When Graphs Are Predictable

The role of sectors in guiding depth distribution in buildings

56

Luiz Amorim
Universidade Federal de Pernambuco, Brazil

Keywords:
domestic space,
sector,

Dr Luiz Amorim
Departamento de Arquitetura e Urbanismo - Universidade de Federal de Pernambuco, Av. Acadκmico Hılio Ramos, s/n, Cidade Universitαria, Recife/ PE - Brazil, 50740-530

tel: (55) 81 3271 8303 / 3271 8311
fax: (55) 81 3271 8772
www: http:// www.ufpe.ufpe.br/
amorim@mail.npd.ufpe.br

0 Abstract
Buildings in general classify, group and order activities and users in sectors. Evidences suggest that sectors' organisation is more determinant in space configuration than previously supposed. Its effects are pervasive enough to determine, to a certain extent, the configurational behaviour of buildings, and to allow, within a certain margin of error, a prediction of how depth is distributed by a simple analysis of the sectors' diagram.

1 Introduction

Previous studies demonstrated that modern buildings, in particular those expressions of a functionalist emphasis on design process, are arranged in sectors composed of similar kinds of activities and users. The idea that buildings are a collection of functional sectors, however, is not modern. It can be identified in the theory of architecture from Vitruvius (1960) to Palladio (1997), but more emphatically amongst rationalists' architects preoccupied with the establishment of objective procedures of architectural interpretation and proposition. The writings of Viollet-le-Duc (Hearn, 1995) and Robert Kerr (1864) are exceptional examples of nineteenth century rationalist thought. They are followed by the *Existenzminum* investigations in Germany, particularly the works of Klein (1975) and Neufert (1980), and the design methods generation, with the seminal works of Chermayeff and Alexander (1963) and Broadbent (1969, 1988). Permeating these studies is the concept of functional sectors.

Modernist housing in Northeast Brazil, recently investigated, demonstrated that the understanding of buildings as a collection of functional sectors was pervasive enough to establish a paradigm for housing design: the sectors' paradigm (Amorim, 1997; Amorim, 1999). In this investigation, the various types of domestic activities where mapped in space and it was detected that they were consistently grouped in sectors, which were phenotypically arranged, but expressed by a few genotypes. These sectors' genotypes, in turn, established restrictions to architectural composition, because they impose a significant reduction in the possible arrangements of plans, topologically and geometrically speaking.

It was also noted that sectors assumed different configurations according to the architectural brief and social practices. Some had clear boundaries, with a single or few connections to their neighbours, emphasising isolation and control. Others had unnoticeable boundaries, suggesting a less restricted program. These extrinsic properties of sectors, suggested their classification into clear and fuzzy bounded types. Their intrinsic properties were also diverse: some were tree-like and others ringy. Each sector assumed a different structure to supply domestic activities with the most adequate space form.

Sectors' organisation, it seems, takes the form of a basic, or fundamental, topologic layer of space organisation, ordering the relationship between spaces. Therefore, sectors' organisation seems to be fundamental to establish space-to-space configuration or to induce the overall pattern of integration of buildings. If this is true, how does this take place? Is sectoring so fundamental to define the integration pattern of buildings? If this is true, can configuration be established from preliminary stages of design?

To answer these questions we must understand the three basic principles of space configuration. Configuration is understood as relations in a complex that take into account all other existing relations in the same complex. Therefore, the properties of the whole complex are created on the basis of local relations, and vice-versa. This defines the fundamental configurational principle: structural properties of the whole are likely to alter when its parts are changed. For example, the overall depth of a system may be drastically altered by simple local changes, as demonstrated in figure 1. By cutting one connection of the highlighted space, the total depth of the system is increased from 80 to 92, whereas by adding a connection to the same space, the total depth of the system is reduced to 74.

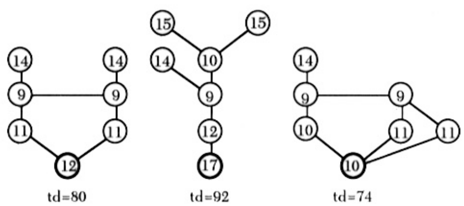


Figure 1. Graphs

In addition, local changes are likely to affect each unit of the system. When one of the connections is cut, the whole system becomes shallower from the highlighted space, but some spaces retain their structural properties. This is important because it demonstrates the second configurational principle: the whole is differently seen from each of its spatial units. This is also why spaces with different structural properties are likely to be used for different purposes, as demonstrated in a variety of syntactic studies (Hanson, 1998; Hillier, 1996; Hillier & Hanson, 1984).

However, the consequences of these changes are very difficult to predict, as demonstrated by Hillier (1997). They are only understood when the whole configuration is analysed from the point of view of each of its component units, i.e., by justifying the permeability graph from each space and counting the distances from each space to all spaces. This third principle explains why graphs are theoretically difficult to predict.

These three principles, also discussed by Hillier (1997) suggest that the sectors' organisation may have little or no effect in configuration, as the space-to-space permeability process would primarily act to shape the configuration of the whole. However, if spatial units are organised in meso-spatial-structures, or sectors, the relative position and permeability of each space is defined by the 'rules'[1] which have structured the sectors themselves. Therefore, it is possible that the structure of the sectors may affect the way local changes generate global changes. Perhaps the nature of these sectors - if ringy or tree-like, if clear or fuzzy bounded, may determine if local changes would be significant or trivial. In other words, these meso-spatial-structures may create a sort of stability in space configurations, and therefore in graphs, while isolating the effects of local changes in the global depth pattern, and consequently, turning the unpredictable graph into a more reliable or 'domesticated animal'.

The next sections present the results of a theoretical experiment. The experiment consist of introducing local changes to a hypothetical sectored building and mapping the effect of these changes on its global pattern of integration. It is expected that, by observing the 'flow of integration' from space to space every time a change is introduced to the hypothetical building, it can suggest how different sectors' arrangements interfere in the overall configuration of buildings. Hence, the study looks at both, change and stability in spatial systems.

2 Experimenting with sectors

The experiment takes a hypothetical building composed of three different sectors and rooted from a carrier space, as presented in figure 2. Sector 1 (thick circle) is tree-like and clearly bounded; sector 2 (black nodes) is a ring with a clear boundary; and sector 3 (thin circle) is ringy and fuzzy bounded. The sectors have the same size, five spaces, in order to distribute evenly the effects of topological changes and to generate a high degree of ringiness or depth. Even though this equilibrium between sectors' sizes is not common in real buildings, this balance is required to better evaluate how depth is distributed amongst the spaces and sectors. For the same reason, the building itself is arranged in order to create a relative symmetry in the system. Sectors 1 and 2 are situated at the same depth from the carrier space and sector 1 is positioned at the centre of the system. In this hypothetical spatial system, the sectors are directly connected to each other without any sort of mediation[2] (Amorim, 1997). A mediator sector is only introduced in a second set of morphological experiments, to better understand the effect of mediation in configuring the system.

The experiment is developed in three stages. Stage one changes the internal arrangements of each sector, reducing distances amongst its spaces by increasing connectivity. Stage two keeps stable the internal structure of the sectors, but increases the connectivity between them, i.e., it 'melts' their boundaries. Stage three 'melts' the boundaries between each sector and the carrier space.

The experiment follows rigid rules: changes are introduced by reducing depth one step at a time, except when changes in the configuration are only achieved by reducing more than one step at a time. Configurational changes are measured by the total depth gained or lost by space and by sector, and are evaluated by a simple comparison to the original arrangement (see figure 3). [3]

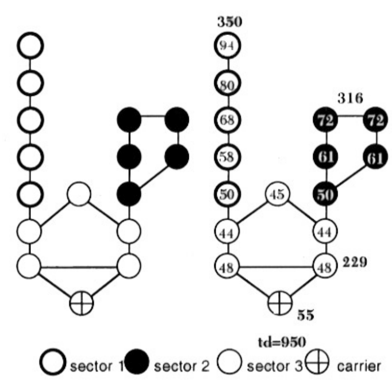


Figure 2. Hypothetical building

2.1. Stage 1: changing internal structures

Altering the internal structure of each sector shows that the tree-like sector is more sensible to increasing connectivity, as it would be expected. This sector has the highest depth loss, generating the maximum depth in the hypothetical building.

Curiously, the configurational core of the building remains stable at the spaces responsible for binding the whole system together. The order of integration is momentarily altered (steps 8 and 9), but as soon as symmetry is restated (step 10) the centre of the configuration returns to its original place. This is because these spaces are cut vertices, i.e., if one of them is removed, the system would fall into two disconnected complexes (Steadman, 1983). It seems that symmetrical systems tend to maintain its configurational core steady, regardless of changes in sectors' structures.

In fact, the most remarkable property of these graphs is how stable they are, even when the internal configurations of their sectors are deeply altered. Changing individual sectors redistributes depth in the remaining sectors proportionally, so that the order of integration of spaces of each sector remains exactly the same. This result suggests that creating clearly bounded sectors preserve the configuration of each individual sector, regardless of changes introduced to the remaining ones.

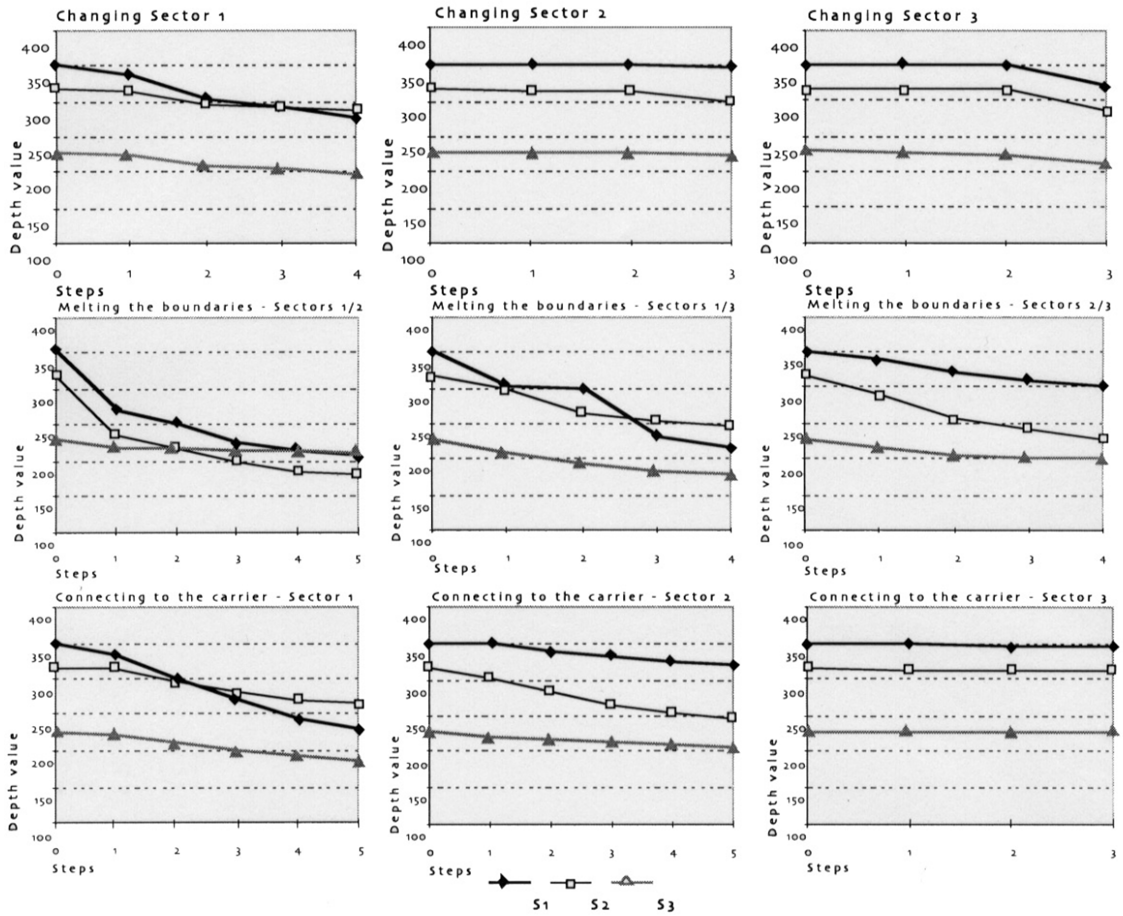


Figure 3. Total depth loss per sector

2.2. Stage 2: melting boundaries

Increasing sectors' connectivity generates more depth loss than when does their internal structures are changed. This is because overall distances are drastically reduced when shorter routes between sectors are created. Sector 1 is, again, the most affected of all, followed by sectors 2 and 3. Sectors lose more depth when their boundaries are melted, confirming that direct changes in sectors' boundaries are more effective than changes in other parts of the system.

The centre of the configuration moves from its original position at the boundaries of the sectors, becoming closer to the sector whose boundary is clearer. The exception is when the boundaries between sectors 1 and 2 are melted, i.e., when the centre moves up to sector 2. This pattern suggests that when the boundaries between sectors are relaxed, and openness prevails, the configurational core will tend to be positioned in the space to which the remaining sector is connected.

The intrinsic stability of graphs is also revealed in this experiment. For example, when the boundaries between sectors 2 and 3, and sectors 1 and 3 are melted, the remaining sectors (1 and 2, respectively) keep the depth distribution amongst their spaces proportional. However, this does not occur when sectors 1 and 2 are melted. The effect on sector 3 is more difficult to predict, but still, a general rule can be enunciated: a) symmetry is preserved when spaces from sectors 1 and 2, which are situated at the same distance from sector 3, are connected; b) asymmetry is found when the connected spaces are situated at different depths from sector 3. Therefore stability in the system depends on keeping a certain degree of symmetry in the graphs intact.

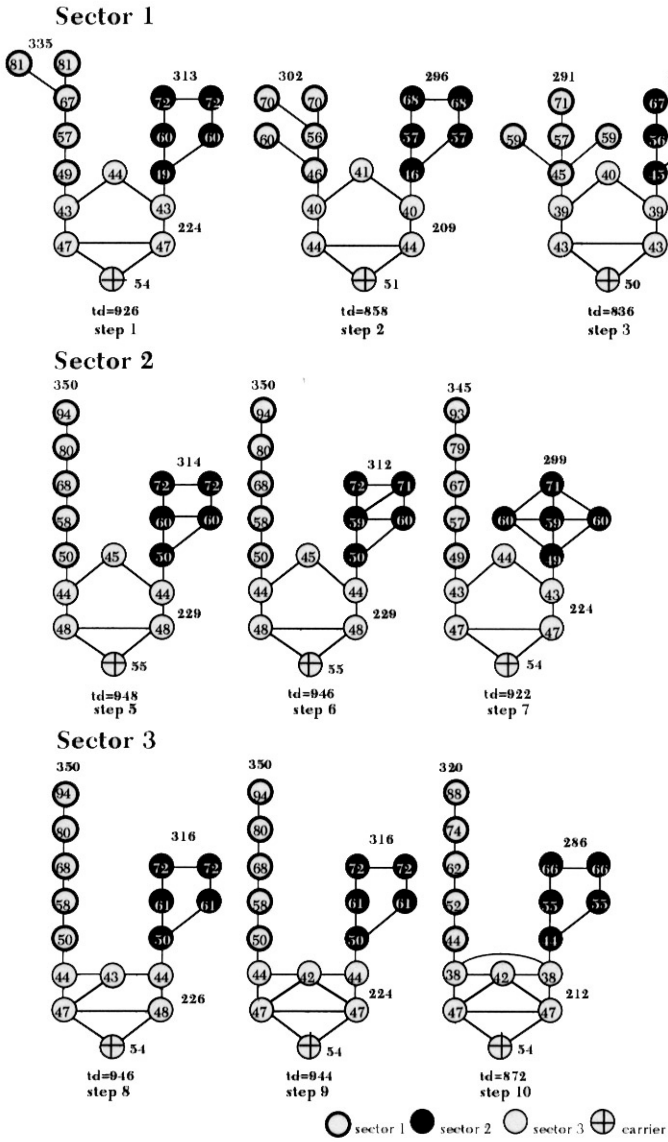


Figure 4. Changing internal structures

2.3. Stage 3: connecting the carrier

The third and final stage increases the connectivity of each sector to the carrier space (see figure 6). Direct changes to a given sector also generate higher depth loss than when changes are introduced elsewhere, with the exception of sector 3, which has a higher depth loss when sector 2 is changed. This is an effect of the high connectivity between sector 3 and the carrier space. As expected, the depth loss by the carrier space is generally higher than in the previous experiments.

The configurational centre becomes closer to the carrier, composed of the carrier itself, the space, which connects sector 3 to the deepest sector (1 or 2, depending on the experiment), and their connecting space. The latter is the shallowest of all, followed by the 'boundary' space and the carrier space. This pattern is so prevailing that it is only 'corrupted' when the carrier is fully melted to sector 3, pulling the core to itself. Nonetheless, the spaces at the boundaries between the sectors follow the carrier in order of integration.

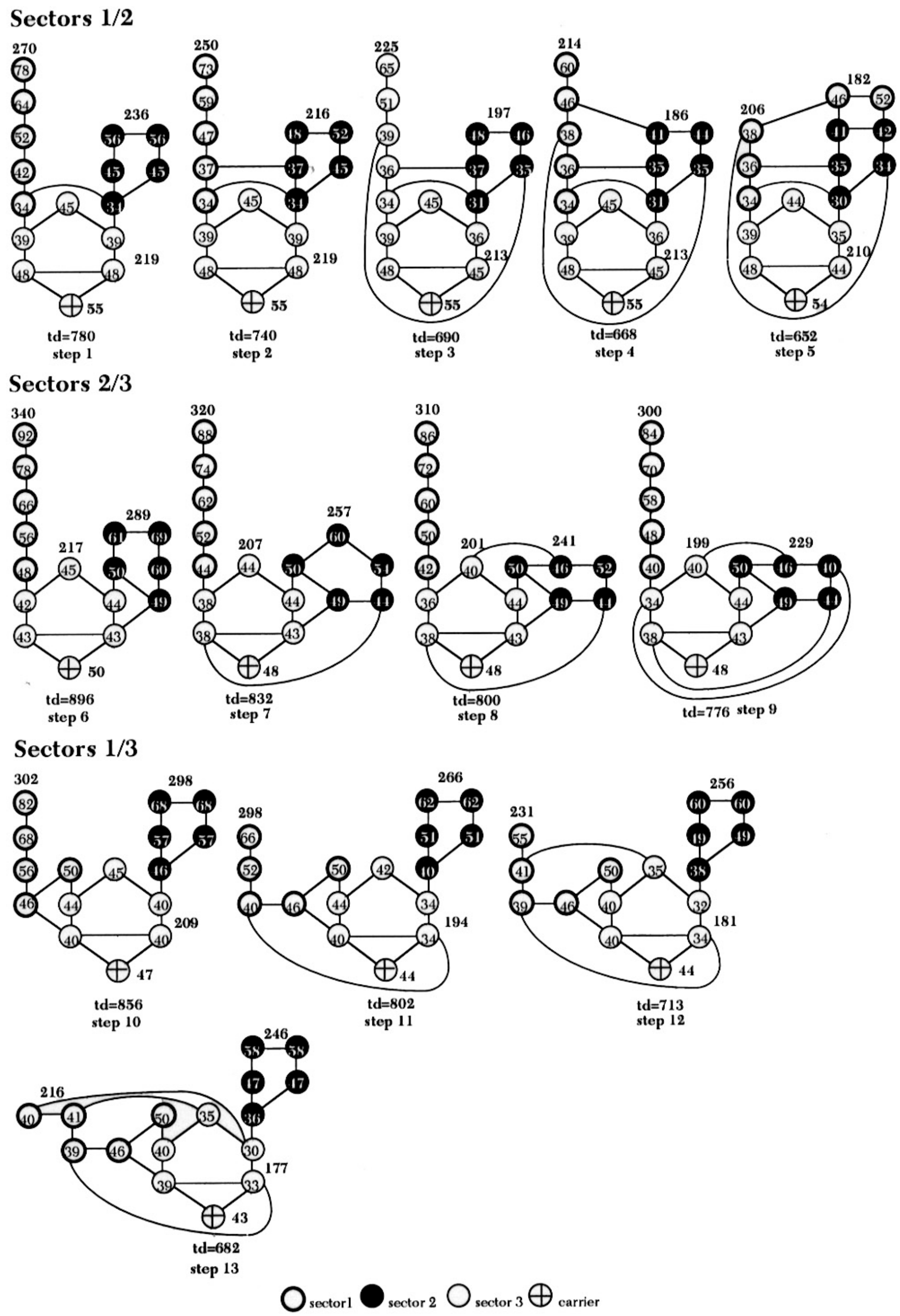


Figure 5. Melting the boundaries

Stability is again present. When sector 1 is connected to the carrier space, sector 2 remains stable, with depth values proportionally reduced every time connectivity is increased. The same phenomenon occurs when the boundary of sector 2 to the carrier is melted. In both cases, sector 3 changes in a less predictable way, but always balancing minimal depth towards the unchanged sector. Symmetry and stability is clearly seen when sector 3 and the carrier are connected.

2.4. The 'flow of integration' through sectors

Figure 7 summarises the experiments by presenting the total depth loss per sector in each operation. The most important result of the experiments is that changing the sectors' boundaries is more effective than changes in their internal structures, as well as in their permeability

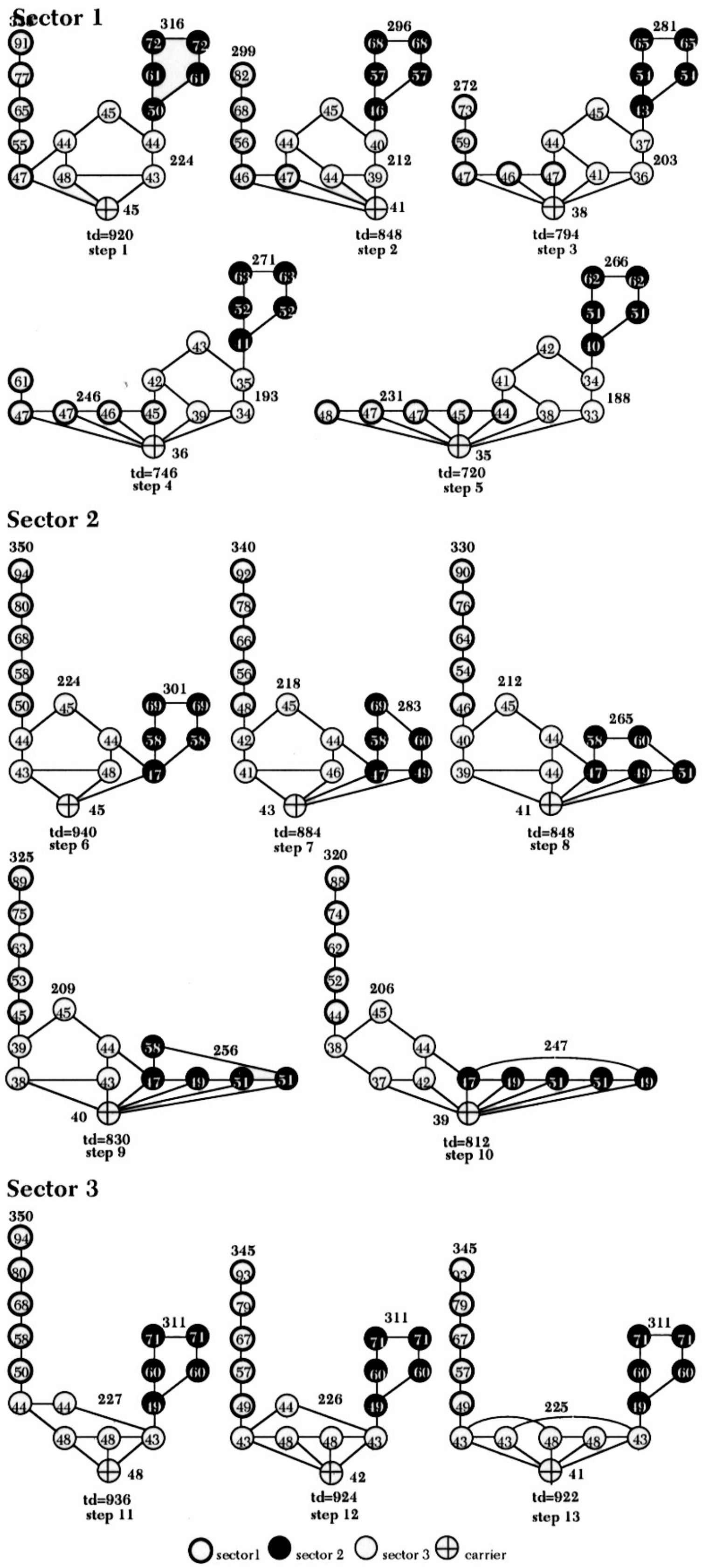


Figure 6. Connecting the carrier

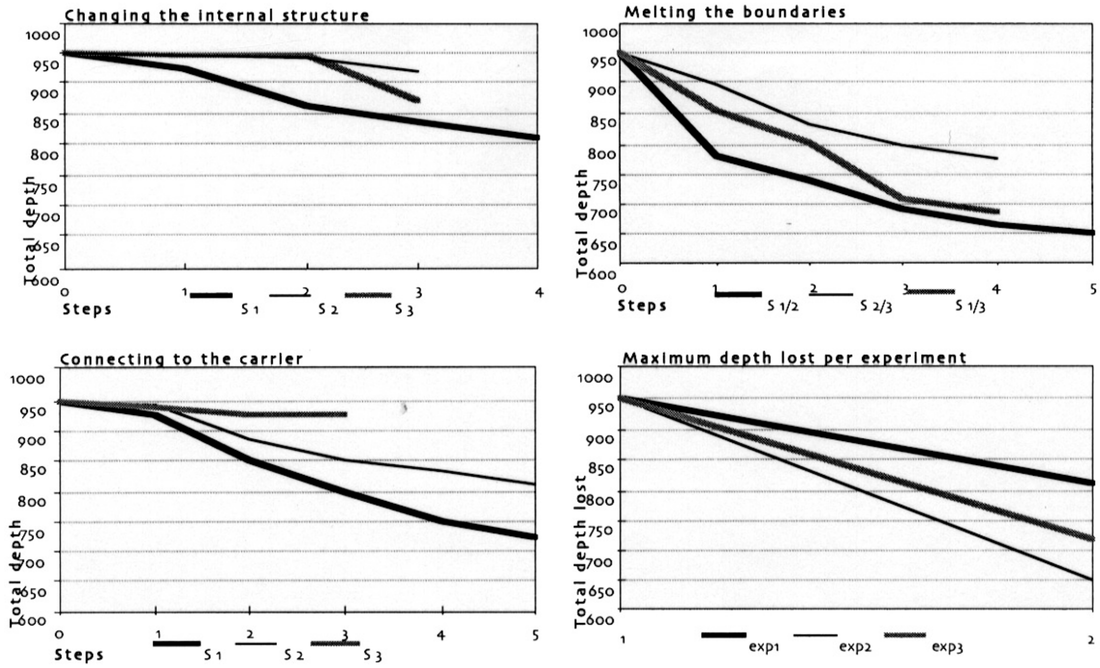


Figure 7. Summary of the results

to the carrier space. This is because, 'fuzzying' the boundaries between sectors reduce overall distances more efficiently reduced. In fact, melting boundaries generates higher depth loss values than any other internal changes in sectors, excepting when sector 1 is connected to the carrier space, because changes in ringy structures are less effective than in trees. This is why sector 1 is the most affected in every experiment.

Some important properties of graphs can be described as follows:

> a. Clear bounded and symmetrical sectors tend to pull the configurational core to their boundaries, regardless of their internal structure. This shall be called 'boundary effect'.
> b. When sectors' boundaries are fuzzy and high connectivity is achieved, the core tends to move towards an eccentric position, balancing the isolation of one sector with the permeability between the other two. This shall be called 'isolation effect'.
> c. The 'boundary effect' is less effective when a stronger configurational centre is created - the carrier. Even so, this 'carrier effect' is always balanced by a deeper and isolated sector.

Just as striking as the graphs' changing patterns is how some of their properties are kept stable. Stability is manifested in particular ways:

> a. When changes are introduced to the internal arrangement of a sector, depth is proportionally distributed amongst the spaces of the remaining ones.
> b. The position of the shallowest space does not change when symmetry is maintained, particularly when the internal structure of the sectors is changed. There are, however, important exceptions. When the boundaries between sectors and between a sector and the carrier space are changed, the shallowest space moves from its original position; however, as soon as it moves, it keeps this new position, regardless of further changes added to the system. This means that, to relocate the configurational centre of a building, it is only necessary to make a 'strategic' move, but after this move, the system keeps its centre stable again.

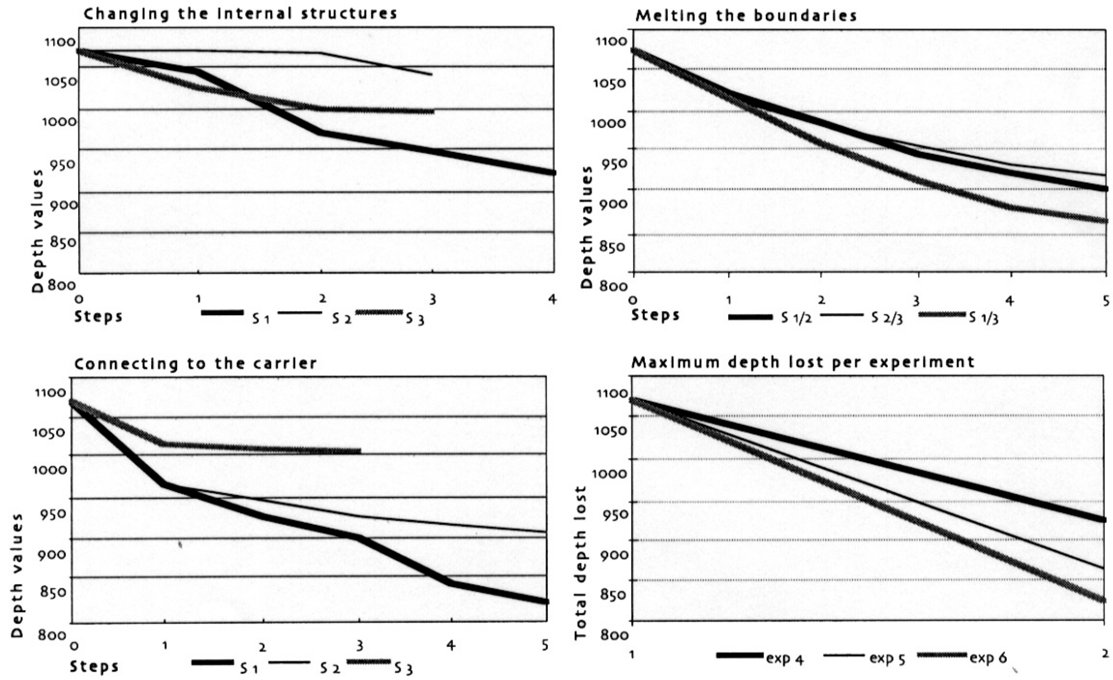
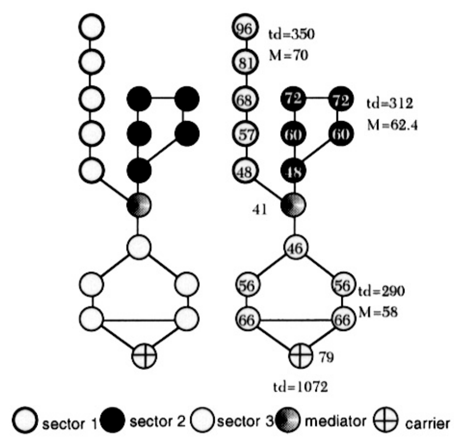


Figure 9. - Mediated building: summary of the results

In sum, internal changes in the sectors are more conservative, whereas changes in sectors' boundaries are more effective. One sustains the established order, whereas the other challenges the order to create new forms of spatial configuration.

Figure 8. Mediated hypothetical building



3. Introducing mediation

A second series of experiments were developed with the introduction of a mediator node isolating the sectors (figure 8). The mediator is positioned as a cut vertex, a position that is likely to pull the configurational core towards its boundaries, but it is worth observing how the whole complex behaves with its introduction. The experiments are summarised in figure 9 and the main results are described as follows:

a. The shallowest spaces of a mediated system, composed of clear bounded sectors symmetrically positioned from the point of view of the mediator, are the mediator itself and its adjacent spaces, regardless of the internal configuration of the sectors.

b. The mediator space remains at the centre of the system, even when the boundaries of the sectors are melted, until the final stages of the 'melting' process, when the core moves towards the most permeable sector, one step away from the mediator. This is because mediation, understood, as a spatial manoeuvre to isolate different categories of space, does not occur any longer, obscured by the high permeability between sectors.

c. The mediator space minimises the effect of changes introduced in one sector to the other ones. This is seen throughout the experiment, but is clearer when the sectors are connected to the carrier space and when sectors' boundaries are melted. In these particular operations, the third sector is almost unaffected.

The introduction of the mediator space increases the degree of stability of the system. Stability is present in the position of the shallowest space, in the rank order of integration of the sectors and in the shallowest space per sector. Nonetheless, when the boundaries are changed, the same unpredictability seen in the non-mediated building is also experienced. The order of integration is slowly altered according to the degree of permeability assumed by the sectors. However, whichever order the spaces may assume, the shallowest spaces by sector remain exactly the same: the spaces adjacent to the mediator space. This property not only confirms the symmetrical and centripetal composition of the mediated system, but also expresses the configurational strength of the mediator, even when boundaries are melted and asymmetry takes control of the system. It seems that mediation is the best source for maintaining a configurational order, even when structural changes are introduced.

4. Mediated and non-mediated compared

Mediation brings more stability and predictability to the hypothetical building, so much so that it is possible to predict the effect of changes, as a consequence of its strong centrality. This is demonstrated by observing the position of its shallowest spaces, always connected to each other, forming a hub of integration. This does not always occur in the non-mediated building, where the shallowest spaces are sometimes disconnected from each other. When sectors' boundaries of the non-mediated building are melted, the most integrated space moves towards the boundary of the isolated sector, whereas in the mediated building, the most integrated space moves towards the opposite direction, closer to the mediator space. Therefore, mediation reinforces centrality, whereas non-mediation distributes it.

Stability is present in both hypothetical buildings, but more evidently in the mediated one, because mediation isolates the effect of configurational changes and secures its position at the very core of the building. Stability is increased when mediation is combined with clear boundaries: the clearer the boundaries are, and hence, the more isolated the sectors are, the more stable the system is. Changes are identified in depth values, but not in the order of depth distribution amongst spaces. This 'boundary effect' is as strong in the mediated as it is in the non-mediated system and, hence, it may be assumed as a general rule in sectored systems: the clear the boundaries are, the more likely to predict the configurational behaviour of buildings themselves.

The 'carrier effect', on the other hand, seems to be more effective in non-mediated systems. This is because the mediator space inhibits carrier's potential of being a strong integrator. The more powerful the mediator space is, the less powerful the carrier is. Therefore, to enhance outdoor integration, one has to balance mediation and connectivity to the outside spaces. This shall be called 'mediator/carrier paradox'. This paradox is more pronounced in mediated buildings but it may be manifested in non-mediated ones when a deep and isolated sector exists. The 'isolation effect' generates a 'centripetal' force, which balances the 'centrifugal' carrier effect.

It seems that the way depth is distributed in sectored buildings is a function of some spatial properties. The existence of clear boundaries is essential to maintain the spatial system stable and to establish the role of each sector in the system, if central or peripheral. Mediation enhances isolation and creates a powerful integration core. On the other hand, fuzzy boundaries open up the field of combinatorial possibilities, as changes in the configuration are less restricted and the effects of these changes are less predictable. This level of unpredictability is more evident in a non-mediated system, as the openness of the boundaries generates an open spatial field, freed from a central integrator. Therefore, the more asymmetrical the system is, the less predictable it will be. In conclusion, the main difference between the two system is that mediated systems are more stable and ordered, topologically speaking; whereas non-mediated systems are less stable and more structured, in a sense that configuration is more susceptible to changes.

5. The guiding role of sectors

So, what conclusions can be withdrawn from these experiments? How does it clarify the role of sectors in defining buildings' depth distribution pattern?

One way to describe how sectors' organisation may work is by observing the experiment in a reversed sequence, in other words, as a result of a process of design decision. Starting from scratch, fifteen spatial units (or sixteen if a mediator unit is required) are to be arranged according to a brief, to social and cultural habits and to designer's idiosyncrasies. One of the various spatial arrangements above [4] is likely to be composed, if the paradigmatic sectoring laws were to be applied. Restrictions to constitute sector 1 as a deep and enclosed, for example, one would dictate if the integration core would be pulled towards its boundary or not. The need to open up the system to a carrier space (a garden, for example) would make it more central, regardless of the internal configuration of each sector. Increasing the potential co-presence of users by restraining any barriers between sectors would tend to evenly distribute integration amongst the interconnected sub-systems.

This does not predict, however, the integration values with exactitude, but it does indicate how sectors operate configurationally. It seems that sectors, by defining meso-structures in the system, eliminates spatial inconsistencies (conflicts between different activities and undesirable co-presence) and reinforces spatial likeliness. It is the way these inconsistencies are spatially managed that gives to the system the necessary basis to 'guide' the constitution of its overall configuration. It is this 'guiding' nature of the sectors that makes the paradigm so pervasive and efficient.

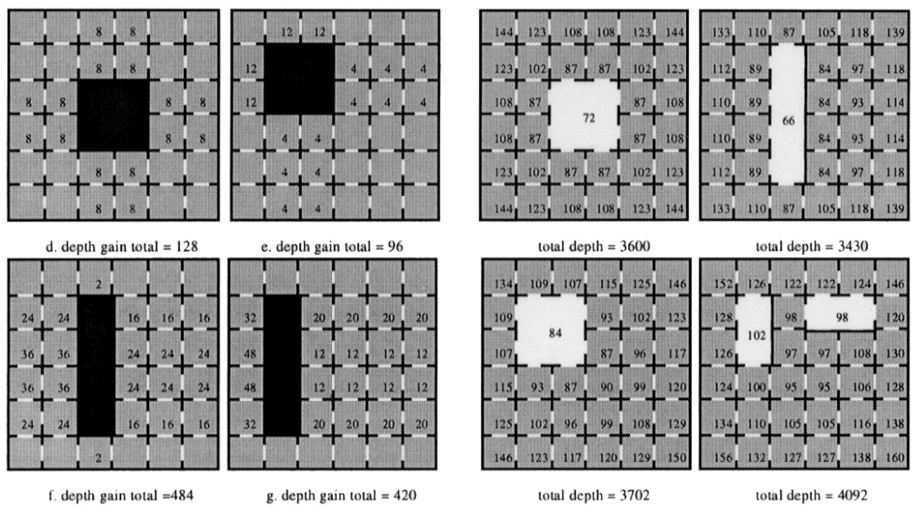


Figure 10. Layered tessellation, after Hillier, 1996

The experiments suggest the existence of two types of sectors' organisation - two 'topological genes' (Amorim, 1997). The first defines isolated and symmetrical sectors, guaranteeing more stability to the system, whereas the second introduces asymmetry and blurs sectors' boundaries. But regardless of the differences between these two families, the topological genes introduce a certain degree of predictability, stronger in the first type, to the unpredictable configurational world of graphs. They do so by constructing a sort of regularity in graphs.

It seems that sectoring follows similar principles already enumerated by Hillier (1996: pp 275-334) in his theory of partitioning, which has emerged from a theoretical experiment aimed to describe regular shapes syntactically. The experiment consisted of closing and opening cells' partitions on a metric tessellation, blocking or opening sets of cells, and calculating the effect of these changes in the overall pattern of integration of a regular shape. The experiment proved that the effects of these changes could be foreseen by the knowledge of some principles. Take the square in figure 10, for example. Blocking the connections between the cells in the centre of the shape creates more segregation than if it were placed in its periphery and, if the block is rectangular; its effect is even greater. If instead of blocking, voids

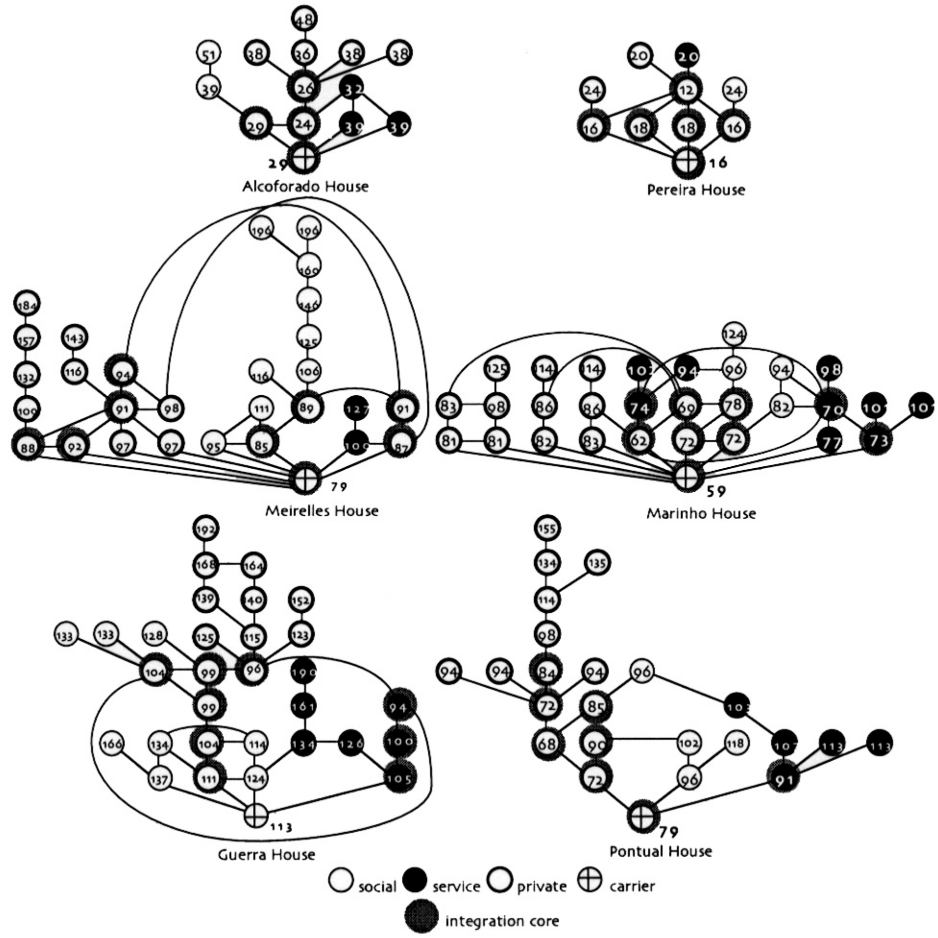


Figure 11a - Non-mediated modern houses

are generated to allow for a high degree of connectivity of certain cells, the effect would be the contrary: 'centrality and linearity will integrate more, squareness and peripherally less' (Hillier, 1999: pp 35.14). The prediction of these changes on the tessellation, and therefore on the graphs, is possible because a sort of geometry was imposed to the system. This geometrisation of the graphs imposes some restrictions to the depth distributing process, allowing the prediction of changes in the configuration. This phenomenon is known as the 'law of sufficient geometry' (Hillier, 1999: pp 35.14-35.16).

It is argued that, similar to the geometrisation of graphs, sectoring generates a significant kind of restrictiveness to their configuration, that suffices to install some predictable principles. These principles, which have been described above, are eminently topological, and not geometrical, as Hillier has observed in his tessellated shapes.

If our theory is correct, real buildings will present properties similar to those found in the hypothetical building. Twenty modern houses (fourteen mediated and six non-mediated) built in Recife, Brazil, showed in figure 11, confirms most of the hypothesis formulated on the basis of the morphological experiments. Despite the differences in size and complexity of arrangements, the sectors, boundaries and carrier effects act similarly. Non-mediated houses also behave similarly to the non-mediated hypothetical buildings. The most integrated spaces were found in the same conditions predicted by the experiments. In mediated houses, the

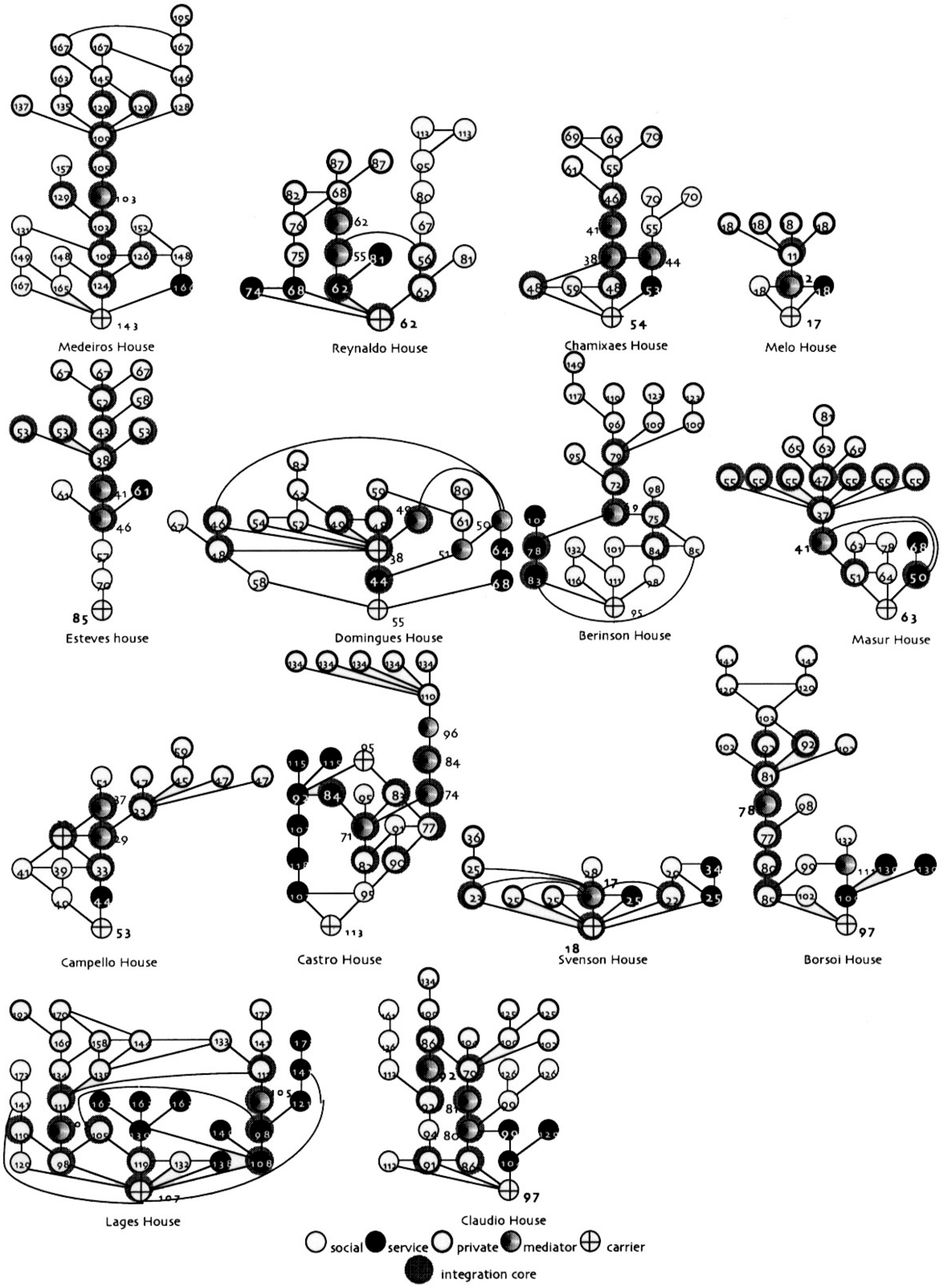


Figure 11a - Mediated modern houses

predictions were even more accurate. The centrality of the mediator is an indisputable rule. Even in double mediated houses, the strength of the mediators drags integration towards their boundaries.

Houses' sectors also induce their integration core. The core tends to be either shallow or deep, according to the relative position of the mediator itself and the openness of the carrier space. The core is shallow and ringy if mediator and carrier spaces are closely related, or deep and tree-like if the mediator is deep, an isolated sector is present and the carrier is poorly connected to the house. In non-mediated houses, the carrier space becomes, in the absence of a mediator space, a powerful instrument in reinventing their configuration. The carrier is present in the integration core of all non-mediated houses, as it is used to create alternative choices of movement about the dwellings.

6. How the sectors' paradigm seems to work

No matter how conclusive the results of the experiments may be, supportive the behaviour of the modern dwellings may be, and logical the proposed theory on the influence of sectoring in the integration pattern of spatial systems may sound, one may argue that, over and beyond sectors' boundaries, the laws of spatial configuration rule. Indeed, one may argue that the boundaries defined by the sectors are artificially created by labels, which might well be restated by changes in space use. Moreover, one may argue that spatial systems will always perform according to configurational rules, regardless of the functions attached to them. Cut vertices and central spaces will always determine the depth distribution pattern.

This is absolutely true. The properties expressed by the morphological experiments described above are configurational. The evidences provided by the experiments and modern dwellings are simple consequences of profound properties of relational graphs. They are not dependent on the form-function nature of buildings. The delimitation of sectors in the graphs, a 'graph colouring process' (Steadman, 1983: pp 100-104), is an artificial procedure to encapsulate some basic topological properties under circumstantial boundaries. Furthermore, simple topological laws may also explain most of the fundamental 'guiding' rules of the sectoring process. The mediator effect can be explained, in the majority of the cases, as a 'cut vertex effect'. The carrier effect can be explained by a simple morphological principle, which says that increasing the permeability of a space, and therefore making it shallower from the point of view of the system, will invariably make this space particularly central. The isolation effect responds to an opposite circumstance, but of a configurational origin: the more isolated or deep a considerable set of spaces is, the more the spaces that are closer to it will tend to be the core of the system.

None of the arguments used to explain, or to propose a general theory on sectors' role in guiding the integration pattern of buildings denies or undermines the intrinsic properties of graphs. On the contrary, the understanding of these properties is funded on the understanding of how space configuration and function are tied together to construct buildings. In fact, it is exactly how spatial systems are managed to perform under certain circumstances, which corroborates with the proposed hypothesis. They exemplify how, consciously or unconsciously, the fundamental laws of space are invoked to shape form into an active field of social and cultural production and reproduction. In this sense, fuzzy or clear boundaries induce the form by which inhabitants, and inhabitants and visitors should face each other. It is when grouping activities and defining permeability that the laws of space are invoked to give a social logic to the system. Thus, it is the combination of functional requirements, social values and configuration, through which spatial systems acquire a sense of social order. Putting in simple words, the sectoring process takes hold of the general laws of configuration to give a social-functional order to buildings. This sense of socio-functional order, it is argued, is much in debt to the form taken by the sectors, in such a way that the clearer these sectors are, or the more consistent their forms are, the more regular and consistent the whole building will be. And this functional logic is the determinant key to guide the depth distribution process.

This is not new. We already know that, from a large number of cross-cultural studies. What we did not know until now is that there are certain spatial arrangements which are more ordered than others, and carry within them a strong sense of stability, strong enough to support significant changes in their configuration and to keep the relationship between their component spaces intact. This means that it is possible to objectively define, with a certain degree of precision, the configurational behaviour of buildings in the early stages of design, when the sectors' diagrams are drafted. In this sense, sectors' arrangements are, indeed, buildings' topological genes, establishing profound properties, which in very few circumstances can be corrupted. This also means that we have to look at integration more carefully, because the experiments showed that depth values are not sensitive enough to describe some of the significant changes introduced to them. The world of space configuration, it seems, is still to be fully understood.

Acknowledgements

This research was funded by the Fundacao Coordenacao de Aperfeicoamento de Pessoal de Nivel Superior - CAPES.

Notes

1 Rules are understood as the imperative restrictions imposed to the classification procedure which governs buildings' sectoring procedures. Some of these rules are objectivelly expressed in architectural briefs, and others, subjectivelly present in designers' minds,

2 A mediator sector 'mediates' the relationship between sectors, working as a buffer zone.

3 Total depth is used to measure morphological changes instead of integration (RRA) for two reasons. Firstly, because it allows for an easier visualisation of the differences within each building, and secondly, because there is no interest in comparing the values for different buildings.

4 Even though the arrangements used in the experiments do not represent all the possible combinations of the fifteen units and the carrier space.

References

Amorim L 1997 "The Sectors' Paradigm: understanding modern functionalism and its effects in configuring domestic space" in *Space Syntax First International Symposium* Eds M D Major, L Amorim, F Dufaux (UCL, London), 2 pp 18.1 - 18.14

Amorim L, 1999, *The Sectors' Paradigm: a study of the spatial and functional nature of modernist housing in Northeast Brazil*, unpublished PhD thesis, University College London, London

Broadbent G, Ward A. 1969 *Design Methods in Architecture* (Lund Humphries, London)

Broadbent G 1988 *Design in Architecture: Architecture and the Human Sciences* (David Fulton Publishers, London)

Chermayeff S, Alexander C 1963 *Community and Privacy: toward a new architecture of humanism* (Doubleday & Company, Inc, New York)

Hanson, J 1998 *Decoding Houses and Homes* (Cambridge University Press, Cambridge)

Hearn M 1995 *The Architectural Theory of Viollet-le-Duc: readings and commentary* (MIT Press: Cambridge, Massachusetts)

Hillier, B 1996 *Space is the Machine* (Cambridge University Press, Cambridge)

Hillier B 1997 "Why space syntax works when it looks as it shouldn't" in *Space Syntax First International Symposium* Eds M D Major, L Amorim, F Dufaux (UCL, London), 2 pp 35.1 - 35.24

Hillier B, Hanson, J 1984 *The Social Logic of Space* (Cambridge University Press, Cambridge)

Kerr R 1864 *The Gentleman's House* (John Murray, London)

Klein A 1975 V*ivienda Mvnima*: 1906/1957 (Gustavo Gilli, Barcelona)

Neufert E 1980 *Architect's Data* (Granada, London)

Palladio A 1997 *The Four Books on Architecture* (MIT Press: Cambridge, Massachusetts)

Steadman P 1983 *Architectural Morphology - An introduction to the geometry of building plans* (Pion Limited, London)

Vitruvius 1960 *The Ten Books on Architecture* (New York: Dover)