UNDERSTANDING SPACE SYNTAX THEORY IN RELATION TO INDOOR ENVIRONMENTS: ANALYZING FRANK LLOYD WRIGHT'S "DESTRUCTION OF THE BOX" THROUGH CONTRASTING A QUEEN ANNE HOUSE WITH WRIGHT'S ROBIE AND KAUFMANN HOUSES

by

AMIT RAMANI

B.Arch., School of Planning and Architecture, New Delhi, India, 1997

A THESIS

submitted in partial fulfillment of the
requirements for the degree

MASTER OF ARCHITECTURE

Department of Architecture
College of Architecture, Planning and Design

KANSAS STATE UNIVERSITY

Manhattan Kansas

1999

Approved by:

Major Professor
David Seamon

ABSTRACT

The relationship between the configuration of spaces and human movement in those spaces has been a central theme of *space syntax*, a theory and method for describing the relationship between physical space and human movement. For example, space syntax has been widely adopted by researchers to explore the cultural and social patterning of homes (Hillier & Hanson, 1984, Hanson, 1998).

Drawing on this space syntax research on houses, this thesis uses space syntax to analyze American architect Frank Lloyd Wright's 'Destruction of the Box' through a comparison and contrast of a prototypic Queen Anne house with Wright's Robie house (Chicago, IL) and Kaufmann house (Bear Run, PA). The aim of the study is to draw directly from the plans of the three houses the 'design prestructures' that the architects adopted to derive the houses forms. The research adopts the methodological framework of Julienne Hanson (Hanson 1994) and John Peponis (Peponis 1997) to identify the underlying relationships that characterize the three houses' contrasting spatial structures. The Spatialist program developed at the Georgia Institute of Technology by John Peponis and his space syntax research group is used as the computational and graphic tool for the study.

Using Hillier's justified permeability graphs and the Spatialist program, the thesis provides graphical and quantitative data to support the shift in spatial patterning of the three houses and substantiates Wright's dismembering of the traditional box. The thesis in turn provides a methodological framework that could be applied to building interiors to understand the role of space in shaping social relations and also understand how society and its institutions evolve over time.

TABLE OF CONTENTS

Chapter 7

AN ANALYSIS OF THE THREE HOUSES USING THE SPATIALIST PROGRAM **103**

Chapter 8

CONCLUSION **131**

LIST OF FIGURES

FIGURE **PAGE**

LIST OF TABLES

ACKNOWLEDGEMENTS

Like so many academic endeavors, this study is a product of many minds. The debt I owe to Professor David Seamon, my major advisor, is inestimable. I am especially grateful to him for his patience and constant guidance during the course of the study. His incisive criticism has contributed greatly in refining the content of this thesis.

I am also indebted to Professor Richard Hoag for his generosity in sharing ideas and encouragement during the inevitable teething troubles of this study. I am thankful to Professor Carolyn Thompson for her constructive criticism and sharing her thoughts on various issues covering a wide base of knowledge.

Many people have also contributed indirectly to the production of this thesis, thanks are especially due to Bill Hillier for inventing the space syntax theory, and John Peponis, who was generous enough for letting me use his Spatialist program at a reduced cost.

I would like to thank the staff at the Weigel Library and the Hale Library, who made available some of the important resources for the study.

I am also grateful to my Pentium-II processor, whose processing speed was much faster than mine and has made a major contribution in timely completion of my thesis.

The final credits are due to my family, Bhagwan, Lakshmi, Vipin and Sangita who have given me constant support and inspiration to enable me finally to bring this work to fruition and complete my Graduate studies.

Amit Ramani

CHAPTER 1

SPACE SYNTAX AND CHANGING CONCEPTION OF SPACE IN THE AMERICAN HOUSE

Space syntax theory is a powerful tool in the analysis of social and cultural functioning of space. [1] It is associated with the discovery that spatial configuration is correlated with the distribution of movement patterns and the probabilistic generation of encounter in urban areas. It has been used in the empirical study of the organizational use of space in buildings and the empirical study of the intelligibility of layouts. In general, the theory has been used as a conceptual tool applied to the formulation, evaluation and reformulation of real-world designs. (Peponis et. al. 1997)

The application of space syntax to houses is not a new phenomenon. It has been used to study function relations in both vernacular and modernist traditions. For example, space syntax has been used to analyze the spatial types in traditional Turkish Houses (Orhun, Hillier, Hanson. 1995). It has also been used to investigate the relation between composition and configuration in the houses of influential modern architects. (Hanson, 1994). Most importantly, it has been used as a method to describe house genotypes (Hillier, Hanson & Graham, 1987). In this sense, configurational analysis of a building's plan can be conceived of as an archeology of space. If the house displays morphological regularities, then the building speak directly of culturally significant household practices,

[1] The central study of space syntax is Hillier and Hanson' s 1984 *Social Logic of Space* (Hillier and Hanson 1984), a book which largely deals with outdoor environments, but also provides useful insights into the study of indoor environments. In the last several years there has been considerable work on indoor environments. The reference list at the end of this thesis identifies some of the most helpful discussions of the space syntax theory.

which have been crystallized in the form of the dwellings. Thus, space syntax describes relational structures of built space regarding the generic social functions and cultural meanings associated with buildings.

This thesis uses space syntax to analyze American architect Frank Lloyd Wright's 'Destruction of the Box' through a comparison and contrast of a prototypic Queen Anne house with Wright's Robie and Kaufmann houses. This first chapter overviews the changing style of architecture through the late eighteenth century to the early twentieth century and reviews the work of architectural historian H. Allen Brooks (Brooks, 1979), who has perhaps most thoroughly explicated the process whereby Wright opened up domestic spaces and gave them a sense of connectedness and flow. The second chapter reviews Hillier's theory of space syntax and discusses how it has been applied to building interiors. The third chapter discusses the software that is used for the analysis here and its application to various indoor settings. Finally, later chapters interpret the Queen Anne prototype and Robie and Kaufmann houses from the viewpoint of space syntax and illustrate how Hillier's ideas support and extend Brook's discussion of Wright's "destruction of the box."

Changes in the American Single Family House

Changes in the design standards and interior spaces of the American single family house from the early part of the seventeenth century to the early twentieth century was a result of changing social conditions and the desire to give tangible expression to specific values (Clark, 1992).

The American single family house developed over the past three hundred years through a variety of different styles. The period from the early seventeenth century to early nineteenth century saw the emergence of "colonial" houses, which included such styles as the Post Medieval English, Georgian, and early Classical Revival (figure 1.1). The early part of the nineteenth century witnessed the development of other house styles, for example, the Romantic period with Greek Revival, Gothic Revival and Italianate as the main styles (figure 1.2); and the Victorian period with the Second Empire, Stick, Queen Anne, Richardsonian and Shingle styles (McAlester and McAlester, 1986) (figure 1.3).

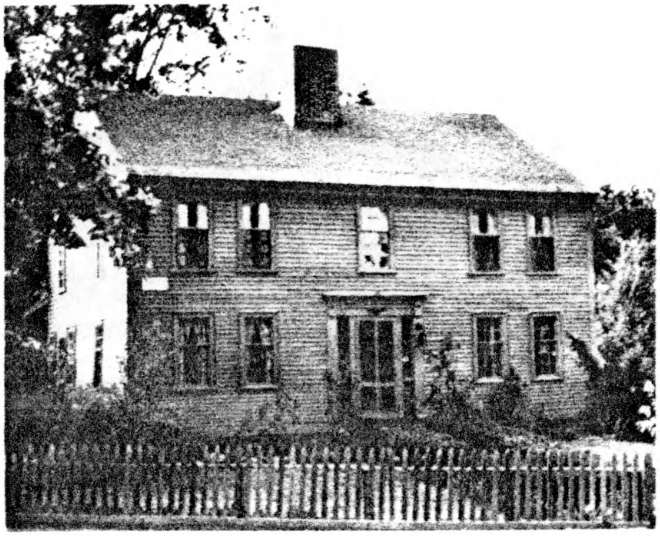


Figure 1.1 An early Nineteenth century Georgian house in Lincoln Massachusetts, ca. 1830. (Clark, 1986, p. 7).

The Victorian crusade to improve the American family home was similar in many respects to the other waves of reform that swept across the nation in the middle decades of the nineteenth century (Clark, 1992, p. 3). The Victorian period especially saw a revival of interest in ornamentation and a preoccupation

Figure 1.2 Greek Revival house built in Bennington , Vermont, 1851. (Clark, 1986, p. 11).

with defined hierarchy of spaces resulting in a closed boxed plan (Camesasca, 1971). In other words, each function in the house was located in a separate room with obvious doors and windows. The emphasis was on exploration of past centuries for architectural expression, rather than developing a new style. The Victorian period also saw the emergence of plan book writers and housing reformers who had set forth a new mission as to the form of the ideal American single family home (Clark, 1992, p. 75).

Figure 1.3 A typical Queen Anne prototype taken from Shoppell's pattern book (Shoppell et *al.*, 1983, p. 49).

The emergence of the plan book writers in the nineteenth century was a result of unprecedented population growth and the resultant demand in housing. These authors idealized Victorian ideas, particularly the Queen Anne Style. The emphasis was on combining the functional with the beautiful. Even though criticized by professional architects, these plan books were quite popular, owing to the easy accessibility and affordability of such house plans (Clark, 1992, p. 77). The plans in these books expressed the styles prevalent during the late nineteenth century and were reflective of the popular tastes of American society.

One such plan book author was R.W. Shoppell, the founder of the Cooperative Building Plan Association, which provided middle class Americans with cheap and fashionable house plans through a series of catalogs and portfolios published periodically (Shoppell, 1983). In later contrasting the Queen Anne prototype with Wright's two houses, this thesis will examine a set of Queen Anne plans from Shoppell's pattern book as part of the analysis.

The Queen Anne style was a result of an attempt to create a more domestic approach to home architecture (Rybczynski, 1986, p. 177). The style was largely based on seventeenth century English architecture. Since irregularity was admired by the architects and the plan book authors, these house plans had little or no symmetry. Rooms were designed based on the functions they served and thus assumed different shapes and sizes and were combined in a variety of ways. As a result, these houses very much emphasized aesthetic appeal over functionality (Rybczynski, 1986, p. 178).

The Queen Anne style typically constituted a boxed plan with four walls and a door. These four walls joined at the corners with a uniform floor and a roof (Brooks, 1979); in this sense, the room continued to be a box. As we shall see, in the discussion of Brooks' ideas below, the boxed character of house is evident through the plan and also from the descriptions of the Victorian style houses by the critics of the nineteenth century. Before we look at this "boxiness" in more detail, however, we need to consider the modernist movement, which was the next major change in American architectural style, including houses.

Modernism, Wright and Destruction of the Box

Modernist architecture was at least partly a result of the profound changes in the social and technological realms in the late nineteenth and early twentieth centuries (Curtis, 1983). The problem of architectural style for modernist architects did not exist in isolation but was related to deeper currents of thought concerning the possibility of creating forms which were not pastiches of past styles but genuine expressions of the present (ibid.).

The Modernist movement was a period in which forms were developed to counter what was seen as the superficial revivalism of the nineteenth century architectural styles. According to Curtis (1983, p. 16), "the Modernist movement was concerned with something far deeper than a battle of styles: It was an expression of a variety of new social visions challenging the status quo and suggesting alternative possibilities for a way of life."

American architect Frank Lloyd Wright was a pioneer in the formation of the Modern Movement. He has been portrayed as one of the first architects to break away from eclecticism and create a new architectural style based on a spatial conception of interpenetrating planes and abstract masses (Curtis 1983). According to Secrest (1992), Wright was one of the first architects to reject the idea of a house and rooms as a series of boxes. By positioning rooms on a diagonal and removing walls, he created a larger open space rather than two smaller closed boxes. In this sense, the house was no longer a box subdivided into smaller isolated spaces. Rather, Wright's interiors were broken up and recomposed into a sequence of autonomous but interconnected spaces each often differing from the rest in size, height, lighting and function. The attention was on a functional and linked space, all parts of which were permeable at a human scale.

Probably the most thorough discussion of the ways in which Wright was able to revise and transform American domestic space is provided by architectural historian—H Allan Brooks in his article, "Frank Lloyd Wright and the Destruction of the Box", published in the Journal of the Society of Architectural Historians in 1979 (Brooks, 1979). Brooks' emphasizes that when Wright entered the profession in the late 1880's the Queen Anne style had largely spent its force (ibid., p. 7). Brooks also notes that the Victorian style did not call into question the basic planning of a room. As he explains, "the four walls, joined at the corners and the uniform floor and ceiling remained; the room continued to be a box."(ibid.).

Brooks points out that the main change that had taken place from the earlier styles prior to the Victorian period was the use of larger openings between different functions, achieved by increasing the size of the room entry and door until they reached the width and height of the wall itself. But still the organization and functions associated with different rooms continued to be the same. The planning gave a sense of spaciousness when looking from one room to another but also resulted in some loss of privacy (ibid.).

Wright was critical of the prevalent Victorian styles with a separate room for each function. As Brooks explains, "In effect, one box neatly labeled was placed beside another and a series of these boxes made up the home. This was nothing new; the room as a box had been a western tradition since earliest times. It was a situation that Wright inherited, yet he soon redefined the concept of interior space, and he began this process by dismembering the traditional box"(ibid., p. 7).

According to Brooks (ibid.) Wright's initiation of the destruction of the box can be seen as early as 1902 by comparing his design for the Ross house at Delavan Lake, Wisconsin, with a typical Victorian style house, by architect Bruce Price's William Kent House here in Tuxedo Park New York (see figure 1.4(a & b)). Wright accepts the basic layout of the plan from the Price's house. Both houses plans are reflective of a cruciform style of planning, both have similar arrangement of rooms, and both have a characteristic

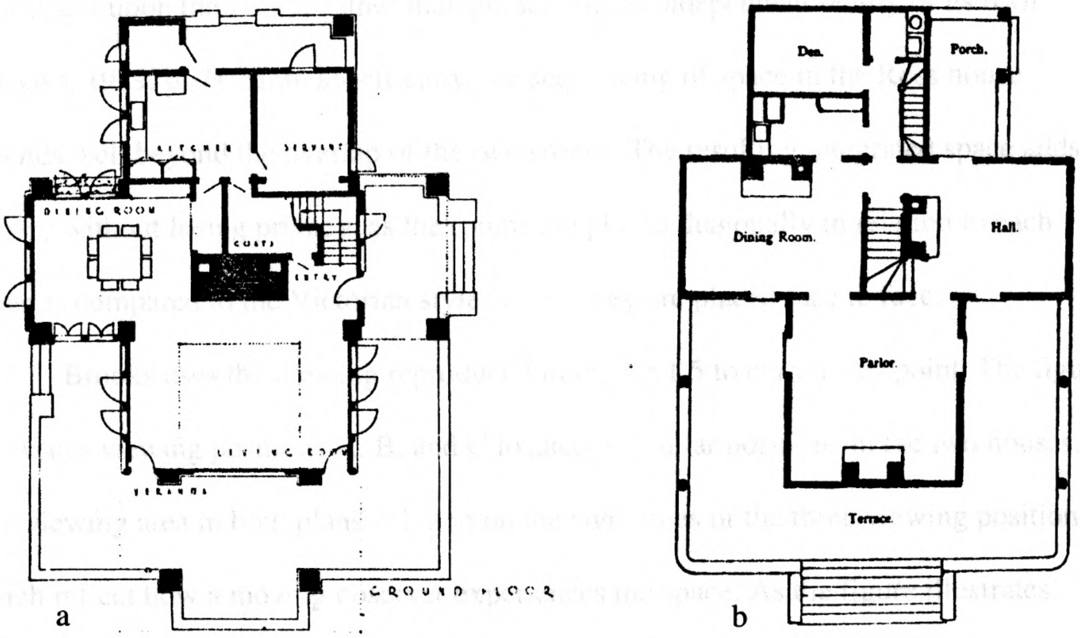


Figure 1.4 (a) Frank Lloyd Wright, Charles s. Ross house, Delavan Lake, WI, 1902, plan (b) Bruce Price, William Kent house, Tuxedo Park, NY, 1885, plan (Brooks, 1979, p. 8).

U-shaped verandah in front. Brooks emphasizes that the plans' essential difference, however is in the relation between the dining and the living room spaces (Brooks, 1979, p. 7).

Brooks says that what we see in Wright's Ross house is his start at attacking the traditional boxed rooms by destroying their corners. In the case of the Ross house, the dining and living rooms were designed in such a manner that their corners penetrated into each other while, at the same time, each room continued serving its own individual function. Therefore, both rooms make use of an area within the other room's space, a relationship that is totally different from Victorian style house where the spaces are spatially separate. In addition Wright's design for the Ross house eliminates doorway and corridors and serves as connecting space that reduces the amount of circulation space. In this sense, says Brooks, Wright's space loses its fixed value and acquires a relative one. As Brooks explains, "it depends upon experience and observation, this is empirical space, contingent upon the viewer rather than possessing an independent reality of its own" (Brooks, 1979, p. 7). More specifically, the sequencing of space in the Ross house extends well beyond the overlap of the two spaces. The resulting integrated space adds variety without losing privacy, as the rooms are placed diagonally in relation to each other as compared to the Victorian style, where they are placed face to face.

Brooks uses the drawing reproduced in Figure 1.5 to clarify this point. The figure illustrates viewing positions A, B, and C located at similar positions in the two houses. The viewing area in both plans is based on the sight lines of the three viewing positions, which reflect how a moving observer experiences the space. As the figure illustrates, Wright gains more privacy and variety. The view into the neighboring room is restricted and changes markedly as the viewer changes position.

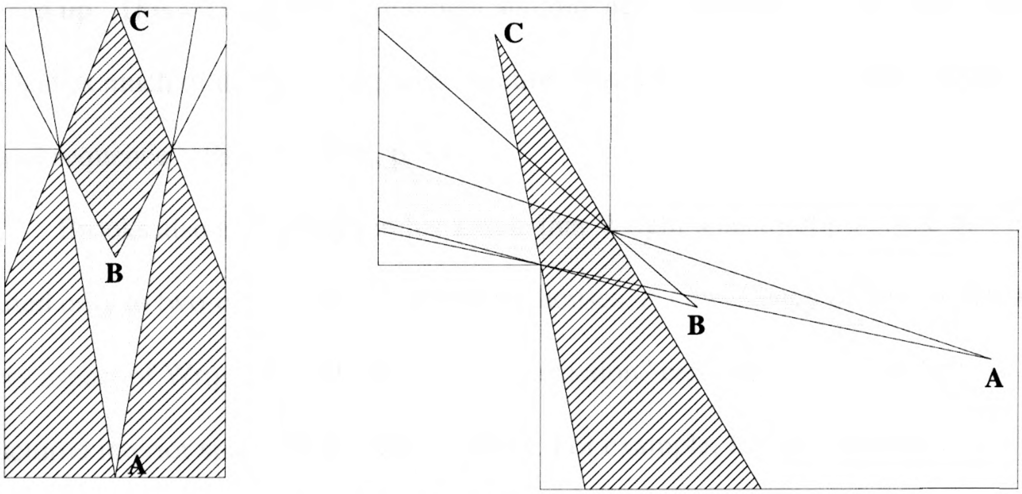


Figure 1.5 Queen Anne *vs.* Frank Lloyd Wright. Left: typical Queen Anne style plan with large openings between principle rooms. Right: in a Wright house, one room penetrates into the other at the corners. A, B, and C show the angle of vision, taken from identical positions, into the neighboring room. Wright achieves more privacy and variety. Room dimensions in two plans are identical (Brooks', 1979).

The same point can also be analyzed with help of the axonometric sketch from Brooks in figure 1.6. This drawing shows what Wright had set out to destroy—a house made up of series of boxes, each placed besides the other, and each serving a specific function. On the other hand, the axonometric drawing at right in the figure indicates Wright's first step in destroying the box. He places two rooms in such manner that part of each room's space is given over to the other. The result of this spatial configuration, as Brooks' explains, is that "the corners, the least useful part of the room, are destroyed and a controlled view into the adjacent area is opened up. This view, which is diagonal and pinched at the point of interlock, is limited and leaves much of the adjoining area obscure, introducing a sense of mystery into the spatial sequence" (Brooks, 1979, p. 8).

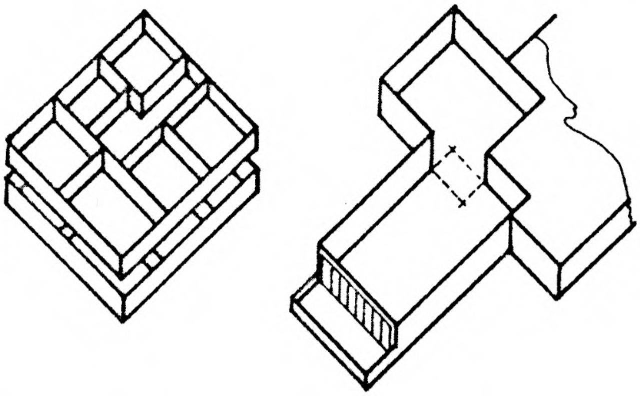


Figure 1.6 Left: typical house composed of box-like rooms. Right: Wright's first step in destroying the box. Rooms are interlocked usually at the corners, with each relinquishing part of its space to the other. The corner has been dissolved (Brooks', 1979, p. 9).

Brooks also emphasizes in his article that Wright's destruction of the box is not limited only to two-dimensional plans of his houses. A consistency of design pervades every aspect of Wright's work, thus this "destruction" can also be seen in the way Wright structured interior space three-dimensionally. For example, Brooks points out that the treatment of a center wall between rooms in Wright's house designs was often completely different from a typical Queen Anne style plan. Instead of creating large openings in wall, which would lead to a loss of privacy, he separated rooms by substituting a screen for a wall that could be walked around. One example of such an arrangement is the Robie house with its fireplace acting as a screen between the living and the dining rooms (figure 1.7). The ceilings of both rooms are visible from either space, adding to the feeling of spaciousness without compromising privacy. The absence of corners and boxed rooms adds to the spatial experience that is no longer dependent on space but is relative to the position of the viewer.

The implications of freeing the wall from its terminal were immense, concludes Brooks (ibid., p. 11), who writes, "once the wall was freed from its corners it became a slab, once it became a slab it was no longer locked in position in space; it could be rotated around its axis; divided into smaller slabs, could be reassembled and reintegrated to define something new."

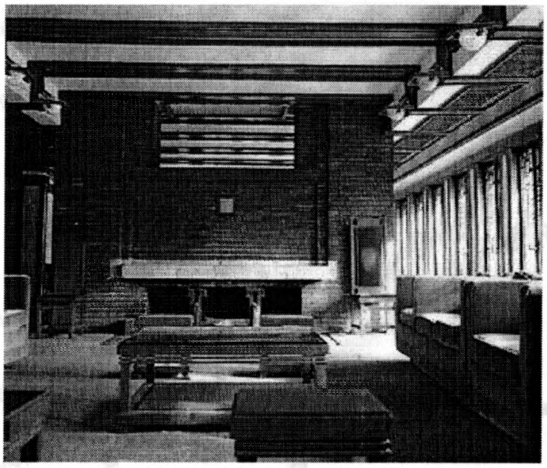


Figure 1.7 Image of Interior space of Robie house, With the fireplace, living room and dining room beyond (author).

The evolution of this process is illustrated in figure 1.8, also taken from Brooks, where the first sketch, plan A, depicts a typical rectangular room with four walls and fixed corners. In contrast, in sketch B, the walls are dislodged from the corners and are independent planes that can be moved around. The third sketch, C, illustrates what Wright achieved after the wall was free of its terminal. The figure is quite similar to the plan of the Robie house and clearly depicts the shift from the Queen Anne spatial arrangement to a much more free-form use of space.

In summary, Brooks explains that the traditional concept of a room with four walls joined at corners and a specific function had existed since a long time unchallenged. Wright recognized this static organization of space and was determined to correct it. As Brooks' (ibid., p. 11) explains, "Wright analyzed the components of a room, which basically was a box. He realized that the corners were the most expressive element, so he demolished them first. He then dismembered the other components of the room—walls, ceilings and even floors, finally reassembling the components into a completely different spatial concept."

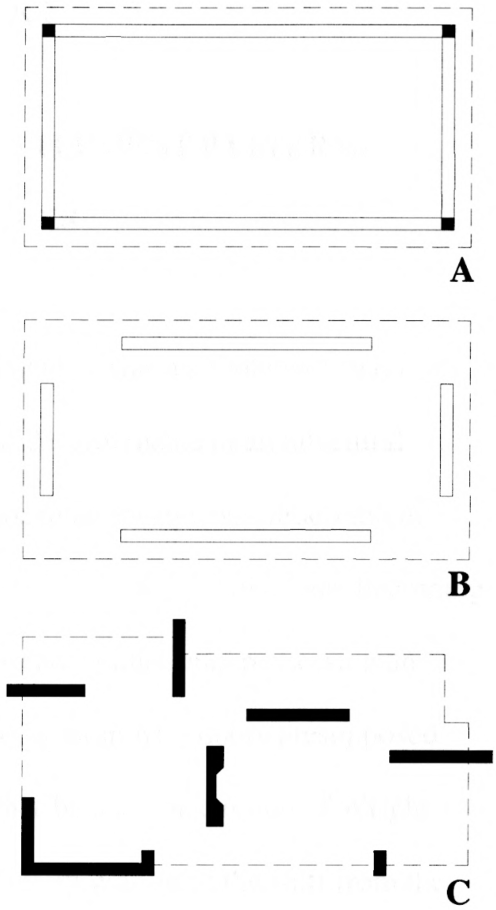


Figure 1.8 A: typical room with walls joined at four corners. B: Wright's first step: eliminate the corners, thus turning the walls into freestanding movable slabs. C: Wright's second step: define, by reassembling segments of these slabs, a new spatial context that integrates the former functions of the demolished rooms (Brooks, 1979, p. 12).

Wright's shift in his use of space was initiated in his earliest Prairie style houses (e.g., the Ross house, 1902), was developed further in his later Prairie style houses (e.g., the Robie house, 1906), and reaches perhaps its most mature expression in his Kaufmann house (1936). As explained above, this thesis analyzes this shift in spatial conception with the help of Hillier's space syntax theory. In order to apply the theory to this shift, represented in the prototypic Queen Anne versus the Robie Kaufmann houses, it is essential to understand better space syntax and its application to building spaces. This is the aim of the next three chapters.

CHAPTER 2

SPACE SYNTAX AS APPLIED TO SETTLEMENT PATTERNS AND URBAN SPACES

The destruction of the box as described in chapter 1 was a simple idea yet, in its ultimate implications, was one of the most important developments in architectural history (Brooks, 1979, p. 7). The definition of interior relationships was redefined in Wright's work as interior space lost its fixed value and acquired a relative one, becoming a relationship dependent on the experience of the observer rather than possessing an independent static reality that the fixed dimensions of a room with doors presupposed.

For this thesis, it is important to emphasize that Brooks' discussion of Wright's destruction of the box provides largely a qualitative interpretation of the shift from the boxed plans of the Queen Anne style to Wright's open and flowing spaces (Brooks, 1979). Instead, this thesis seeks to analyze the shift from fixed to relative space based on Bill Hillier's space syntax theory, since it provides a combination of qualitative and quantitative techniques that are both objective and precise and provide empirical data that can be analyzed easily. But before this shift in space can be analyzed in terms of the Queen Anne, Robie and Kaufmann houses, it is imperative to understand space syntax theory and its specific quantitative methods. This chapter reviews space syntax theory as it is applied to outdoor urban space, while the next two chapters cover the application of the theory to indoor environments.

The Beginnings of Space Syntax Theory

Space syntax theory originated in the mid 1970's at the Barlett School of Architecture and Planning, University College, London, as proposed by Bill Hillier and his space syntax research group. According to Hillier (1983), urban space today has lost the informal liveliness that was once part of quality of urban life. The search for urbanity has become a central theme in architecture—for example, Jane Jacobs' work is one of the most important studies of the 20th century to emphasize the importance of the physical setting as a major determinant of the liveliness of urban streetscapes. As Seamon explains, however, "a criticism of Jane Jacobs' conception of the city was that her evidence was anecdotal and that she offered no precise empirical proof for her claim that the physical environment played a pivotal role in supporting urban diversity and lively streets" (Seamon, 1994, p. 41).

At the time Jacobs' was writing—1961—designers did not have the concepts and techniques to describe and investigate the kinds of spatial order that perhaps can be found in highly complex physical structures like towns and cities (Hillier, 1983). This fact could be attributed to the lack of understanding patterns of spatial relationships. Hillier (1983) argues that, conceptually, urban space had been looked at from a single standpoint. Rather he believes that urban as well as architectural space must be analyzed from many points if its social nature and consequences are to be understood (ibid.). Visual presentations that are used by most designers give them a local view of the urbanscape, but Hillier argues that, in order to analyze spatial properties completely, one must look at the entire set of spatial relationships for outdoor and indoor spaces.

The main finding of Hillier's Research group in regard to urban space is that it is the overall organization of space that acts as the means by which towns and urban areas may become powerful mechanisms to generate, sustain and control patterns of movement of people (Hillier, 1983). To study space in this way, Hillier and his research team at the Barlett School developed their theory of space syntax, which proposes an objectively precise method to investigate how well environments work by relating social variables to architectural forms. To simulate the performance of real as well as hypothetical towns, the research group included in their research techniques the use of the computer as a suggestive and evaluative design tool.

To provide empirical evidence for their concepts, Hillier's research group applied the space syntax method to more than a hundred towns and urban areas throughout the world, simulating and analyzing patterns of movement and use. The results led to three basic principles: first, the intelligibility of space—that is how easily inhabitants can distinguish between the larger pattern and the local parts of an urban space; second, the continuity of occupation—that is, whether there are packets of unused or underused space in an area; and, third, the predictability of space—that is, how well the potential pattern of human encounter can be predicted from the spatial pattern. These principles in turn led to a formal method of analysis for urban space.

Villages and Beady Rings

Hillier begins by acknowledging that buildings and towns have a fundamental property that distinguishes them from most other artifacts: that they organize space. He also wonders if there is some "deep structure of the city itself" which contributes to its urban life. Hillier's interest in this "deep structure" at least partly began in Southern France as he studied village layouts, especially the village of Gassin in the French region of Var (figure 2.1). Hillier hypothesized that there exists a spatial order to the village of Gassin and that socioeconomic factors or the culture of the community do not solely determine it. To test his hypothesis and demonstrate theoretically the relative spatial autonomy of a settlement fabric, Hillier examined several villages of the Var region for fundamental commonalties. He found the following (Seamon, 1994, p. 38):

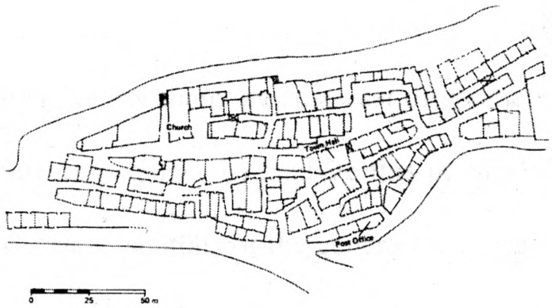


Figure 2.1 The small French village of Gassin (Hillier and Hanson, 1984, p. 90)

1) All building entrances face directly onto the village open spaces, thus there are no intervening boundaries between building access and public space;
2) The villages' open spaces are irregular in their shapes, in other words, they narrow and widen like beads on a string;
3) The spaces join back on themselves to form a set of irregularly shaped rings;
4) Thus ring structure, coupled with direct building entry, gives each village a high degree of permeability and access in that there are at least two paths and, typically, several more from one building to any other building;

Hillier's studies further led to the conclusion that the above four findings were found in a great number of other traditional settlement patterns throughout the world. Because of the irregularly shaped spaces linked by irregularly shaped rings, Hillier came to call this recurring spatial pattern the *beady-ring structure*.

A Computer Model

Hillier's next step was to establish whether or not there are some set of geometric rules that, in themselves, contribute to the recurring pattern. To analyze this possibility, Hillier developed a computer model to establish "the essentials of the generative process" (Seamon, 1994 p. 38). The model is based on two spatial rules:

1) Each building has one entrance, and the building, in turn, is attached to an equallly sized unit of open space—a unit Hillier called the *doublet*;

2) The joining of these "doublets" with the building's entrance side to open space and aggregating randomly but with the requirement that each new doublet attach itself to the building side of another doublet or to an open side of the open space.

Figure 2.2 illustrates four stages of a beady ring structure as arising through one of the many random simulations done by Hillier using the doublets. As one sees in the figure, the beady ring structure is quite visible by the fourth stage. With the help of his computer simulations, Hillier claimed to have established spatial rules of the urban object itself. In short, he argues that the beady ring structure is generated through a simple and elementary geometric pattern. According to Hillier, it is this underlying spatial morphology that describes the underlying spatial coherence

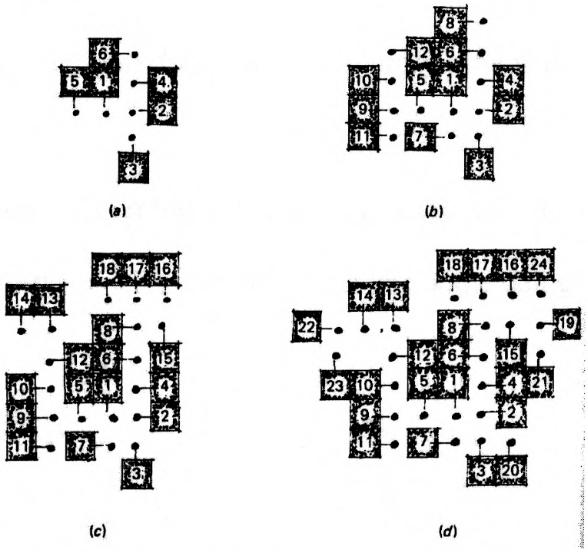


Figure 2.2 The first four stages of a computer simulation; note by the fourth stage that the beady-ring pattern has become clearly visible (Hillier and Hanson, 1984, p. 60).

providing settlement layouts with an underlying geometric pattern and connectedness. As Seamon explains (1994, p. 38), “at the start, one must realize that this geometric coherence runs beneath a spatial network like the hand beneath a glove provides its organized form. This geometric form is not additive but synergistic: invisible and whole throughout, it is always already there to support one dynamic of circulation and exchange rather than some other.”

Convex Spaces

Next, Hillier proposes two kinds of contrasting spaces—*convex* and *axial* spaces—to understand morphological regularity in term of mapping and measurement. These convex and axial measures provide the basis for the development of his more sophisticated analytical measures. The spaces are also drawn on to account for the way space structures movement.

First, we consider *convex spaces*, which according to Hillier, are spaces that relate to the two-dimensional character of an open space, with some being fat and some being thin. These spaces are best exemplified by gathering areas in traditional settlements such as squares, plazas and parks and serve the function of drawing people together. In a traditional settlement, for example, a convex space would typically be the location for weekly markets and fairs.

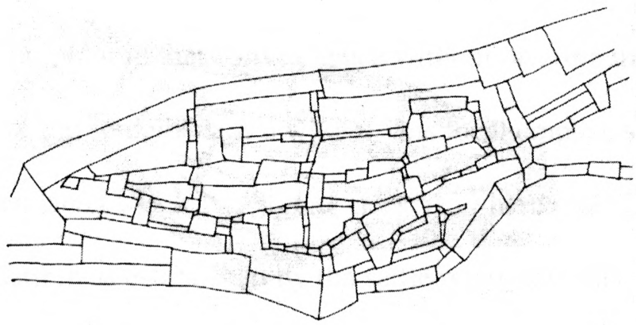


Figure 2.3 A map of Gassin’s convex spaces (Hillier and Hanson, 1984, p. 92).

The key distinguishing feature of a convex space is that each point within is visible and accessible from every other point. Graphically, a convex space can be identified by areas inside of which no line drawn between any two points goes outside the space. As Hillier explains, "by definition, any convex segment will not contain concave parts. Any two points in a convex segment can be joined by a straight line that does not go outside the boundaries of the open space"(Hillier, 1983, p. 50). Figure 2.4 shows two different linear arrangements where in figure 2.4a points 'x' and 'y' form a convex relationship, while in figure 2.4b the two points are in a non-convex relationship.

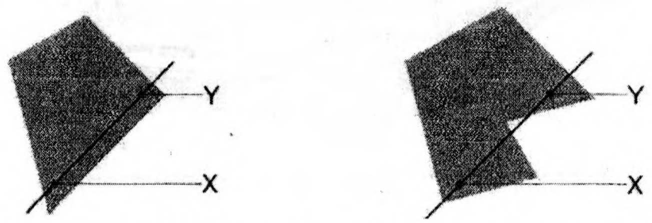


Figure 2.4 (a) the two points are joined by a single straight line which does not go outside the boundary—convex relation. (b) the line crosses a boundary to join two points—non-convex (Hillier, 1983, p. 50).

In other words, in a convex space, each point within a space is visible from all other points, for example, all building entrances on that space. In this sense, convex space relates to the beadiness of the *beady-ring structure* (Seamon, 1994, p. 39). Furthermore, a convex space is a *local* measure in the sense that its boundary is defined by every point that is directly accessible to every other point in that convex space without offering many clues about the larger spatial pattern of the settlement as a whole. This local emphasis is in contrast to an axial space (discussed later) which is a *global* measure, where global relates to the interconnected spatial pattern as established by the settlements pathway network as a whole.

Hillier's idea that every point in an urban system has a one- and a two-dimensional aspect is different from the idea of streets and squares where spaces are either one- or two-dimensional. Thus seeing every point both one- and two-dimensionally means that every point has a local and global dimension. It is how the two come together that distinguishes the different morphological features of different types of towns and urban areas (Hillier, 1983, p. 50).

The convex map for the French village of Gassin as seen in figure 2.5 thus consists of the largest and fattest spaces that cover the entire area being analyzed. These convex spaces relate to the two-dimensionality of Gassin's street pattern and are associated with the copresence of others in specific spaces like plazas and squares rather than potential human movement through the village as a whole

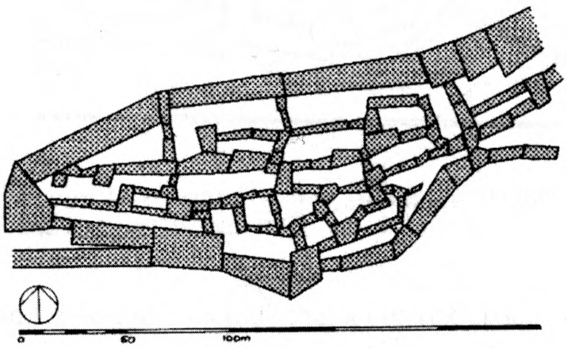


Figure 2.5 Convex map of Gassin in the south of France with convex spaces shown in White and buildings in Grey (Hillier, 1989, p. 9)

Axial Spaces

In contrast to convex spaces are axial spaces, which relate more to the one-dimensionality of space and are best illustrated by long narrow streets of a settlement layout. An axial space can be represented graphically by the maximum straight line that can be drawn through an open space before striking an edge (building, wall, and material object). Therefore, an axial map consists of the fewest and longest straight lines that cover the entire area (Figure 2.6). In this sense, axial spaces relate to the stringiness of the beady-ring structure (Seamon, 1994, p. 39). Thus, an axial map is a way of seeing and experiencing a space as it is connected to its larger spatial network, since an axial line extends as long as at least one point is visible and directly accessible. The axial lines, thus, usually run through a number of convex spaces. This relationship to the larger-scale pathway system is an important property in defining urban spatial experience (Hillier, 1989, p. 10).

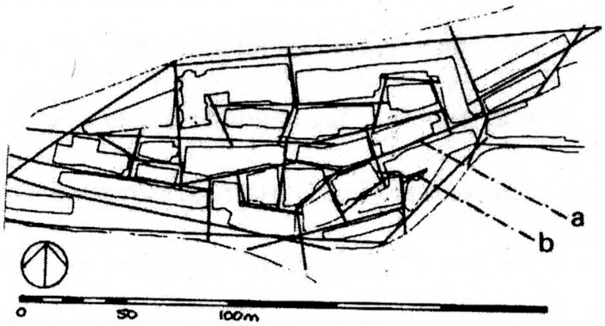


Figure 2.6 A map of Gassin's axial spaces (Hillier and Hanson, 1984, p. 91).

Drawing from the above discussion, one can conclude that a convex space is that portion of a settlement layout where all points are visible and directly accessible from all other points, whereas axial spaces are related to several convex spaces which are visible and directly accessible as far as the straightness of the axial space can reach without striking some boundary. Therefore as Hillier explains (1989, p. 10), "through this relation between convexity and axiality in space, we are in effect given two kinds of information from space: complete *local* information about the space we are in through the convex organization; and partial *global* information about spaces we might go to through the axial organization."

The convex spaces more often relate experientially to rest, locality and events in place. Even though long and narrow streets possess convexity and may have a sense of place, they can be better understood in relation to axial space organization as they are essentially used for movement and circulation flow. In contrast, convex spaces are typically places that support events—for example a plaza or a piazza where social gatherings are held (Seamon, 1994, p. 40).

Integration vs. Segregation

The convex and axial maps form the base around which Hillier constructs a wide range of numerical measures. In this sense, he seeks to establish a technique that will identify which pathways in a settlement make themselves most readily accessible to other pathways and thereby integrate the locality with the wider surroundings. Using a similar technique, he also devises measures to identify the pathways that make themselves less accessible to their surroundings. Essentially what is being discussed here are the twin properties of what Hillier calls *integration* and *segregation*.

These properties can be understood with help of figure 2.6. The axial map shows that every other line is linked to every other line, either directly or by way of the particular minimum number of intervening spaces or lines. This is, what Hillier calls, the property of *depth*. The concept of depth is one of the most important relational properties in space syntax (Hillier, 1983, p. 54).

Depth exists where it is necessary to pass through a number of intervening spaces—convex or axial—in order to reach a space. Thus the opposite of depth is *shallowness*, where the route between spaces is more direct. Depth then can be seen and experienced from any given point inside or outside a system of spaces (Hillier, 1983, p. 54). Furthermore, the axial or convex map can be turned into a graph and the particular system can be represented as a depth diagram from any chosen space or line. Each axial line then can thus be considered as one space traversing through a specific number of convex spaces. In other words, a space is as deep as the least number of intervening spaces that must be passed through to go from one space to another. In this sense, a space is at depth one from another space if it directly connected to it, at depth two if it is two spaces away and so on until all the spaces in the town have been included.

The resultant depth diagram gives a graphic picture in the form of a justified graph as well as a numerical measure which can be computed based on a mathematical formula, thus giving a precise index of relative depth or shallowness of any spatial system as seen from one particular point. An axial space that is shallow from all points, based on the comparison of all depth diagrams from all points in the system, is integrated, whereas one that is deep will be segregated from most other pathways of the settlement. In other words, a space (axial line) is integrated if the number of lines to be crossed to reach every other line in the settlement is less and is segregated if it is more. Therefore integrated lines relate to the property of shallowness and segregated lines relate to the property of depth. Figure 2.6 shows an axial map of Gassin and illustrates the number of convex spaces each line traverses and the relation between different axial and convex spaces.

Before the numerical and qualitative measures based on depth can be introduced, it is essential to understand that the encounters based on movement and co-presence are only potential. It follows that even though a line may be most integrated and traverses through a number of convex spaces, yet, in fact, it might not result in the most integrated space of the whole settlement because the integration might depend on how space is structured within a spatial layout and its built qualities. Actual integration might also depend on adjoining activities, uses and building types located within the space. Figure 2.7 is an axial map of Gassin showing lines of high integration, superimposed on the largest convex spaces. The convex spaces in the figure are only potential for encounter and copresence but in reality they might not be the most integrated spaces of the settlement. Thus, a space may attract people based on its function rather than its location in the spatial layout. For example, a village square may attract people based on location of specific shops rather than the spatial layout, while another square might be a complete failure owing to its linear structuring. Integration and segregation are only potential measures and may not prove to be true in reality.

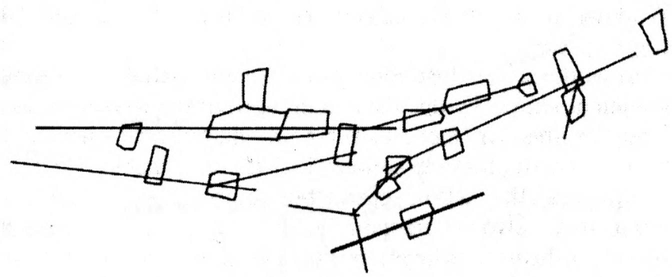


Figure 2.7 Axial Map showing the interior lines of high integration, superimposed on the largest convex spaces (Hillier and Hanson, 1984).

Therefore, Hillier uses the term *virtual community* to describe the field of potential encounters as they are grounded in settlement's physical layout. As Seamon explains (1994, p. 43), "he chooses the word 'virtual' because this spatial field is always present, though sometimes only latent and unrealized." The community is always present but only becomes real through the particular spatial design and the relation between the people and their activities within the space.

Justified Graphs

A graphical way of expressing depth is what Hillier calls a justified graph. This graph is based on the property of depth, by which, as was explained above, refers to the number of intervening spaces one must pass through to get from one space to another. The justified graph can be better understood with help of figures 2.8a and 2.8b. Figure 2.8a is a justified graph of the system of lines as seen from the point of view of the most integrated line of the system (marked 'a'). The points in the graph represent lines, and the connections represent the intersection of lines. The long line marked 'a' in figure 2.6 is the root of the graph and each level of depth away from that line is aligned vertically, so that the height of the graph shows how integrated the line is: the shallower, the more integrated and vice versa. Figure 2.8b is a similar graph drawn from a short line (marked 'b'). The greater height of the graph shows that the system has more depth from that line, and that line is therefore less integrated, or more segregated. The property of depth can also be analyzed quantitatively with the help of mathematical formulae, some of which are considered in the next section.

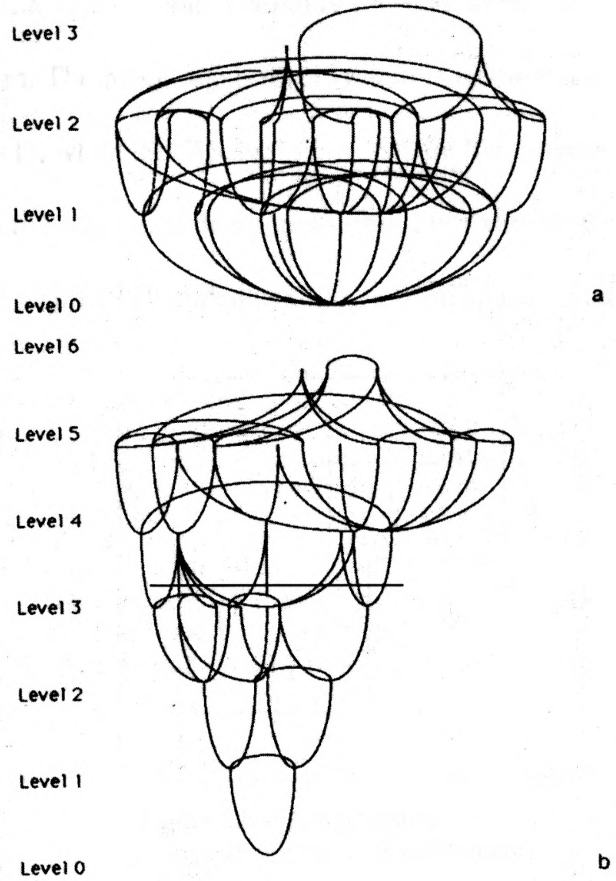


Figure 2.8 A justified graph of spatial relations in Gassin (a) from an integrated line, (b) from a segregated line (Hillier, 1989, p. 11).

Integration Quantitatively

It follows that the integration value of a line is a mathematical way of expressing the depth of that line from every other line in the settlement and finally giving a theoretical possibility of how deep or shallow the system can be. The measure can be calculated by the following formula: $Ix = [2(MD-1)] / [k-2]$, where Ix is the integration value for a specific point in the settlement, MD is the mean depth of the system below and k is the number of spaces in the system. The mean depth for a system is calculated as: MDx = (Sa+Sb+Sc...........Sn) / (k –1), where Sa, Sb, Sc..........Sn are the number of spaces that the particular space is from the space x is being measured. For example a spatial arrangement as shown in figure 2.9 can be calculated as follows from space 1 and space 6. Therefore for space I_1,

$$MD_1 = (S2 + S3 + S4 + S5 + S6) / (k-1)$$
$$MD_1 = (0 + 0 + 1 + 2 + 3) / (6-1)$$
$$MD_1 = 6 / 5 = 1.2$$
$$I_1 = 2(1.2-1) / (6-2) = .4/4 = .1$$

Similarly for space I_6

$$MD_1 = (S5 + S4 + S3 + S2 + S1) / (k-1)$$
$$MD_1 = (0 + 1 + 2 + 4 + 3) / (6-1)$$
$$MD_1 = 10 / 5 = 2$$

$$I_1 = 2(2-1) / (6-2) = 2/4 = .5$$

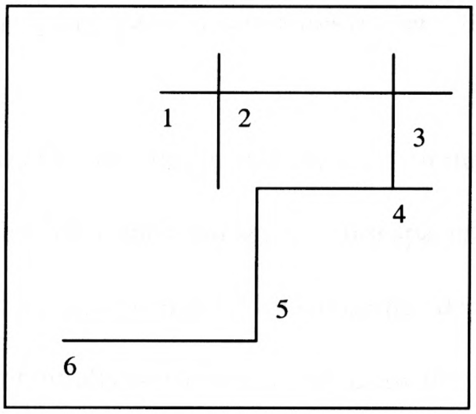


Figure 2.9 A simple spatial arrangement with six spaces (author).

The values calculated above can be interpreted as follows. Values that are lower or closer to 0 indicate a shallow or integrated space, while a higher value closer to 1 indicates a deep or segregated system.

Hillier argues that the most integrated lines together represent the integration core of a settlement and can be arranged in order of integration. The integration core in a settlement is identified by the top one-tenth most integrating lines for large settlements (a settlement having a hundred axial spaces or more), or by the top one-

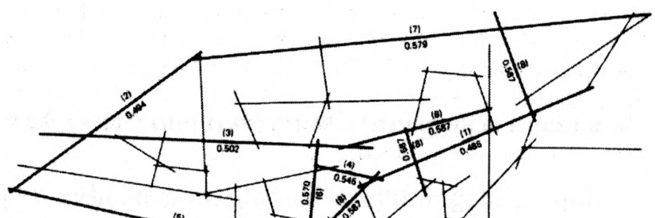


Figure 2.10 Integration core of Gassin, in this case the 25% most integrating spaces, with lines numbered in order of degree of integration (Hillier &Hanson, 1984).

quarter most integrating lines for smaller settlements like Gassin. Figures 2.10 and 2.11 represent the graphical representation for Gassin based on these quantitative measures. Figure 2.10 shows the integration core of Gassin with lines numbered based on their degree of integration, while Figure 2.11 shows the integration and segregation map of Gassin. The integrating spaces are represented by solid lines and segregating spaces by hatched lines. As Seamon explains (1994, p. 41), "the streets marked by solid lines depict the village's integration core—those streets that potentially most powerfully draw the movement of other streets to themselves and, therefore are alive with public and commercial activity. In contrast, the hatched lines indicate Gassin's segregation core—the streets that deflect activity away from themselves and, therefore, potentially indicate pockets of quiet and seclusion."

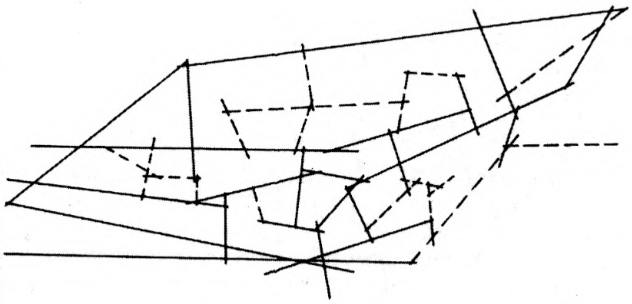


Figure 2.11 Integration-Segregation map of Gassin. Integrating spaces are represented with solid lines and segregating spaces by dotted lines (Hillier, 1989, p. 11).

The Deformed Wheel

Hillier next asks if the axial lines of more potential activity (integrated lines) and of less potential activity (segregated lines), indicate some larger morphological structure for settlements as a whole. In fact, after studying the integration and segregation cores of many settlements, both Western and non-Western, Hillier concludes that such a larger global structure exists, and he calls it the *deformed wheel* (Seamon, 1994, p. 41). According to Hillier this wheel is the deepest integrative structure of a settlement.

The rim, spokes and hub of this wheel are the pathways with higher integration values (in figure 2.12 the solid lines). Thus, these streets are, on the basis of integration calculations, the most used potentially by the residents of the settlements because so many other axial spaces feed into them. The effect of the

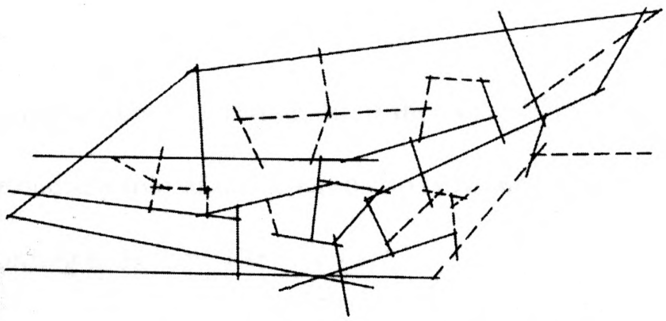


Figure 2.12 Gassin's "deformed wheel". Note that the streets of greater movement potentially are marked by the solid lines whose shape roughly suggests a wheel and spokes; in contrast, the hatched lines indicate streets of lesser movement potentially. Note that overall these more sgeregated streets are between the more active thouroughfares potentially (Hillier and Hanson, 1984, P. 91).

integrated lines is to access the central areas of the town from outside, while at the same time keeping the core lines close to the segregated areas. As Hillier explains (1989, p. 10),

> since the core lines are those that are most used by people, and also those on which most space-dependent facilities like shops are located, and the segregated areas are primarily residential, the effect of the core is to structure the path of strangers through the settlement, while at the same time keeping them in close interface with inhabitants moving about inside town. Indeed, it seems reasonable to propose that the spatial structure of the settlement exists in order to construct this interface.

Therefore, spatial configuration creates the field of probable—though not all possible—encounter and co-presence within which we live and move.

The main idea here is that the earlier mentioned virtual community is a direct product of spatial design. As Seamon explains (1994, p. 43), "the design and planning need is, first, to understand the significance of space syntax in life of the city; and, second, to use physical design to construct the field of potential encounter and copresence that we call the virtual community."

Space Syntax and its Implications

The relationship between architecture and community formation, if they occur in the way Hillier claims, exist through the intermediary role of the relationship between spatial from and the virtual community. According to Hillier (1989, p. 13):

> since the virtual community is a product of spatial configuration it can only be detected through space-syntax analysis coupled with precise and systematic observation of where people are in space and how they move. This observation shows that the rates at which people use space and move through it are statistically reliable properties of spaces, and can be assigned to space as *encounter rates* for those spaces. These encounter rates represented as numbers can then be correlated with values assigned to the spaces by syntactic analysis. The resulting correlation patterns allow one to build up a picture of the fundamental relationship between the spatial configuration and encounter pattern of an area.

The result of these correlations is integration, which, according to Hillier is nearly always the best spatial parameter for predicting the encounter rates of moving people. As he explains (1989, p. 15), "People construct their patterns of movement, it seems, according to the picture they have of the axial depth of the spaces from each other, with reference to a fairly large system of spaces." Thus the knowledge of spatial structure of an area is also knowledge of its encounter potential.

The virtual community and its encounter potential are key concepts, Hillier believes, which help facilitate active streets through a settlement and urban areas. Thus, for designing the virtual community, the most important notion is the deformed wheel. As Seamon explains (1994, p. 43), "a deformed wheel links local street life and interpersonal encounter with the larger global structure of which locality is a part." According to Hillier, it is the global pattern which affects how towns work and create patterns of use and movement. Thus Hillier's theory suggests an approach whereby the larger whole—the pathway network—should be designed first before designing the parts—the districts and neighborhood comprising the settlement as a whole.

As Hillier explains, "If we want to recreate urban life, then we have to start by reading the larger scale pattern of an area, then design the internal structure of new developments to take advantage of the large scale pattern" (Hillier, Hanson & Peponis 1987, p. 231). In this sense, space syntax research treats built environments as systems of space, analyzing them 'configurationally', and attempting to bring to light their underlying patterns and structure.

As we shall see in the next two chapters, the concepts and ideas explicated for the outdoor environments through space syntax can be easily extended to building interiors. Indoor spaces, like outdoor spaces, consist of global and local patterns of space. The global pattern is the building as a whole, while the individual rooms form the local measure. The concepts of convex and axial spaces, depth and shallowness, justified graphs, and integration can all be extended to building interiors and will be discussed in chapters three and four.

CHAPTER 3

SPACE SYNTAX AS APPLIED TO BUILDINGS

In describing and analyzing space, space syntax seeks to understand the *emergent structure* of the physical city, and to account for both its constructive functional logic and its functional impacts. Chapter two discussed space syntax as applied to settlements and urban spaces, providing rigorous quantitative descriptions of built space so that we can enquire with greater precision and argue with greater conviction about the social and cultural consequences for choosing one pathway arrangement rather than another (Peponis, 1989, p. 334). Hillier, after his encouraging results with analysis of settlements and urban open spaces, extends its application to analyze building interiors. The basic principles underlying the analysis remain the same with only the terminology and the methodology undergoing a few changes. Hillier, through his work on building interiors, argues for a considerable influence of socio-cultural norms on the spatial organization of buildings.

Space syntax has been described as a method for analyzing the relational structure of built space in conjunction with the development of theories regarding the generic social function and cultural meaning associated with buildings (Peponis, 1997, p. 761). The main argument is founded on the assertion that building forms are embodied in social norms of societies. Thus analyzing and interpreting spatial qualities of artifacts like buildings reveal the social dimensions of space and its relation to its users. The procedure is based on graphic representations, nodes and links of architectural floor plans, and quantification of graph properties using mathematical formulae (Osman & Sulman, 1994, pp. 189-190).

The application of the space syntax theory to indoor environments seeks to answer two basic questions:

a) How does a building floor plan establish how a building is used and who can go where?

b) Do different institutions (e.g., hospitals, schools, museums) have different patterns of space use and permeability?

To answer the two basic questions, Hillier applies the space syntax method for quantifying, describing and comparing the morphological patterns of buildings for the purpose of projecting the social norms of their inhabitants (Osman and Suliman, 1994, p. 190).

The Permeability Graph

The study of indoor environments is based on graph theory, which is also the key to Hillier's work on settlement layout as well as buildings. As discussed in chapter two, a justified graph uses geometric representations to understand the relationship between

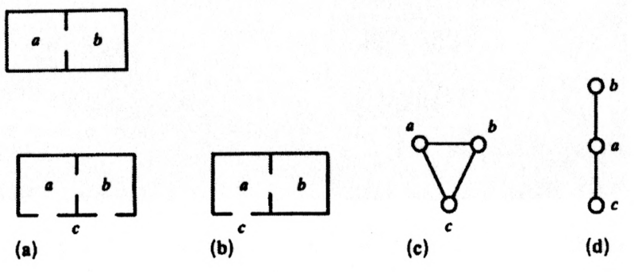


Figure 3.1 Top: shows a divided cell; Bottom (a), (b) shows the possible relations of spaces a and b to the outside space c, and (c), (d) the corresponding justified graphs (from Hillier et al, 1987, p. 363).

sets of elements or entities. The foundations of a justified graph are the concepts of depth and shallowness that govern how a space relates to all other spaces in a settlement. The two concepts also form the bases for what Hillier calls a permeability graph.

This kind of graph basically deals with the access of a building's interior spaces in relation to each other and also to the buildings exterior. The concept can be better understood in figure 3.1, which shows a divided cell in which space 'a' is linked to space 'b' through a gap. The gap creates a relation—what Hillier calls *permeability* between the two spaces. But the relation means little until the relations of each to at least one further space is established—that is to say, until the position of each is known with respect to a configuration (figure 3.1 (b)). Similar to an outdoor environment, a room can be compared to a single convex space and the whole spatial layout of the building to the settlement.

With a few exceptions, the construction of a permeability graph is similar to an adjacency graph. Each room is represented by a point called a *'vertex'* (figure 3.2). Whenever two rooms form a connection, a line can be drawn joining the two vertices and is called an *'edge'*. Each of the edge signifies a means of access between adjacent spaces. Further-more, the access links between the building and its surrounding space are identified. Hillier calls this exterior space the *carrier* and represents it with a circled cross. The carrier is conceived as a continuous space and not

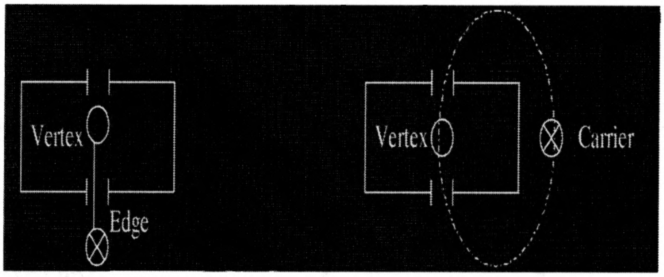


Figure 3.2 This shows the example of the vertex with the edge and the carrier around it. The edge is a point and the carrier is shown with a circle with a cross (author).

divided into specific exterior regions. For example, if a building has three separate entrances, the outside space is considered as one.

The Justified Permeability Graph

Since permeability graphs can be difficult to read, Hillier devised another kind of graph—what he called a justified permeability graph—a more global version of the permeability graph as shown in figure 2.3. The graph is standardized in terms of the carrier or a particular interior space. In a justified graph, the vertex of the carrier is placed on the lowest level. Spaces, which are directly accessible from the carrier, are placed on the next level, up one from the previous level or level 1. In turn, the spaces two edges from the carrier are placed on level 2, and the delineation continues to the required number of levels.

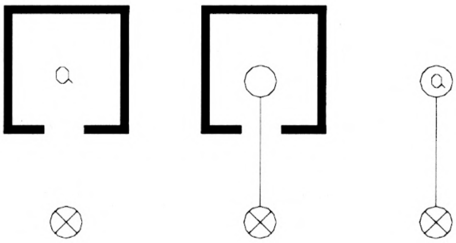


Figure 3.3 A justified permeability graph of a simple spatial configuration (author)

The justified permeability graph is based on two main properties—*depth* and *choice*. Choice can be further subdivided into the properties of symmetry and distributedness. Depth, as it relates to indoor environments, is similar to depth discussed for outdoor environments. Depth is described as the number of edges connecting a particular interior space with the carrier and is dependent on

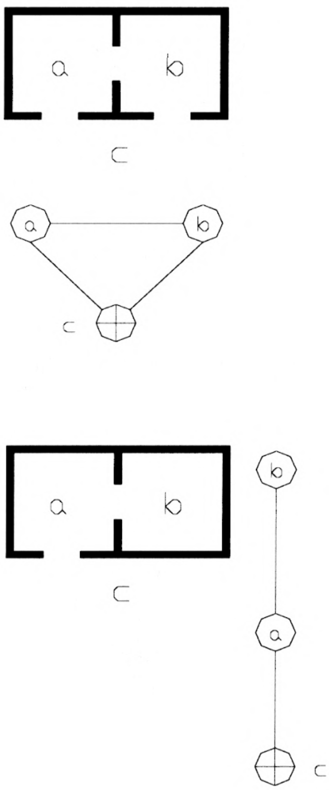


Figure 3.4 (a) a deep configuration (b) shallow

accessibility to a given space rather than its adjacency. Depth assumes the shortest distance or fewest number of edges a room is from the carrier. Distance here relates to the syntactic or topological distance, rather than a measure of metric distance.

Thus the shortest distances with many edges are deep while the shortest distances with few edges are shallow. Figure 3.4 shows a comparison between a deep and a shallow graph, with 'a' being a simple linear tree (i.e. maximum depth), while 'b' involves a direct abutment between interior space and carrier (i.e. minimum depth). The property of depth thus provides a graphical representation that can be used to establish depth and shallowness of buildings and their parts.

The Property of Choice

A second property of the justified permeability graph is *choice,* which is based on the properties of symmetry and distributedness. *Symmetry* gives clues about the access of one space to another. Figure 3.5a shows a symmetrical graph, where spaces b and c are independent and neither controls access to the other from a third space.

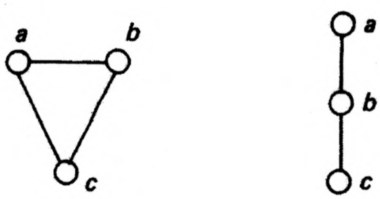


Figure 3.5 (a) a symmetrical graph; (b) an asymmetrical graph (author)

On the other hand, figure 3.5b shows an asymmetrical graph, where space b controls the access to space c from space a, thus one space controls access to the other in regard to some third vertex. The third and last property is *distributedness* which relates to

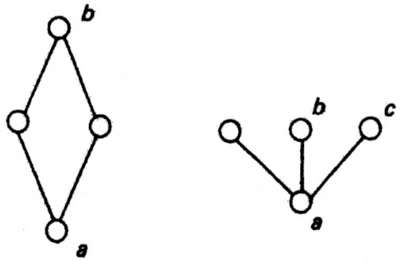


Figure 3.6 (a) a distributed graph; (b) an nondistributed graph (author)

the beady-ring structure similar to the one described in relation to outdoor environments. A distributed graph as seen in figure 3.6a has a continuos sequence of at least three vertices and edges that return to the original vertex—the beadiness of the beady ring structure. In contrast is the nondistributed graph in figure 3.6b, where the vertices without connections are linear in their structure.

Essentially, the property of choice is the existence of alternative routes from one space to another. As Hillier explains, "regardless of depth, all graphs which are trees... will have only one route from any space to any other" (Hillier *et* al, 1987, p. 364). In other words, there are alternative routes that show themselves as rings in the graph. Spaces thus can be distinguished from each other according to whether or not they lie on rings, how many rings they lie on, and which rings they lie on.

The two properties of distributedness and choice together illustrate several configurational properties of spatial layouts and can therefore be useful for articulating cultural ideas and social relations (Hillier et al, 1987, p. 364). The property of depth provides more quantitative and developed measures as compared to the property of choice, since depth can be measured as a form of integration. The integration value of a space expresses the relative depth of that space from all others in the graph through the formula: integration=2(d-1)/(k-2), where d is the mean depth of the spaces from the space and k is the total number of spaces in the graph.

The resultant value is a measure of 0 for maximum integration, (i.e. no depth) and 1 (maximum depth). As Hillier explains "the integration value of a space thus expresses numerically a key aspect of the shape of the justified graph from that space" (Hillier et al, 1987, p. 364). The integration values are different for different spaces and are visually evident through the justified permeability graph. In his thesis, spatial complexes will be analyzed only through visual properties of the justified permeability graph.

The difference in a visual graph versus numerical values is one of the keys to the way in which culture and social relations express themselves through space. As Hillier explains "different functions or activities in a dwelling are usually assigned to spaces which integrate the complex to differing degrees. Function thus acquires a spatial expression that can be assigned a numerical value. If these numerical values are consistent order across a sample, then we can say that a cultural pattern exists, one which can be detected in things, rather than just in the way it is interpreted by minds" (Hillier et al, 1987, p. 364).

Convex Spaces, Axial Spaces and Isovists

The properties of convex and axial spaces for building interiors are exactly the same as for settlements. In the case of buildings, a convex space can be understood as a space in which each point within is visible and accessible from every other point.

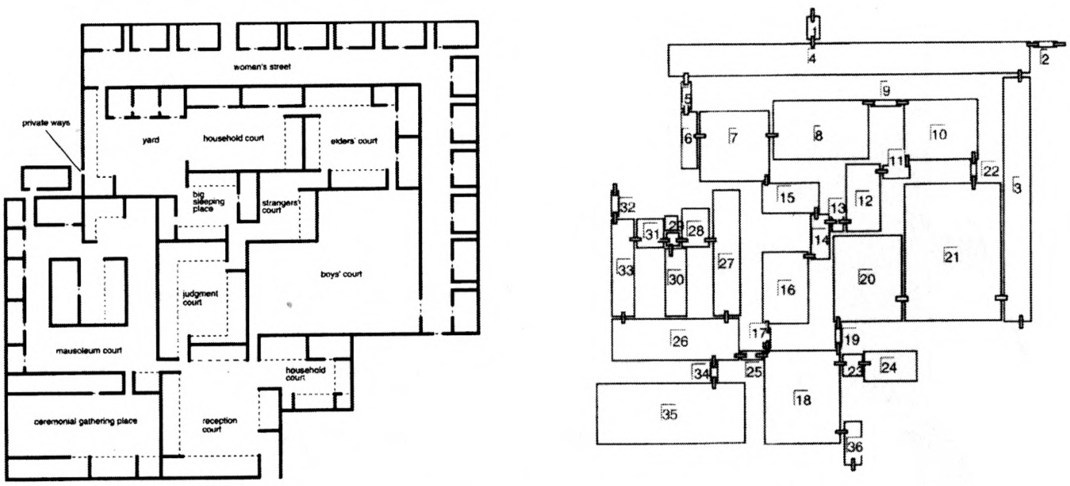


Figure 3.7 (a) Plan of a palace; (b) with its convex spaces (Hanson, 1998, p. 41).

Graphically, a convex space can be identified by spaces inside of which no line drawn between any two points goes outside the space. A convex representation of a plan should comprise the least set of fattest spaces that cover the whole plan of a building (Hillier and Hanson, 1984, p. 92). Figure 3.7 shows a simple plan represented as a convex map with its convex spaces.

An axial space can be represented graphically by the maximum straight line that can be drawn through an open space before it strikes a wall or partition. The axial map for interior space includes the fewest and longest straight lines of uninterrupted visibility and movement that cover the entire plan. According to Peponis (1994, p. 2), "the axial map is the most economical way of describing a layout as a pattern of potential movement, calling our attention to the changes of direction and the number of transitional spaces that are necessary as one moves through a building." Figure 3.8 shows the plan as an axial map with its axial spaces.

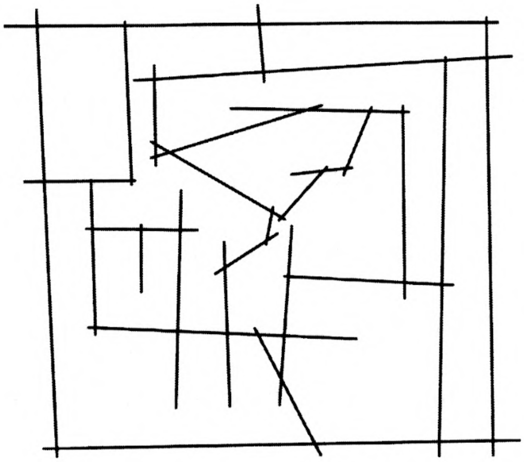


Figure 3.8 Plan of a palace with its axial spaces (Hanson, 1998, p. 41).

Importantly, these plans can also be visually analyzed for integration based on what have come to be called the *isovists.* In a key article, Benedikt (1979) defined an

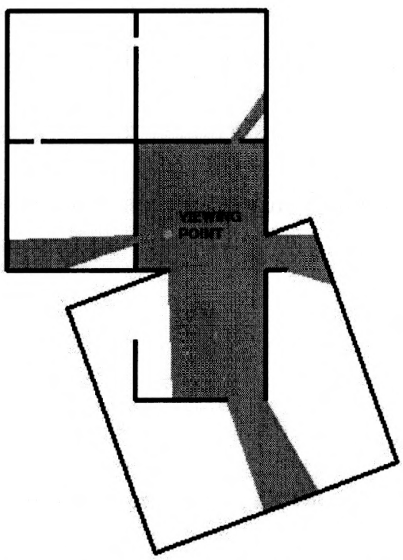


Figure 3.9 Isovist taken from a single point (author)

'isovist' as the set of points visible from a vantage point in space as shown in figure 3.9. In his article, Benedikt has proposed useful numerical measures that quantify some of the size and shape qualities of isovists. According to Benedikt (1979, p. 47), "isovist can be applied to behavioral and perceptual studies in architecture, especially in the areas of view control, privacy, 'defensibility', and in dynamic complexity and spaciousness judgements." The main drawback of isovists, according to Peponis (1997, p. 769) is that they can be drawn from a great number of positions in any plan.

In space syntax research, Hillier (1993) and Hanson (1994) have utilized 'isovists' to provide a visual analysis of buildings spatial configurations. Their studies adapt Benedikt's concept of the isovists so that it corresponds to convex spaces rather than points. As Peponis explains (ibid., p. 771), "intuitively, these isovists are intended to cover the areas visible from any of the points, either of the entire convex space under consideration or from one of its parts." In this sense, isovists can be represented two-dimensionally in relation to a building plan or they can also be shown three-dimensionally by applying them to a vertical building section. The use of isovists in space syntax is discussed more fully later in this chapter.

The properties mentioned above—justified permeability graphs, convex spaces, axial spaces, and isovists—are the key concepts that will later become important for analyzing the destruction of the box based on the shift from the prototypic Queen Anne house to Wright's Robie and Kaufmann houses.

A Case Study

The concepts reviewed above have been applied to a variety of different indoor environments, largely through the work of the space syntax laboratory in London and

John Peponis and his space syntax research group at the Georgia Institute of Technology. Peponis has applied the space syntax theory to a variety of indoor settings such as educational institutions (Peatross and Peponis, 1991), museums (Peponis, 1993), and houses (Peponis et al, 1997). The theory has also been applied to office environments, hospitals, retail stores and prisons, largely through the work carried out at the space syntax laboratory in London (www.spacesyntax.com)

The space syntax method has also been adopted by Julienne Hanson to investigate the relation between composition and configuration in the houses of four influential modern architects whose work exemplifies a preoccupation with the formal decomposition of the cube. The architects and their houses that Hanson studied are: (1) Mario Botta's, Pregassona house in Switzerland; (2) Richard Meier's, Giovannitti house in Pennsylvania; (3) John Hedjuk's, Diamond house A,(unbuilt); and (4) Adolf Loos', Muller house in Prague. Hanson applied the space syntax analysis to make comparisons among the dwellings and the stated aims of the architects (Hanson, 1994).

As Hanson explains, "Architects compose a building along axes, differentiate its parts by articulating larger and smaller spaces, and render its overall form more or less comprehensible by the strength of visual fields. People move along axial lines, form groups in two-dimensional convex elements, and see three-dimensional nonconvex visual fields or 'isovists'" (Hanson, 1994, p. 676). The space syntax methodology she uses analyzes four different spatial aspects of the four houses: (1) the convex spaces, (2) the axial space, (3) isovists and (4) permeability graphs. The convex and axial analyses are used to derive quantitative values for integration, which refers to each space as an element in relation to every other space in the house. The isovists are used as a conceptual tool to analyze the most visually integrating spaces in the house. Last, the permeability graphs are used to determine how different functional spaces of the house are differentially embedded within the spatial configuration of the house.

Hanson breaks the four houses into their convex and axial organization and calculates a mathematical value for each convex space or axial line according to how integrated or segregated that element is within the dwelling as a whole. An integrated element is a space which minimizes the distance to every space in the house, while a segregated element is a space which maximizes the distance to every other space (Hanson, 1994). A color code ranging from black to white is used to show the integrated and segregated parts of the house, with black being the most integrated and white the most segregated. Another method Hanson uses for showing integration was permeability graphs, which illustrate how different functions of the house are differentially embedded within the spatial configuration. Thus a graph formation like a tree is the most integrated element possible from a given root, while a linear sequence the most segregated (Hanson, 1994). Last, the isovists can be drawn to analyze each of the primary living functions to see how these relate to the strength or weakness of the static visual fields within the domestic interior. In sum, the study used space syntax methods to better understand the relation between the stated aims of the architects and the experiential dimension of each house as a configured space.

Hanson's analysis reveals that the houses permutate the morphological properties of the depth and rings differentially to embed domestic functions within the home and to interface household members (ibid., p701). Two houses (the Pregassona and Diamond houses) were judged to be well composed but configurationally banal, while the other two (the Giovannitti and Muller houses) appeared more inventive in relating compositional principles to space configuration. Hanson discovered that the knowledge of both the internal laws of form and the social logic of space is required to generate the practical conjunction of formal rigor with functional ease, which, she claims, is recognized in the houses of great architects.

Botta's House at Pregassona

The analysis of Mario Botta's house (figure 3.10) is presented here as an example to explain the methodology adopted by Hanson to derive the conclusions about the spatial patterning of each of the four houses.

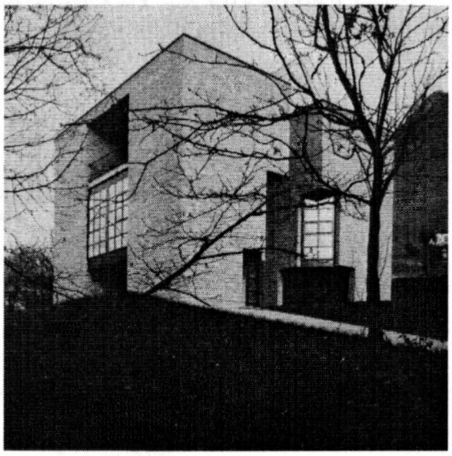


Figure 3.10 Photograph of the Mario Botta house at Pregassona, 1979 (Nicolin and Chaslin, 1983, p. 20).

Botta's house is a simple glass and brick box and has been largely regarded as a summation of architect's work. The house is on three levels (figure 3.11a) and reveals a certain preoccupation with the cube. The house at the entry level is entirely devoted to a sheltered portico that functions as an outdoor living area, entry, and space for utilities. The main floor of the house is the first floor and is accessed through a staircase from the portico. From the head of the staircase, a living room with an attached shower room lies to the left; a kitchen and dining room to the right; and a small study beyond. The second floor of the house consists of two principal rooms on each side, each with a small external balcony—a bathroom and dressing room on the left and a smaller bedroom on the right. According to Hanson, "the planning of the house is classic. Vertical layering expresses arrival, daytime, and nighttime activities, respectively, and the front-back dimension differentiates major and subsidiary functions on each floor"(Hanson, 1994, p. 677).

Hanson demonstrates that the convex space organization (figure 3.11b) reveals a compartmentalization of the house into discrete rooms. The black to white distribution of integration (figure 3.11c) shows that rooms are not integrated by the circulation core,

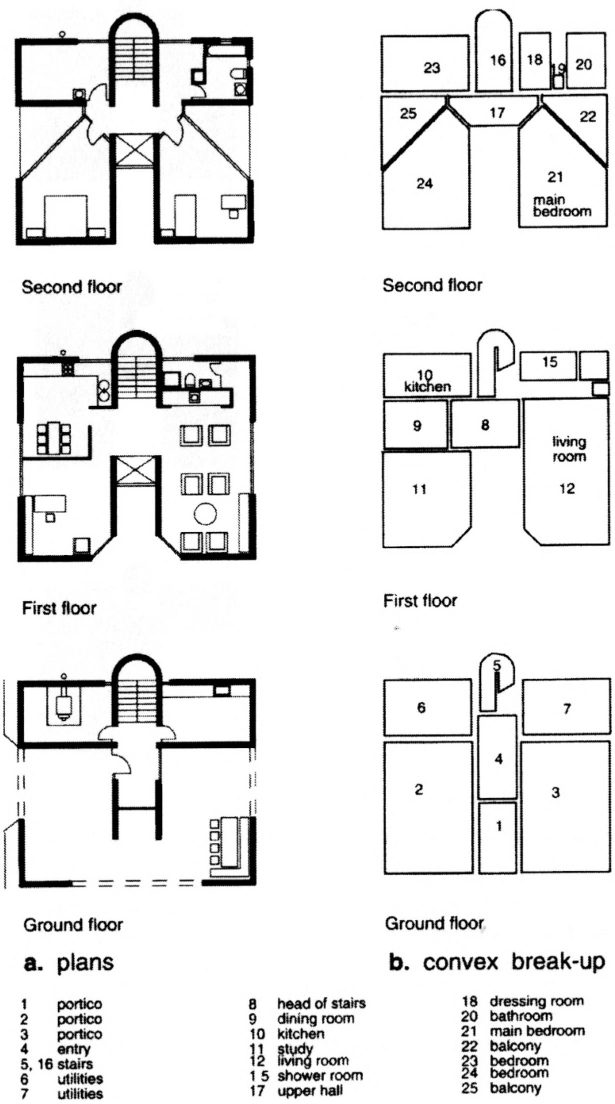


Figure 3.11 (a) the three floors plans; (b) convex breakup of Mario Botta's house at Pregassona (1979-80), (from Hanson, 1998, p. 245).

which instead acts as a segregator. The axial organization shown in figure 3.12 is straightforward and is totally symmetrical about the circulation core. As Hanson explains "the axial integration confirms what convex organization indicates: that movement organizes a simple and vertical and frontal experience of the house"(Hanson, 1994, p. 677).

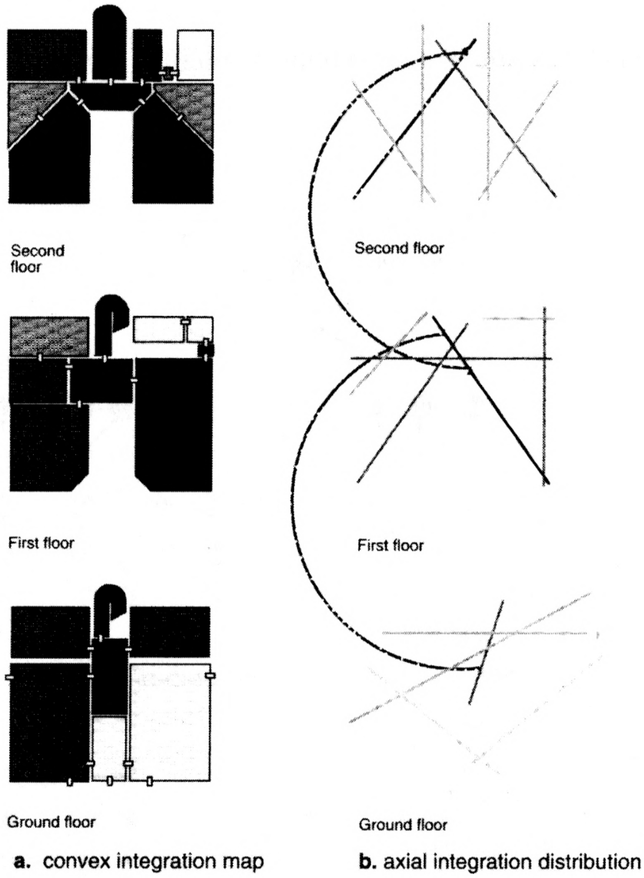


Figure 3.12.) (a) convex integration map; (b) Axial representation; and greyscale axial integration distribution for Botta's house at Pregassona. Loops indicate staircases linking floors (from Hanson, 1998, p. 246)

Hanson demonstrates that a Justified graph (figure 3.13) reveal the maximum information about the spatial configuration of the house. This graph forms a treelike configuration of the interior. Distinct functions occupy separate branches, and the house lacks ringiness which could have been easily introduced by closing off or opening up of routes. According to Hanson, "the graph from the outside shows that the construction of a single attenuated approach to the main living floor heightens the anticipation for the guests, but distances the occupants of the house from immediate contact with the site, with the result that it is most segregated place of all. The living room draws more of the functions of the house towards it, but the relative separation of the kitchen hints at gender division within the home, which is, if anything, more significant that the public-private dimension displayed in space unfolded from the main bedroom" (Hanson, 1994, p. 679).

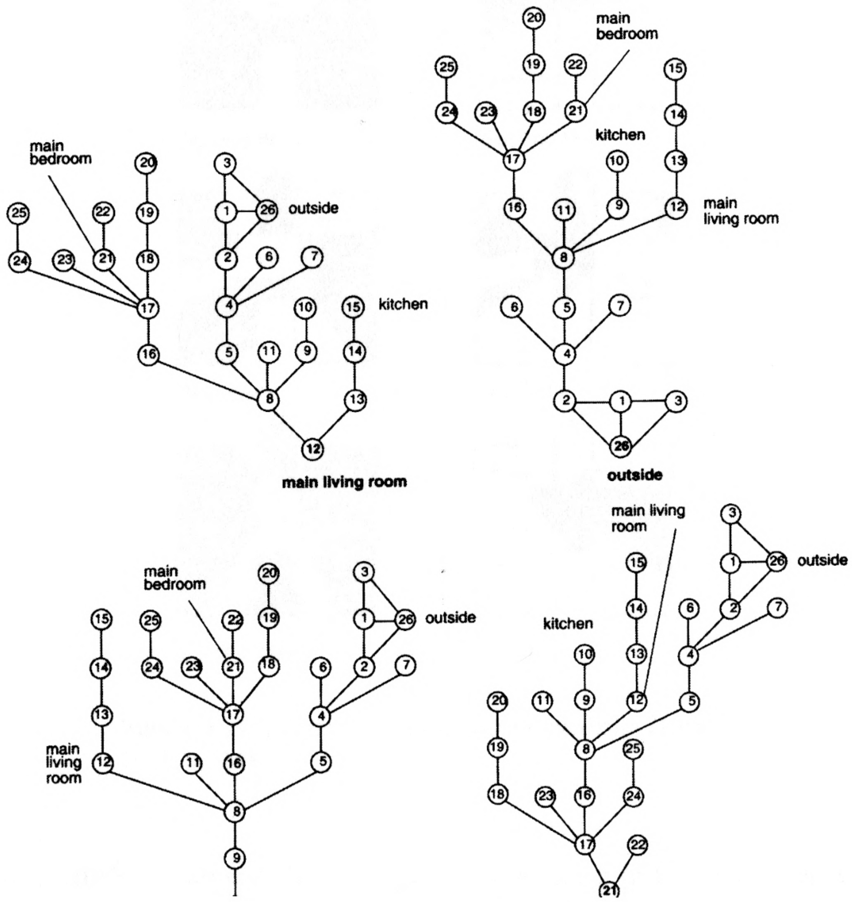


Figure 3.13 Justified permeability graphs of Botta's house at Pregassona from: (a) the outside; (b) living room; (c) kitchen; and (d) principal bedroom. The numbers refer to the key in figure 12 (from Hanson, 1998, p. 247)

Finally, the isovists (figure 3.14) reveal how the visual fields are dominant in relation to vertical circulation and arrival. In contrast, the visual fields from living spaces are restricted and only partially reveal the living spaces, which systematically partially reveal adjacent rooms. The visually most integrating three-dimensional isovist coincides with the route from the entry up to the main bedroom, yielding glimpses into the spaces on each level en route (Hanson, 1994, p. 680).

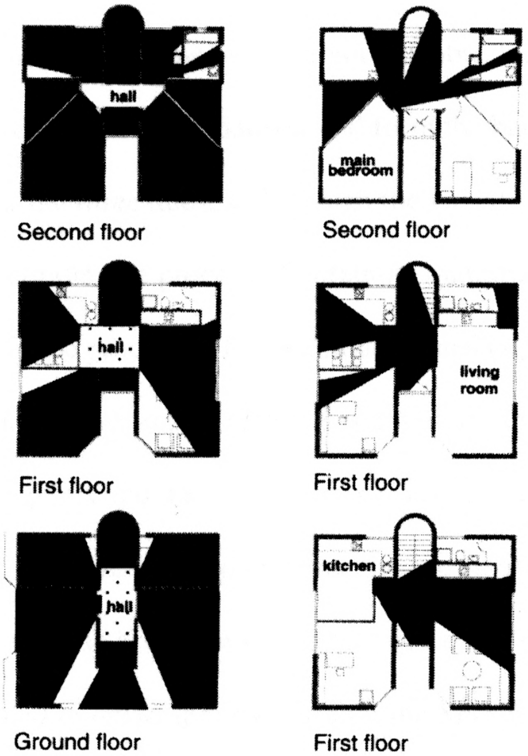


Figure 3.14 Isovists from halls and rooms (from Hanson, 1998, p. 248)

According to Hanson the configuration of space in Botta's house can be interpreted as "an essay in dramatic space" (ibid., p. 680). As Hanson (1994, p. 680) explains,

> [Botta] constructs a simple social theatre which modulates back-stage and front-stage activities. Center stage is on the main floor of the house where strong visual fields, particularly in the public circulation areas of the house, contrast with partial seclusion's in each room where it is possible to wait in the wings, or modulate front-stage activities. However, the house does not generate either significant cultural-functional differences or route choices. The house may be well composed but it is configurationally boring.

In sum, Hanson's study provides a useful methodology to analyze and compare different house types and their spatial patterning. As shall be shown in chapters six and seven, this thesis utilizes Hanson's methodological framework as a way to analyze and compare the Queen Anne prototype with Wright's Robie and Kaufmann houses. A four-part analysis similar to that used by Hanson will form the base for conceptually analyzing the spatial patterns of the three houses. Although the analytical procedure of Hanson's method is relatively simple, the process of obtaining quantitative results remains complex. To simplify the procedure for quantitative analysis and draw upon the latest developments in space syntax analysis, this thesis will use the Spatialist software developed by John Peponis and his space syntax research group at the Georgia Institute of Technology. This software is based on space syntax theory but has been developed a step further to overcome the limitations of earlier space syntax techniques. The Spatialist software can be applied to drawing files based on the Microstation format and can provide quantitative data to be analyzed in any statistical software. Chapter four discusses the Spatialist software and its application to building interiors.

CHAPTER 4

THE SPATIALIST PROGRAM: CONCEPTS AND APPLICATIONS FOR BUILDING INTERIORS

The preceding chapters discussed the underlying concepts of space syntax theory and its application to outdoor as well as indoor environments. The Spatialist program is an extension of the space syntax theory and draws on the latest developments in the field of syntactic analysis. This thesis utilizes the Spatialist program to perform the quantitative part of the analysis on the three houses. The software is a plug-in application for Microstation 95, computer aided design package from Bentley Inc. The application of the software is fairly simple if one is already familiar with Microstation 95, but before the software analysis is applied and discussed, it is essential to understand the underlying concepts that govern its application.

The software can be applied to both buildings and settlements and in its current version performs four kinds of analysis—E-partition, S-partition, Visual field and lines. The principle behind the analysis is quite similar to space syntax theory but the program overcomes the limitations of space syntax analysis and proposes 'informationally stable units' of space (Peponis et al, 1997, p. 764). Therefore, a brief comparison of the two theories is essential before the fundamental properties of the software can be discussed.

Space within buildings becomes intelligible to our understanding and useful for human activities through the disposition and arrangement of boundaries (Peponis et al, 1997, p. 761). Boundaries are thus essential to create patterns of enclosure, sub-divisions, accessibility and visibility. Interior spaces are configured on the basis of the perimeter of the buildings and sub-divided according to the location of partitions, thus buildings can never be experienced entirely from a single point except in the most elementary cases (e.g., a single-roomed building). Therefore, movement forms a constitutive part of our experience of space inside buildings (Peponis et al, 1997, p. 761).

The relationship between space and movement also has been at the core of the space syntax theory. Movement relates directly to the change of the viewer's position which, in turn, is dependent on the views of the building it offered. Positions can be differentiated with respect to the changing perspective of the viewer in two ways: (a) while the set of elements and environment remain constant; and (b) as different parts of the environment are exposed offering a discrete a transition from one space to another—that is, from one set of environmental elements, (consisting of corners, edges and surfaces), to a completely different set. According to Peponis (1997, p. 761), "transitions are defined according to the appearance and disappearance of corners, edges and surfaces as one moves inside buildings."

The main emphasis of Peponis's research is identifying units of space within which the visual information regarding corners edges and surfaces remain stable. Thus, visually stable units can help to describe a plan as a pattern of potential transition from one informationally stable area to another. The shape of the building plan is defined as a set of wall surfaces and a set of discontinuities (figure 4.1). Discontinuities are

Figure 4.1 Changing relationship of a moving subject to the discontinuities that define a shape (Peponis et al, 1997, p. 762).

defined to include the edges of free standing walls and the corners formed at the intersection of two wall surfaces (Peponis et al, 1997, p. 763). Thus, for a subject moving through building discontinuities and wall surfaces either appear in his or her field of vision or disappear outside it. It is assumed here that the observer occupies a single point and possesses 360 degrees of vision.

According to Peponis (1997, p. 764), “the major thrust of space syntax has been to describe space and movement as a dimension of social copresence. The way in which the structure of space and movement affects our exposure to the elements of shape has been a secondary consideration.” For the development of the Spatialist program, Peponis reverses the emphasis, even though from the point of view of a formal analysis, the two—space and movement—stem from a similar foundation. Peponis (1997, p. 764) proposes that, “the description of shape and spatial configuration from the point of view of the moving subject can be discussed by linking projective and convex relationships.” Projective here refers to relationships of incidence between lines. As Peponis explains (1997, p. 764), “given a point in space and given the lines that project from it to the discontinuities, the underlying question is which lines intersect walls and thus do not represent a relation of visibility, and lines which do not and therefore correspond to the relation of visibility.”

The idea of convexity is fundamental because it is linked to the structure of space as a field of potential copresence of the occupants of the building. Convexity can be better understood by the following example. Space and the transition from one space to another can be viewed from the standpoint of potential occupants. Within an empty space, anytime subjects A, B, C are directly visible and accessible to each other, they can

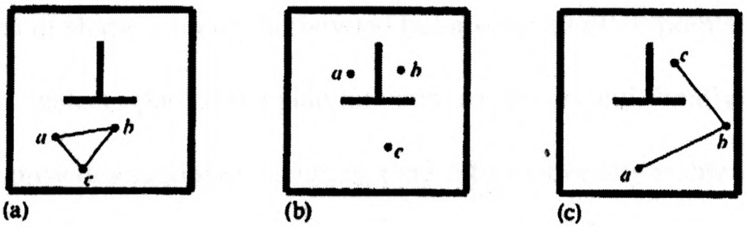


Figure 4.2 Convex and non convex relationships between positions on a plan (Peponis et al, 1997, p. 763).

all be linked by a straight line. But with the addition of a partition, the configuration of space changes and the relationship between the three subjects undergoes a transformation. For example in some situations, if subject A and B see each other and subject A and C also see each other then, we can infer that subjects B and C see each other as well. As Peponis explains (1997, p. 763), "in such situation all relationships of visibility are not only reciprocated but also communicative. This is what we normally mean when we say that we are together in a space." In other situations, the opposite condition prevails and none of the subjects sees another. In still other cases, the relations which hold are not commutative—e.g., A and B, as well as B and C, see each other, but A cannot see C. These possibilities are shown in figure 4.2.

The underlying idea being discussed here is convexity. As explained in chapter 2, a space is said to be convex when any two points can be joined by a line that lies entirely within the space. Convexity thus is the underlying property with which an area can be identified as an integral and discrete spatial unit. Therefore a set of points on a plan are in convex relationship to each other if there is a convex polygon that contains all of them in its interior (Peponis et al, 1997, p. 763).

The two ideas of, elementary projective relationship and elementary convex areas come together to form the basis for informationally stable units. A spatial unit can essentially be stable if all points within the unit are linked not only to the same discontinuities of shape around and beyond but also to all other points inside the unit. Thus, Peponis seeks to partition a plan into convex spaces and, finally to propose a partition that provides spatial elements that are informationally stable in relation to their exposure to shape.

According to Peponis the convex partition proposed by Hillier—that is, the convex representation of a plan should comprise the least set of the fattest spaces that covers the system—is questionable as the balance between the search for large space and preserving fattness is ambiguous. The recent developments at the space syntax laboratory in London have led to new ways of partitioning a plan into convex spaces. According to Hillier (Hillier, 1996, p. 125), "convex elements are defined with reference to the surfaces of built form; the edges of convex spaces are collinear with the lines produced by extending wall surfaces, until extensions reach another wall surface." Since, with the extension of lines defined by the wall surface, a large number of overlapping convex spaces are produced, thus a convex partition consists of only those convex spaces each side of which contains a wall surface of the system, essentially leading to the conclusion that only the largest convex spaces defined by various combinations of extended wall surfaces are considered. Figure 4.3 shows such overlapping convex spaces.

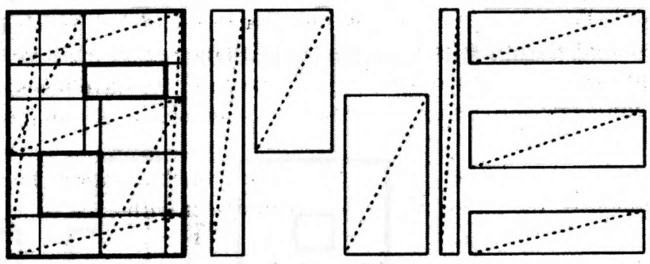


Figure 4.3 Partition of space into overlapping convex spaces (Peponis et al, 1997, p. 765).

The two convex partition methodologies mentioned above are contrasting. The first method starts from space and treats the built shape as a constraint which limits the extent to which space can retain its convex integrity. In the second method, the partition of space proceeds according to the components of the shape. As Peponis (1997, p. 766) explains, "the built shape drives the analysis, and space itself is shaped into convex elements as a consequence of the presence of built shape." The main difference between the two methods is the different number of convex spaces and different kinds of relationships (adjacency versus overlap) produced in each case.

Based on the various concepts discussed above, Peponis and his space syntax research group proceed to propose different convex partitions that take into account the way in which built shape appears to a moving subject and also form the basis of underlying concepts on which the Spatialist program analyzes different environments.

S-Partition, S-Spaces, and S-Lines

The first kind of partitions proposed by Peponis (et al., 1997, p. 768) are obtained by extending all free standing end-points (which occur where a wall is terminated without being joined to another wall) and all sides of reflex corners which occur where two surfaces create an angle of more than 180 and less than 360), until their extensions hit another wall surface. Since the partition is obtained by extending surfaces, it is called a

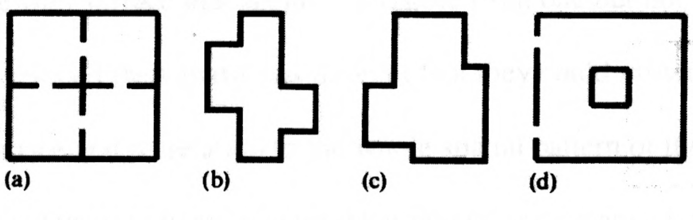


Figure 4.4 Four hypothetical plans (Peponis et al, 1997, p. 767).

surface partition and the corresponding lines and spaces are called *s-lines* and *s-spaces* respectively. The s-partitions for four different types of arrangement are shown in figure 4.5. The figure 4.5b, 4.5c and 4.5d are example of open plans; the surface partition produced in these three cases produces spaces whose corners do not correspond to the intersection of two walls, and at least one solid wall extends across most s-lines. Thus the surface partitions are demarcated by the boundaries which extend across it. This feature is

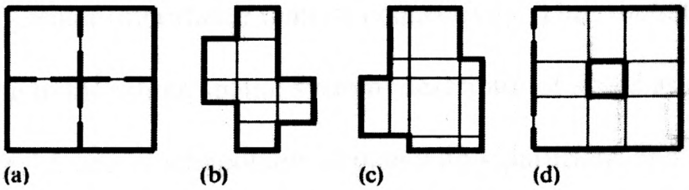
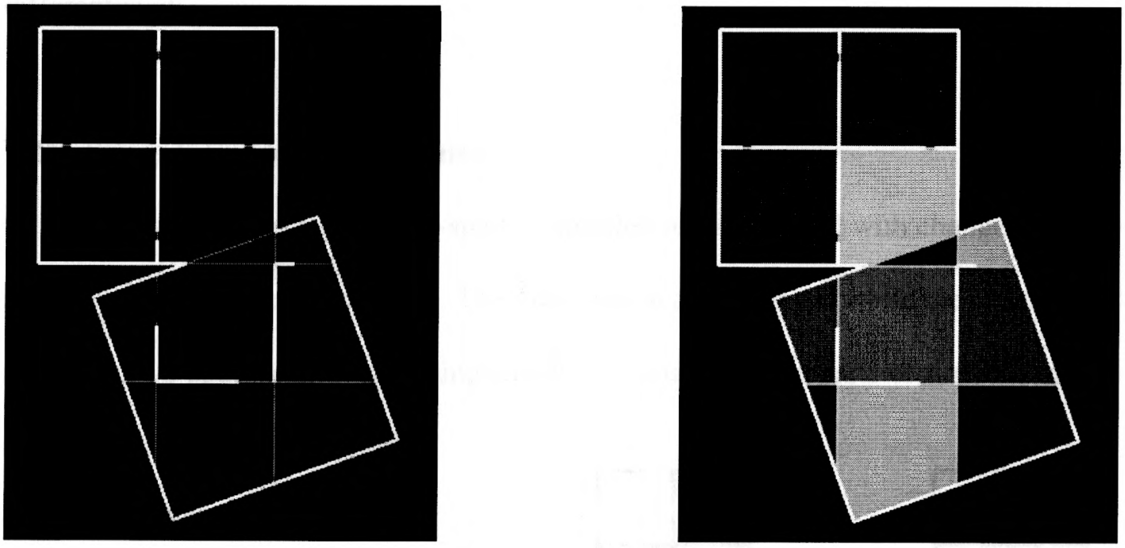


Figure 4.5 S-partition of four hypothetical plans (Peponis et al, 1997, p. 767).

seen clearly in figures 4.5b, 4.5c and 5d, which are examples of an open arrangement, but is absent from figure 4.5a, which is an example of a boxed type of arrangement. The s-partition is a development on Hillier's convex spaces and can be derived by considering a union of sets of discrete spaces produced by the s-partition. According to Peponis (1997, p. 768), "the s-partition is a first step towards capturing the experience of shape that is available to a moving observer. Each time an observer crosses a s-line, an entire surface either appears into the visual field or disappears outside it. For any two s-spaces, there is at least one wall surface that is entirely visible from one but not from the other."

Peponis developed the s-partitions in order that they could provide quantitative description about space and its relation to the whole spatial pattern of the building. The Spatialist program automatically recognizes what other s-spaces are adjacent to each s-space and which of those s-spaces are permeable to it. Based on these relationships, the

Spatialist program is able to analyze the whole plan as a pattern of connections. The key configurational variables involved are connectivity and integration. Connectivity here refers to the relation of space to its immediate neighbors, while integration describes the relationship of a space to the entire spatial pattern to which it belongs. Connectivity is a local measure and does not describe how the space relates to whole system (Peponis et al, 1997, p. 768). As discussed earlier (Hillier and Hanson, 1984), from the point of view of the social use and cultural meanings of layouts, the relation of each space to the rest of the system is of far greater importance than its connectivity. Thus the integration value is a global (i.e. relating to the whole spatial system) descriptor of space as compared to connectivity. Figure 4.6 shows a hypothetical plan with s-partitions and corresponding s-spaces.



a b

Figure 4.6 (a) the hypothetical plan with s-lines; (b) with corresponding s-spaces. The integration value is based on a color coding with red for the most integrated and blue for the least. Eight shades of color between red and blue are used for the intermediate ranges of integration (**www.gatech.edu**).

The integration values of figure 4.6 in terms of s-spaces can be interpreted in the following manner. A spatial configuration with higher mean integration values for all its s-spaces is one where fewer surface extension lines are crossed as the whole system is experienced. High integration value also implies that the other parts of the system can be reached traversing fewer intervening spaces. Thus, in figure 4.6a the hypothetical plan shows the s-partition. For an observer situated inside the plan, the s-partition describes the thresholds at which entire surfaces either completely appear into, or completely disappear, outside the observer's field of vision. Figure 4.6b shows a hypothetical plan divided into s-spaces. In the case of cellular plans, s-spaces correspond to well defined rooms. In freely composed plans, s-spaces may correspond to clearly defined areas, even though walls are often continuously extended across the thresholds between s-spaces. In open plans, s-spaces do not correspond to intuitively defined areas. Figure 4.6b is a combination of all three kinds of plans and thus, shows the manner in which areas are differentiated.

E-Partition, E-Spaces, and E-Lines

The transitions from one s-space to another are associated with changes in the available information about shape. The information also changes while the observer moves in an s-space without crossing an s-line, as surfaces and parts of surfaces may appear or disappear. As Peponis explains (1997, p. 768), "different points within the same s-space may differ by being linked to a different set of discontinuities of the built shape [as illustrated by the figure 4.7]." Thus, to

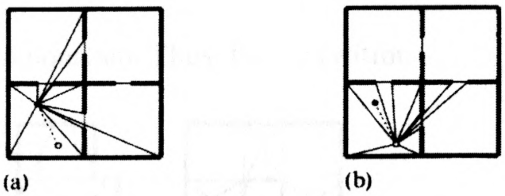


Figure 4.7 Changing relationship of a moving subject to the discontinuities available to an s-space plans (Peponis et al, 1997, p. 768).

obtain informationally stable spaces, and to identify explicitly all thresholds at which information regarding shape changes, Peponis proposes another partition—the e-partition

The basic elements of the e-partition are the diagonals that can be drawn in a shape and their extensions. A *diagonal* is defined as a line that joins two discontinuities without crossing a wall. Diagonals in a few cases cannot be extended without going outside the shape; these are called *non-extendible* diagonals. Other diagonals can be extended inside the shape at one or both of its ends and are called *extendible* diagonals. A convex partition is thus proposed which includes the extensions of the extendible diagonals in addition to all the lines used to generate the surface partition. The partition thus produced has two properties: first, every time a demarcation line is crossed a discontinuity either appears or disappears from the field of vision of a moving subject, second, the resultant space is informationally stable (Peponis et al, 1997, p. 769). The partition is called an *end-point partition* or an *e-partition* and the resultant spaces and lines are called *e-spaces* and *e-lines* respectively. Figure 4.8 shows the end-point partition of the four plans discussed earlier. The e-partition describes significant properties of built shape. Every time an e-line is crossed and only when such a line is crossed, at least one edge of a surface either appears or disappears from our field of vision. While the observer stays within the e-space his visual exposure to discrete elements of space, such as complete surfaces or individual edges, remains constant. Thus, the e-partition

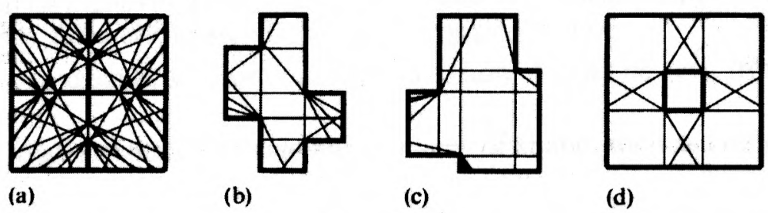
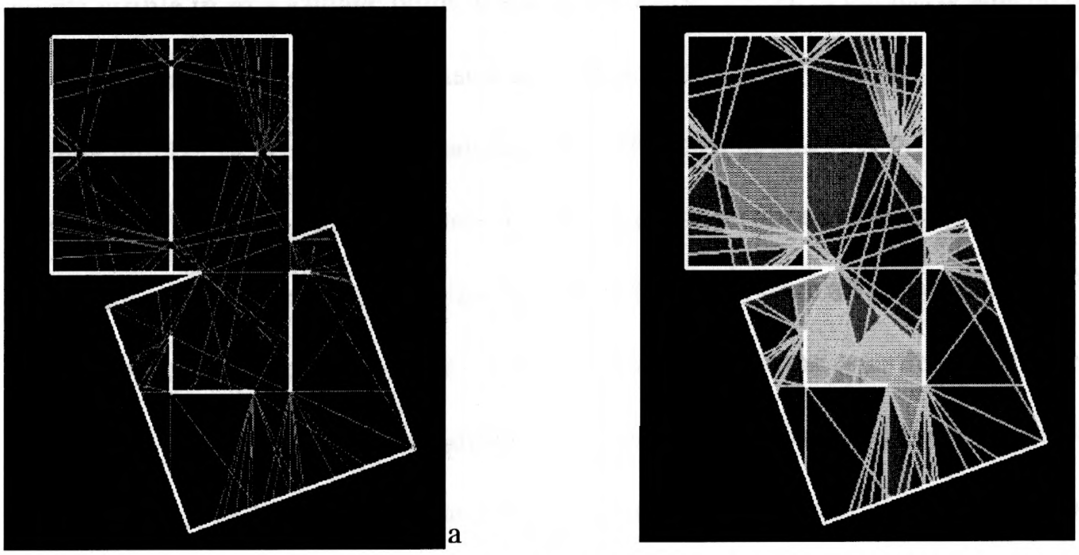


Figure 4.8 E-partition of four hypothetical plans (Peponis et al, 1997, p. 768).

corresponds to the underlying pattern of informational stability and informational change that characterizes the visual fields as one moves inside a spatial pattern.

The Spatialist program automatically recognizes what other e-spaces are adjacent to each e-space and also which of those e-spaces are permeable to it. Based on these relationships the Spatialist program analyzes the entire plan as a pattern of connections. As in case of the s-spaces, the key variables are connectivity and integration. The e-spaces do not correspond to the differentiation of areas or rooms but they are what is available to the normal intuition of a observer. Figure 4.9 represents a hypothetical plan with e-lines and corresponding e-spaces. The e-partition seen in figure 4.9b describes significant properties of spatial configuration with respect to built shape. In figure 4.9b every time a observer crosses a e-partition line, at least one edge of a surface either



a b

Figure 4.9 (a) the hypothetical plan with e-lines, (b) with corresponding e-spaces . The color-coding is similar to the one in case of s-partition. (www.gatech.edu).

appears into, or disappears from our field of vision. As can be seen from the plan, inside an e-space, visual exposure to discrete elements of shape, such as complete surfaces, or individual edges remains constant. Thus, as mentioned earlier, the e-partition corresponds to the underlying pattern of informational stability and informational change that characterizes our visual fields as we move.

In general, the interpretation of e-spaces can be described as follows: A spatial configuration with higher mean integration value for all its e-spaces is one where the observer is exposed to fewer changes of visual information as he moves about the system. On the other hand, a spatial configuration with lower mean integration values are characterized by many changes of visual information. Thus, as Peponis explains (1997, p. 770), "the e-partition helps us to define movement as a finite pattern of discrete transitions rather than as an infinitely variable pattern of perspective views."

The Spatialist program also produces a visual analysis of the spaces based on isovists, as described in chapter three. These isovists can be defined as the set of all other points visible from a vantage point in space (Benedikt, 1979). A complete analysis of a plan according to the structure of isovists is impossible as they can be drawn from an infinite number of points. As Peponis explains (Peponis et al, 1997, p. 770), "though surfaces can be described completely according to the positions of edges and corners, which are always a finite set, isovists can never be drawn from all possible points." Therefore, to proceduralize isovists, Peponis bases them on the e-partition. The idea of linking the isovists to convex partitions is not new and, as described earlier, has been used by Hillier and Hanson in their studies, whereby the isovists correspond to convex spaces rather than points (Peponis et al, 1997, p. 771). Thus, isovists drawn from within the same e-space encompass the same discontinuities and the same edges and the same set of completely visible surfaces along its perimeter. (Peponis et al, 1997, p. 770). Only the relative exposure of partially visible surfaces varies.

In sum, the three levels of analysis the s-partition, the e-partition and the isovists give a graphical and numerical description of integration of shape and spatial configuration inside the buildings. In the following chapters, these three level of analysis will be applied to the Queen Anne prototype and the Robie and Kaufmann houses.

Application of The Spatialist Program

The first step towards applying the Spatialist program to the s-partition or the e-partition is to draw a simplified plan, with the walls shown as single lines. The thickness of the walls is ignored for the purpose of the analysis. The plans can be laid out directly in Microstation using its own tools or the tools provided by the Spatialist. The plans can also be imported directly from other CAD based software and can be analyzed using the Spatialist program, which then performs the analysis and computes both graphical and quantitative data for the whole system.

The output of the analysis is generated in the following manner. The original plan is modified to give e-partitions and e-spaces that are graphically color-coded according to integration values. The color-coding is based on the following procedure: The range of integration values is divided by ten and, individual e-spaces are assigned a color according to the interval in which they fall. The color red is assigned to the most integrated spaces, and, the color blue to the least integrated. Eight shades of color between red and blue are used for the intermediate ranges of integration. The graphic output enables the user to examine the distribution of the integration values and identify the integration core of the shape. This core is the area where the spaces with the highest integration values are found.

The Spatialist program numbers the e-spaces so that the graphical output can be related to the numerical values which are produced in a tabular form. This table lists all the e-spaces and provides the connectivity and integration values for each corresponding e-space. The tables thus produced can be easily imported into any statistical software and analyzed to produce correlations between spaces.

In case of isolated subsystems such as staircases, service cores and large structural members, Spatialist automatically recognizes them and does not consider them while computing connectivity and integration values, so that the output pertaining to major system remains unaffected by the possible presence of inaccessible subsystems. The subsystems are color-coded as yellow and are represented only graphically.

As already explained, the third kind of analysis derives from the concepts of isovists. The visual field analysis involves the construction of visibility polygons from specific points inside a given plan and studying their properties. The visibility polygon—i.e. the isovist from a point—covers all the areas of a plan that are visible from that point in all surrounding directions. Drawing the isovist from a few selected points is a good way of representing the shape of the visual field surrounding that point.

In identifying isovists, the first step is the construction of the simplified plan, with walls represented as single line. The next step is to specify the observation point from which the isovist can be computed. The Spatialist

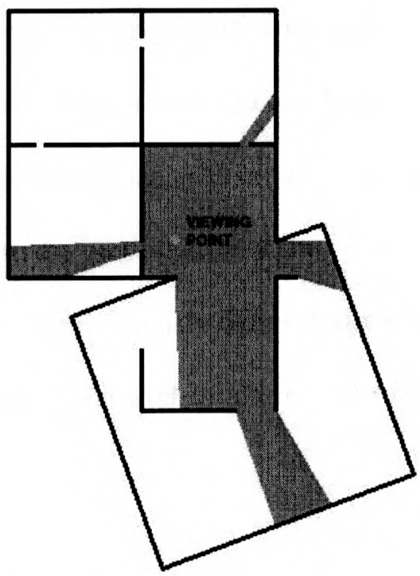


Figure 4.10 Hypothetical plan with isovist drawn (www.gatech.edu)

program automatically generates isovists in three ways: The isovist can be computed from an individual point, a set of individual points, and finally also along a path (Figure 4.10)

Figure 4.11 represents a simplified plan of the Brick house by Mies Van der

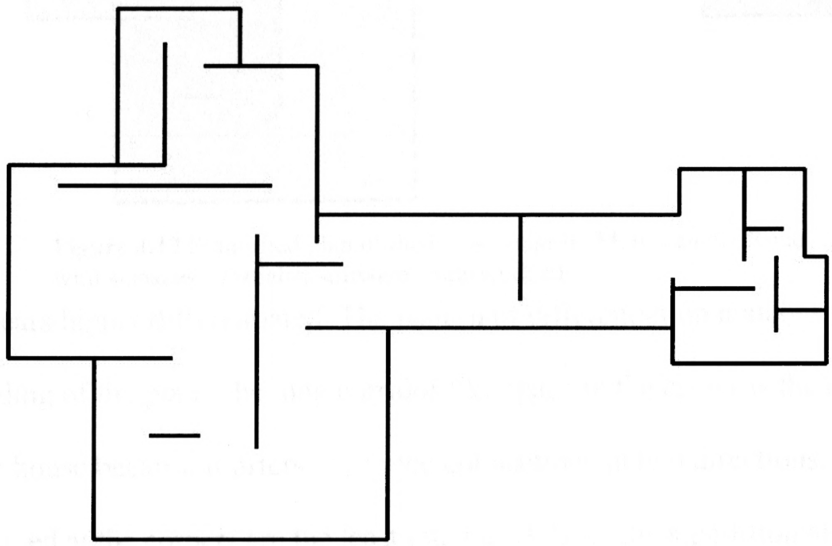


Figure 4.11 Simplified plan of the Brick house by Mies Van der Rohe (Spatialist software compact disc).

Rohe, while figure 4.12 represents the simplified plan with the s-partitions drawn, and the graphical representation illustrates the most integrated spaces with red and the least integrated with blue. Figure 4.13 represents the simplified plan with e-partitions drawn and one notes that the output illustrated is similar to the presentation of the s-partition.

The s-spaces in case of the brick house are unambiguously delineated and are recognized as discrete spatial units. It is noticed that the spatial structure of the Brick

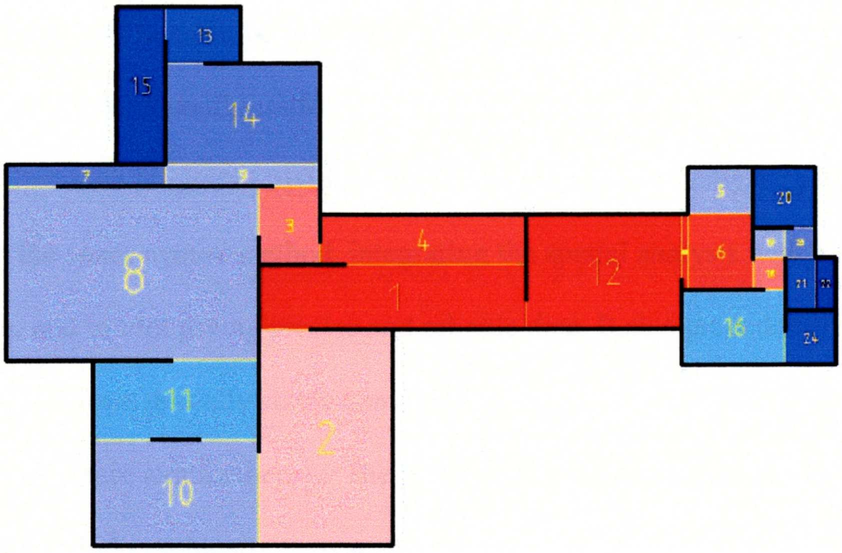


Figure 4.12 Simplified plan of the Brick house by Mies Van der Rohe
with s-spaces (Spatialist software compact disc).

house appears highly differentiated. The pattern of differentiation matches the intuitive understanding of the plan. The long corridor like space in the center is the most integrated part of the house because it offers expanded connections in two directions, while, the spaces formed at the corners are the least integrated. Both the s-partition and e-partition

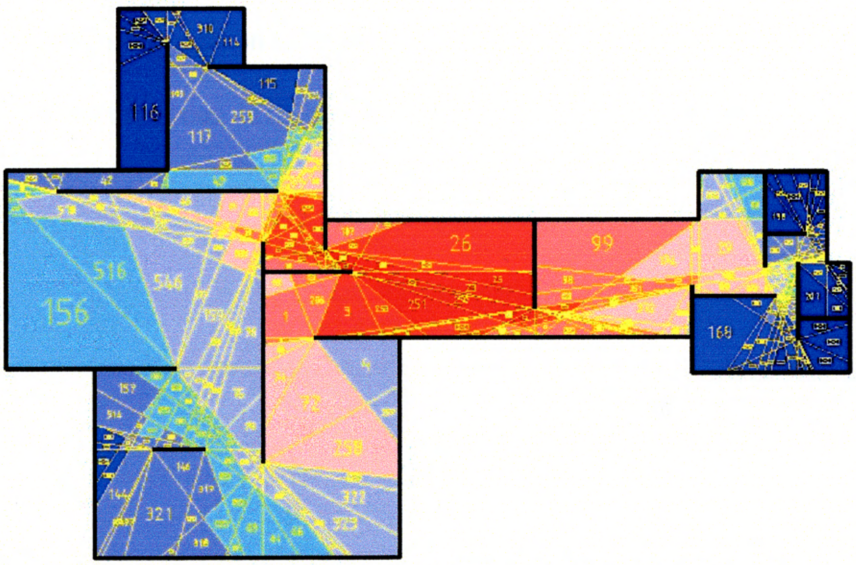


Figure 4.13 Simplified plan of the Brick house by Mies Van der Rohe
with e-spaces (Spatialist software compact disc).

provide visual graphs that can be used to interpret the integration of different spaces within the whole spatial configuration.

The Spatialist program provides enhanced techniques to analyze spatial layouts as compared to the space syntax method, integrating the spatial analysis with a powerful CAD system, and in turn giving precise and reliable data. It also proceduralizes the construction of informationally stable convex partitions, which had been a major drawback of the space syntax theory. The program also develops new methods to compute isovists and graphically represent them. The software provides graphical representation and numerical data for syntactic analysis on a single platform.

This thesis utilizes the Spatialist program for analyzing the plans of the three houses and representing these plans graphically and computing the integration values for the systems analyzed. Furthermore, the program will also be used to compute isovists and thus perform a visual analysis of the plans of the three houses. Before this analysis can be presented, however, a more complete discussion of the three houses is essential, including a thorough description of their layouts and the various principles involved in their design. This is the focus of the next chapter.

Chapter 5

THE THREE HOUSES: THE QUEEN ANNE PROTOTYPE AND THE ROBIE AND KAUFMANN HOUSES

The space syntax theory discussed in the preceding chapters is a useful tool for the analysis of both interior as well as exterior spaces. As mentioned earlier, this thesis analyzes Wright's changing manipulation of interior space through a contrast of a Queen Anne prototype with Wright's Robie and Kaufmann houses. Therefore, before space syntax can be applied to the three houses, it is essential to provide a brief historical background of the three buildings and understand their spatial configurations.

The Queen Anne Style

The period from the sixteenth century to the early eighteenth century saw a dramatic shift in family life of middle class America, since life during this period was unpredictable and society was vulnerable to ravages of disease, crop failure and war. In this sense, the family functioned in a highly utilitarian way as the basic mechanism for survival (Clark, 1986, p. 9). Thus, by the start of the eighteenth century, the uses of the internal spaces of the house had evolved to the extent that the function and layout of the rooms corresponded to the cooperative ideal of the family life (ibid.).

In the early eighteenth century, a single room was utilized for multiple purposes. This arrangement was reflected in the variety of names used for a single space. In this period, until a kitchen was designated as a separate function, the front room was often labeled in inventories as the hall, a great room, outer room, dwelling room, fire room or even "house". Similarly, the hall was a center for family activity and was used for cooking and dining, household handicrafts and amusements (Clark, 1986).

By the middle of the eighteenth century, with changing social ideals, house plans evolved into a hierarchical space with the room in the front usually gaining more importance than the back ones. This arrangement also reflected the awareness of boundaries between public and private space. The upper floor came to be used as a totally private zone, often exclusively for sleeping. Thus the internal arrangement of the house had come to correspond with the family ideal. As Clark explains (1986, p. 15), "just as the family had a hierarchy that ran from the father at top down to the children below, so too, did the house with the most important rooms in front and the kitchen and the service areas relegated to the rear."

The advent of the nineteenth century plan book writers was a result of the effect of an economic transition in the United States. The close ties of the agricultural economy were now difficult to maintain in the new factory-dominated society. The American society seemed to have outgrown the old standards without establishing new ones. The crusade to establish new standards for the American family largely drew its strength from a group of individuals with basic design skills who wanted to promote themselves as 'architects'. These 'designers' proposed a standardized approach to architecture in the form of "pattern books," which rejected the earlier revival styles prevalent during the early nineteenth century, and proposed instead more "patriotic" American styles that included Gothic, Italianate and Bracketed (figure 5.1).

The distinction between work and home led to the American family house being considered as a refuge, a shelter and a sanctuary from the outside world. The family ideal portrayed the individual with a degree of independence while at the same time contributing to the whole. These new plans of houses were also reflective of this ideal, which reinforced the cohesiveness of the whole family while at the same time also providing for needs of each individual member. Plan book writers thus stressed that each room in the house, like each member of the family, should have clearly a defined role and function (Clark, 1986, p. 40). A typical house of this period was the Queen Anne style, which in most cases consisted of a porch, an entrance hall containing staircases, front parlors used as drawing rooms, a second front room serving as a sitting or dining room, non-public work rooms at the back of the house serviced by a secondary staircase, and upstairs spaces given over exclusively to the bedrooms.

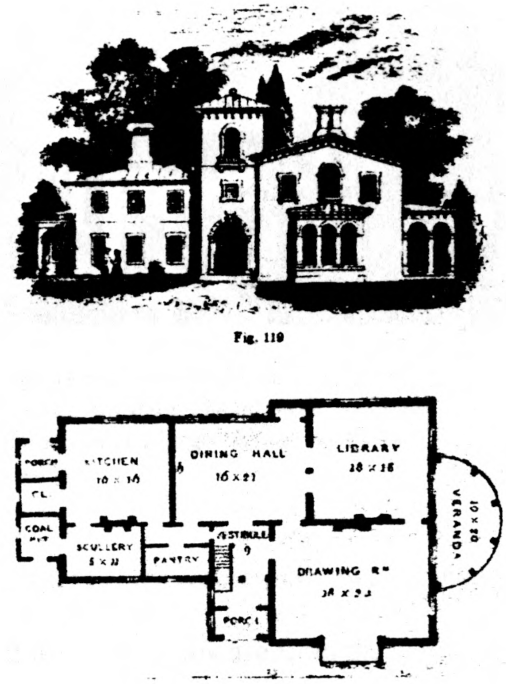


Figure 5.1 House from the Italianate period known for its asymmetrical grouping of forms (Clark, 1986, p. 21).

One important source of Queen Anne designs was the pattern book by R.W. Shoppell (1983; original 1880-1900), the founder of the Cooperative Building Plan Association, which provided middle class Americans with cheap and fashionable house plans through a series of catalogs and portfolios published periodically. A typical exterior of a Queen Anne style house has distinctive features that set it apart from other styles. These features include steep gabled roofs decorated with half timbering, large corbelled chimneys with elaborate chimney pots, balconies, large vertical windows and distinctive porches which form a integral part of the whole plan (figure 5.2).

Figure 5.2 A typical Queen Anne style house with steep gabled roofs, corbelled chimneys and large vertical windows (author).

As we shall see below, the plan chosen for space syntax analysis in this thesis is from Shoppell's Pattern book, which constitutes an exceptionally rich record of late-Victorian house in America. The designs in this pattern book are from the early 1880's through 1900. These later houses displayed even more massiveness and complexity of form than the earlier styled houses of the 1860's and 70's. The plans of this period also displayed the asymmetry of parts that was seen at its extreme in the Queen Anne style (Shoppell, 1983). Shoppell's pattern book consists of 118 designs which are reprinted from *Shoppell's Modern Houses,* which was a series of catalogs and portfolios created for prospective purchasers of new houses and was published periodically by the Co-operative Building Plan Association, a new York architectural firm founded by Shoppell.

All the designs in the book include floor plans and perspectives or elevations of the houses. In many cases, detailed specifications of building material, concealed structural features, arrangement of accommodations, exact dimensions, feasible modifications and even colors are also included (Shoppell, 1983). The houses plans are not architecturally innovative, but they are important because they are the typical houses in which the average middle-class American around the turn of the century actually lived.

The Queen Anne Plan for Space Syntax Analysis

The specific plan chosen from Shoppell's pattern book for space syntax analysis in this thesis is catalogued as Residence design number 648 and is from the January-March 1890 issue of *Shoppell's Modern Houses* (figure 5.3). The cost for the house in 1890 was estimated at fifty-five-hundred dollars. The plan is a typical Queen Anne with key distinguishing characteristics such as porch, boxed rooms, and decorative façade features. Importantly, this plan is also comparable to Wright's Robie and Kaufmann houses in terms of square footage and similar functional spaces, including living area, bedrooms, kitchen, servant's room, and service areas.

Figure 5.1 The perspective of the Queen Anne style plan to be analyzed through space syntax. The gabled roof, large vertical windows, a front porch can all be seen in the image (Shoppell, 1983, p. 50)

The plans for this house are shown in figure 5.4. As the plan illustrates, the living functions are all boxed as separate entities with one space placed next to another. The entrance to the house is through a large porch that can be accessed directly from the dining space and through a vestibule from the main hall, forming an outdoor seating space. The porch is used as an extension of the front rooms of the house and provides a sense of spacious formality. As Clark (1986, p. 173) explains, "the front porch was an important feature of a single family house. Sometimes called a veranda or piazza, the front porch tied the house directly to the world of nature."

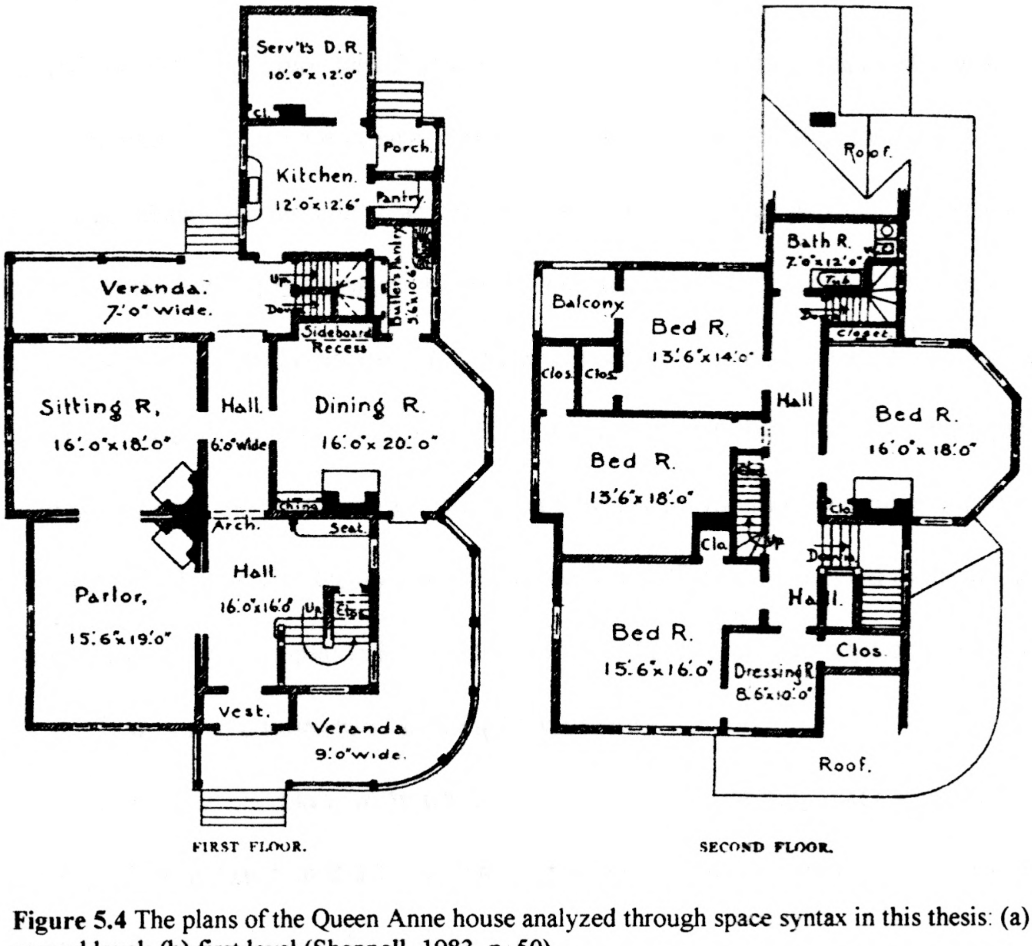


Figure 5.4 The plans of the Queen Anne house analyzed through space syntax in this thesis: (a) ground level; (b) first level (Shoppell, 1983, p. 50).

The entrance to the main hall of the house is through a small vestibule that acted as a transition space. The hall works as a mediating space between the front porch, library, front parlor and dining room (ibid., pg. 44). The hall in this case also acts as central gathering space leading to the parlor, a smaller hallway and a stair which connects with the second floor.

As this plan indicates, by the middle of nineteenth century there was a clear division between public and private spheres of the house. The parlor, the main hall, the sitting room and dining space were considered public zones and were accessible to visitor, while other spaces were considered private—for example the kitchen, servants' room and the sleeping areas, which in most cases were located on a separate floor.

The plan of figure 5.4 clearly demarcates public and private functions. Some spaces were clearly private and it was important that the service aspects of the house be hidden from the eyes of the visitor. These spaces are therefore accessed through a verandah at the back of the house. This verandah acted as a service yard and enabled the service persons to come and go unnoticed. The more private functions like the bedrooms were located on the second floor and were accessed from the main entrance hall in front and verandah in back. The second floor has a central hall that connected to the four bedrooms and a staircase that led to the attic on the third floor. The attic area consisted of two small bedrooms, a large hall, a storage room and a balcony.

In looking at the plans in figure 5.4 in more detail, we note that the parlor acted as a formal gathering space, and the elaborate furnishings and the care taken to maintain it implied that the parlor was to be a place for social interaction and display rather than for relaxation. The parlor also functioned as a treasure house, full of art objects and curios that, by association to events or experiences which took place outside the home, provided a window on the larger world (Clark, 1986, p. 116). The sitting room towards the back acted as an informal gathering space and was used for relaxation by the family. The dining room, located across the sitting room, was sometimes given equal importance as the parlor. As Clark (1986, pg. 42) explains, "plan book writers intended the meals to be formal occasions at which the family could interact and enjoy one another." In turn, the dining room was connected to the kitchen through a butler's pantry. The pantry helped to keep out the noise and the heat from cooking and also worked as a transition space between a public zone—the dining space—and the private area—the kitchen and the servants' room beyond. A small porch next to the kitchen served as a relaxation space for the servants, without their interfering with household members.

The Robie House

The second house to be analyzed through space syntax is Frank Lloyd Wright's Robie house, built in 1908, and said to be among the clearest of Wright's expression of Modernist house ideal (Curtis, 1983, p. 83). As Curtis explains, "all parts were drawn into a symphony—a masterwork transcending merely period concerns and possessing extraordinary depth" (Curtis, 1983, p. 87). Wright was a pioneer in the formation of the Modern Movement. Even though his earlier designs were drawn from the Queen Anne, Shingle, and Colonial Revival styles, he was quick to grasp the effect of mechanization on society and incorporated innovations in his designs. Wright was particularly opposed to the boxed character of the Queen Anne style and was one of the first architects to reject the idea of a house as a series of separate, individualized spaces.

The client for the Robie house, Fredrick Robie, was a one of the many late nineteenth-century bicycle manufacturers who were in the process of taking the next big step toward the assembly of cars. According to Wright, Robie was a "business man with unspoiled instincts and untainted ideals" (Hoffman, 1984, p. 12). Robie approached Wright with some sketches of the kind of house he wanted; these diagrams showed an unusual arrangement of rooms, and when he showed then to contractors, he kept getting the reply "you need one of those damn Wright houses" (Hoffman, 1984, p. 9). Robie's choice of a corner rectilinear site located adjacent to the University of Chicago gave Wright the opportunity to create a house that was a shift away from the prevalent styles of the period and also satisfied his own character. According to Hoffman (1984, p. 17), "Wright would later explain that the site itself suggested a long, low, streamlined, shiplike house: the prairie, the nearby lake, the new sense of speed, the unshaken faith in the machine."

Figure 5.5 The exterior of the Robie house (author).

Construction on the house began in the spring of 1909 and gave Wright an opportunity to make a connection, within the university campus, between the life of the mind and creation of an appropriately modern environment (Hoffman, 1984, p. 27). Robie had approached Wright knowing exactly the functions he wanted in his house. He required a servants wing and a billiard room, as well as the usual dining and living-rooms, bedrooms, kitchen and bathrooms, and indicated that he wanted to see his neighbors on the sidewalk and also the park which lay a block away (Curtis, 1983, p. 86). Wright sensed Robie was a man waiting to be educated, willing to come halfway, and move towards the architect's ideals. Wright at this time had started to think of himself as the voice of people who could not speak for themselves, idealizing his client and his tastes (Hoffman 1984, p. 12).

The Robie house was typical of Wright's style of design, extremely complicated as a total composition but easily broken down visually into simpler parts (Connors, 1984, p. 19). As mentioned above, the final design was reflective of the long rectilinear site (figure 5.6). To take advantage of the corner location and prominent neighborhood, Wright oriented the house in such a manner that the main entrance was located on Woodlawn Avenue, respecting its eminence and the longer southern side on south, favoring the climatological aspects such as the southern sun, the summer breezes and the low sun of the winter.

In plan (figure 5.6), the building was arranged as two bands, sliding alongside one another with some degree of overlap. The smaller of the two bands lies to the rear of the site and contains mostly the house's service functions, including the garage, boiler room, laundry and entrance on the first floor and the kitchen and guest room on the second floor. The second band incorporating the front of the house, is the more prominent of the two, arranged with chimney and stairs as a unit passing up through the center. The children's room and billiard room are on the first floor of this band and the living and dining room on the second floor. The house would be totally symmetrical if the bedroom block located on the third floor had not been allowed to interpenetrate the two stories underneath the long cantilevered roof (Hoffman, 1984, p. 32).

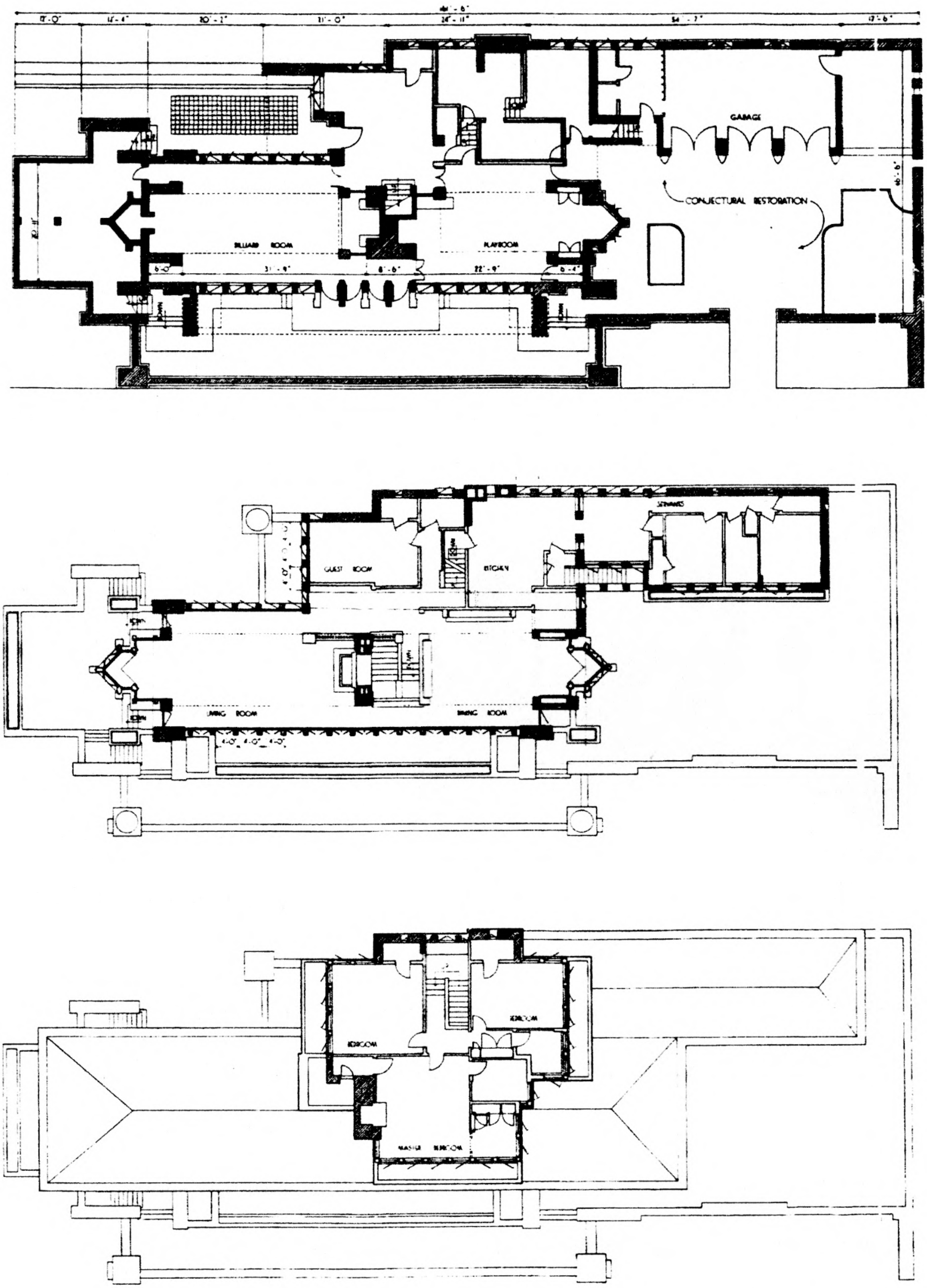


Figure 5.6 The plans of the Fredrick C. Robie house (1906): (a) first floor; (b) second floor; (c) third floor (Hoffman, 1984).

As Hoffman explains (1984, p. 35)

> the Robie house embraced so many opposite tendencies that no one but Wright himself could have resolved them so well. If the Robie house plays with the ideas of speed, it also weighs heavily on its site. It can speak of democracy, free and open, but from almost every direction it is closed or cunningly screened. It honors nature, but by meeting nature's soft shapes with its own order of sharp edges and planes.

The entrance hall of the Robie house is a small reception room, leading to the two main areas on the ground level—the billiard room and the playroom. The hall also provides access to a toilet and a coat closet which leads to the heat room, coal room and laundry located on the same level (figure 5.7). The entrance hall is designed in such a manner that the light coming from the stairwell beckons the visitor to explore the space. The act of ascent up the stairs has been dramatized by a stair that turns a number of times before the second floor is reached. Instead of a conventional space, one enters a fluid space, where the boundaries are not solid walls but thin wooden screens, curtains and an extraordinary number of glass door and windows. According to Connors (1984, p. 36), "what awaited the visitor was one of the greatest breathtaking spaces of American domestic architecture."

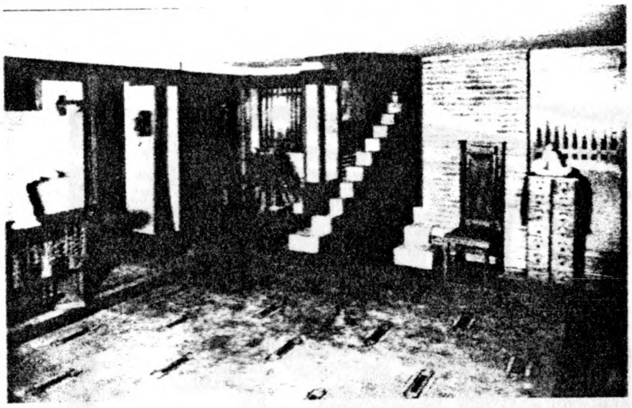


Figure 5.7 The entry hall with the stair leading to the first level and the coat closet on the left (Hoffman, 1984, p. 49).

The spaces that were earlier kept separate Wright now, joined together to form a single space. Even in his earlier works Wright had joined the front parlor and the sitting room into one, but in the case of the Robie house he went a step further and combined the dining space and living space. These two rooms function as a single space partially divided by a fireplace (figure 5.8), which, usually signifies a closure of room, here is treated like a movable piece of furniture (Connors. 1984 p. 38). At its top the fireplace is reduced to two slender piers of brick, allowing the whole space to flow through it, visually connecting dining and living room.

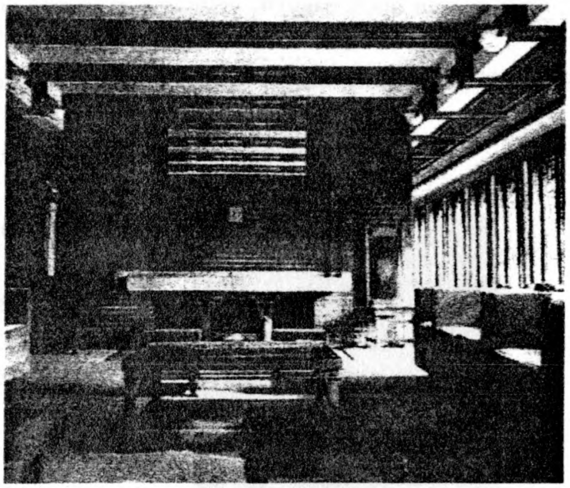


Figure 5.8 The interior of the Robie house with the fireplace and living room (author).

The space in front of the stairs on the first level acts as a small transition area, initiating and connecting the visitor to the larger living space and private areas of the bedroom on the upper floor. This space also connects to the guestroom and the kitchen. In this sense, walls are placed in such a manner that the whole space is not revealed to the visitor at once. Even though the whole living and dining space is just one single entity, strategically placed walls and screens form a sequence of spaces which are revealed as the visitor explores the space (figure 5.9).

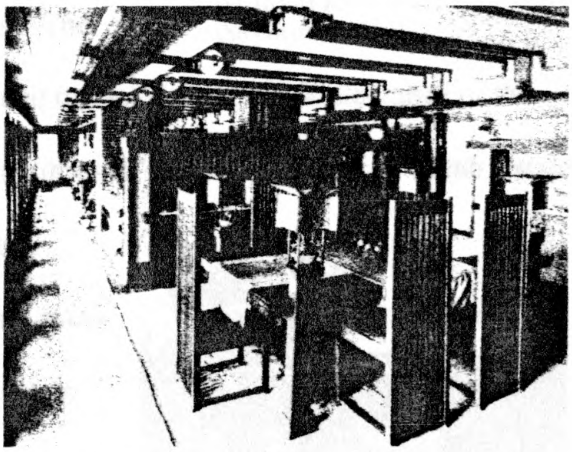


Figure 5.9 South aisle and dining room, looking northwest (Hoffman, 1984, p. 75)

The kitchen acts as a buffer between the main living spaces and servants quarters. A staircase from the driveway terminates into a small vestibule, separating the servant's entry from the kitchen entrance. The bedroom block is a totally private zone and is only accessible through a single staircase. The staircase from the hall on the first level leads to a central hall that connects to the three bedrooms on the second level.

The entrances relate the outside to the inside and provide route choices to inhabitants and guests. Importantly, the transition from outside to inside the house is subtler than the silhouettes and elevations indicate (Hoffman, 1984, p. 32). All the entrances are located in out of the way places, making it difficult to locate them. The house can be accessed from several entrances located on various side of the house. The principle entrance of the Robie house is located tucked under the low clearance of the guest room balcony. It is also possible to enter through the billiard room, or climb a stairs and enter through the porch (figure 5.10). The intense drama prevalent in all Wright's houses starts with a simple act of ascending the stairs, owing to the creation of tension between the narrow staircase and massive brick wall. The porch acts as a transition space and provides an option of entering the living room directly or descending the stairs on the north end and approach the main door (figure 5.11)(Connors, 1984, p. 30). There are also three entrances from the driveway, one through the

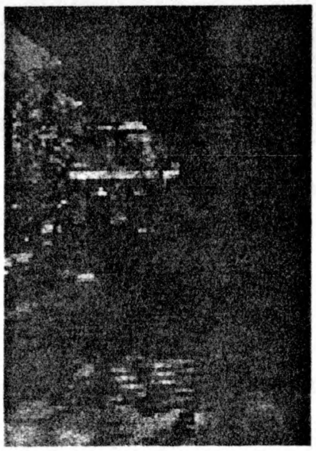


Figure 5.10 Entrance to the Robie house from the porch (author)

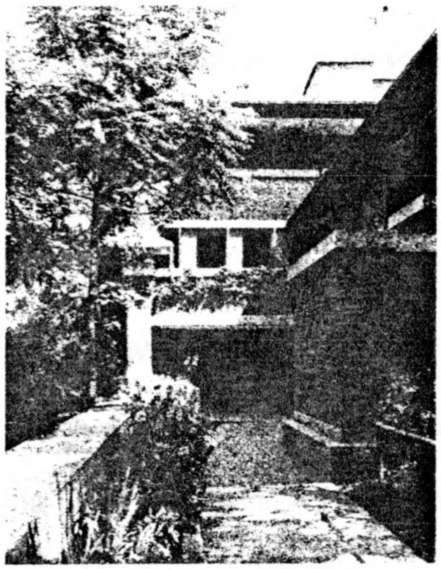


Figure 5.11 Main entrance to the Robie house (author)

children's play area on the ground level (figure 5.12), another from the laundry and furnace on the same level, while yet another is through a servant's staircase leading to the kitchen on the first level.

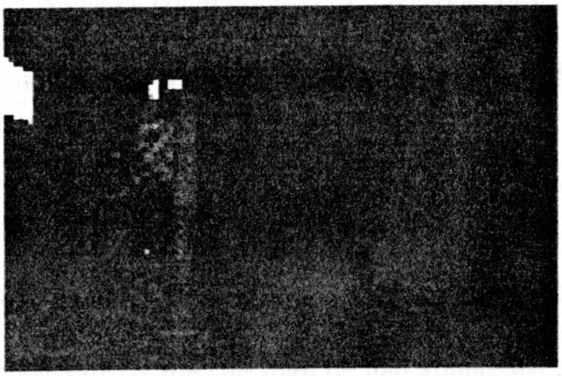


Figure 5.12 Entrance to the Robie house from the children's play area (author)

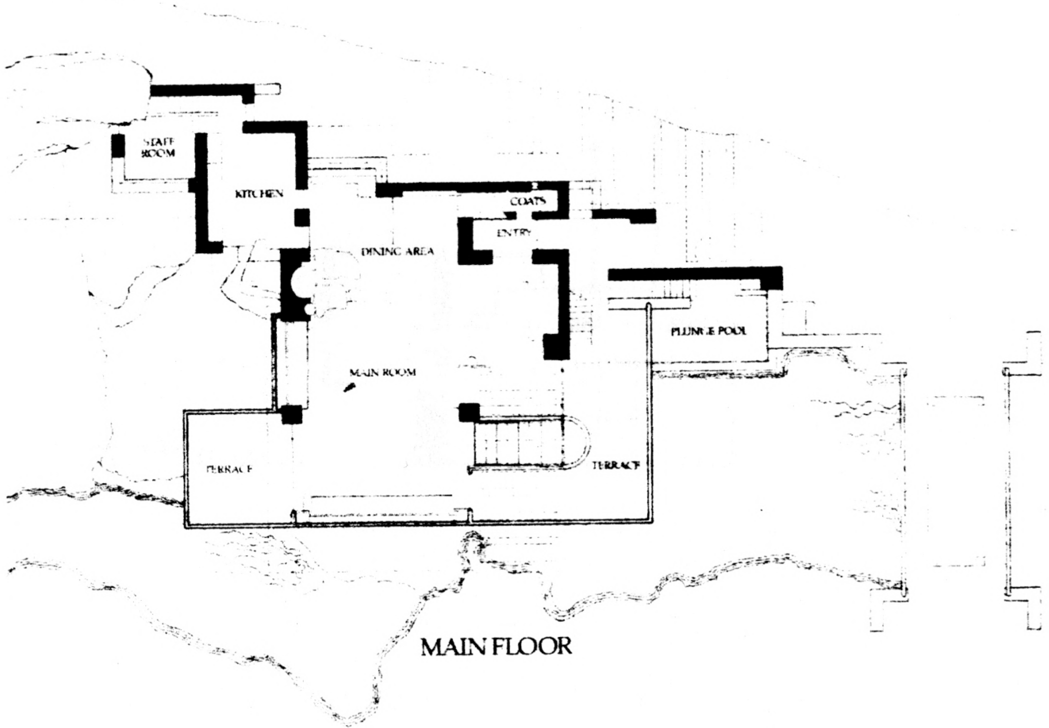
The Kaufmann House

Built in 1937, the Kaufmann house is often considered to be the culmination of Wright's domestic architecture. Fallingwater, he named the house, has been named the best American building of the last 125 years by the American Institute of Architects (McCarter, 1994, p. 4), even though some historians believe the Kaufmann house to be influenced by other prevalent international style. Curtis (1983, p. 200) claims that, "the forms of the house were rooted in Wright's earlier principles and discoveries." According to McCarter (1994, p. 8), "the plan of the Kaufmann house was developed from those of Prairie houses; the basic organization of a cruciform interpenetrating a square is to be found here, as is the typical asymmetrical spiraling perimeter movement pattern and hidden entry."

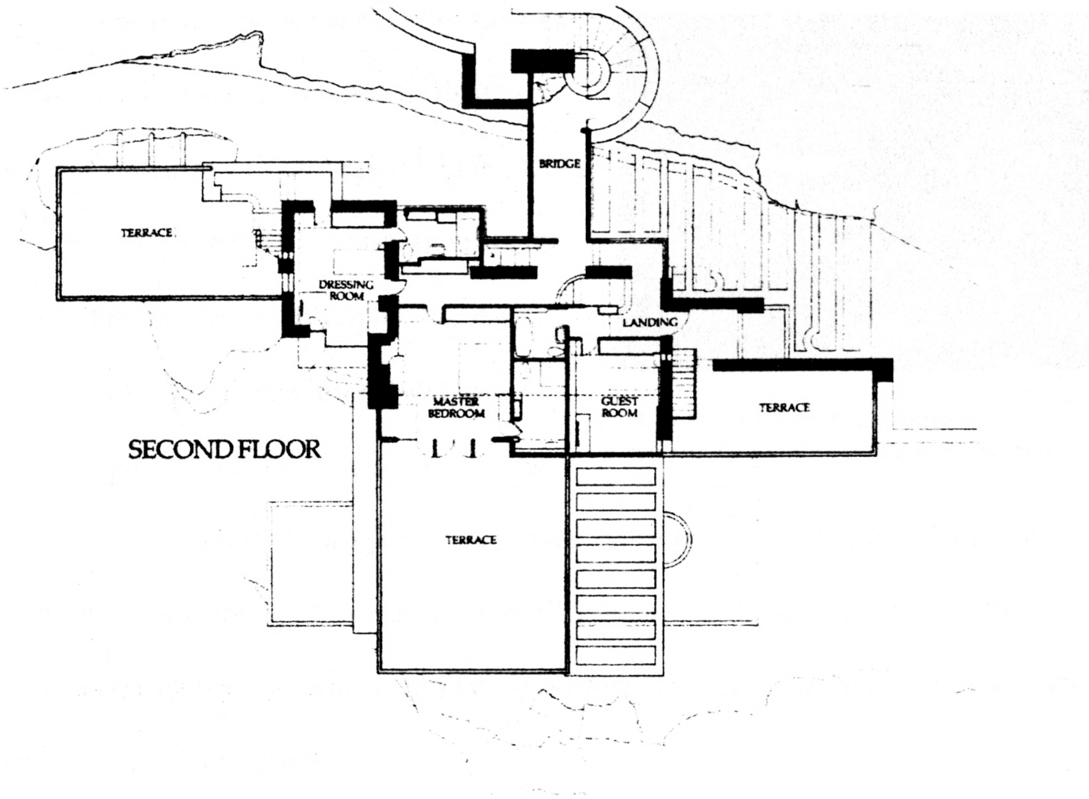
Fallingwater was a result of a chance meeting between Wright and Edgar Kaufmann, owner of a department stores chain in Pittsburgh. One of the apprentices who joined Wright's Taliesin fellowship in October 1934 was Edgar Kaufmann, Jr., the elder Kaufmann's son. At the end of 1934, the Kaufmanns visited their son at Wright's architecture school, Taliesin, and Wright was invited to Pittsburgh to discuss several projects, one of which was a country house to replace a small cottage in the mountains southeast of Pittsburgh that the family had used for over a decade (McCarter, 1994, p. 5); it was then that Wright first visited the site.

Bear Run, the stream over which the house is placed, was typical and unexceptional before it became the site for Fallingwater. The initial design was approved by Kaufmann despite its being in a different location on the site than he had apparently imagined. Kaufmann had expected the house to be located south of the stream, looking at the falls from below. He was surprised that the house was to be built above the falls. As Wright explained to Kaufmann (McCarter, 1994, p. 7), "I want you to live with the waterfall, not just to look at it, but for it to become an integral part of your lives." In laying out the plan for the house, he placed the structure at a sixty-degree angle to falls and entrance road. This arrangement provided for the dynamic diagonal views of the house both from the entry drive and from the flat rock ledge below the falls (McCarter, 1994, p. 7).

The plan of Fallingwater (figure 5.13) emphasizes the underlying order of a series of parallel walls and piers, standing on a rock ledge that supports the main volume of the house. The house merges with the natural surroundings and utilizes the existing ground for its structural support; in turn, the rock walls of the stream relate to the actual masonry walls of the house. The natural rock layers are repeated almost exactly in thickness and random pattern of setting in the vertical walls that emerge from the boulders of the waterfall (McCarter, 1994, p. 15).c



MAIN FLOOR



SECOND FLOOR

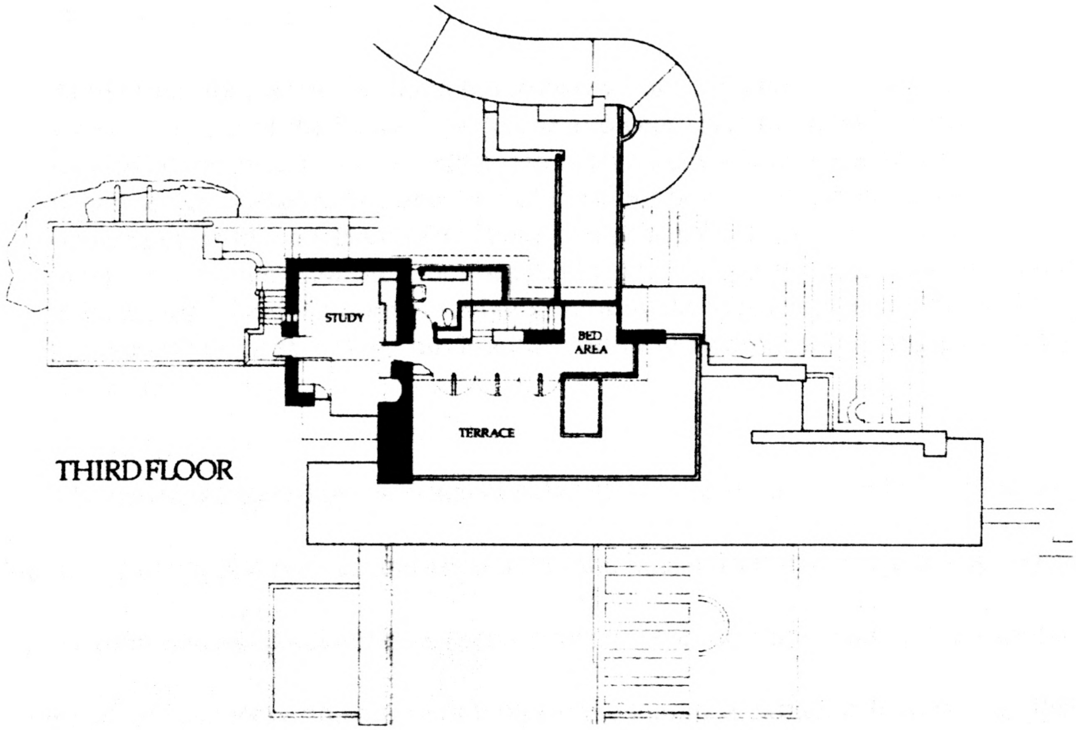


Figure 5.13 The plans of the Edgar Kaufmann house (1935): (a) first floor; (b) second floor; (c) third floor (Kaufmann, 1986, pp. 73, 135).

The first view of the house is a series of horizontal terraces that seem to float without visible means of support (figure 5.14). As one moves around the house, the vantage point changes dramatically in height. As McCarter explains (McCarter, 1994, p. 17), "the horizontal concrete planes and vertical rock walls constantly change position relative to one another, not allowing the viewer to establish a static image of its exterior form." The most concise description of the interlocking planes and their relation to the vertical elements can be found in McCarter's description of Fallingwater.

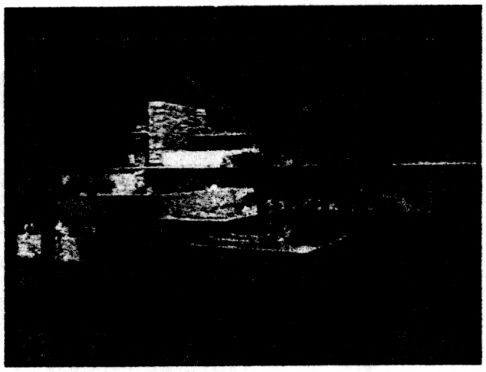


Figure 5.14 Kaufmann house with horizontal terraces as one approaches the house (author).

He explains (McCarter, 1994, p. 17),

> At the first floor level, the main horizontal volume extends from the vertical set of walls rising out of the back of the house and cantilevering in both directions parallel to the stream below. The main horizontal volume of the second floor, which serves as the ceiling and roof of the floor below, nevertheless projects perpendicular to the stream bed. These two primary planes cross, one above the other, creating a composite cruciform and capturing the space of the living room at its center. The third floor is set back, split by the vertical masonry mass, the horizontal planes stretching out to either side and again cantilevering parallel to the stream.

The house is entered by crossing a bridge across the stream. The living room is visible through the glass wall as one approaches the house from the bridge but, as in case of other Wright houses, it cannot be entered directly. One must move along the edges of the house, all around its perimeter, searching for the entrance, which is hidden from the initial view.

The visitor then crosses the driveway, cut into the natural rock wall (figure 5.15). To the left of the driveway, an opening between layered rock walls brings one into a kind of loggia: to the left is a view to the living room terrace

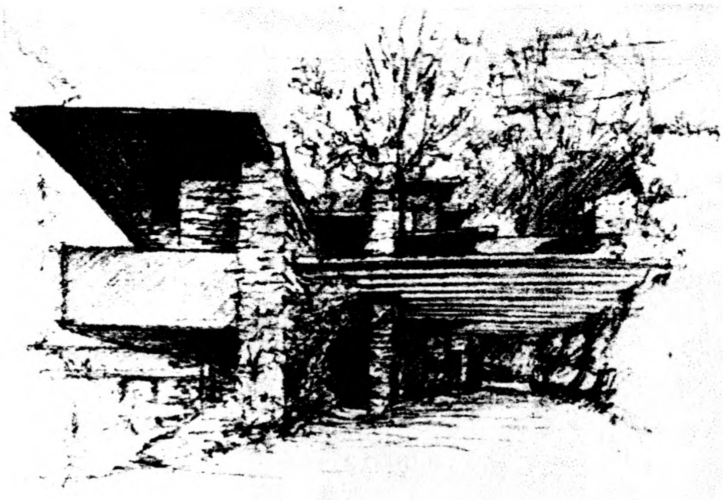


Figure 5.15 The main entrance to the Kaufmann house, approach from the bridge (author).

through a suspended concrete staircase, to the right a small fountain shoots a stream of water into a basin set into the earth. Straight ahead is the front door set deep into the rock walls with a low concrete slab header over it, creating a sheltered entry similar to the one of the Robie house.

Entering through the main door, one enters a small foyer with rock wall ahead and, to the right, one turns to an opening at the left, which leads to the living room. The entrance into the living room is a dramatic transition. As McCarter explains (McCarter, 1994, p. 20), "before climbing the three stairs up to the living room floor, we should notice that from the level of this foyer, the eye-level is almost exactly at the center of the space between floor and ceiling. From this vantage point, the two horizontal planes are in a perfect balance, the white ceiling above and the dark flagstone floor below." Since no walls are seen from this point, the living room seems to open out in all directions.

Upon entering the living room (figure 5.16), one can see the natural surroundings accessible through the terraces and hear the sound of the waterfall. A low glass-enclosed hatch opens to the concrete stair that descends to the stream below. The fireplace located diagonally across from the stairs forms the main focus of living room. The fireplace is not set into the wall but is the wall itself, with the hearth being the boulder of the site cutting into the flagstone floor. To the right of the fireplace lies the built-in dining table. In the corner between the fireplace and dining table is the door to the kitchen, which is enclosed on almost all sides by the stone anchoring the house to its site.

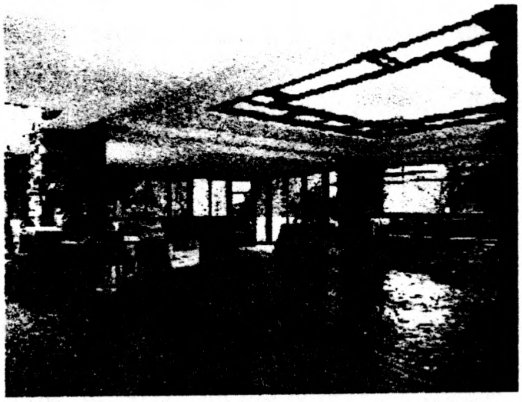


Figure 5.16 The interior of the Kaufmann house, with the living room (author).

Similar to the Prairie house style, the living room of the Kaufmann house is essentially a square central volume off the corners of which open the entry, stairs, kitchen and terraces. According to McCarter (1994, p. 10), "this great room contains in a single volume almost all the rooms—living, dining, library and entry—typically found in the first floor of Wright's Prairie houses." The symmetrical order in plan of the earlier houses allowed the corners to open up; in the case of the Kaufmann house, the open corner becomes such a strong spatial element in its own right that it allows the plan to do without literal symmetry (McCarter, 1994, p. 10).

The stair to the second floor begins across from the kitchen, behind the entry foyer. The second floor hall lead to the master bedroom with a large fireplace and a series of glass doors that open into a terrace far larger than the bedroom itself. The large scale of the terrace here demands that it be considered a second large room of the house with unencucumbred views out in three directions (McCarter, 1994, p. 17). The bedroom used by Mr. Kaufmann is over the kitchen, with a long terrace cantilevered to the west and accessed through a series of steps. The guest bedroom is located towards the east of the master bedroom and segregated from the rest of the spaces on the floor. On the third floor is a long gallery facing a smaller terrace, and the bedroom used by Edgar Kaufmann Jr., sits directly above his father's and shares the west terrace. The careful provision of a vertical slot in the walls allows glass to be directly set into it, thus allowing the space to flow from inside to outside and from outside to inside, eliminating the corner altogether.

According to McCarter (1994, p. 24), "all of Wright's work can be thought of as a rediscovery of the possibilities of dwelling in space and time. In this Wright was perhaps one of the only architects of our time to engage fundamental ancient principles in the creation of interior space, seeking the space within which was defined without boundaries; defined instead by the rituals of daily experience."

The Chapters Ahead

Having discussed the three houses in detail, it is essential to provide a brief summary of the discussion up to this point before presenting the analysis and conclusions. The first chapter overviewed the changing architectural style through the late eighteenth century to the early twentieth century and also provided a synopsis of the work of architectural historian H. Allen Brooks and his discussion of Wright's changing conception of space. The second chapter reviewed Hillier's space syntax theory as applied to urban spaces and settlements. The third and the fourth chapters discussed the space syntax theory as applied to building interiors and the Spatialist software and its application to various indoor settings. The chapters that follow discuss space syntax analysis as applied to the three houses and illustrate how Hillier's ideas support and extend quantitatively and qualitatively Brook's discussion of Wright's "destruction of the box."

CHAPTER 6

AN ANALYSIS OF THE THREE HOUSES USING JUSTIFIED PERMEABILITY GRAPHS

The remainder of this thesis uses the approach and framework of the space syntax theory, to explore in detail the shift in organization of house space from the late nineteenth-century Queen Anne style to the early twentieth-century Wrightian space. The present chapter analyzes this shift in domestic space organization with help of justified permeability graphs. Before the houses are analyzed with the help of these graphs, it is essential to recapitulate the underlying concepts of permeability graphs. This is the aim of the first section of this chapter. Following sections present permeability graphs for the three houses and compare and contrast results.

Permeability Graphs

As discussed in chapters two and three, a justified graph uses geometric representation to understand the relationship between a set of elements or entities. A spatial relation exists where there is any kind of link between two spaces. Such a relation turns into a configuration when the connection between the two spaces changes according to how the two spaces relate to a third space or to any number of additional spaces. The permeability graph can be drawn from any single space in relation to all other spaces in the system. Justified graphs for small number of spaces tends to show configurational differences quite clearly. According to Hanson (1998, p. 24), “they capture significant properties of spatial configuration in an immediate visual way."

Figure 6.1 shows justified permeability graphs for five simple dwellings.

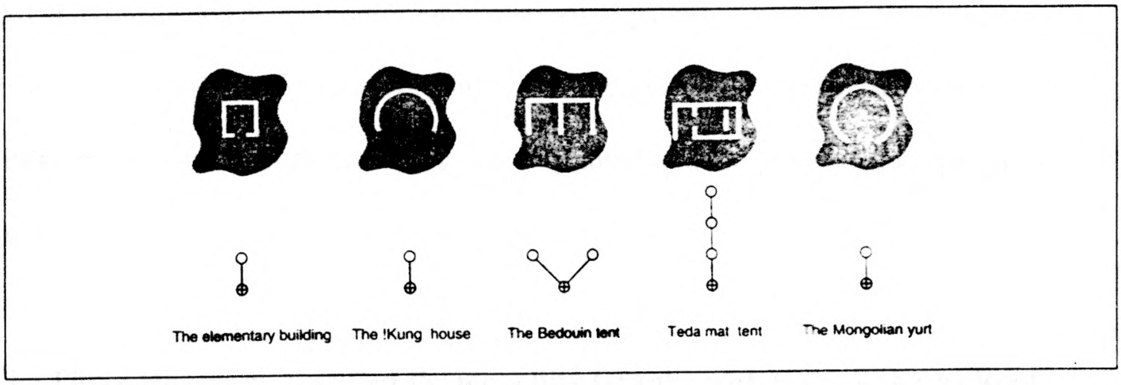


Figure 6.1 Permeability Graphs for five simple dwellings (Hanson, 1998, p. 24).

The justified graph is based on two main properties of *depth* and *choice*. As discussed earlier, *depth* is described as the number of links, or *edges*, as Hillier calls them, connecting a particular interior space with the carrier space or the outside the building. Thus, the shortest distances with many edges are deep, while the shortest distances with few edges are shallow. The property of *choice* is the existence of alternative routes from one space to another which show themselves as rings in the permeability graph. Based on the properties of depth and choice, all graphs can be divided into four categories—a shallow configuration, a deep configuration, a shallow ringy complex or a deep ringy arrangement (see figure 4 in chapter 3). Justified permeability graphs of house plans drawn from different rooms give a clear indication how the rooms are placed within a configuration. Some rooms draw the entire configuration towards the root, while other rooms push the rest of the house deep.

The depth and shallowness of the whole layout varies depending on the position from which the graph is drawn. Therefore, the most integrated spaces in the house are shallow and pivotal and the most segregated spaces are secluded and private. Thus, integration is one of the fundamental ways in which houses convey culture through their configuration (Hanson, 1998, p. 26). Historically, different spaces with similar functions and activities acted as integrators of given spatial pattern. Therefore, there exists a relation between the way space is configured and the way it is used. According to Hanson (1998, p. 32), "functional patterning was imprinted into the physical and spatial from of the house."

The Three Houses as Justified Permeability Graphs with the Carrier as Root

Houses everywhere serve the same basic need of living, cooking, eating, entertaining, bathing, sleeping, storage and similar functions, but a glance through architectural history reveals an astonishing variety in the ways in which these activities are accommodated in the houses of different historical periods and culture. As Hanson (1998, p. 2) explains, "the important thing about a house is not that it is a list of activities or rooms but that it is a pattern of space, governed by intricate conventions about what spaces there are, how they are connected together and sequenced, and which activities go together and which are separated out."

The Queen Anne style house plans are associated with enclosed rooms with specific function for each space. The four walls of a room join at corners and involve uniform floors and ceilings. As discussed earlier, Wright has been associated with dismembering the traditional box. The shift from the Queen Anne closed plans to Wright's open and flowing space can be analyzed with the help of justified permeability graphs.

To analyze, therefore the plans of the three houses, justified permeability graphs were drawn for each house for three main functions in the house. In the first instance, the exterior space of the house, or carrier, was taken as the root. In the second case, the graph was drawn in terms of the living space as the root. In the third instance the master bedroom was taken as the root. We will examine each of these permeabilities, in turn, for each of the three houses.

As shown in figure 6.2, the permeability graph for the three houses in relation to the carrier clearly shows differing spatial structures for each plan, even though the three houses are more or less comparable in relation to their square footages, the graphical representation for Kaufmann house suggests that it can be considered as a simple house from the point of view of the number of rooms in the plan, while the Queen Anne house is more complex and the Robie house the most complex.

As figure 6.2a illustrates, the graph for Queen Anne prototype is deep and sequenced with nine levels of depth in its justified graph. In contrast, the graph for Robie house (figure 6.2b), despite its number of spaces and internal complexity, is still relatively shallow, with just six levels of depth in its graph. The justified graph of Kaufmann house (figure 6.2c) is even shallower than the Robie house with just five levels of depth in its graph. This pattern suggests that the impression a nineteenth century house like the Queen Anne is highly permeable to the exterior is somewhat of an illusion (Hanson, 1998, p. 171).

As figure 6.2 also indicates, the three houses relate to their carriers in different ways. The Queen Anne has three entrances of which two are service entrances for kitchen and servants room and form ringy routes with kitchen and pantry. The main entry of the

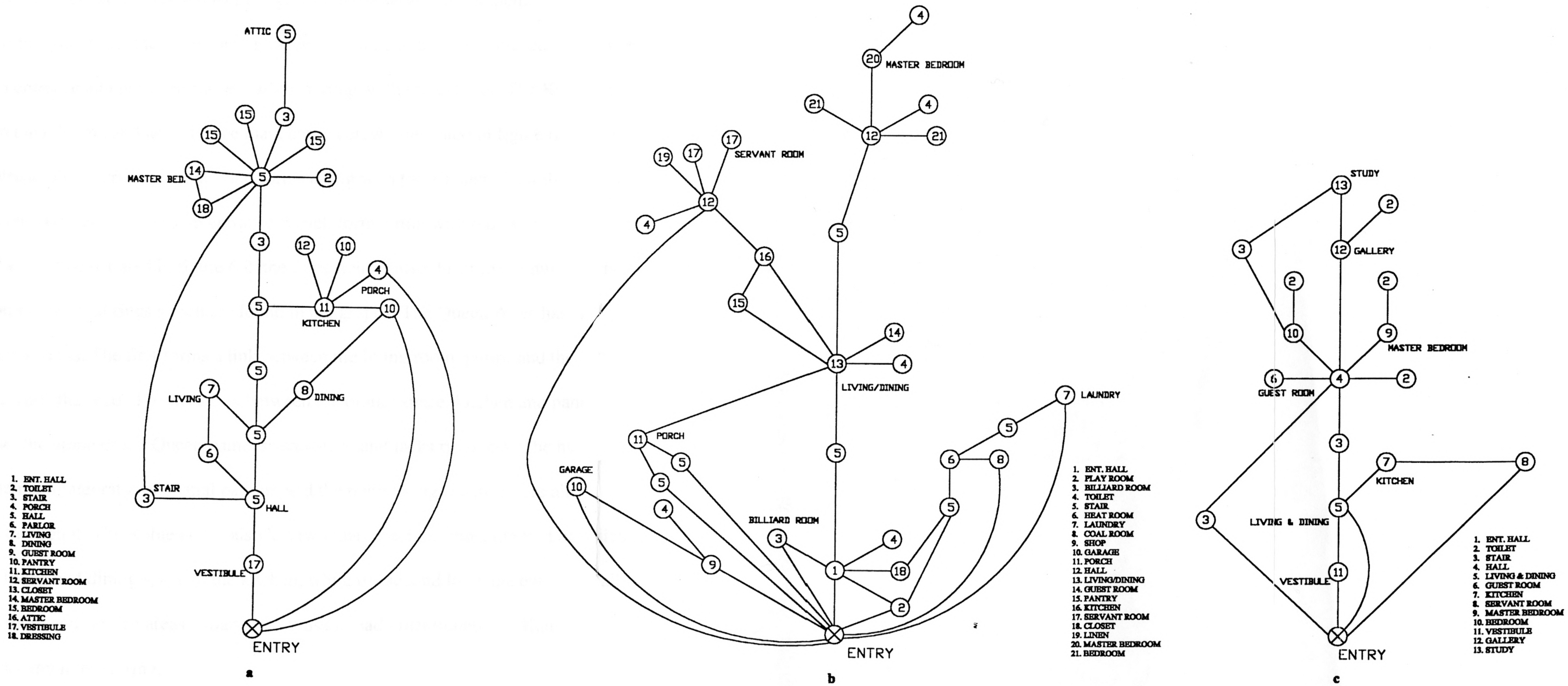


Figure 6.2 The permeability graphs for three houses drawn from the house plot (a) Queen Anne prototype; (b) Robie house; (c) Kaufmann house (Author)

Queen Anne leads to a vestibule and a series of hallways which connect to the main functions of the house. In this sense, one can move through the whole house by using the hallways only and without entering any rooms.

As explained earlier in chapter five, the Robie house has eight entrances of which four are service-related entries and form rings within the service areas themselves. As illustrated in figure 6.2b, the other four entrances—main entrance, billiard room entrance, playroom entrance and porch entrance—all form rings with the exterior. The Kaufmann house, on the other hand, has just three main entrances. As indicated in figure 6.2c, one of the entrances is a service entrance and forms a ring with the kitchen. The other two are the main entrance and living room entrance, which form a ring with the exterior.

As is also illustrated in figure 6.2, the three houses also differ in the number and type of purely internal rings which are found in the graphs. The Queen Anne has two main internal rings. The first forms a link between the living room, parlor and the hallway , while the second forms a link between the dining space, kitchen and pantry. Otherwise, the graph of the Queen Anne is sequenced and lacks ringiness. The hallway acts as the main integrator of spatial pattern, and the main living functions are all accessed through it. The Robie house also has two main internal rings, the first of which links the living and dining space to the kitchen, while the second links the entrance hall with playroom and service areas. Apart from those already mentioned, the Kaufmann house lacks any internal ring.

Individual House Spaces as Four Topological Types

Figure 6.2 also indicates that the individual spaces which make up the layout of each house also have different functional characteristics. Hanson (1998) argues that, locally, configurations can be defined in terms of four broad topological space-types. First, there are terminal spaces, which are end points in the justified graph and are linked to the rest of the complex by only one entrance. As Hanson (1998, p. 173) explains, "such spaces can only accommodate movement to and from themselves, and so it is in their nature that they are intended mainly for static occupation, either by people or things." The influence of such spaces is local and, eliminating any one space from the complex by unlinking it, would make little difference to the rest of the layout. Second, Hanson says that there are spaces which are themselves thoroughfares and part of the larger sequenced complex. These spaces cannot be dead ends, but they are on the way to or from a dead end thus, by implication, any movement through the space is highly directed. Third, says Hanson, there are spaces which have more than one link and so can be traversed, but which also lie on a single ring so that it is possible to enter at one point on the ring and leave at another (Hanson, 1998, p. 173). Finally, Hanson speaks of spaces with more than two links and which form the intersection of more than one ring. As Hanson explains (1998, p. 173), "movement through these spaces generates choice as to where to go within the whole sub-complexes of spaces within the overall configuration." Hanson has termed these four space types *a*, *b*, *c* and *d* spaces (Hanson, 1998, p. 174).

The numbers and percentages for the individual space types for each of the three houses are tabulated in table 6.1, which indicates that the Queen Anne's dominant space type is *c*—that is, spaces linked together into a single deep ring. Fifty-three percent of the

Queen Anne spaces are of this dominant type. The next most important space type for the Queen Anne is type *a*—i.e. terminal spaces—of which there are thirty-six percent of the total spaces. Yet again, seven percent of the spaces are type *d*—that is, spaces at the intersection of the deep circulation rings. Only four percent of the total spaces are type *b*—that is, spaces located on unilinear sequences.

	a spaces	b spaces	c spaces	d spaces	Total spaces
Queen Anne House	10 (36%)	1 (4%)	15 (53%)	2 (7%)	28
Robie House	12 (38%)	1 (1%)	10 (32%)	9 (28%)	32
Kaufmann House	5 (29%)	1 (6%)	8 (47%)	3 (18%)	17

Table 6.1 Quantitative measures for four space types—a , b, c, and d –for each of the three houses (author)

Most *c* spaces in the Queen Anne house contain important functions, including the hallways, living room, parlor, dining room, and pantry on the first floor and the master bedroom on the second floor. The rest of the *c* spaces are passages or stairs where routes intersect. The only *d* spaces for the Queen Anne are the hallway on the second floor, which forms a link with the sleeping areas, and the first floor hallway and the kitchen which forms a link with the pantry, the main hallway, and servant room. The storage, toilets and private chambers of the Queen Anne are *a* spaces as is the attic on the third floor.

When we turn to the Robie house, we note a shift in terms of functional space-types. Though the proportion of both *a* and *d* spaces increases slightly, the number of *c* spaces falls dramatically to thirty-two percent of the total. The slight increase in *a* spaces to thirty-eight percent can be attributed to the fact that, in addition to storage and private spaces, several service spaces are also located in terminal spaces. The drop in *c* space to thirty-two percent seems to be a by-product of the more open planning of the house. Thus, passageways and halls are minimized, and the living spaces act as the main integrators. When we look at the Robie house, we see that it has the highest proportion of *d* spaces of all the three houses—twenty-eight percent—and, unlike the Queen Anne, they are mainly functional spaces that include, on the first floor, the entrance hall, billiard room, children's playroom, two service areas; and on the second floor, living and dining area, terrace and hall. For the Robie house, the *b* spaces are almost negligible with just one percent of the total spaces because the transition spaces are eliminated and spaces are directly linked to main passageways or halls.

We also notice in table 6.1 that the Kaufmann house has the least number of spaces as compared to the other two houses. Also in the Kaufmann house, the number of *c* spaces increases to forty-seven percent and includes hallways, staircases, kitchen and pantry. On the other hand, the proportion of *a* spaces falls to twenty-nine percent; these spaces are found only on the upper floors of the house and include the private bedrooms and baths. Yet again, the proportion of *d* spaces at eighteen percent is more than the Queen Anne but less than the Robie house. As in case of the Robie house, these spaces include the main living functions on the first floor and hallway and bedroom on the second floor. The principal floor of the house is made up of only *c* and *d* spaces, while the only *b* space is the master bedroom on the second floor.

For the three houses as a whole, we note that the dominant space type is space *c*, but its specific functions change in the three houses. In the Queen Anne, space *c* includes all the main functional spaces as well as the passageways and hallways. In the case of the Robie and Kaufmann houses, however, the *c* spaces include only subsidiary functions such as the kitchen, pantry, hallways, and staircases, while the main functional spaces are *d* spaces, which act as transition and connecting spaces, integrating the plans as a whole. The dominance of *d* spaces in the Robie and Kaufmann houses clearly demonstrates the shift from a closed-boxed plan to open and integrated space.

Since the Queen Anne house required a separate room for each function, one box was placed beside another, and a series of these boxes made up the home. Therefore, this kind of a design called for a number of connecting corridors and transition spaces—a situation that justifies the large number of *c* spaces as thoroughfares. As mentioned earlier, in the Queen Anne plan, it is possible to traverse the whole house without ever entering into any major functional space. In the Robie and Kaufmann houses, in contrast, there is a pronounced shift in domestic room arrangements away from a sequenced planning and towards integrated space. This change is quite significant, and indicates a clear preference for constructing deep continuous rings of space linked together by a common system of access to intersection spaces that integrate the transition and functional spaces into one. We also note in the Robie and Kaufmann houses that the intersection spaces—i.e., *d* spaces—also control the intersection between the exterior and interior rings of circulation.

Furthermore, the permeability graphs of the three houses in figure 6.2 also reveals certain stark differences. The Queen Anne plan connects the main living functions of the house through a series of hallways, forming a totally sequenced graph. The route choices from the outside to inside are limited, as the hallway is the only connection from the various living functions outside. A lack of rings and tree-like arrangements in the graph segregates each function into individual rooms, and each space thus possesses a independent reality of its own. The parlor, living and dining rooms are located separately and are connected through a main hallway, which forms the main link to outside and other spaces on the first and second floors. The Robie house, on the other hand, provides a variety of route choices to the user from the outside to inside. The various functional spaces—the entrance hall, billiard room and children's playroom on the first floor and living and dining room on the second floor—connect the whole plan into a series of integrated spaces. Here, Wright defines the functions the rooms serve rather than enclosing them into separate units. The Kaufmann house is quite similar to the Robie, as the main living and dining space acts as the integrator of the whole plan, forming a link between the outside and the inside spaces.

Justified Permeability Graphs for Main Living Spaces and Master Bedrooms

As illustrated in figure 6.3, the justified graphs drawn from the main living space for the three houses gives a clear indication of its configuration within the spatial pattern of the individual houses. In the case of the Queen Anne prototype, the graph indicates a totally boxed living space, segregated from the rest of the areas of the house. In contrast, the living spaces in the Robie and Kaufmann houses act as central focal points that

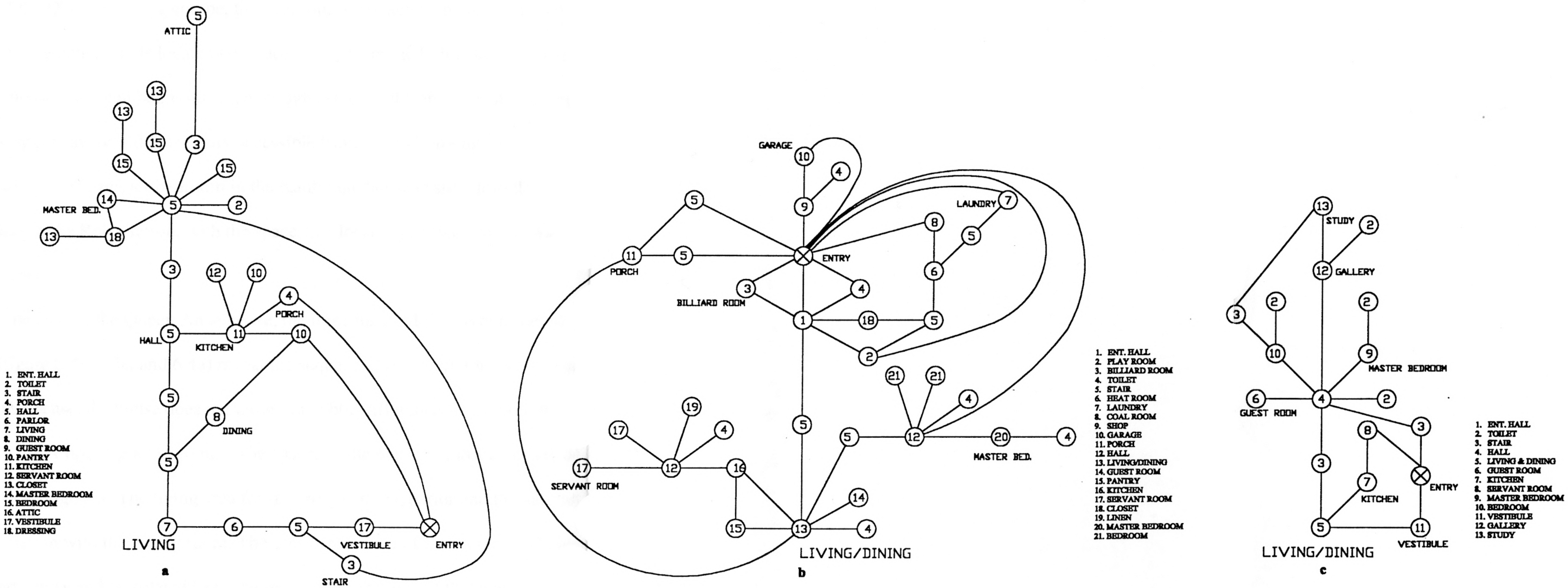


Figure 6.3 The permeability graphs for the three houses drawn from the living room: (a) Queen Anne prototype; (b) Robie house; (c) Kaufmann house (Author)

integrate the entire plans. Also, the structure of space in both houses provides visual links to other connecting spaces such as the hallways and stairs that lead to the upper floor, while providing actual links to other spaces on the same floor.

In turn, as illustrated in figure 6.4, the permeability graphs drawn from the main bedroom blocks indicates a totally segregated space in the graphs for all three houses. In the case of the Queen Anne prototype, the bedroom is isolated from all other living functions of the house and is located six spaces away from the living area. In the case of the Robie house, the main bedroom, even though segregated from the rest of the spaces, is just two spaces away and thus easily accessible from the main living area. Configuration for the master bedroom in the Kaufmann house is similar to the arrangement in the Robie house, with the space also located just two spaces away from the living area.

In the case of the Queen Anne house, the three justified graphs considered together (figure 6.2a, 6.3a, and 6.4a) reveal the sequenced configuration of the interior space. In this sense, the house does not allow for subtle differences to be introduced by the closing off or opening up of routes. The spaces in the house in most cases are dead ends and lack ringiness. The living area forms a ring with the parlor and the hall but lacks a similar relation with the dining room. The dining room only forms a ring with the kitchen and pantry and is isolated from the rest of the functions of the house. The sequenced structure of the house and its lack of ringiness offer little or no possibility of spatial fine-tuning to take into account different social situations. The Queen Anne plan basically remains boxed.

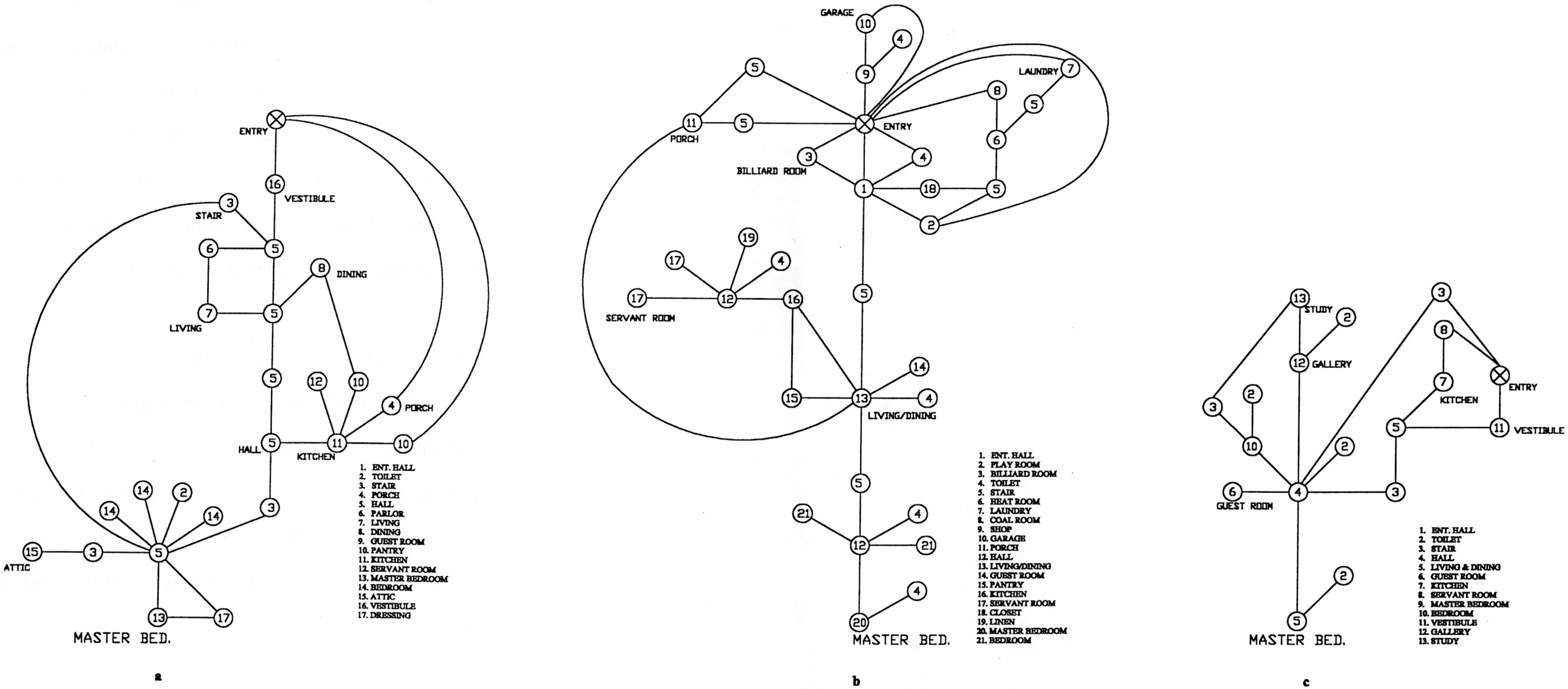


Figure 6.4 The permeability graphs for the three houses drawn from the master bedroom: (a) Queen Anne prototype; (b) Robie house; (c) Kaufmann house (Author)

In contrast, the Robie house's justified permeability graphs (figure 6.2b, 6.3b, and 6.4b) illustrate a house rooted to its surroundings that form four outer ringy routes connecting the outside to the inside. The most telling graph is through the main living space (figure 6.3b), which illustrates how the shallow and ringy set of living spaces connect to destroy the concept of a boxed room structure.

In a similar way, the Kaufmann house's justified graphs (figure 6.2c, 6.3c, and 6.4c), illustrates a house with three ringy routes connecting the outside to inside. The living space graph (figure 6.3c) again reiterates the idea of open and flowing space as it links the outside to spaces on the same level as well as to the upper levels of the house. On the second floor, the hallway acts as an integrator connecting with the bedrooms on the same level.

One also notices in both the Robie and Kaufmann houses that their transition spaces are minimized by Wright's innovative removal of boundaries associated with individual rooms. The living areas in both the Robie and Kaufmann houses have a fluid spatial arrangement, while the private areas on the upper floors are compartmentalized. This pattern is in contrast to the Queen Anne plan, which suggests a totally compartmentalized spatial arrangement, both in terms of living as well as private areas.

Conclusion

As the above analysis suggests, justified permeability graphs are a useful tool to analyze the spatial patterning of house plans. These graphs also provide a empirical basis for examining the functional patterning imprinted into the physical and spatial form of the three houses. The graphs immediately clarify the relationship of a single space to all other spaces in the system and provide a vehicle through which the key themes in the organization of domestic interior can be explored. Although the graphs clearly demonstrate a shift in spatial organization from the Queen Anne prototype to the Robie and Kaufmann houses, they do not provide specific quantitative data to support the 'destruction of the box'.

Rather, this transformation quantitatively can be better understood with the help of the Spatialist program, which utilizes e-spaces and s-spaces to calculate the integration core of a particular configuration based on how people experience and use space. The Spatialist program also provides analysis of isovists, which can be drawn upon to indicate the shifting visual fields experienced from different parts of a house and as people move through its various spaces. Chapter seven provides a Spatialist analysis of the three houses.

CHAPTER 7

AN ANALYSIS OF THE THREE HOUSES USING THE SPATIALIST PROGRAM

The discussion in chapter six focused on the configurational and spatial patterning of the three houses as illustrated through justified permeability graphs. This analysis concentrated on the relational structures between a single space and all other spaces in the system but lacked quantitative data to support the results. On the other hand, the Spatialist program, based on underlying concepts of connectivity and integration, provides quantitative data to indicate more precisely the shift in spatial structures from the Queen Anne house to Wright's Robie and Kaufmann houses.

As discussed earlier, the Spatialist program performs four kinds of analysis that focus on e-partitions, s-partitions, visual fields and lines. Before the program is applied to the three houses, however, it is essential to briefly discuss the underlying assumptions that govern its application.

The Spatialist program analyzes different building interiors based on division of space into convex partitions that take into account the way in which built space appears to moving subjects. The two partitions proposed by Peponis are the e-partition and s-partition (Peponis, 1997). As discussed earlier, the s-partition is obtained by extending surfaces until they strike another surface. The s-partition is the first step towards capturing the experience of shape that is available to a moving observer. The Spatialist program automatically recognizes what other s-spaces are adjacent to each s-space analyzed and which of those s-spaces are permeable to it. The Spatialist program is able to analyze the whole plan based on key configurational variables of connectivity and, integration and in turn, give numerical values for each space. As mentioned earlier, connectivity is a local measure, while integration is a global measure.

Since the information about an s-space changes while an observer moves within it without crossing an s-line or s-partition, Peponis proposes the e-partition to obtain informationally stable units of space. As discussed earlier, the basic elements of a e-partition are the diagonals that can be drawn in a shape and their extensions. While an observer stays within the e-space, his visual exposure to discrete elements of space remain constant. As in the case of s-spaces, the Spatialist program is able to analyze the plan based on connectivity and integration and gives quantitative measures for each space. As mentioned in chapter four, e-spaces do not correspond to the differentiation of areas or rooms, rather, they are what is available to the normal intuition of a observer.

The quantitative values for integration can be described as follows: A spatial configuration with higher mean integration value for all its e-spaces and s-spaces is one where the observer is exposed to fewer changes of visual information as he moves about the system. On the other hand, spatial configurations with lower mean integration values are characterized by many changes of visual information.

The Spatialist program also performs a visual analysis of spaces based on isovists, which are defined as the set of all other points visible from a vantage point in space. The three levels of analysis—s-partition, e-partition and isovists—give a graphical and numerical description of integration of shape and spatial configuration and are utilized to study the changing conception of space from the Queen Anne house to Wright's Robie and Kaufmann houses.

Application of the Spatialist Program

As described earlier, the first step towards applying the Spatialist program to produce s-partitions or e-partitions is to draw a simplified plan with the walls shown as single lines. The thickness of the walls is ignored and the plan is considered as an elementary shape. The analysis does not seek to analyze the main architectural qualities of the buildings. For example, the analysis does not discuss the visual relationship of the building to its external environment, or the placement of the building on its site, both of which are part of a building's architectural quality.

The output of the analysis modifies the original plan to give s- or e-partitions and s- and e-spaces that are graphically color-coded according to integration values. As mentioned earlier, the color red is assigned to the most integrated space and the color blue to the least integrated, with eight shades of color between red and blue used for intermediate ranges of integration. The graphical output enables the user to examine the distribution of integration values and identify the integration core of the shape—area where the spaces with highest integration values are located.

The Spatialist program numbers the s-spaces and e-spaces so that the graphical output can be related to numerical values. Since the number of e-spaces for each of the three houses are over five hundred, a few values from each major functional space are chosen and tabulated to compare and contrast the integration values for similar functional spaces in the three houses.

The Spatialist program automatically recognizes isolated sub-systems such as staircases, service cores, and structural members and does not consider them while computing connectivity and integration values. These isolated sub-systems are color-coded in yellow.

The third kind of analysis provided by the Spatialist program is based on the concept of isovists. Drawing the isovists from a few selected points is a good way to represent the shape of the visual field surrounding that point. As mentioned earlier, the isovists can be computed from an individual point, a set of individual points, or, finally, along a path. For this thesis, isovists are only computed from individual points because isovists drawn from multiple points overlap and complicate the visual-field analysis.

Also, the Spatialist program is applied in all the three houses only to the floor containing the main living functions—the first floor, in the case of the Queen Anne and Kaufmann houses; and the second floor, in the case of the Robie house—because the Spatialist program does not support connections between levels. When the distribution of integration value is given for each house, the differences between their system of spaces come into sharper focus.

Analysis of the Queen Anne House Using the Spatialist Program

Figure 7.1 represents a simplified plan of Queen Anne house, while figure 7.2 represents the simplified plan with the s-partition drawn and figure 7.3 represents the simplified plan with the e-partitions[1] The graphical representation illustrates the most integrated spaces in red and the least integrated in blue.

---

[1] In the case of the Queen Anne house, the porches have not been included in the computation of the s- and e-partition spaces because these spaces are not an integral part of the spatial configuration as a whole. On the other hand, porches have been included in the case of the Robie and Kaufmann houses as they are essential elements of the houses as experienced as spatial sequences.

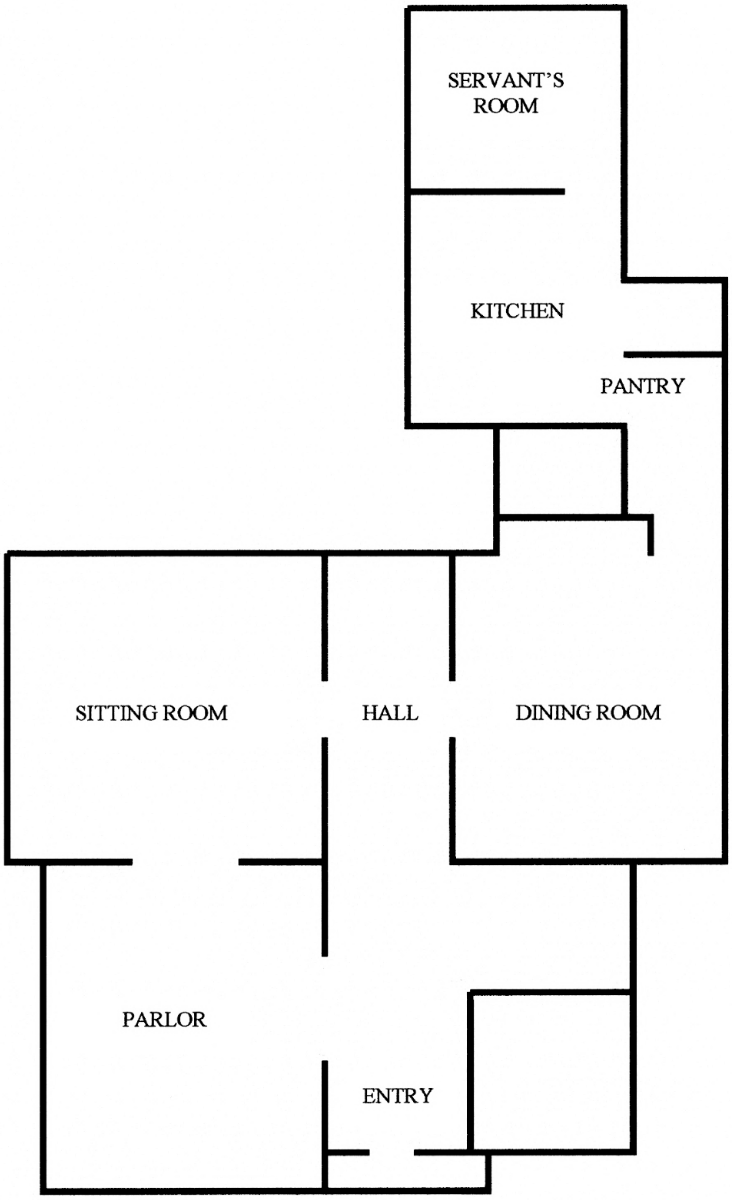


Figure 7.1 The simplified plan of the Queen Anne house (author).

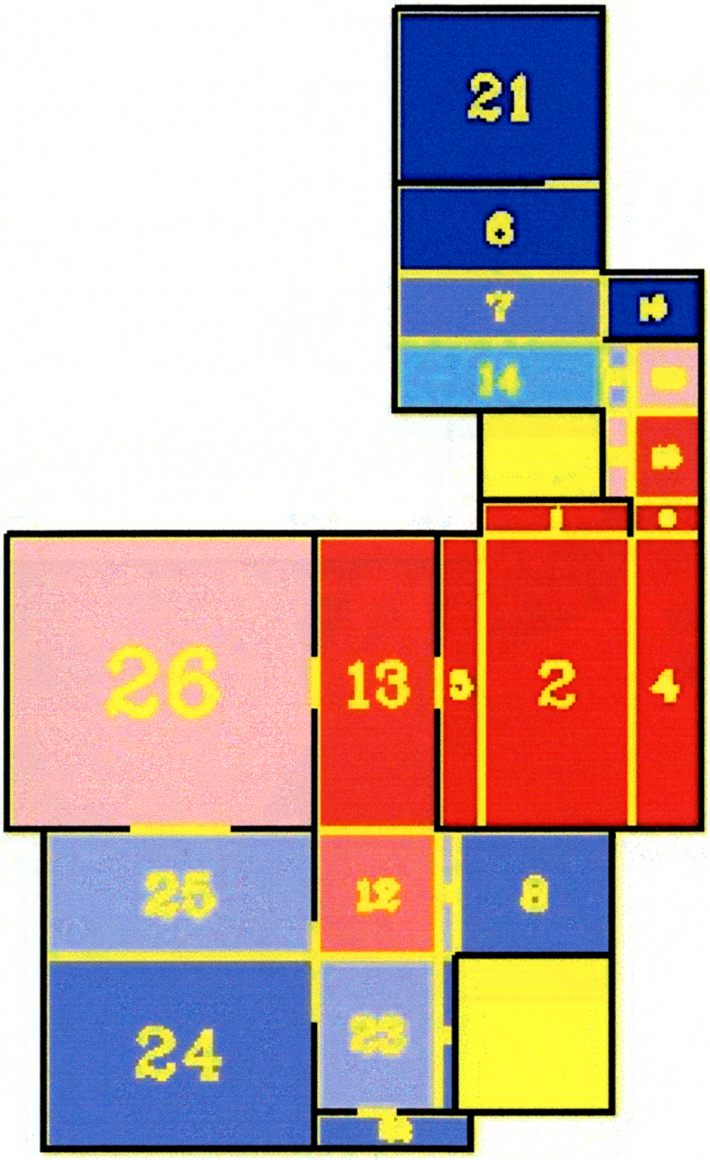


Figure 7.2 The simplified plan of the Queen Anne house with its s-partitions and s-spaces computed (author).

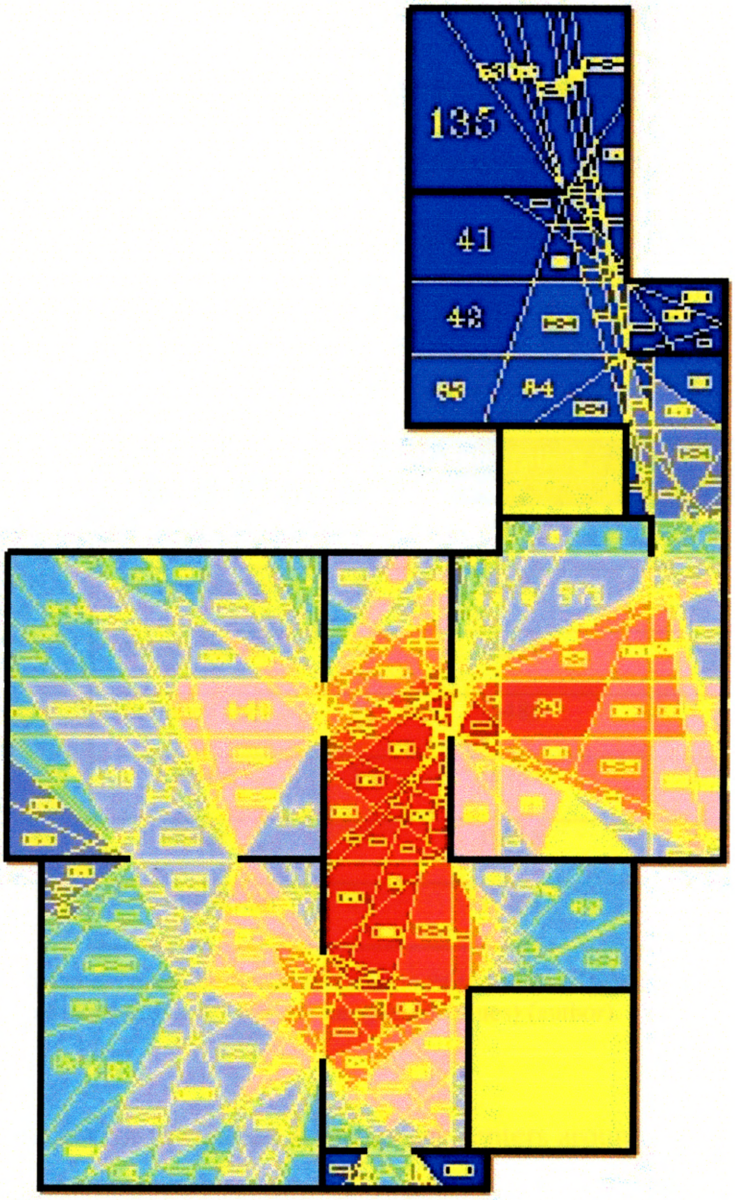


Figure 7.3 The simplified plan of the Queen Anne house with its e-partitions and e-spaces computed (author).

As illustrated in figure 7.2, the s-spaces for the Queen Anne can be recognized as discrete spatial units with each s-space corresponding to a single room. The spatial structure of the Queen Anne house appears highly differentiated, and the pattern of differentiation matches the perceptual understanding of the plan. The different integration and connectivity values for the main functional spaces based on the s-partition are provided in table 7.1. As computed in this table, the hallway is the most integrated space and the servants room the most segregated.

Space Name	Space #	Integration	Connectivity
Hallway	13	0.681	3
Dining Space	2	0.631	3
Sitting Room	26	0.518	2
Entrance Hall	23	0.488	4
Kitchen	14	0.431	2
Parlor	24	0.418	2
Servants Room	21	0.291	1

Table 7.1 The different connectivity and integration values for the Queen Anne house based on the s-partition plan (in descending order of their integration values) (author).

Integration for the Queen Anne spaces centers around the long corridor-like hallway in front of the dining space as it offers expanded connections in three directions. The next most integrated space is the dining area, which acts as a link between the main living functions and the service functions of the house. The integration value for the sitting room drops drastically, but is higher than the parlor which is even less integrated than the kitchen and the entrance hall. The relative segregation of the parlor captures the extent to which the inhabitants of the house have retreated to the cornered space of the parlor. In other words, as explained earlier, the parlor acted as a formal gathering space and was to be a place for social interaction and display rather than for relaxation. The sitting room, on the other hand, acted as a more informal gathering space.

The configurational analysis of the Queen Anne house confirms the separation of rooms into formal and informal spaces. As illustrated in figures 7.2 and 7.3, the processional route is a graduated sequence from the segregated spaces of the entrance hall and parlor to the integrated spaces of the sitting room and dining hall and, finally, to the least segregated space of the servants room. The spatial patterning clearly demarcates the public and private functions of the house and reflects the importance of separate rooms for different functions.

The reader might note that the deeper spaces of the house are more integrated than the shallower spaces. While, this seems in contrast to the justified permeability graphs, the reason can be attributed to the fact that the justified permeability graphs are taken in relation to the carrier—i.e. the exterior space. On the other hand, the Spatialist analysis does not consider the external environment and computes the e and s partitions based on spatial relations within the interior spaces. It also must be noted that the hallway in front of the dining space, even in the case of the justified permeability graphs, acts as an integrator of the interior space. Therefore, both analyses provide similar results, even though the methodologies are different. For example, the entrance hall is the shallowest part of the configuration if the external environment is considered, but when only the internal relations are taken into consideration, the entrance hall becomes a segregated space.

Overall, the Queen Anne house seems analogous to Brooks' discussion of the closed boxed planning of the Victorian period, where one box, neatly labeled, was placed beside another and a series of boxes made up the home. The domestic activity in the Queen Anne house was centered around the dining space and the hallway in front, and the house seems designed to segregate the formal and informal aspects of domestic life.

Analysis of the Robie House Using the Spatialist Program

Figure 7.4 represents a simplified plan of the Robie house, while figure 7.5 represents the simplified plan with the s-partition drawn. As with figures 7.2 and 7.3, the graphical representation illustrates the most integrated spaces in red and the least integrated with blue. Figure 7.6 represents the simplified plan with e-partitions, and one notes that the output illustrated is similar to the presentation of the s-partition in figure 7.5.

As illustrated in figure 7.5, the s-spaces of the Robie house lack physical definition with relation to corners for each s-space. This s-partition also creates spaces that may not otherwise be recognized as discrete spatial units. This pattern is so because the spatial structure of the Robie house challenges the idea of discrete spatial units and moves away from the four-walled concept of a room. As Brooks (1979, p. 7) explains, "the room as a box has been a western tradition since earliest times. It was a situation that Wright inherited, yet he soon redefined the concept of interior space, and he began this process by dismembering the traditional box."

The changing dimension of space in the three houses has been analyzed in the preceding chapter with the help of the justified permeability graphs. The application of

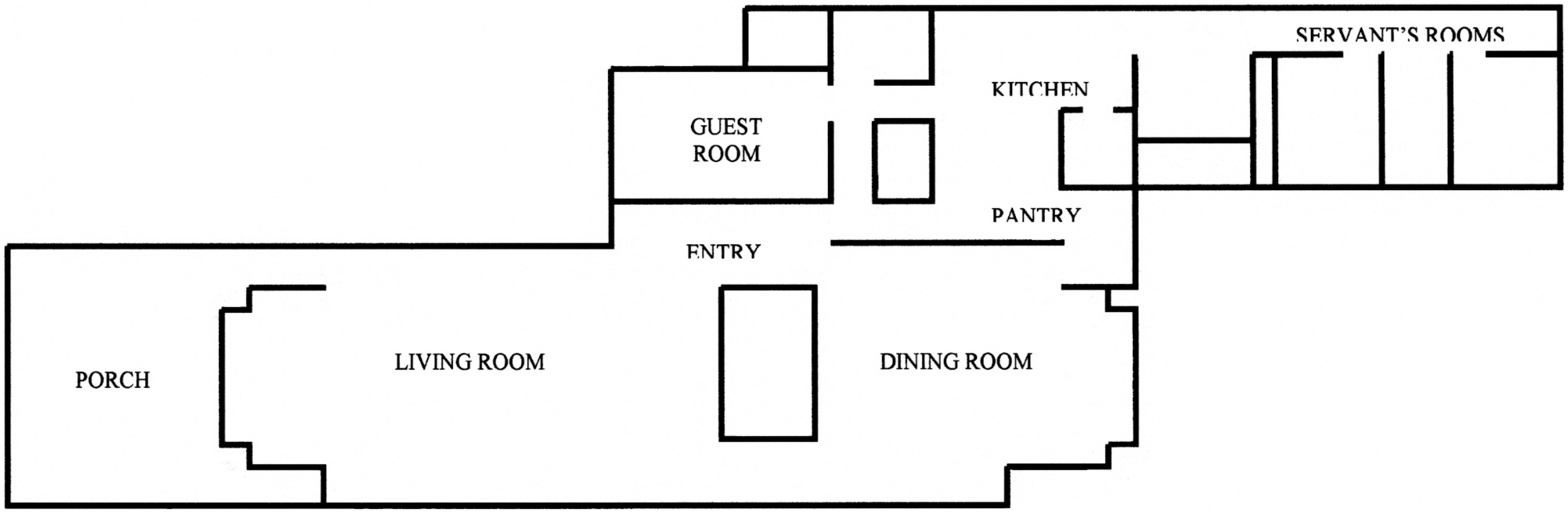


Figure 7.4 The simplified plan of the Robie house (author).

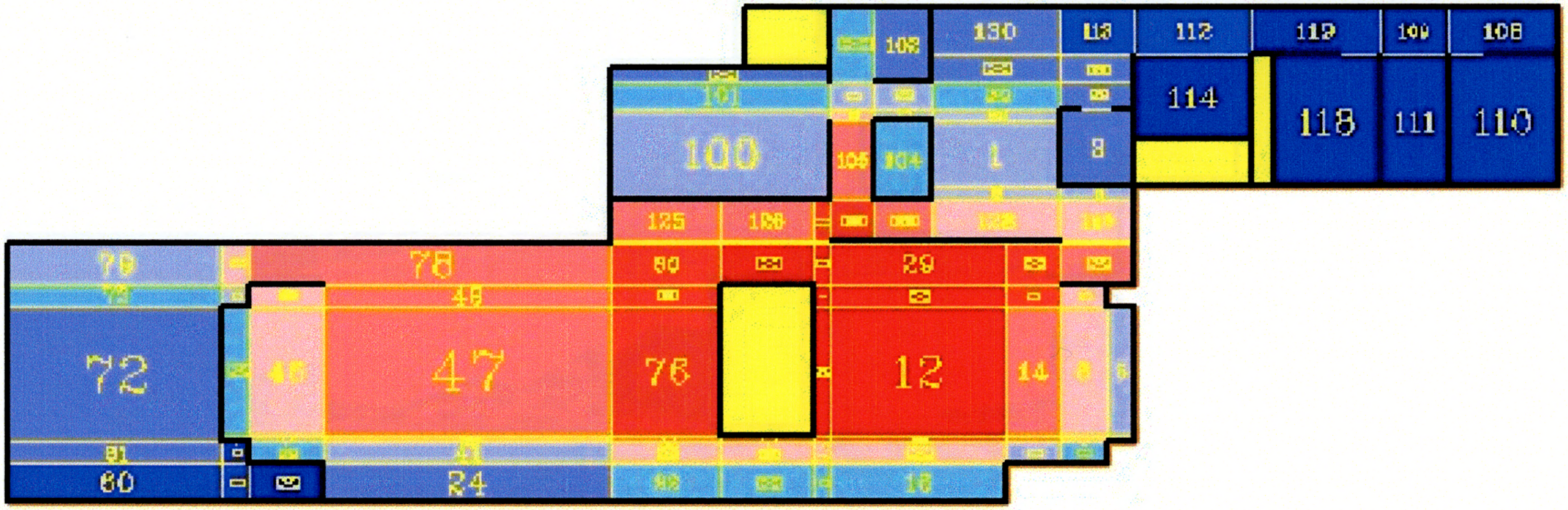


Figure 7.5 The simplified plan of the Robie house with its s-partitions and s-spaces computed (author).

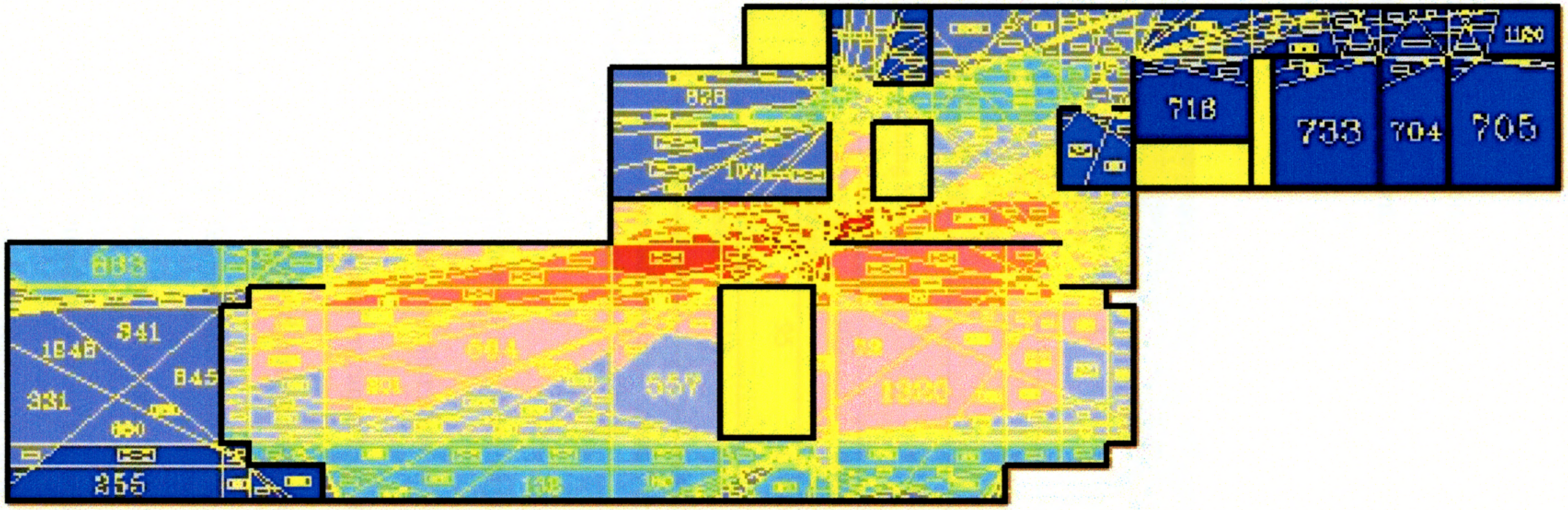


Figure 7.6 The simplified plan of the Robie house with its e-partitions and e-spaces computed (author).

the Spatialist program to the Robie house strengthens the arrangement of Wright's 'destruction of the box'. The Robie house appears integrated, and the spatial pattern of integration matches the intuitive understanding of the plan. The different integration and connectivity values for the main functional spaces based on the s-partition are represented in table 7.2.

Space Name	Space #	Integration	Connectivity
Living & Dining Space (entry)	82	0.743	4
Living & Dining Space (dining)	12	0.736	4
Living & Dining Space (living)	76	0.677	3
Hallway to guest & Kitchen	105	0.631	2
Kitchen	95	0.467	4
Servants Room	118	0.301	1

Table 7.2 The different connectivity and integration values based on the s-partition plan of the Robie house (in descending order of their integration values) (author).

The spaces in the Robie house do not correspond to specific rooms—for example the living and dining space acts as a combination of various functions which include parlor, sitting room, dining room, and entrance hall. Therefore, a series of s-spaces are considered within the larger living and dining space to make it comparable to the spaces in the Queen Anne house. As represented in table 7.2, the entry to the living and dining area is the most integrated space and the servant's room the most segregated. The living and dining room is the most integrated part of the house because it acts as the integrator of the plan and links other functional spaces of the house. The integration value for the living and dining room drops as one moves farther away from the fireplace in opposite directions. In this sense, the space around the fireplace is the integration core of the Robie house.

A comparison of tables 7.1 and 7.2 shows that the integration values for the living spaces in Robie house are much higher than those in the Queen Anne house. The hallway in front of the guest bedroom and kitchen also has a high integration value as it connects the living and dining space to the private bedrooms and service functions of the house. On the other hand, the values for service spaces such as the kitchen and servant's room are comparable in both the cases.

As illustrated in figure 7.4 and 7.5, the integration focus on the living and dining space in the Robie house celebrates open planning and is central to the instrumental functioning of the house. All the spaces in the Robie house connect through the living and dining space, which acts as a informal gathering space that is easily accessible to its users. Wright begins by interlocking the two main functional spaces—the living room and the dining room—so that part of each space is given to other. As Brooks (1979, p. 8) explains, "the corners the least useful part of the room are destroyed and a controlled view into the adjacent area is opened up." In the Robie house, the fireplace controls the view from the living and dining space into other spaces. The structuring of space in this manner also eliminates the transition spaces that are traditionally formed by corridors and hallways. The open planning of the Robie house makes the experience of the users informal and immediate, as all the spaces can be easily accessed from one central space. The Spatialist analysis consolidates the shift in spatial configuration which was only partly demonstrated in the earlier presentation of the justified permeability graphs.

The interior of the Robie house illustrates how ingeniously Wright could attune his broad approach to the individual case on multiple levels—formal, functional, structural, and symbolic (Curtis, 1983, p. 88). The Robie house contributed to a totally new conception of design and thus broke with an age-old tradition in architecture. In the Robie house the spatial patterns were attuned to reflect the dominant horizontality and the triangular theme of the plan.

Analysis of the Kaufmann House Using the Spatialist Program

In examining the changing use of space as illustrated in the shift from the Queen Anne house to the Robie house, one notes a shift from segregated, closed-boxed planning to integrated, open, flowing space. Still however, the 'destruction of the box' is not completely complete. We thus turn to the Kaufmann house, which is considered to be the pinnacle of Wright's work. It can be said that in the Kaufmann house, Wright totally destroys the box, and this fact can be better demonstrated through the use of the Spatialist program.

Figure 7.7 illustrates the simplified plan of the Kaufmann house, while figure 7.8 represents the simplified plan with its s-partitions drawn. Again, this graphical representation illustrates the most integrated spaces in red and the least integrated in blue. Figure 7.9, in turn, represents the simplified plan with its e-partitions, the color coding is the same as for the s-partitions. In looking at figure 7.8, one notes that the s-partitions for the Kaufmann house are quite similar to the s-partitions for the Robie house. As with the Robie house, the s-partition in the Kaufmann house also creates spaces that otherwise would not be recognized as discrete spatial units.

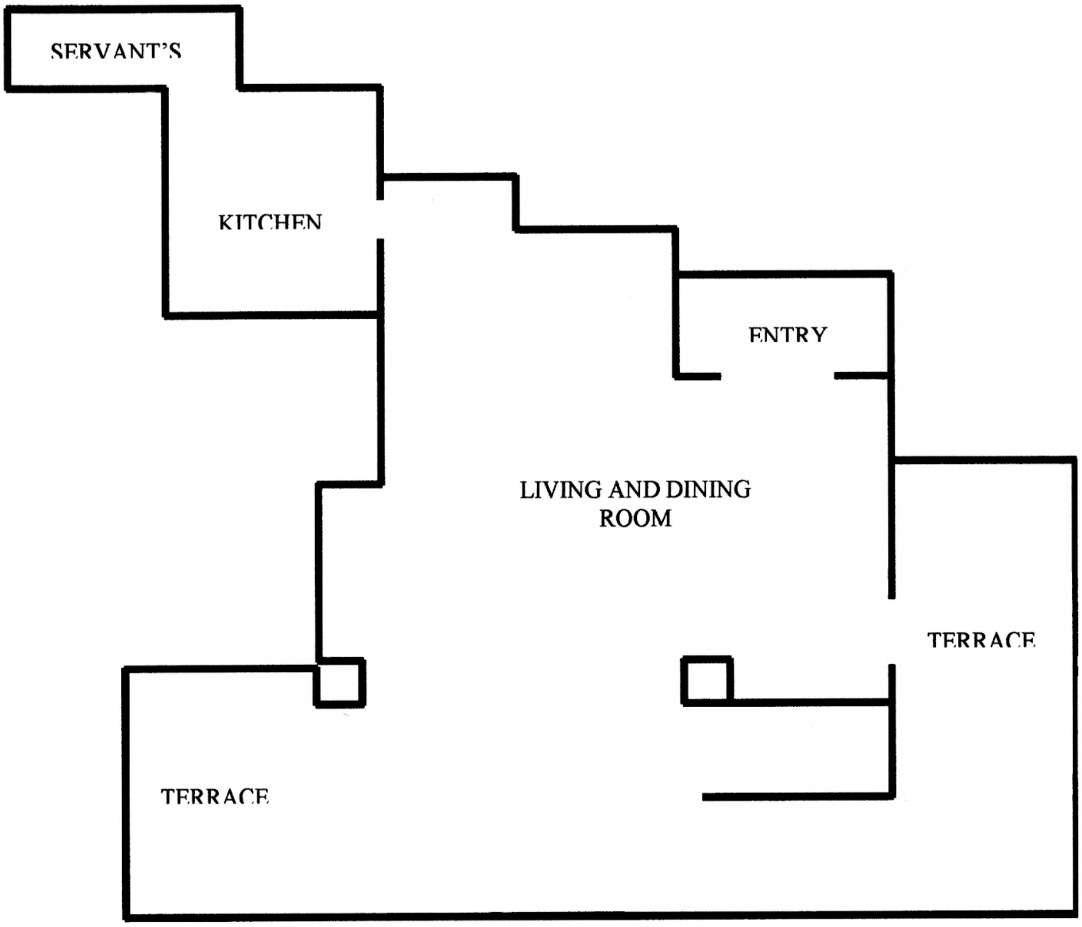


Figure 7.7 The simplified plan of the Kaufmann house (author).

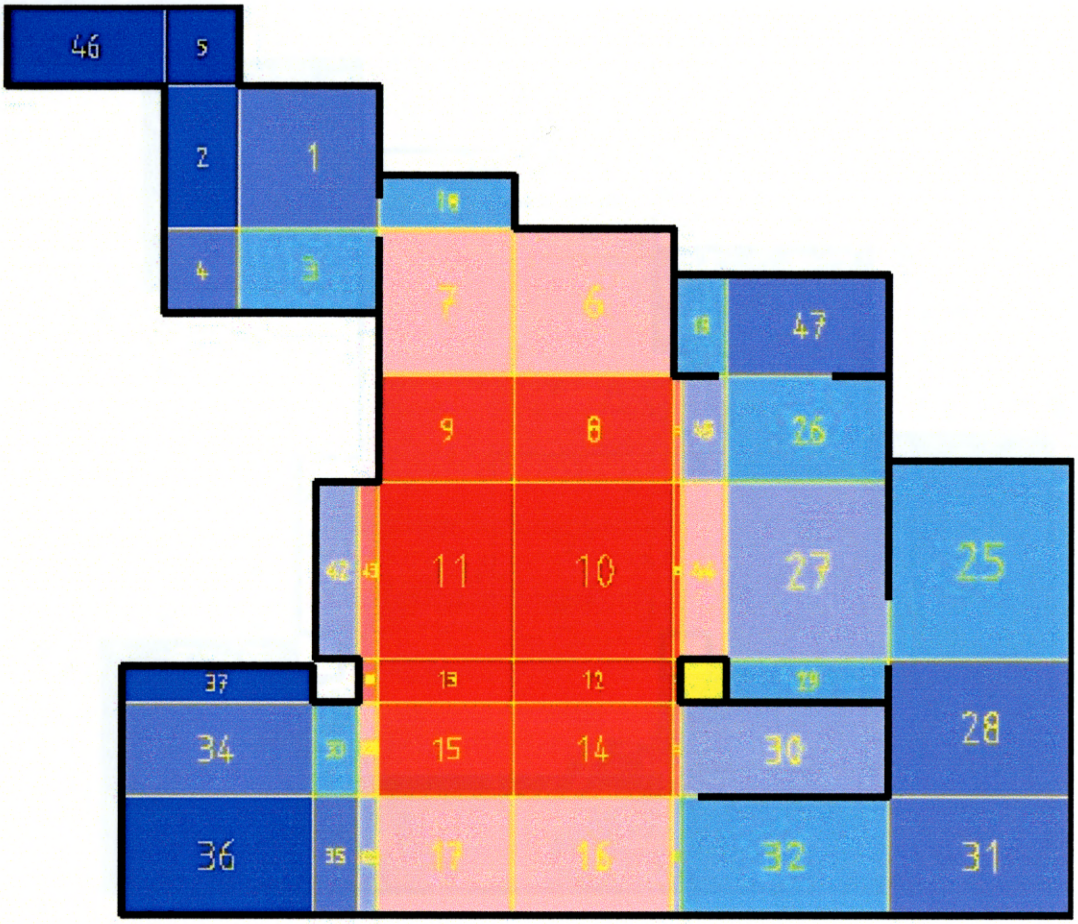


Figure 7.8 The simplified plan of the Kaufmann house with its s-partitions and s-spaces computed (author).

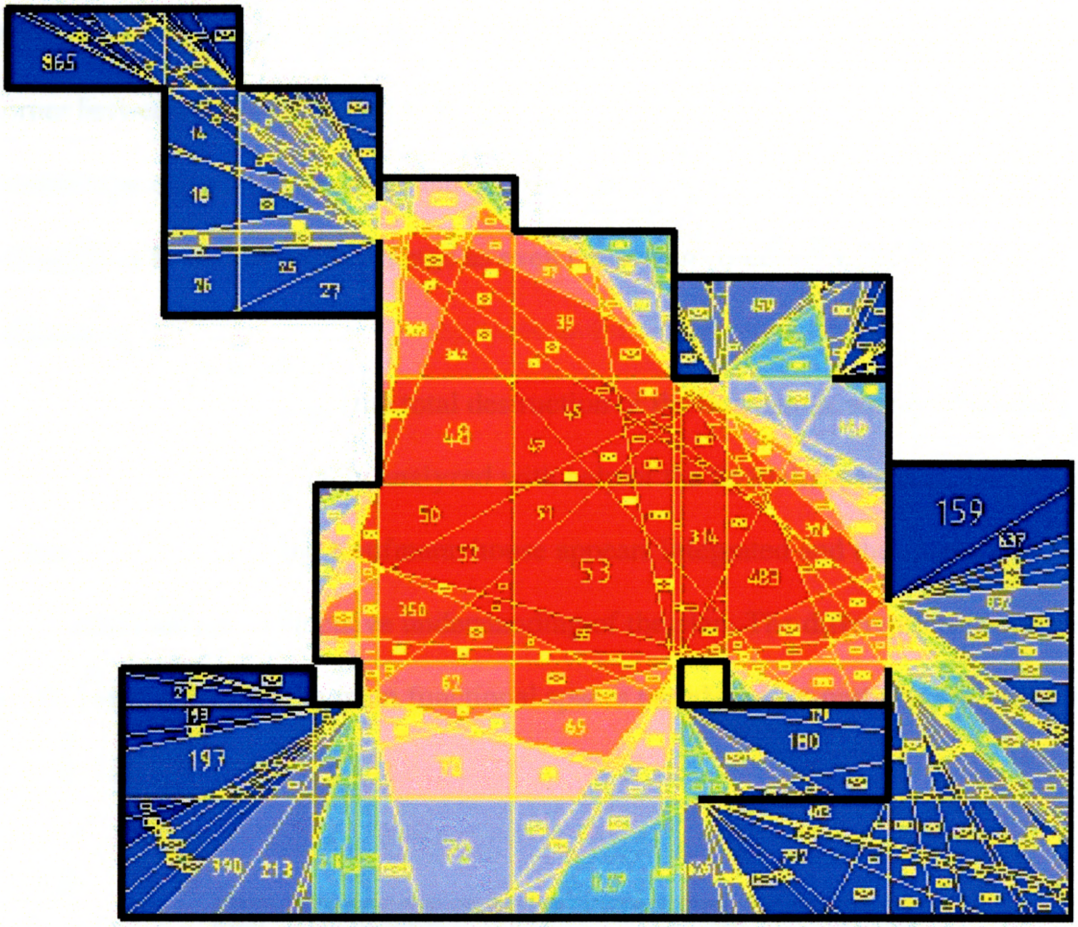


Figure 7.9 The simplified plan of the Kaufmann house with its e-partitions and e-spaces computed (author).

According to Peponis (1997, p. 779), "in the Kaufmann house the embracing quality of the wall boundaries, which are 'fine-tuned' to create alcoves for placing furniture, objects or seats, is combined with a property of openness rather than closure." Wright attacks the traditional room at its point of greatest strength—at the corner. The corner between the living and dining space in the Kaufmann house is completely dissolved as one room penetrates the other. In addition, the space in the Kaufmann house undergoes a further dramatic change as even the screens used in the Robie house are eliminated.

In this sense, the total destruction of the box can be seen in the Kaufmann house and is more completely analyzed with help of the Spatialist program. As figures 7.9 and 7.10 illustrate, the Kaufmann house appears integrated and the spatial pattern of integration matches the incisive understanding of the plan. The different integration and connectivity values for the main functional spaces based on its s-partition are represented in table 7.3.

Space Name	Space #	Integration	Connectivity
Living & Dining Space (center)	10	1.095	4
Living & Dining Space (living)	8	0.986	4
Living & Dining Space (dining)	14	0.959	4
Kitchen	1	0.582	3
Entrance Hall	47	0.554	2
Servants Room	46	0.383	1

Table 7.3 The different connectivity and integration values based on the s-partition plan of the Kaufmann House (in descending order of their integration values) (author).

Since the spaces in the Kaufmann House are similar to the ones of the Robie house, they do not correspond to individual rooms with specific function. Therefore, a set of s-spaces are chosen to represent the larger living and dining space in order that it is comparable to the Queen Anne and the Robie houses. As tabulated in table 7.3, the s-space in front of the fireplace is the most integrated section of the house, since it has the highest integration value of any of the spaces in all three houses. Even the single s-spaces chosen as representative of the living space and dining space from the whole living and dining area, have the highest integration value as compared to any other space in the three houses. As shown in figure 7.9, the integration value decreases as one moves away from the center of the living space towards the walls in all directions; in this sense, this space in the center of the living room is the integration core of the building. Similar to the Robie house, the living and dining room in the Kaufmann house is the most integrated part of the house as it links to various functional spaces of the house. On the other hand, the Kaufmann house's entrance hall is even less integrated than the kitchen, as the entry to the house is enclosed within walls and has been created to give a feeling of enclosure before the large open space of the living room is presented to the user. As McCarter (1994, p. 20) explains,

> Opening the door we move into a small foyer, rock walls directly ahead and to our right; we turn to the opening at the left, towards the living room. Before mounting the three stairs up to the living room floor, we should notice that from the level of this lower foyer, our eye-level is almost exactly at the center of the space between floor and ceiling. From this brief vantage point, the two horizontal planes are perfectly balanced, the smooth white plaster ceiling above and the rippling dark flagstone floor below, seeming to completely define the space, with only the thin steel mullions of the windows and two square stone piers standing between them—no walls can be seen save those that enclose us at the entry. From this perspective, the living room seems to open out in all directions.

As mentioned earlier, the living room of the Kaufmann House is essentially a square central volume off the corners of which open the entry, stairs, kitchen and terraces. The symmetrical order in plan of the earlier houses allowed the corners to open up; in the Kaufmann house, in contrast, the open corner becomes such a strong spatial element in its own right that it allows the plan to do without literal symmetry (McCarter, 1994, p. 10).

The outside terraces, which are an integral part of the Kaufmann house, are also analyzed for their relative integration within the whole plan. The integration values for the terraces on both sides of the living room are comparable to the values for the kitchen and the entry hall, as they do not form any major connections and are accessible only through the living room. As in the case of Queen Anne and Robie houses, the servant's room is the most segregated space of the house.

Conclusion

Based on the results tabulated in table 7.1, 7.2, and 7.3, the living space for the Kaufmann house is the most integrated space of the three houses. A comparison of the three tables also reveals certain commonalties—all service areas including the kitchen and servant's rooms are segregated and are enclosed within walls. The graphical comparison of s- and e-partitions of the three houses clearly establishes the shift from enclosure and formality to openness and an informal character of spatial configuration. The transformation of space from the Queen Anne house to the Robie house and finally to the Kaufmann house constitutes a changing dimension of social values within American society. The Queen Anne house clearly demarcates formal and informal functions and is based on a circulation system consisting of passageways and halls. The result of such planning is the boxed character of the plan.

In the Robie and Kaufmann houses, in contrast, the transition spaces are eliminated as one room interpenetrates in other and connecting passageways are eliminated to achieve a highly integrated plan. All three houses thus employ transitions to a greater or lesser extent, but the transitions are minimized and integrated with respect to function spaces in the Robie and Kaufmann houses and, thus, these houses configure space efficiently to achieve a plan that synthesizes the whole house together. On the other hand, the Queen Anne house seems to have an excess of transitions, which suggests that space has been deployed divisively to separate and insulate activities and people from one another rather than to draw them together.

The preceding integration analyses highlight the way in which the three houses differ as a consequence of their social and historical setting. In the Queen Anne house, social activities and places which are assigned in order to perform their everyday functions tend to occupy the most integrated spaces. On the other hand, more formal spaces, such as the spaces where guests are received and entertained, are located in more segregated locations. In the Robie and Kaufmann houses, in contrast the division between informal and formal spaces does not exists because Wright combines everyday functions with spaces reserved for formal occasions. In particular, one notes the changing function of the hall from that of creating a more formal space for the reception and entertainment of guests to that of drawing the members of the household together informally in an everyday living space.

Analysis of the Three Plans Using Isovists

Up to this point, this thesis has established the changing dimension of space in relation to its functional patterning imprinted into the physical from of the house with help of the justified permeability graphs and the Spatialist program. In addition, the contrasting distribution of integration in the three houses gives clear account of the relative degree of informal, formal and private functions which are enmeshed in the configurational patternings of the houses. The above findings from this analysis clearly supports Wright's 'Destruction of the Box' and substantiates the ideas of Brooks. To corroborate his concept of interpenetrating planes and Wright's conception of mystery and variety, however, it is essential to analyze the three house plans in term of a visual field analysis and isovists.

We have already seen that the Queen Anne house was a box with large openings between rooms, leading to a sense of spaciousness while looking from one room to another, but at the same time losing privacy. As discussed above, Wright's first step in destroying the box was achieved by interlocking two rooms together so that part of each space is given over to the other. As Brooks (1979, p. 8) explains, "The corners are destroyed and a controlled view into the adjacent area is opened up. This view, which is diagonal and pinched at the point of interlock, is limited and leaves much of the adjoining area obscure, introducing a sense of mystery into the spatial sequence."

This shift in the nature of room space can be better understood with the help of visibility analysis based on the isovists. These isovists are drawn to reveal the shifting visual fields experienced from different parts of the house and help to analyze the ideas of mystery and, interpenetrating planes. Visual fields may vary from exposing a panoramic vista of the house to offering penetrating glimpses through a domestic interior or, yet again, they may conform closely to the room arrangement of the house (Hanson, 1998, p. 243).

Here, isovists are drawn from various functional spaces, including the living functions and kitchen to analyze the plans of the three houses. As illustrated in figure 7.10, isovists drawn from the main living spaces of the Queen Anne house indicate the relatively restricted visual fields from the main living spaces, which partially reveal

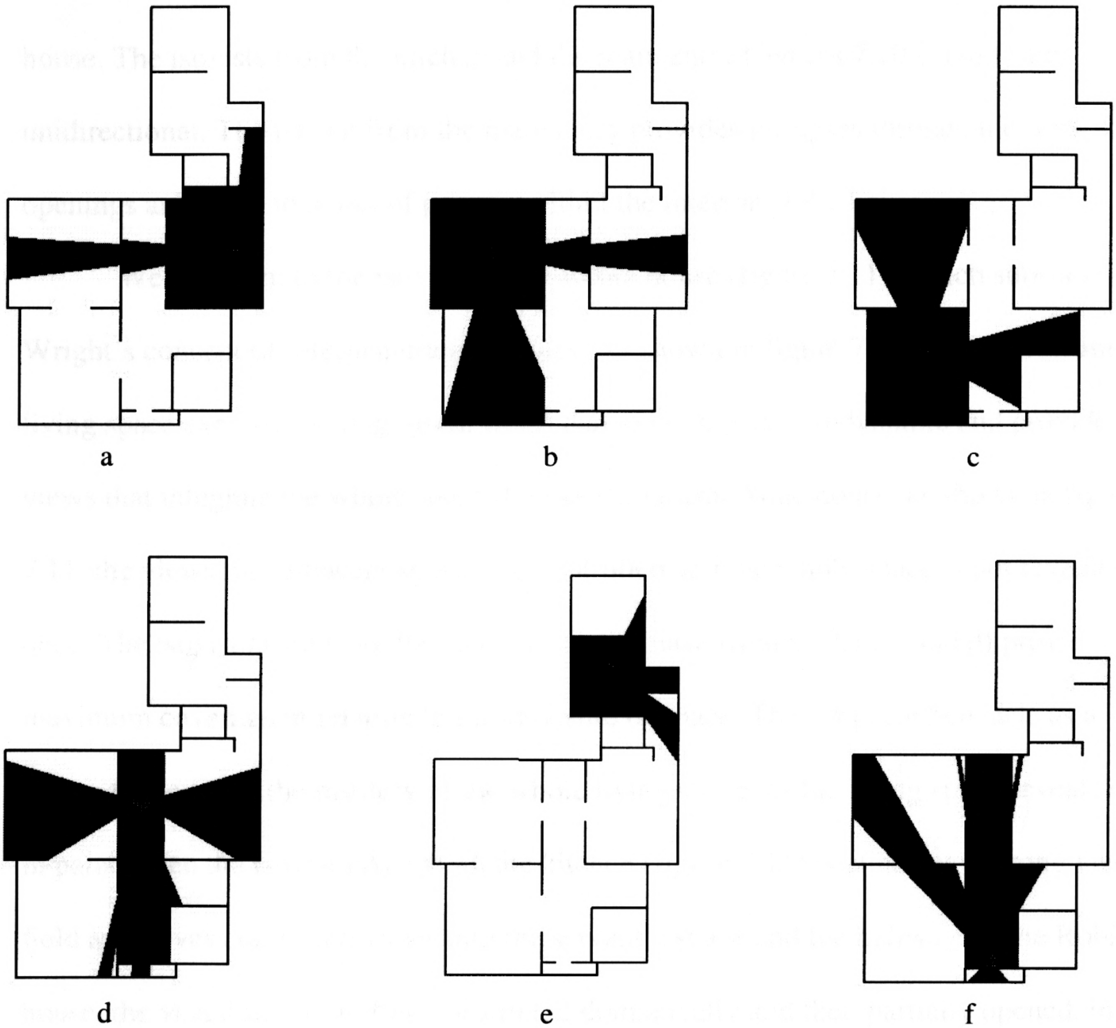


Figure 7.11 The isovists for the Queen Anne house drawn from (a) dining space; (b) living room; (c) entry to living space; (d)fireplace; (e) kitchen (author).

adjacent rooms. The isovists are largely confined to the four walls of the room. The isovist taken from the dining space (figure 7.10a) is restricted to the dining area itself and limits the view into other adjacent spaces. The isovist from the sitting room (figure 7.10b) is also similar to the isovist of the dining room and clearly illustrates the loss of privacy between rooms as the visual field extends into the large openings of the adjacent rooms. The only powerful isovist in the whole house is the one from the hallway (figure 7.10d) because it gives expanded views in all directions, similar to the isovist from the siting room, however, it reveals the whole space at once to the observer moving through the house. The isovists from the kitchen and the main entry (figures 7.10 e and f) are unidirectional. The isovist from the main entry provides glimpses through the large openings and leads to a loss of privacy within the interior of the house.

We next turn to the isovists of the Robie house (figure 7.11), which substantiate Wright's concept of interpenetrating planes. As shown in figure 7.11 the isovist from the living space exercises strong visual fields that are complex and dynamic and provide views that integrate the whole space. Unlike the Queen Anne house, as shown in figure 7.11, the views into adjacent spaces are controlled and the whole space is not revealed at once. The isovist taken from the sides of the fireplace (figures 7.11 c and d) provide maximum coverage in relation to the exposure of space. The fireplace here acts as a screen that adds to the mystery of the whole living space, as the living space reveals itself in parts. Even the isovist taken from the kitchen (figure 7.11e) delineates a strong visual field as it gives controlled views into the servant's space and the hallway. In the Robie house, the visual fields are first constricted dramatically and then partially opened, in an expansive gesture to the main volume.

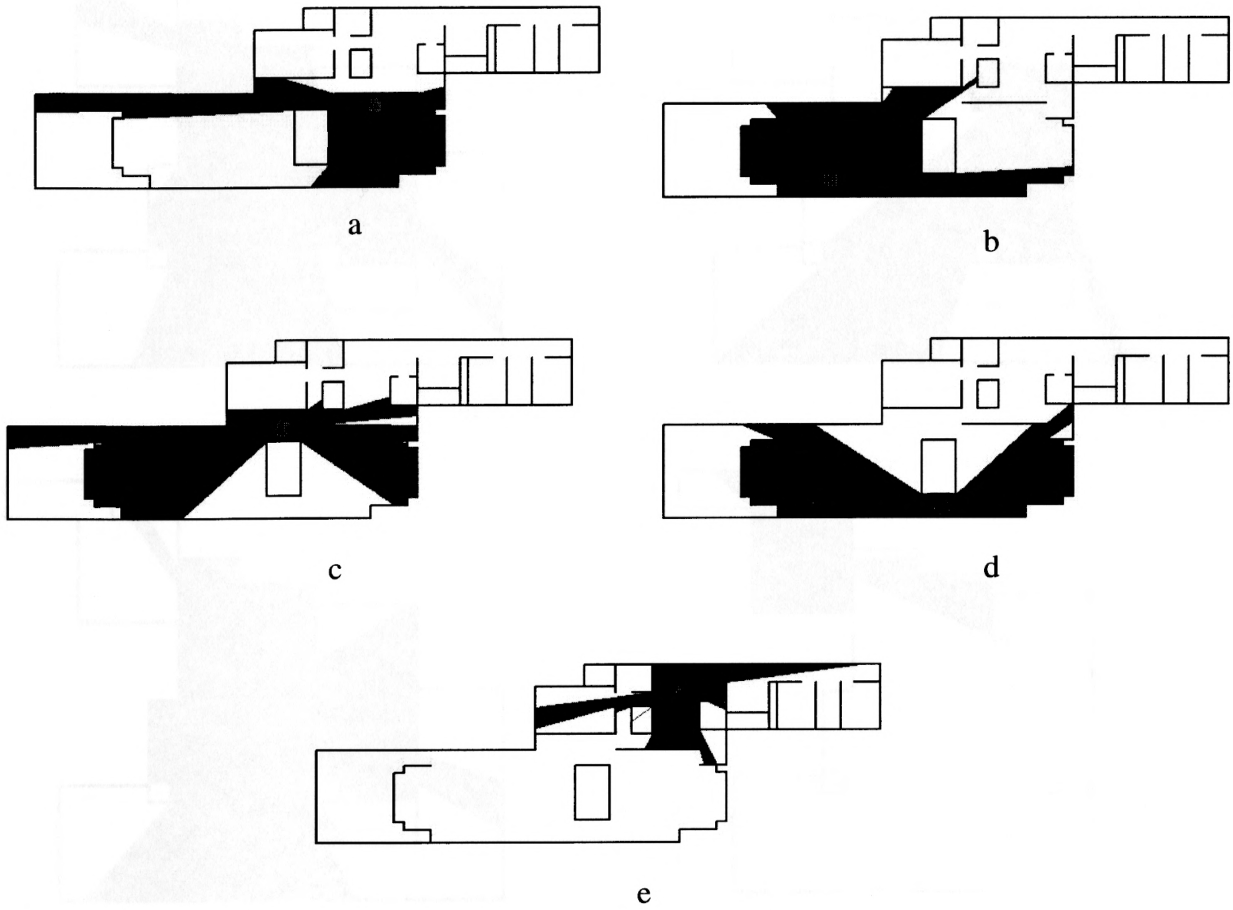


Figure 7.10 The isovists for the Robie House drawn from: (a) dining space; (b) living room; (c) fireplace north; (d) fireplace south; (e) kitchen (author).

Last we consider the isovists from the Kaufmann House (figure 7.12), which in case of the Kaufmann house are even more dramatic than the one's in the Robie house. The isovists visually extend space. The drama towards the living space is initiated from the entrance itself. As discussed earlier, Wright prepares the viewer for the large open space of the living room by enclosing him in a cave like entrance and slowly reveals the expanse of the living room. The isovist taken from the entrance (figure 7.12c) provide controlled view into the living space and contributes to the mystery and variety of the whole space. The isovists taken from the living and dining space (figures 7.12 a and b)

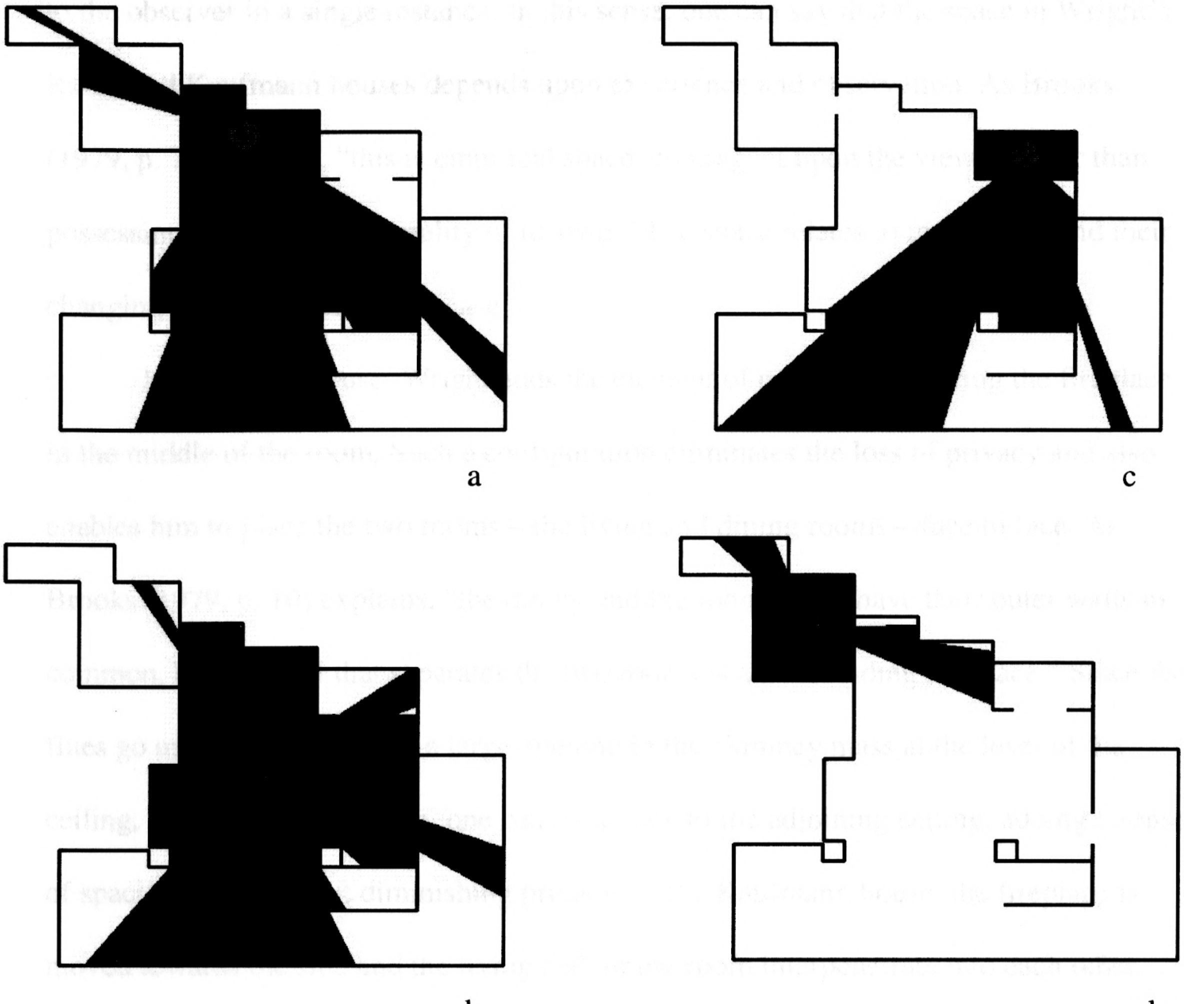


Figure 7.12 The isovists for the Kaufmann house drawn from: (a) dining space; (b) living room; (c) entry to living space; (d) kitchen (author).

has expanded visual fields in all directions. Yet again, the isovist from the kitchen (figure 7.12d) is similar to the one in Robie house, and provides surveillance into the servant's space and restricts the visual fields into the living room.

Conclusion

A comparison of the isovists for the three houses reveals the ingenuity of Wright's work. In his work, space loses its fixed value and acquires a relative one. While the visual fields in the Queen Anne house lead to a loss of privacy and space is revealed to the observer in a single instance. In this sense, one can say that the space in Wright's Robie and Kaufmann houses depends upon experience and observation. As Brooks (1979, p. 7), explains, "this is empirical space, contingent upon the viewer rather than possessing an independent reality of its own." The space relates to individuals and their changing position within that space.

In the Robie house, Wright adds the element of mystery by placing the fireplace in the middle of the room. Such a configuration eliminates the loss of privacy and also enables him to place the two rooms—the living and dining rooms—face to face. As Brooks (1979, p. 10) explains, "the dining and the living room have their outer walls in common, but the wall that separates the two rooms is a freestanding fireplace." Since the flues go up the sides, there is a large opening in the chimney mass at the level of the ceiling, and, from either room, one can look back to the adjoining ceiling, adding a sense of spaciousness without diminishing privacy. In the Kaufmann house, the fireplace is moved towards the side and the living and dining room interpenetrate into each other. Thus, by visually extending space, Wright makes the space seem larger. Further, as seen in the addition of extending and receding planes, Wright creates a subtle spatial relation between rooms.

Therefore, the isovists authenticate Wright's idea of interpenetrating planes and a sense of mystery in his houses. In this sense, the isovists prove to be a helpful tool for a visual analysis of spaces within a spatial configuration. From the above discussion, it is evident that space syntax is an effective tool for study of spatial patterning and comparison of building interiors. The final chapter summarizes the results achieved through this thesis and discusses the importance of space syntax theory in the understanding buildings, in particular houses.

CHAPTER 8

CONCLUSION: SPACE SYNTAX AND THE THREE HOUSES

The underlying spatial order which exists in the interior of the dwelling and the way in which that interior is related to the exterior is predominantly an aspect of social relations. As chapters 6 and 7 have demonstrated, the three levels of analysis—the justified permeability graphs, s- and e-spaces, and isovists—prove to be useful tools for the understanding of the spatial relations within the building interior and also its relation to external space.

The discussion in chapter 6 focused on the analysis of the three houses using the justified permeability graphs. As the results showed, the graphs proved to be an effective tool for analysis of the three houses and for an understanding of the functional patterning imprinted into their physical and spatial form. The justified permeability graphs help in clarifying the interior-exterior relation which, in some cases, has a profound effect on the overall space configuration while, in other instances, makes very little difference. In the Robie and Kaufmann houses, the exterior holds the key in forming relations within the interior spaces; on the other hand, in the Queen Anne house, the effect is only marginal.

The justified permeability graph is a simple graphical tool that helps to investigate and compare dwellings with one another and, in turn, to interpret their sociological significance (Hanson, 1998, p. 22). The graphs drawn with the carrier as root clarify the interior-exterior relation, while the graphs drawn with the various functional spaces as root help to understand how the specific space is embedded within the larger spatial configuration.

The house is a reflection not just of how individuals and families choose to live their everyday lives but also of the constitution of society at large (Hanson, 1998, p. 46). Therefore, as discussed in chapter 6, the justified permeability graphs clearly demonstrate a shift in organization of space from the nineteenth-century Queen Anne plan to open and flowing space in the twentieth-century Robie and Kaufmann houses.

The thesis also suggests that the segmented use of space and the existence of a segmented architecture correlate directly with the society in question. In the Queen Anne period, The justified permeability graphs clarify the hierarchical division of space, with the rooms in the front usually gaining more importance than those farther back in the plan. In the case of the Robie and Kaufmann houses, the permeability graphs also provide descriptive data to support Wright's dismembering of the box and the openness of his plans. Furthermore, the analysis of the plans based on Hanson's four types of topological space confirms the shift in domestic room arrangements from the deep and segregated Queen Anne house to the shallow and integrated Robie and Kaufmann houses.

Chapter 7 discussed the use of the Spatialist program to achieve quantitative results to analyze more precisely the shift in spatial structure from the Queen Anne house to Wright's Robie and Kaufmann houses. Based on the properties of connectivity and integration, the Spatialist program highlights the way in which the three houses differ as a consequence of their social dimensions. Based on the s- and e-partition plans, the graphical presentation of the houses' integration cores clearly demonstrates the shift from the formal and cornered use of living spaces in the Queen Anne house to its informal and integrated manner in the Robie and Kaufmann houses.

The analysis in chapter 7 also provides empirical data to support the redundancy of transitional spaces in the Robie and Kaufmann houses, resulting in an integrated plan, as compared to the Queen Anne which deploys transitional spaces to separate and insulate activities and people from one another. The analysis also clearly established a shift from enclosure and formality to openness and informality of spatial configuration.

Wright's ideas of interpenetrating planes and variety in his dwellings were also substantiated with the help of visual analysis based on isovists. In the case of the Queen Anne house, the isovists render much of the interior space opaque, while the isovists in the Robie and Kaufmann houses are penetrating, revealing narrow glimpses into interior space, adding an element of mystery. The barriers in the Queen Anne house, which stop visual fields, indicate the boxiness of its spatial pattern, while the absence of such blank walls in Wright's houses, provides controlled views in all directions.

The three levels of analysis—justified permeability graphs, s- and e-spaces, and isovists—clearly indicate the division of the Queen Anne house into two distinct and spatially segregated zones—the *formal,* including the parlor and the entry hall in front, and the *informal,* including the sitting room and dining room behind. In the Robie and Kaufmann houses, in contrast, the whole space acts as a single interconnected community with living space at its core also forming a shallow interface with the exterior.

A house is the primary space where society is continuously constituted in the shape and patterns of everyday living (Hanson, 1998, p. 194). At the same time, houses, like other buildings, obey the laws of space. According to Hanson (1998, p. 194), "because society is continuously constituted in the patterns of movement and interaction that take place in space, social purposes take hold of space and shape it through generic function."

In sum, this thesis has systematically amplified the taken-for-granted patterns of space in the three houses and clarified the social intentions of the specific historic periods the houses represent. Furthermore, the thesis provides a methodological framework that could be applied to other building interiors to understand the role of space in shaping social relations and also to understand how society and its institutions evolve over time. In this sense, the techniques which have been used here to analyze dwellings can form the basis for a more intelligent approach to architectural design.

The built environment is the most mundane, enveloping artefact that humans create. Within the built environment, the most basic, widespread and necessary of buildings is the house (Hanson, 1998, p. 312). The framework outlined in this thesis can be developed further to understand houses and their relation to society, which in turn might help designers to create domestic environments that respond to the needs of users, the groups to which they belong, and society.

REFERENCES

Brooks A, (1979) "Frank Lloyd Wright and the destruction of the box" *Journal of Society of Architectural Historians* **23** 7-14.

Camesasca E, (1971) "History of the house" New York: G.P. Putnam's Sons.

Clark E, (1992) "American single family home" Chapel Hill: University of North Carolina Press.

Connors J, (1984) "The Robie house of Frank Lloyd Wright" Chicago: University of Chicago Press.

Curtis W, (1983) "Modern architecture since 1900" New Jersey: Printice Hall Inc.

Hanson J, (1994) " 'Deconstructing architects' houses" *Environment and planning B: Planning and design* **21** 675-704.

Hanson J, (1998) "Decoding homes and houses" Cambridge: Cambridge University Press.

Hillier B, (1983) "Space syntax: A different urban perspective" *Architects Journal* 30 Nov pp. 47-63.

Hillier B, Hanson J, (1984) "The social logic of space" Cambridge: Cambridge University Press.

Hillier B, Hanson J, (1987) "Introduction: A second paradigm" *Arch. & Comport/ Arch. Behavior* **3** 197-199.

Hillier B, Hanson J, Peponis J, (1987) "Spatial analysis of settlements" *Arch. & Comport/ Arch. Behavior* **3** 217-231.

Hillier B, Hanson J, Graham H, (1987) "Ideas are in things: An application of the space syntax method to discovering house genotypes" *Nordic Journal of Architectural Research* **7** 363-385.

Hillier B, (1988) "Against enclosure" in *Rehumanizing Housing*, Teymur, M., Markus, T., Woolley, T., eds. London: Butterworths 63-88.

Hillier B, (1989) "The Architecture of the urban object" *Ekistics* **56** 5-21.

Hoffman D, (1984) "Frank Lloyd Wright's Robie house: The illustrated story of an architectural masterpiece" New York: Dover Publications.

Hoffman D, (1984) "Frank Lloyd Wright's Fallingwater: The house and its history" New York: Dover Publications.

Kaufmann E, (1986) "Fallingwater: Frank Lloyd Wright country house" New York: Abbeville Press Publishers.

Levine N, (1995) "The architecture of Frank Lloyd Wright" New Jersey: Princeton University Press.

McAlester V, McAlester L, (1986) "A field guide to American houses" New York: Alfred A. Knopf.

McCarter R, (1994) "Fallingwater: Frank Lloyd Wright" London: Phaidon Press Limited.

Orhun D, Hillier B, Hanson J, (1995) "Spatial types in traditional Turkish houses" *Environment and planning B: Planning and design* **22** 475-498.

Osman K, Suliman M, (1994) "The space syntax methodology: Fits and misfits" *Arch. & Comport/ Arch. Behavior* **10** 189-204.

Peponis J, Peatross F, (1995) "Space, education and socialization" *Journal of Architecture and Planning Research.* **12** 366-385.

Peponis J, (1989) "Space syntax – The guest editors foreword" *Ekistics* **56** 4.

Peponis J, Wineman J, (1997) "On the description of shape and spatial configuration inside buildings: Convex partitions and their local properties" *Environment and planning B: Planning and design* **24** 761-781.

Rybczynski W, (1986) "A short story of an idea: Home" New York: Viking Inc.

Seamon, D. (1994). "The life of the place: A phenomenological commentary on Bill Hillier's theory of space syntax," *Nordic Journal of Architectural Research* **7** 35-48.

Seamon D, "Bill Hillier's theory of space syntax" *Personal notes.*

Secrest M, (1992) "Frank Lloyd Wright: A biography" New York: Alfred A. Knopf.

Shoppell R, (1983) "Turn-of-the-century houses, cottages and villas: Floor plans and line illustrations of 118 homes from Shoppell's catalogs" New York: Dover Publications.

Wright G, (1983) "Building the dream: A social history of housing in America" Cambridge: The MIT Press.