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Assessing the Efficiency of Functional Performance of Shopping Malls in the Kingdom of Bahrain

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ABSTRACT

The functional efficiency of the internal spaces of shopping malls considered one of the most important criteria underlying the success of the interior design process for such complexes, as well as its success in economic terms that constitute a destination in itself. The process of distribution of internal activities and building a network connecting linkages between them are important factors that affect the properties of the spatial configuration and functional efficiency of malls. Study the impact of spatial configuration of shopping malls on the efficiency of functional performance of such complexes in the kingdom of Bahrain has formed a research problem sought to be solved through identifying the characteristics of the spatial configuration of malls to explore their ability in providing greater opportunities for optimal functional efficiency by applying the methodology of Space Syntax in measuring the syntactical properties concerning the functional efficiency for each of these malls. Results show that Giant mall offers better design solutions in terms of the functional efficiency in comparing with the rest of malls, in accordance to the indicators and measurements of space syntax methodology. Conclusion reveals variation in the spatial configuration characteristics of malls being studied led to variation in the level of functional efficiency of these malls. The data collected will be valuable in the design process of future malls in the Kingdom of Bahrain.

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1. Introduction

In recent years, the shopping malls imposed a civilized and cultural role it was impossible to imagine in the past. This is evidenced by the trend towards internal spaces in order to organize such complexes to achieve the desired objectives of the shopping malls in a real competitive environment. The "Urban Land Institute" defines the shopping malls as "a group of commercial establishments planned, developed, owned, and managed as a unit related in location, size, and type of shops to the trade area it serves; it provides onsite parking relating to the types and sizes of its stores" (ULI, 2002; Vernor *et al*., 1993). Shopping malls play the role of a monolithic commercial facility subject to a unified commercial and administrative system depends on the properties of the commercial area that serves it. It represents a closed space performs the function of merchandise trade (Dawson, 1970). The history of the first enclosed shopping malls linked to Greek civilization, where the structural composition built for the market appeared in city centers and has gained increasing importance with the passage of time (Mumford, 1971). In Islamic civilization, this kind of buildings can be returned to a form of Bazaars, as in the Grand Bazaar in Isfahan, Iran, the tenth century AD, and the Grand Bazaar in Istanbul, which includes under its roof 4000 shop and 58 street, in the fifteenth century. These examples represent the first covered markets in the modern history (Sedlmaier, 2005). The form of the market in the Islamic civilization has taken different patterns varied between an extended commercial bars within the fabric of the city, were sometimes covered to protect pedestrians from the external environment, and in other cases where the shops gather around an open courtyard. The emergence of commercial centers in the modern era goes back to the period after the Second World War, which devastated by the economic recession, led to the creation of new outlets for selling through organizing it in line with the concept of the new shopping; followed by the emergence of markets known (department store) which was characterized by wide and large areas, to display different merchandise within an environment fit with the shopping process (Beddington, 1991). In the mid-twentieth century with the spread of suburbs cities and cars in the United States, huge shopping centers have been built away from urban centers. Victor Gruen was one of the first centers created by Gruen; he built and developed many of them in America which began to grow and grow to include many diverse shops (Sedlmaier, 2005). These centers contained a variety of indoor environments with a sophisticated appearance along with fountains, trees and termination precious materials. Thus, these centers have evolved from one level to two levels, lower level was used for parking and then a third level added to serve the purposes of shopping; this in turn has led to the high cost of establishing such centers but it provided the possibility of the establishment of such centers in the cities in the other hand (Rybczynski, 2003).

Thus, a new generation of these centers has emerged known under the title of shopping centers aims to attract the attention of consumers by providing a regulated environment climatically, visually, and psychologically allow the performance of the activities of shopping and jobs associated with them effectively, as well as serve evolution in the production and competition of modern propaganda (Beddington, 1991). Gruen has contributed through transferring the concept of shopping centers being established for the purposes of profit only to being represented community centers. He considered that the shopping mall is a place for the meeting includes interactive facilities provides an environment for social interactions as well as its marketing function. This concept has been inspired in many of the shopping centers established in Europe at a later time, where these centers included many sculptures, fountains and seating facilities. Its role is not confined only in trade but also extended to include social, cultural and entertainment at the same time (Sedlmaier, 2005).

In the light of the changed perception of the concept of shopping centers, these centers have evolved to include among its walls, in addition to shopping function on other activities such as theaters, restaurants and post offices, banks, hotels, public libraries, health clubs and health centers. In the nineties, several shopping centers appeared which were marked by the architectural complexities and upscale constructions raised the cost to a large extent, accompanied by an increase in the number of shoppers and family gatherings enjoying in their meetings in these buildings; which in turn impact on the number of hours spent by people walking inside these buildings (Rybczynski, 2003). In general, the shopping malls have faced two major challenges: How can these centers to include the largest possible number of shoppers; and how to gather them in one building so as to achieve the best functional efficiency of the building.

2. Movement and Shopping in Shopping Malls

The interior design of shopping malls showing great interest in the process of planning and organization of movement paths accompanied by visual effects and psychological impact lead the shopper to enjoy during the performance of the shopping activity, and pay for the survival of a longer period of time, achieving efficiency in the economic factor of the building (Gruen & Smith, 1965). The planning of shopping malls sees that the kinetic axis is the main generator of the system, as the clarity of gradient between the various axes that constitute the building is the basis for the visibility of these axes (Malnar and Vodvarka, 1992). As for the movement of shoppers, it contributes to enrich the experience of movement relay within the shopping spaces,

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providing a relaxed atmosphere allows consumers to take decisions effectively without hesitation, and achieves success for its intended commercial activity (Maitland, 1991). The organization of the internal spaces of shopping malls incorporates several areas along the kinetic planning and the overall organization, including by understanding the act of shopping itself, where studies have indicated that the act of shopping is built on three different cases, including:

1. Non- intentionality: a lack of clarity of purpose as a result of not setting goals, and this results in the length of stay in order to gain experience and see the exhibits before purchase.

2. The clarity of purpose to some extent: where corresponds to provide a simple experience to the shopper; this type of shoppers are vulnerable to the surrounding environmental effects, which contribute to the strengthening or reverse what they were carrying of a mental image in their minds.

3. Spontaneous response: a shopper has clarity of intent, whether to buy or choose a shopping place, therefore, this type of shoppers will head to the specified location to pick and sell (Howard, 1973).

Understanding the act of shopping in various cases offset by three perceptions of the kinetic configuration for users of the building:

Firstly, the theory of kinetic determinism: it indicates that the spatial configuration determines the kinetic behavior within that space. This theory assumes that it is possible to achieve fundamental changes in human behavior and therefore his movement and method of interaction inside spaces through a change in the organizational pattern of space.

Secondly, the theory of spatial possibility: it indicates that the internal environment provides possibilities and constraints on the behavior of users and their movement depending on other criteria.

Thirdly, the theory of spatial probability: it assumes that the spatial environment provides the potential for multiple options for users' movement, which is non-binding, but some options are more likely to occur in a certain physical surroundings (Al-Hankawi, 1993).

Based on the foregoing, it can be said that the sequence of movement on planned paths may expose the recipient to a greater number of physical effects which increases the sensory data as a result of the continuous reproduction of scenes and emotions. This in turn provides durability in the emotional sense, which is an effective element in attracting shoppers to their various destinations of the different parts in the shopping mall and thus contribute to the achievement of an efficient functional performance.

3. The Shopping Process and Spatial Configuration

The process of shopping refers to the meaning of a deeper and more comprehensive than shopping or buying process that is due to the need or demand. It is a process that includes everything can be practiced by human motives may be multiple instinctive exceed the motives of the need and demand (Beddington, 1982). Based on this understanding, we find that shopping complexes tend to be spaces for social gatherings where people congregate, and spend their leisure time and create friendships in these spaces increase the time spent by people inside the complex (Aktas, 2012). Thus, the act of shopping is a state of dynamic change over time, influenced by various humanitarian needs and social concepts (Beddington, 1991). In other words, the interior design of shopping malls plays an important role in interweaving various aspects, achieving high performance with a shopping trip through successful concepts (Northen & Haskoll, 1977). Thus, the purpose of the building is to organize the internal space, and the physical element is a way to reach that goal (Kent, 1993); where the space creates a special relationship between the function and the building, as the encapsulation of the relationship between things (Malnar and Vodvarka, 1992). Accordingly, the space can take its distinctive shape by doing two senses: firstly, organizing individuals (people) in space through the organization of their relations with each other, depending on the degree of separation or aggregation, and secondly, self organization of spaces through buildings, paths, zones and so on; thus, the physical environment of the society takes a particular style. In both senses, society acquires a definite and recognizable spatial order (Hillier, 1984).

Spatial configuration of shopping malls has allowed convergence of many desires and humanitarian needs within a balanced and protected environment helps to perform the activities of shopping and allow the participation of consumers in the life of this environment (Gruen, 1973). It means that there is a social logic of space and spatial logic to the community, and through that we can realize and distinguish the presence of the cultural differences between social environment and others (Hillier, 1984). Bullough (1970) refers to five factors may affect the process of interior design and spatial configuration of shopping malls, namely: functional zoning of the mall's activities as a whole, effective facts and the responsiveness design to it, spaces allocated to the components of shopping mall, the organization of internal movement, and finally the internal environment and design styles that reflect the strength of business activity that takes place within the space of the building (Bullough, 1970). This process of organization invests the principle of cumulative attraction, which refers to the accumulation of activities similar to the shopping activities but not identical, such as the

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activities of restaurants or fast food outlets or furniture shops near the shopping activities so that there is a relationship between consumer expectations and prospects for competition. This type of relationship invested for organizing internal activities and forming the attractions within the shopping mall (Vernor et al., 1993). Spatial configuration of the internal spaces of shopping malls includes the harmonization of the physical components and displays them more efficient and enjoyable within different design possibilities.

On the other hand, the process of linking shopping spaces across the kinetic paths inside shopping malls constitutes an essential point in the spatial configuration. The process of formation and planning of circulation paths, which includes within them both necessary and optional activities for shoppers, based on linking kinetic routs starting from the point of entry to these activities with each other in an interconnected fabric to achieve the flow for shoppers from one place to another. Moreover, it provides a simple and balanced movement for shopper, enabling him to review the overall exhibits through the formation of visual breakpoints represented by attraction points that contribute to stimulate the shopper to pass multiple points slowly down to the end of the kinetic paths that can be reflected positively on the functional performance of any shopping mall (Northen & Haskoll, 1977).

3.1 Spatial Configuration and Functional Efficiency

Configuration is defined in general as, at least, the relation between two spaces in any building layout taking into account a third, and at most, as the relation among spaces in the complex, taking into account all the other spaces in the complex. In other words, we can say: put simply, relations taking into account other relations (Hillier *et al*., 1987a; Hillier, 2007). The relations between the various interior spaces have an influential role on the nature of spatial configuration of the building layout in general. In addition, the method used in the treatment and the locating of the internal spaces also affect the nature of spatial relationships, which in turn affect the degree of the functional efficiency of these spaces (Rapoport, 1990; Hillier et al., 1984; Kent, 1993). A building achieves its function not through its built form but mainly within its layout spaces. Accordingly, buildings create and order the empty spaces in which their purpose and function take place. Social meanings in buildings take place within the spaces of the buildings, and the ordering of spaces in buildings is really about the ordering of relations between people (Zako, 2006; Reveron, 2009). The determinants of internal spaces in shopping mall layouts, including horizontal (floors) and vertical (walls) in particular, which contains the openings (doors and windows), create kinetic and visual axes, leading the space to possess functional and visual relationship.

The functional relationships in the shopping mall layouts can be achieved through the physical elements that separate adjacent spaces. The visual relations can be determined through other spaces (transitional spaces) located between the main spaces. Thus, the functional relationships generated between the spaces reflect the existence of human, way of life and his pattern of thinking in dealing with such building spaces (Schulz, 1979; Nesbitt, 1996; Voordt et al., 1997). The functional relationships reflect the characteristics of spatial configuration of the building based on the characteristic of integration as an indicator to measure the degree of functional efficiency of space, because the structure of spatial relations of any building depends on the way of handling the determinants of space (walls and floors) which include joints of the kinetic links, on the one hand. On the other hand, the magnitude of kinetic penetrations in these parameters reflects the permeability of space within the spatial system (shopping mall layout), which in turn reflects the flexibility and accessibility of shopping spaces (Hillier and Hanson, 1988; Meiss, 1996; Nesbitt, 1996; Franz et al., 2005).

3.2 Functional Efficiency of Shopping Mall Layouts

One of the most important approaches that carry the imprint of society is the manner by which space is organized for human purposes, which lies in achieving the appropriate and efficient functions of building layouts (Aspinall, 1993; Voordt et al., 1997). A product or process is considered functional when the product or process used is suitable for the purpose. For buildings, functionality may be defined as the degree in which activities are supported by the built environment. Functionality is related to the amount and form of space, the spatial relationship between spaces (functional zoning), and the routing through the building for the distribution of people (Voordt et al., 1997). In architectural design, function is approached mainly as a sequence of human actions coupled with equipment to satisfy specific practical requirements on a daily basis inside a given spatial unit (Reveron, 2009). Hillier defines functionality: "*as the ability of a complex to accommodate functions in general and therefore potentially a range of different functions, rather than any specific function*" (Hillier, 2007). Functional factors such as the relationships between spaces and activities, appropriate axes of movement, flexibility, suitability, and safety are the key aspects of a building layout design. These factors are closely related to the activities and organizational performance of the occupant. Functional considerations play an important role in the success of a building. Thus, incorrect configurational decisions will result in inefficient and unacceptable functions (Al-Nijaidi, 1985; Karlen, 2009). Therefore, functionality is the overall viability of a building in accommodating functions (multifunctionality and diversity) and achieving a range of different functions rather than a specific function (Hanson, 2003). The built space is considered

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efficient when everyday users, shoppers, and visitors can participate in various activities without experiencing difficulties. The spatial–functional features that are relevant to efficiency include the spatial clustering of functionally related activities, short distances (spatial depth), and prevention of physical barriers between frequently used spaces in mall layouts. The degree of efficiency achieved by building layouts can be determined by indicators such as the availability of interior spaces for individual and communal use and the openness or closeness of physical partitions. Thus, the two following components are important:

1. **Psychological Efficiency:** refers to the extent in which a building "invites" the potential user or shopper to enter by using the appearance of and activities in a building. The relevant spatial aspects include a recognizable entrance; clear transitions and circulation from the public to private sectors; syntactical characteristics that facilitate spatial–functional orientations, such as a clear outline of a building layout, visual axes, points of recognition, and differentiation in the use of spaces.
2. **Physical Efficiency:** refers to the ease in which users and shoppers can reach, enter, and move through a building to use various spaces. A particular focal point is integral accessibility, that is, people with physical disabilities can also enter and move through the building independently. "Access for all" can be determined from the floor plans based on indicators such as the type of space, degree of integration of each space within the spatial layout, depth of space, manner of distribution of functional spaces into zones, and variety of internal arrangements of spaces in terms of flexibility, freedom, inclusiveness, and other design devices. These indicators provide opportunities to improve the physical efficiency of a building (Voordt et al., 1997; Habraken, 1998). Spaces are usually connected in ways that modify the distribution of integration throughout a structure, thus causing a number of areas to become more accessible than the rest. This sequence of integration regulates the interactions among users/shoppers and causes spatial–functional relationships to become efficient and flexible (Dawson, 2002).

4. The Sample and the Case Studies

This part of the research aims to identify and measure the syntactic characteristics of different types of spatial configurations. For this purpose, five shopping malls in the Kingdom of Bahrain adopted as case studies to give the possibility of comparison and evaluation between spatial configurations. The methodology of space syntax and its parameters has been applied for analysing and measuring, due to its ability to analyze and describe the spatial systems as well as the process of assessing and modeling different patterns (layout design). The analysis included the following shopping malls (case studies):

City Center: the largest and most modern shopping mall in the Kingdom of Bahrain, opened in 2008, located in downtown Manama, the most vital site in the Kingdom. The complex covers an area 140,000 square meters, provides enough space for more than 300 retail stores and international trading centers spread over three floors, as well as the largest water park in a roofed area, gymnasium and the largest cinema complex in the Middle East, a 20-screen cinema (Figure 1a).

a. City Center **b.** Al-Saif Mall

c. Al-Aali Mall **d.** Giant Mall **e.** Dana Mall

Figure 1 (a, b, c, d, e): The sample of study consists of five shopping mall layouts (case studies)

Al-Saif Mall: the second largest commercial complex in Bahrain. The complex located in the Al-Saif district to the north of Bahrain complex and to the west of the Al-Aali complex. It contains more than 200 shops, 2 cinema complexes, restaurants, entertainment center for children and adults, and hotel. It was opened in 1997 (Figure 1b).

Al-Aali Complex: one of the biggest shopping complexes in the Kingdom of Bahrain after the Al-Saif Mall. This complex is characterized by unique architecture and beautiful form, contains a distinct complex for Bahraini and Gulf Heritage. It was opened in 1996, has added two expansions, the last expansion ended in April 2007. The complex includes many of the famous brands on an international level (Figure 1c).

Bahrain Mall (Giant Mall): The complex includes more than 120 global brand, and covers an area of 750,000 square feet, includes a Giant center, a division of a multinational corporation, specialized in a series of business centers, where the headquarters in France. Currently owns about 113 huge marketing centers around the world. The goal of this complex is to provide all supplies such as household utensils, food, computers, and home entertainment devices. This series is the fifth-largest chain retailer in the world and the second largest in France after the chain Carrefour (Figure 1d).

Dana Mall: the complex is located directly opposite the City Center complex separated by Sheikh Khalifa Street in the city of Manama, the advantage of the complex that combines shopping, entertainment, and the best restaurants in the medium-sized compound (Figure 1e).

5. Space Syntax Method for Interpreting Shopping Mall Layouts

Space syntax is a theory of space and contains a set of analytical, quantitative, and descriptive tools that can be used to analyze the spatial formations of building layouts, cities, and landscapes (Hillier & Hanson, 1988; Hillier, 2007). Space syntax reveals the relationship between human beings and their occupied spaces. The distinctive characteristics of societies exist within spatial systems and are conveyed through space and the organization of spaces (Osman & Suliman, 1993). Space syntax refers to this relational characteristic of space as configuration; this characteristic forms human behavior and contains social knowledge (Dursun, 2007). Space syntax research aims to develop strategies for describing the configurations of occupied/inhabited spaces to articulate underlying social meanings. This process allows the development of secondary theories or practical explanations regarding the effects of spatial configuration on various social or cultural variables. A related theme in space syntax research is the comprehension of configured/functioned space itself, particularly the formative process and social meaning of space (Bafna, 2003). Space syntax attempts to formulate a configurational theory in architecture by generating a theoretical understanding of how people create and use spatial configurations (such as mall layouts). Thus, space syntax attempts to identify how spatial configurations express a social or cultural meaning and how spatial configurations generate the social interactions in built environments. A considerable variety of research and publications have shown that previous space syntax studies focus on real environments and identify the intrinsic nature of man-made environments.

By developing consistent techniques to represent and analyze spatial patterns, recent space syntax studies have attempted to simulate spatial designs in mall layout proposals and predict how these designs will work (Fong, 2005; Hillier et al., 1984, 1987a, 1987b; Hillier & Hanson, 1988; Hillier, 1999; Hillier, 2007; Kuribayashi & Kishimoto, 2009; Min et al., 2012; Peponis & Wineman, 2002; Ratti, 2004; Steadman, 1983; Verdil, 2009). Space syntax research and application have demonstrated that the spatial arrangements in any building layout (such as mall layouts) have a discernible and measurable influence on human (shopper) behavior. Considering that these effects can be modeled, predicted, and improved prior to construction, designers must understand the relationship between layout design and human behavior (Bafna, 2003). The space syntax method is an approach developed to analyze spatial configuration. Space syntax aims to describe spatial models (mall layouts) and represent these models in numerical and graphical forms, thereby facilitating scientific interpretation (Franz et al., 2005; Hanson, 2003; Manum, 2009). This method was adopted in dealing with the syntactical characteristics of the spatial configuration of mall layouts because of the following reasons:

- **i.** This method combines physical and social indicators in explaining the spatial–functional systems to identify configurations in terms of differences and similarities, thereby allowing the diagnosis of the strengths and weaknesses of structures (mall layouts), types, and patterning.
- **ii.** This method adopts the syntactical characteristics of spatial configuration (such as symmetry–asymmetry, distributedness–non-distributedness) in interpreting the structures of different mall layouts.
- **iii.** This method facilitates the analysis, evaluation, and comparison of various spatial systems.
- **iv.** This method can assess, understand, describe, and model various formal and spatial systems, thus providing sufficient credibility and reality.

5.1 Space Syntax Analysis of Shopping Mall Layouts

Space syntax indicates that the organization of architectural space in mall layouts can result from two keys syntactic characteristics, namely, symmetry–asymmetry and distributedness–non-distributedness, which are directly linked to the functionality of the mall layout. The symmetry–asymmetry property expresses the kinetic-visual depth of various spaces within the spatial system (mall layout) in terms of the main space (main gate/entrance). If the depth of the space within the mall layout is lower than the depth of the other spaces in the system, the space is more symmetric and vice versa. Space segregation increases when the number of kinetic-visual steps between the spaces in the mall layout increases, thus resulting in the weakening of the functional relationship (efficiency). This phenomenon is caused by the inverse relationship between segregation and functional efficiency. This relationship refers to

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the degree of symmetry of any space in the spatial system. Thus, when any space in the mall layout moves away from the main space (for instance, the entrance) by one kinetic-visual step, space separation will not occur. However, the link will be direct, and the space will be symmetrical. Increasing the space symmetry decreases the space segregation, thus resulting in an efficient functional relationship. When the space moves away by more than one kinetic-visual step from the main space, the space will become asymmetrical (Fong, 2005; Hillier & Hanson, 1988; Hillier, 2007; Min et al., 2012).

The distributedness–non-distributedness property reflects the available options for accessing all spaces in the system (mall layout). By increasing the number of methods of accessing a particular space, the distributedness of a space in a system will increase, thus suggesting that the kinetic permeability of a space is in a high level with little segregation and vice versa. A non-distributed space has simple permeability, thus suggesting the existence of one kinetic method to enter another space. Permeability (i.e., distributedness–non-distributedness) reflects the movement of shopper within the spatial system in terms of smoothness, efficiency, and flexibility and represents a certain organizational behavior of shoppers and its circulation. Thus, depth-maximizing plans (mall layouts) are functionally inflexible and unsuitable for most types of functional patterns compared with depth-minimizing plans, which allow the efficient function of a mall (Hillier, 2007).

5.2 Space Syntax Indicators and Measurements

The syntactical characteristics of spatial interior configurations (symmetry–asymmetry and distributedness–non-distributedness), which affect the functional efficiency of the mall layout, can be measured by numerical values by the following benchmarks and indicators.

5.2.1 Indicator of Integration Degree (Real Relative Asymmetry-RRA)

The integration degree of a space is an indicator that is related to the property of symmetry–asymmetry. This indicator reflects the relative depth of space in relation to the rest of the spaces in any spatial system (Hillier & Hanson, 1988). The mean depth of a space (MD) from all other spaces in the configuration (mall layout) is the integration (i.e., real relative asymmetry (RRA)) that describes the extent of permeability of that particular space. Low values correspond to high integration, whereas high values correspond to high segregation (Manum, 2009). The integration degree of space can be calculated as follows.

a. Calculating MD

i. A justified graph is created by designating the intended space as the key space (root space) at the base of a mall layout to measure the relative depth of the intended space. The remaining spaces are then aligned above the root space according to the number of spaces that must be taken to arrive at each space from the root space. Each space in the system is represented by a small circle, whereas the permeability between spaces is represented by linked lines.

ii. The depth of each space is calculated in the graph from the root space, wherein the depth of each space is represented by the number of spaces that is needed to transition from the root space to any space in the system (Figure 2).

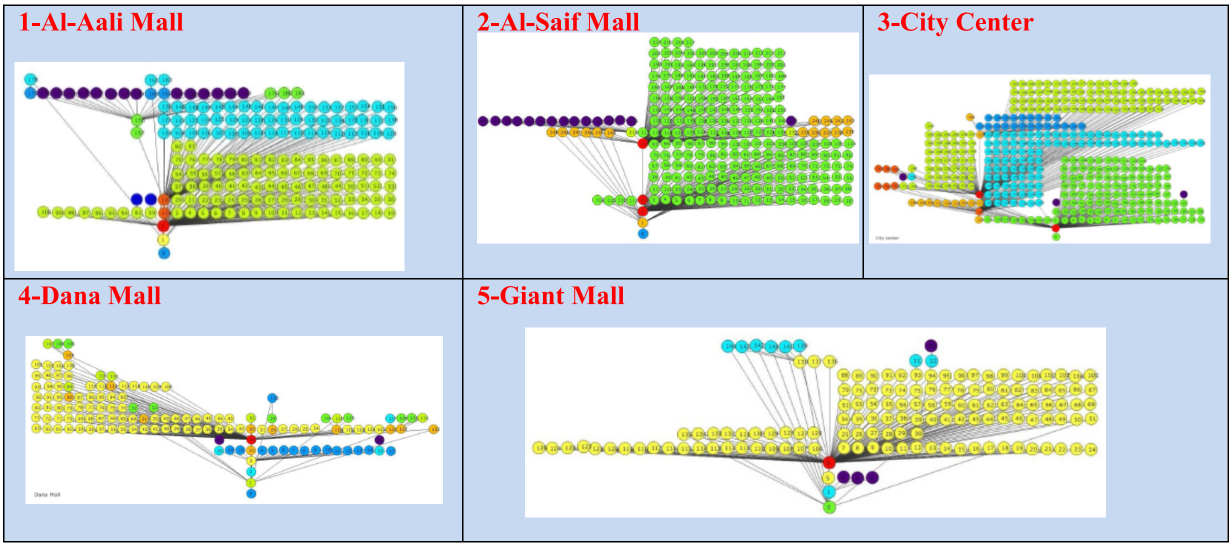

Figure 2: Justified permeability graphs (Gamma analysis method) of shopping mall layouts (5 case studies) in the kingdom of Bahrain

The least depth can be achieved when all spaces are directly connected to the original space (root space), whereas the greatest depth exists when all spaces are arranged in a linear sequence away from the original space. The space is symmetric in the former case with respect to the other spaces in the system, whereas the space is asymmetric in the latter case (Hillier & Hanson, 1988; Hillier, 2007), (Figure 3).

a- Spaces connect directly to the root space; minimum depth: symmetric system

b- Linear sequence of spaces; maximum depth: asymmetric system

Figure 3: (a)Symmetric spatial system; (b) asymmetric spatial system (Hillier et al., 1987a)

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MD can be calculated as follows:

$$M.D = \frac{\sum D}{K-1} \quad (1),$$

where $M.D$ is the mean depth of space from the root space, Σ_D is the total magnitude of depth for all spaces in the system from the root space, and K is the total number of spaces in the graph.

b. Calculating the Integration Value of Space (Relative Asymmetry-RA)

The relative depth of a space from all other spaces in the graph can be expressed as follows:

$$R.A = \frac{2(M.D-1)}{K-2} \quad (2),$$

where $R.A.$ is the relative asymmetry integration value of space, $M.D.$ is the mean depth of space, and K is the total number of spaces in the graph.

Therefore, relative asymmetry (RA) numerically expresses a key aspect of the shape of the justified graph from that space. RA varies between zero and one; zero indicates maximum integration, that is, no depth (high functional efficiency), whereas one indicates maximum segregation, that is, maximum depth (low functional efficiency) (Hillier et al., 1987a; Zako, 2006). The measurements of integration and depth are obtained by using the exterior space (of the mall) as the root space in relation to the rest of the spaces in the spatial system (mall layout). The depth from the root is considered the number of steps that separate a determined space from the front the gate/main entrance. Describing the sequence of activities from the mall entrance is of particular interest because this sequence describes the primary experience in buildings, that is, movement from the entrance to any specific place in the structure. Therefore, RA is a useful measurement for understanding front and back notions, as well as the relationship between spaces that are open to shoppers and spaces that are specifically for shopping.

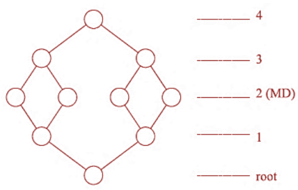

Figure 4: Diamond-shaped graph used to calculate integration of spaces (Hillier et al., 1987a; Hillier & Hanson, 1988; Asami *et al*., 2003)

c. Calculating the RRA

The RA value resulting from Equation (2) must be adjusted to facilitate the numerical comparison between spaces of different systems. The RA value for each space in the system is adjusted with its value in the depth graph with a diamond-shaped or pyramid-shaped pattern

(Hillier et al., 1987a; Hillier & Hanson, 1988; Asami et al., 2003), (Figure 4).

The depth of the diamond-shaped graph represents an intermediate situation between the maximum mean depth of space when the spaces are organized in a linear sequence with respect to the root space (as pre ed) and the least mean of depth when all spaces are linked directly to the root space (Hillier & Hanson, 1988). Thus, RRA can be calculated as follows:

$$R.R.A = \frac{R.A}{D_K} \quad (3),$$

where *R.R.A.* is the real relative asymmetry of space, *R.A.* is the relative asymmetry of space, and D_K is the RA of space from a diamond-shaped graph.

RRA is a sensitive measure of building layouts. This value varies around the number one; values less than one correspond to the most integrated and least segregated spaces in the system, whereas values greater than one correspond to the most segregated spaces. The relations among functional activities are expressed in space through the spatial relationships between the spaces of any spatial system under the assumption that the properties of integration and segregation indicate space efficiency (Hillier et al., 1987a; Zako, 2006) and the type of functional use of spaces occupied by shoppers.

5.2.2 Difference Factor of Space (H*)

Integration values indicate the permeability of a configuration in quantitative terms. Extensive research has demonstrated that integration values are highly predictive of the use of space. The degree of variance in integration values is considered an indication of the strength or weakness of social relations with respect to spatial ordering, that is, the amount of interchangeable space. The difference factor is used to quantify this difference as a proportion of the sum of integration values of spaces under consideration (Guney, 2005; Bellal, 2007). In most spatial complexes, different functions and activities are assigned to spaces, thus integrating complexes to different degrees (numerical values). If the integration values of these spaces are consistent across a sample, a cultural pattern is assumed to be expressing itself spatially. This particular type of consistency in spatial patterning is called "inequality genotypes." The strength or weakness of the inequality between integration values expresses the degree of cultural importance placed on the integration or segregation (Hillier et al., 1987a; Al-Jaff, 1989; Hanson, 2003). An entropy-based measure called a difference factor is used to

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quantify the degree of difference between the integration values of any three spaces (or more with a modified formula) or functional activities. This measure is essentially an adaptation of Shannon's H-measure for transition probabilities, wherein the integration values of the spaces are substituted for transition probabilities (Zako, 2006):

$$H = -\sum\left[\frac{a}{t}\ln\left(\frac{a}{t}\right)\right] + \left[\frac{b}{t}\ln\left(\frac{b}{t}\right)\right] + \left[\frac{c}{t}\ln\left(\frac{c}{t}\right)\right] \qquad (4),$$

where H is the unrelativized difference factor for three spaces; a, b, and c are the integration values of any three spaces in the configuration (ma layout); t is the sum of the three spaces, that is, $t = \Sigma\,(a + b + c)$.

Thus, Equation (4) describes the variance in the integration within each spatial structure, and this variance may be a result of the functional differentiation in the use of space (Bustard, 1999). H can be "relativized" between Ln2 and Ln3 to obtain the "relative difference factor" (H^*), which varies between zero and one. $H^* = 0$ corresponds to maximum difference, that is, strong functional differentiation, which refers to the real functional efficiency of the space. $H^* = 1$ corresponds to minimum or no difference, that is, no functional differentiation, thus indicating that no real difference exists in the values of integration and that no real functional efficiency exists for the space (Hillier et al., 1987a). Therefore, H^* can be calculated according to the following modified formula:

$$H^* = \frac{H - \ln 2}{\ln 3 - \ln 2} \qquad (5),$$

A low H^* value indicates the existence of a "strong" genotype. By contrast, values close to one indicate the existence of "weak" genotypes, thus suggesting that no functional differentiation and weakness exist in the functional efficiency of a space. These simple measures, as clarified by Zako (2006), can express culturally significant typological differences among various mall layouts over time, because such measures are based on concepts founded on intrinsic "social logic."

5.2.3 Indicator of (Space - Link Ratio) of the Spatial System

Integration has been proposed as a syntactical measure to assess the symmetry-asymmetry properties of a spatial system; whereas the relative "ringiness" measure was proposed to assess the distributedness–non-distributedness properties. Distributedness reflects the existence of more than one non-intersecting route from a given point in a system to another point. If only one route exists for any two points in the system, the system is considered a non-distributed system with a tree-like structure (Figure 5a). In a tree-like structure, p-1 lines connect the structure together, where *p* is the number of nodes in the spatial system (Guney, 2005; Bellal, 2007).

Any increase in the number of lines in the system will indicate the existence of rings in the system, that is, such a system has a ringy structure (Figure 5b). Thus, this indicator is used to measure the distributedness–non-distributedness property of each space and the entire spatial system (mall layout). Measuring the degree of "ringiness" of a spatial system, i.e., space–link ratio *R* represents the extent of permeability of the spatial system. The space–link ratio is the ratio between the number of links located between the spaces plus one and the number of spaces in a spatial system of a mall.

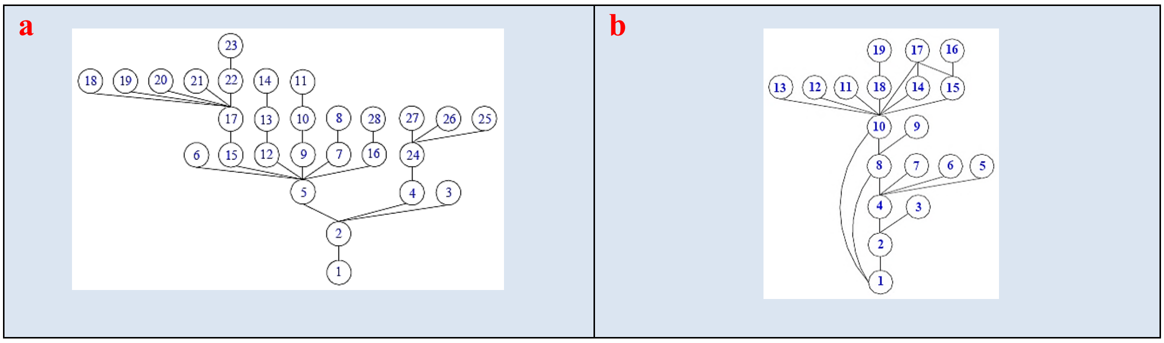

Figure 5: (a) Tree-like structure; (b) Ringy structure

The R values vary around the number one, where the values greater than one correspond to a high degree of "ringiness" and distributedness of a spatial system (ringy structures). This distributedness property indicates a high degree of flexibility (functional efficiency) in using the space, thus enabling the user to change the layout to adapt to different circumstances by closing or opening doors. Values less than one indicate that the spatial system has a tree-like structure, thus suggesting the lack of distributedness and the increase in the depth of spaces within the layout (Guney, 2005; Bellal, 2007). *R* can be calculated as follows:

$$R = \frac{L+1}{K} \quad (6),$$

where *R* is the space–link ratio of spaces in a spatial system (mall layout), *L* is the number of lines of the link between spaces in the justified graph, and K is the number of spaces in the system.

6. Discussion of Results

When the results of the analyses are examined, the following data are obtained. The MD

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value is 3.2 for Al-Aali mall, 3.02 for Al-Saif mall, 3.32 for City Center, 2.77 for Dana mall, and 2.21 for Giant mall. The overall spaces in the Giant mall layout are more integrated than the overall spaces in the remaining mall layouts. This finding is supported by the high mean value of RRA (0.18) for the Giant mall. This finding demonstrates the tendency of the system (layout) to be significantly integrated (more accessible, efficient, and flexible) compared with other cases that have low mean RRA values. Thus, the spatial configuration of layouts with low mean RRA values tend to be segregated, controlled, and less efficient in terms of function.

The justified graphs (gamma maps) reveal that overall mall layouts having "ringy" structures (having a different numbers of rings within their configurations). The overall mall layouts having "ringy" structures; the mean value of R is greater than 1, suggesting that these layouts are spatially and functionally distributed structures. The mean R value is 1.04 for Al-Aali mall, 1.15 for Al-Saif mall, 1.04 for City Center, 1.07 for Dana mall, and 1.12 for Giant mall; these values suggesting that both layouts of Al-Saif mall and Giant mall are generally more distributed comparing with other mall layouts. The values of *H** for all cases can be obtained from the values of RRA. These values are presented as follows: H* is 0.78 for Al-Aali mall layout, 0.86 for Al-Saif mall, 1 for City Center mall, 0.91 for Dana mall, and 0.64 for Giant mall. These findings indicate that the Giant mall layout has the lowest difference factor value among overall mall layouts (Table 1).

Table 1: MD, RRA, R, H* values of the case studies (shopping malls).

Mosque layout pattern	Mean Depth (MD)	Real Relative Asymmetry (RRA)	Space Link Ratio (R)	Difference Factor (H*)
Al-Aali mall	3.20	0.38	1.04	0.78
Al-Saif mall	3.02	0.24	1.15	0.86
City Center	3.32	0.33	1.04	1.00
Dana mall	2.77	0.35	1.07	0.91
Giant mall	2.21	0.18	1.12	0.64

7. Conclusion

Results of analysis reveal that the indicators of the methodology of space syntax and its techniques adopted in this research have contributed effectively in identifying the preference of case studies (mall layouts). Based on these results, it can be concluded that the Giant mall layout represents the best among the mall layouts, in terms of functional efficiency with respect to the indicators of spatial depth (MD) and the degree of integration (RRA). The values of the indicator of difference factor (H*) reveal that a Giant mall layout has the highest difference, thus indicating strong distinction and functional differentiation compared with the other mall layouts. This finding confirms the need to adopt such layout and its interior spaces in any future mall layout designs, because the difference factor demonstrates the independence of space (for instance, the main lobby or the main part/space of the mall) with other spaces. A strong independence corresponds to a high level of functionality and efficiency. The R values reveal that the Al-Saif mall layout has a high distributedness, thus indicating the importance (efficiency) of this type of layout at the spatial – functional level. This high distributedness is due to the presence of large number of rings in its configuration, which provide high accessibility to the system. Based on justified graphs (Gamma maps), the study shows that (100%) of the mall layouts are "ringy" structures. This points that the entire case studies are distributed structures spatially and functionally (having different numbers of rings within their configurations). Despite the fact that all cases of study appeared distributed configurations (ringy structures), but it can be concluded that the Al-Saif mall layout and Giant mall layout appeared more integrated, accessible, and distributed spatially and functionally in comparison to other cases, which means that both of these cases are considered more efficient in terms of function.

The results of analysis reported positively the relationship between the process of spatial configuration and the level of functional efficiency of mall layouts according to their different configurations and patterns, through an analytical comparative approach adopted in discussing and interpreting these resulted data. Overall indicators contributed effectively in defining the impact of the spatial configuration process on the mall layouts, which paved the way in determining and assessing its level of functional efficiency. The results clearly show that the efficiency of mall layout changes due to the change in the spatial configuration of these layouts. Conclusions reveal variation in the spatial configuration characteristics of mall layouts led to variation in the level of functional efficiency of the cases being studied. Consequently, this study confirms the following:

- Shopping is the integration between marketing strategies and design of shopping venues, in other words, the study in this regard is consistent with what has been inferred by (Bullough,1964,) and (Vernor,1993).
- The process of spatial configuration for shopping malls is built on the basis of the zoning or the distribution of activities within a comprehensive spatial configuration to achieve functional and economic efficiency as well as encourage the provision of a fun activity performance.

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