Intelligent shaping elements |

Table 4. The difference between the tracks of the technological cities Researcher preparation

| The Smart Path | The Digital Path | The Virtual Path |
|----------------|------------------|------------------|
| The smart path is also a digital and virtual path, not the other way around | Providing various services through modern technologies (digital services) | Cities that integrate physical elements of urban reality with virtual reality through simulation |
| | Simulating the digital network and wireless networks and relying on a large database dedicated to being responsible for managing a sector in the city and linked with a main database | The existence of an immaterial physical reality through which the physical world can be managed differently according to the person’s desire |
| | Individual cooperation to develop services and products (creating a digital space for interaction between individual) Create a digital space to develop and invest in collective intelligence to reach the requirements | A digital society based on infrastructure and based on flexible standards, a communication network, and the internet, with the enabling of operation by the administration controlling the city |
| | Wireless infrastructure | Digital representations of cities that work to embody their appearance through computers and special perspectives to prepare a comprehensive visualization of the city |
| | | It is based on VR technologies |
4. Conclusions
The research explored the existence of different paths within the technological dimension, with technical and use differences between these paths, and even in the connection of each path within city levels, which helps in the development of cities and their transformation into contemporary cities. In conclusion, the contemporary formation of technological cities linked with paths requires the presence of several systems and levels. Therefore, methods of forming and patterns may be proposed to accommodate the technological dimension of contemporary cities. These contemporary cities have dimensions and indicators related to the methods of organizing themselves according to the dimension of technology based on the existence of systems of formation, levels, patterns, methods and elements, and combinations of all these components. As well as the research indicates the necessity to link technology paths within the city’s development plan to utilize the largest amount of technology to alter the formation of cities and find solutions to the problems facing any city. Also, divide any city development process into levels in order to reduce the cost and reduce the momentum in technological connectivity through the inclusion of sequential processes for all city levels, gradually from the most important level to the least important level.

Table 4. continued

| The concept of participation | Connecting the government administration to the internet | Carries out all required tasks within the virtual cyberspace |
|----------------------------|-------------------------------------------------------|----------------------------------------------------------|
| Investing the intelligence of individuals | The link between physical and virtual reality | They are virtual plans that can be tried to find out the most important pros and cons of the reality |
| Sustainability is one of the characteristics of smart cities | It is based on the idea of information exchange | Building a virtual network for each level that is separate from the other levels |
| The ability to find solutions and face disasters | Focuses on building and connecting multiple urban patterns | The presence of private networks of buildings that are not connected to the public network |

The presence of private networks of buildings that are not connected to the public network
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