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The morphology of early modernist residential plans*
Geometry & genotypical trends in Mies van der Rohe's designs

Sonit Bafna
Ph.D. Program, College of Architecture Georgia Institute of Technology 327768 G A Tech Station Atlanta GA 30332
Tel: (404) 894-1630 E-mail: sonit.bafna@arch.gatech.edu

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0. Abstract

The absence of a clear genotypical tendency in the boundary space configuration of some Miesian houses is discussed. In response, the role of geometry in the description of genotypes, and within the logic of design at large, is reassessed.

1.

A striking illustration (Figure 1) appears in March and Steadman's The Geometry of Environment (March and Steadman, 1971: 27-28). The figure demonstrates, more persuasively perhaps than any verbal description would, the remarkably similar topological structure underlying the varying geometrical schemes that Wright used in the planning of his Usonian houses. The three houses illustrated within are organized around armatures of three different geometries —an orthogonal one, a circular one and a triangular/hexagonal one—yet the graph, which maps relations of accessibility between individual spaces within these houses, remains the same.

[Insert Figure 1 about here]

This illustration makes a telling contrast with that of Hillier and Hanson (Figure 2) from The Social Logic of Space (1984: 150-151). Their purpose, ostensibly, is just the opposite—to demonstrate how a single geometrical scheme (a nine-square division of a larger square) can accommodate completely different topological arrangements of accessibility.

[Insert Figure 2 about here]

Notwithstanding the contrast, both these figures illustrate a common point: the significance of the topological descriptions to the formal analysis of built space. This remarkable insight—that the topological description of space can have value in its own

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right—can be said to have inaugurated a particularly productive period in the formal studies of plans. The advantage of the topological description has been seen to lie in two distinct aspects. One is evident in the illustration above: the topology of plans offers a key to the manner in which they accommodate patterns of habitation and use. Such patterns, in general, seem to be less dependent upon the higher geometrical attributes such as the shape and dimensions of spaces, than upon the manner in which they adjoin and connect to each other. The underlying similarity of the topological structure in the three houses of Wright clearly refers to the common sociological and, therefore, the programmatic requirements of these houses. The other has to do with an accounting of the possibilities of plans under strictly geometrical constraints: as far as the higher geometrical properties are considered, plans may have innumerable variations, but once the description is limited to the topological space, the variations fall within discrete classes. A topological description can therefore provide a good first level at which built spaces can be classified. A good example of such a descriptive scheme is the rectangular grating on which plans with rectangular spaces may be enumerated (Steadman, 1983: 11).

The two illustrations go further than asserting the significance of topology, however. In both cases, the topological structure is represented by a linear graph. An important consequence of the use of the graph is that it allows the continuous space of a plan to be seen as a configuration of discrete elements. This abstraction of a given plan into a configuration of spatial elements has been a potent step in the development of techniques for formal analysis, generating a host of research programs. It has lead, on the one hand, to studies which enlist developments in discrete mathematics-graph theory, symmetry theory and enumeration methods-to generate and enumerate specific, or all possible, plans under specified conditions (March and Earl, 1977; Steadman, 1983). On the other hand, it has allowed interpretive and descriptive techniques such as those of network theory to be applied to plans-a line of research perhaps most fruitfully and consistently developed within the Space Syntax program.

It is a basic tenet of the theory of space underlying Space Syntax program that the relations of accessibility between the elements of a spatial configuration are closely linked to the social situation that it houses. As Hillier et al write, "The theory of 'space syntax' is that it is primarily—though not only—through spatial configuration that social relations and processes express themselves in space" (1987: 363). The relationship between social processes and the spatial configuration is generally seen as being two-way. On the one hand, spatial configuration is a major factor in the determination of social processes; on the other, it is itself engendered by social processes, at least in the case of all naturally configured spaces such as market towns, and large building complexes which have grown accretively over time-a fact well documented by a large number of empirical studies. One reason why spatial configuration is a good descriptor of such spaces is that their formation is largely aggregative: they take shape gradually through local moves and under local conditions. The same "social relations and processes" that are realized within such a configuration are also factors in its formation. In short the logic of their function is the logic of their formation.

But this begs the question whether the graph is as useful a descriptor of spaces configured by design. As the accessibility graph is essentially a descriptor of the social relations and processes embedded within the space, even in the case of designed spaces the graph should offer a useful description of these spaces from the point of view of their logic of function. But how close does it come to describing their logic of formation? The logic of formation—or, more correctly in the case of designed objects, the logic of design-is undeniably as much, if not more, concerned with those geometrical properties of shape and dimensions, as with topological properties of proximity and access. But these are the very properties that Space Syntax methods tend to abstract out of plans. In neglecting these properties, is the Space Syntax methodology discounting some vital properties which help us understand why designed buildings take the form they do? Do the properties of shape and dimension have any significance for the formal description of built spaces? Or are they merely architectural play—a superstructural elaboration upon a less easily modified sociological base of accessibility patterns, which only serve as indicators of style and circumstantial preference?

Admittedly, it would be incorrect to claim that such geometrical properties have been entirely disregarded within Space Syntax research. As a matter of fact, recent years have seen an increasing amount of attention given to the geometrical aspects of built spaces. One of more commonly accepted ideas is that even graphical techniques such as axial map analysis and convex map analysis will encode some geometrical information—for instance, in measures such as lengths of axial lines, angles between them and relative areas of convex spaces. The values of such parameters are generally understood as being culturally determined (Hillier, 1997: 35.19). Another way in which geometrical properties come to play a role within analysis of built space is when visibility patterns are taken into account. This has been largely operationalised in terms of visual fields (isovists) both at the level of individual buildings and urban spaces. But while these techniques have proved valuable in capturing the indirect and local effects of the geometry of built spaces, they are not designed to describe the overall geometry of such spaces, and certainly not the implicit, global geometrical relationships that are typical of designed objects in general.

There has been some effort in this direction too. Hillier has demonstrated how the geometry of any shape may be described as a configuration of regular pixels and studying the accessibility graphs of the pixels that constitute it (Hillier, 1996: pp. 100-123). The distribution of global values such as Integration of these pixels shows a remarkable sensitivity to changes in the overall shape. Recent work at Georgia Tech, a more direct motivation for this paper, has focused upon the question of making explicit the global geometrical structure of a plan evident to a moving observer within the plan (Peponis et al, 1997). The approach taken in this case has been to automatically partition a given plan into convex areas (called the E- and the S- spaces) defined by the amount of visual information related to the shape of the plan available to them. This partitioning has been useful in suggesting solutions to long standing problems such as the art gallery problem and the automated production of axial maps, and in capturing the latent effects of local compositional moves upon the shape of the resulting plan (Peponis et al, 1998a; 1998b).

In general, these techniques have tended to translate geometrical structures of entities into configurations of spaces-in effect, into linear graphs. This use of topological structures to describe the global geometric properties of built spaces, however, has proved too cumbersome in practice. This is true even in the case of S- and E- spaces, although the component spaces are derived from operations sensitive to the shape of the given spatial object. The latest work at Georgia Tech on this actually makes a case against the possibility of systematically capturing perceptual and geometrical properties of space by topological descriptions alone (Rashid, 1998; Peponis 1999). The main difficulty lies in constructing a general theory, which can predict the effects of variations in shape upon the topological measures and vice versa. In the absence of such a theory no property of consequence can be assigned to the geometrical attributes of a built space.

Moreover, these techniques do not directly address the crucial question of the role of geometry in the logic of design. The graphs may be able to "internalize" several geometrical properties of built spaces, but it is a moot point whether they are able to capture those geometrical attributes that are significant to the logic of design. Oddly, although early papers by Hillier, Leaman and others were directed specifically at this issue, the later developments within Space Syntax have tended to marginalize it. There appears, within the Space Syntax literature at large, an implicit assumption that the issue of the logic of design may not be germane to the theory of social space at all. It is accepted after all that all usefully habitable space, whatever shape it may take, has to conform to the requirements of basic function. In other words, whatever geometrical qualities an architect may invest into the design of a plan, the design is restricted to a pre-determined topological structure that reflects the programmatic or functional requirements of the space. The logic of design and, in effect, the geometrical qualities through which it is operationalized, then appear to be less consequential to the social logic of space than is its topology. The topology, in effect, determines the design, acting as a constraint upon the geometrical variations and defining their range and possibility.

The importance of topology is further enhanced by the special interest that Space Syntax research evinces in the study of generic form. This is informed by the idea that as one moves from the geometrical level of description to a topological one, the description slips from that of the individual building (the phenotype) to a more generic one (its genotype). March and Steadman's diagram illustrates this precisely: the graph underlying the three houses may very well be seen as a genotype.

Ultimately, this distinction between the geometrical and the topological aspects of a built space creates problems on two counts. First, by reducing the essential properties of a plan to its topology and that, in turn, to an accessibility graph, it somewhat trivializes the role of geometry within built spaces; at the very least, it leaves the questions surrounding the role of geometry in the formation of such spaces unresolved. Even in cases where geometrical characteristics of a space are explored and measured—the lengths and the angles of intersection of axial lines, for instance—they seem to play a secondary role, fine-tuning a structure already determined at a topological level. Second, the idea of the graphical genotype does not seem to work so well in practice. Reconsider the March and Steadman diagram. Careful examination reveals that the graphs of the three plans are not quite so similar (figure 3). Do such variations of the accessibility graphs in houses, which are programmatically similar, threaten the idea of the graphical description of a genotype? In practice, the idea of the genotype does not depend upon a precise reproduction of common accessibility graph amongst all the phenotypes—rather it is defined over statistical measures of inter-spatial depth between the component spaces of the graphs (Hillier et al, 1987). Such a description of the genotype, called the inequality genotype, leaves it robust enough to accommodate such variations as appear here. What are of interest here, in any case, are not the variations themselves, but rather why they arose in the first place. Several of these differences seem to arise from geometrical moves: the connection between the bedroom and the upper terrace in the Sundt house, for example, could only be made at the cost of sacrificing the symmetry of the terraces. This issue—the description of genotype and the role of geometry in defining it—is one that I want to address through a more detailed example

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[Insert Figure 3 around here]

2.

The following is based on an analysis of certain early twentieth century residential plans. The focus is on the work of Mies van der Rohe. In the few years from around 1923 to 1938, the decade and a half during which he established himself as an avant garde architect of international repute, Mies designed a number of country houses around Germany, many in the industrial town of Krefeld and its surrounding areas. At first glance these villa plans show a gradual move from the more conventional cellular organization to a radical free planning of interior spaces. However, a closer look does not support a strict chronology of development. Mies had started his experimentation with the free plan as early as 1923; his seminal Brick house proposal dates to that period, and the proposals for the glass and concrete office towers with completely open plans followed soon. At the same time, the designs for houses, which were actually built, were far more conventional. Even at the time of his Tugendhat house (1928-30)—the first built residence to feature his trademark open living space articulated by freely distributed partitions—he was designing the Lange and Esters residences using a vocabulary of massive masonry walls separating the exterior from the interior and the individual rooms from each other.

This phase, then, was definitely not a period of gradual and systematic change in Mies's style. It might rather be described as a phase of experimentation, during which Mies tried out a number of alternative schemes varying in their interior organization, visual aesthetic as well as constructional vocabulary. What led him towards such a vigorous formal experimentation? Mies himself had very little to say on this matter; his writings of the period were typically polemical and intended as statements of his philosophical position. But clues may be had from a careful look at his designs. Part of the reasons may have had to do with practicalities of designing a livable space in the face of new ideas of spatial composition, which he was trying to introduce. The more radical free-plan vocabulary created an openness that might not have been welcome to several clients. Mies himself reports the aversion of the Langes and Esterses towards his attempts to open up their villa (Tegethoff, 1985: 62-63). Similarly, an unsympathetic critic of his Tugendhat house castigated it for its lack of homeliness—an opinion, incidentally, with which his clients themselves disagreed (quoted in Tegethoff, 1985: pp. 97-98.). Even for clients sympathetic to the idea of open living spaces the issue of privacy was important. Mies had to somehow ensure the internal privacy between the different spaces of the house without sacrificing the openness that he was aiming at. Nevertheless, practicality could not have been the sole factor for all the experimentation in Mies's designs. An interesting example from this angle is Mies's first proposal for Ulrich Lange's residence (c. 1935). In this relatively late design, at a time when he had ostensibly mastered his free-plan style, Mies reverted to a cellular organization, although with a different type of arrangement altogether. My initial object was to study this variation in the design of the Miesian villas. Despite the formal differences, there were good reasons to expect that the houses would share a common programmatic sub-structure. A majority of the villas were designed in the context of a culturally defined area (centered around the industrial towns of Krefeld and Brno); they were commissioned by families which belonged to same economic and social class (either rich business families or professionals); and they were all designed within a relatively short period of little more than a decade. The only programmatic variations that could be expected at this level could be due to the composition of families housed, or due to the aesthetic choices of the clients; apart from these there was all the reason to suppose that the houses were designed to house a typical domestic social unit of the affluent German middle class. Accordingly, I expected a strong degree of similarity between the houses at the level of the accessibility graph—or, more precisely, a fairly strong inequality genotype. My intention was to accept this genotype as a basis on which to study what could be called the phenotypical variations in the plans, which would generally result from the architect's preoccupation with form, geometry and dimensions.

The results of the analysis were, however, rather unexpected. Not only was there no indication of a strong inequality genotype, but no genotypical pattern could be found within these houses. I would like to present this analysis in some detail.

3.

I chose, as a sample, fourteen residential plans that Mies produced during this period (figure 4). The major source of the plan was Mies's archive published by MOMA (Drexler and Schulze, 1986), though at times Tegethoff's extensive survey of Mies's residential projects has been useful (Tegethoff, 1985). Some of the plans selected were alternative schemes that Mies had designed for the same commission. The sample excluded those residential plans (such as the Brick and Concrete villas of 1923, and some experimental courthouses) which did not accommodate a clearly specified program. Accessibility graphs were taken as the basis of the formal description in line with the argument that the sociological aspect of a plan (where the genotype would be most consistent) is best captured at the topological level. The discrete nature of the accessibility graphs and the possibility of quantifying their characteristics allows both a reliable description (subject, of course , to the reliability of the method of abstraction) and a precise comparison.

[Insert figure 4 around here]

I chose to base the accessibility graphs upon a modified version of the boundary map of the plans, rather than go with the more conventional minimum convex partition. One reason for this was that minimum convex partition generates spaces to which programmatic labels might be difficult to assign; another, that it is based upon a heuristic method which, given the free-plan arrangement of several houses, could be quite inconsistent. The boundary map, by contrast, is generated by recognizing programmatically defined boundaries between individual components. It generates spatial elements which are not convex, but in this case, convexity was not considered an essential property, since the architect's conception of the space was the chief object of investigation, not the behavioral properties of lived space. A modification was introduced to the normal boundary map through the idea of 'thresholds'. Thresholds were defined as unambiguously defined permeable boundaries between two distinct boundary spaces. In addition to normal doors and portals, a step, a low lintel or even a change in flooring pattern could demarcate a threshold. The accessibility graph was generated by taking each of the spaces defined by the walls and thresholds as a node in the graph and all the thresholds as the links between them. The spatial configuration that is abstracted out through this procedure is not so rigorous as that generated, for instance, by the E- and S-partitions. However, the lack of abstract rigor was compensated by increased practicality in the creation of the component spaces. A correspondence between programmatic labels and the individual boundary spaces arose naturally, although in a few cases of open plans, more than one functional label was assigned to a node. In short, the basis of the approach was the simple notion that buildings under normal circumstances already exist as discrete configurations of spaces.

The first column in Figure 4 shows the boundary spaces created for each of the houses and the second column shows the resulting accessibility graphs justified from the carrier space at the main entrance. Already, at this level, it is evident how different the individual graphs are. Especially interesting is the comparison of the Esters and the Lange houses. These two were constructed during the same period, side by side on the same locality for two similar business families. Their programmatic requirements were almost the same and in their planning and design, they look so similar that it is difficult to distinguish one from the other. And yet, the difference of their graphs is rather striking. There are few noticeable consistencies or trends at this general level, either in the location of rings or of the relative asymmetry of spaces. The unsystematic variation was further emphasized when the first measure of the inequality genotype—the ranking of spaces according their integration values—was computed. The integration values for this ranking were generated without taking the exterior (the carrier) into account. All floors of the individual houses were compared. In effect, the accessibility graph represented each house as a single internalized configuration. As the Chart 1 shows, the ranking of the individual spaces fluctuates wildly with no discernible pattern. In several, the entrance is the most integrated space, but not in enough houses to constitute a rule. The bedrooms, similarly, are highly segregated in many houses, but the rule is broken so often that exceptions predominate. The difference in the graphs of the Lange and Esters houses, continues: the ranking of their spaces by integration values has few correspondences. Even three different versions of a similar house—the residence for Emil Nolde—supposedly designed to a common program do not concur with each other in the ranking of spaces.

[Insert Chart 1 around here] [Insert Table 1 around here]

It is possible that the variation in the assignment of the programmatic labels to the boundary spaces contributed to some extent to the overall fluctuation of their ranks. Several houses feature a combined living-dining space, while others contain distinct areas for dining, men's (library) and women's sitting. Table 1 lists all the programmatic spaces found in the entire batch of plans and integration values for these spaces in each of the houses and illustrates the extent and nature of the variation. One way to establish a more common ground for comparison was to assign all the spaces to broader categories, which would be shared across all the houses. The categorization was done largely on a functional basis (separating the 'social' spaces from the 'private' spaces and these two from the service spaces such as toilets and storerooms). Certain 'service' spaces such as kitchen, pantry, entrance and cloakrooms, were separated out into a separate category of 'functional' spaces, since these spaces were typically one-off spaces. All dedicated 'circulation' spaces were also put into a separate category. The integration value for each category was then computed as the mean integration of all the spaces included in it. This is listed in Table 2. The results of the table, illustrated in Chart 2, show again the remarkable degree of variation even at this level of generalization.

[Insert Chart 2 around here] [Insert Table 2 around here]

Another way to establish a common basis for comparison is to use a smaller set of spaces or labels, common to all houses. The most common of the labels that feature in Table 1 were selected for comparison. Table 3 shows the integration values of all these spaces assigned to these labels. In those few cases where more than one label was assigned to a threshold space, the integration values of the space were listed for each of these labels. Ranking the labels by integration values reconfirmed the variation. However, at this level of analysis, some coherence was discernible in the rankings (Chart 3). Although their rank order varies considerably, one can see that the bedrooms as a rule rarely occur in the top half of the ranks; in contrast, the living/dining areas are invariably found within the top half of the ranks.

[Insert Chart 3 around here] [Insert Table 3 around here]

In addition to the inequality of ranking, a few other measures were tested to confirm the absence of a genotypical pattern. Table 4 shows the distances, in terms of depths, between typical pairs of spaces. The first [five] rows consist of depths of some major living spaces from the carrier. The latter rows contain the depths between the main functional areas: bedrooms, family and social space and the kitchen/service area. Here again, there is no consistent common pattern either at the global level or at the level of local configuration of spaces.

[Insert Table 4 around here]

There is, in other words, no genotype for this sample at the level of the configuration of programmatic elements. Simultaneously, it is also clear that no genotype exists in terms of pure formal configuration of spaces. The individual graphs are visibly different from each other. The only hint of a genotypical pattern is seen when selected basic labels are taken for comparison. But this trend is so generic that it would work for any set of houses; it is to be expected, after all, that bedrooms would in general be deeper than the daytime living areas. The value of a good genotypical model lies in its ability to generate not just the common elements that underlie each phenotype, but also the limits of variations possible for the phenotypes. In this case, no such mechanism appears to be operating as Mies seems to experiment almost at will.

How is one to read this result? Clearly, the variation in the graphs and their labeling is much more than can be accounted for by the difference of individual choices of clients or of the programmatic elements. It may be argued that the differences are merely accidental, but that would be tantamount to rejecting the sociological validity of graphs entirely. The argument that I would like to follow, instead, is that such differences were the result of a deliberate, but not direct action on Mies's part. In other words, the variations of graphs were directly connected to the formal experiments that Mies was conducting at the level of the geometry of shape and measure.

4.

Let me illustrate this with an example (figure 5). Consider the plans of the Lange residence. The entire floor consists of rooms organized around a central corridor. In one wing, the rooms (bedrooms on one side and service rooms on the other) open directly into a corridor that itself connects to a central corridor. In the other wing, there are two clusters of rooms , each grouped around a lobby. The lobbies in turn connect to the central corridor. The ground floor is organized in three clusters too—a cluster of formal and semi-formal reception rooms, a kitchen/pantry cluster and an entrance area, all connected together in a ring. Syntactically, with respect to the ground floor, the three bed clusters are organized in a symmetrical relationship with each other. Additionally, it is possible to go from one cluster (and even each room) into another without going through a third. Suppose, now, that the architect is faced with the problem of relocating all the space on one floor. The only way that the bedroom clusters can be located in a mutually symmetrical manner with relation to the original ground floor rooms would be through the use of a central corridor (figure 5b.i). If additionally, the architect decides not to use a corridor or some circulation space, a problem is created: the graph with five or more mutually connected nodes (even if, for the sake of simplicity, the entire ground floor is reduced to a single node) is not planar (figure 5b.ii).

[Insert Figure 5 around here]

One solution is to have the rest of the body of the house (or any of the rooms) act as the mediating element between the rooms (figure 5b.iii). This approach may take two directions—one, under the constraint that the convexity of the rooms be maintained and the other where this constraint is relaxed. In the first case, the master-bed cluster is located off the living room, and the secondary bedrooms, in another cluster off the dining room (figure 5c.i). With some geometrical rearrangement, and the removal of some extra rooms, the resulting arrangement transforms into the plan of the Lessing house (figure 5c.ii). In the second case, the living rooms (library, sitting room, dining room and the hall) all merge together and deform into an L shape to which the master bedrooms and the secondary bedrooms attach (figure 5d.i). This, in turn, with a few geometrical liberties, gives us the plan of the Ulrich Lange house (figure 5d.ii).

At this point, several questions may be raised about the entire exercise—it appears to be both somewhat ad hoc and whimsical. With what right do I take the liberty of breaking up the houses into clusters and reassembling them? And, with what logic do I select and relax constraints? Partly, my defense is to state that the exercise is not intended to be analytical or rigorous—its purpose is illustrative. But at the same time, neither the choice of my constraints, nor my rearrangement of the interior configuration, is completely arbitrary.

To take the second point first, while rearranging the plans, I have maintained integrity at two levels—at a higher level, entire clusters are relocated. At a lower level, all the rearrangement happens within each cluster—no room is moved out of one cluster into another. The reasoning behind this is obvious once embedded graphs of all the houses are considered (figure 4, third column). It is evident that typical clusters—a primary bedroom cluster (PB), a secondary (and sometimes a tertiary) bedroom cluster (SB1 and SB2), a reception cluster (R), a kitchen-pantry cluster (K) and an entrance-cloakroom cluster (E)—appear in all the houses. More remarkably, the relationship between these clusters remains more or less consistent. In each case except one, the reception cluster, the kitchen cluster and the entrance cluster construct a ring. The location of bedroom clusters varies, but they are always in a symmetrical relationship to each other, vis-a-vis the rest of the house.

While it may appear that clustering of rooms is a common feature of plan layouts, and that the clusters occurring here, themselves, are typical, two points make these clusters distinctive—first, that the clusters here are spatially determined and, second, that each cluster is self-sufficient from the point of view of internal accessibility. The example shows, how just by rearranging the composition of clusters and the composition of rooms within clusters, but not modifying the assignment of rooms to clusters, it is possible to transform one plan into another—even in such mutually different cases as the Lessing, Esters and U. Lange houses.

This observation is significant on a number of counts. For one, it clarifies the formal experiments that Mies tried out during this period by giving us a sense not just of what was possible, but also what was not possible for him to do. The variations amongst the houses happen in two ways-the manner in which the bed clusters relate to the rest of the house (either directly or through corridors) and the manner in which each cluster is organized internally. The impact of Mies's formal concerns-avoiding corridors, opening up the house to the exterior, composing a freely flowing interior space-can be studied in a precise manner. For the present however, I would like to attend to more general issues that arise from this.

5. The typical representation, within Space Syntax, of the topological description to some form of the accessibility graph gives the configuration a flat or non-hierarchical flavor. The only organization that is considered is at the level of each component space (whether convex or boundary) of the configuration. The exercise above recognizes that there may exist levels of hierarchy within the topological description. In the Miesian schemes above, at least two levels of hierarchy are maintained. At one

level are the clusters, which are arranged within a remarkably consistent pattern of variation. At the other level is the arrangement within each cluster. At the level of the individual boundary spaces, the variation in the configuration is random, but once both the levels are considered, the variation appears to be much more consistent.

Once we begin to concern ourselves with the hierarchical arrangement of plans, geometry enters into the picture. By geometry here, I mean not just issues of shape and sizes, but the entire gamut of spatial relations beginning with topological relations. For it is important to note that although we have been discussing graphs as representatives of the topological structure of a plan, the manner of using them in Space Syntax abstracts out much of the basic topology of the plan as well. The unembedded graph that is used as the descriptor of spaces within Space Syntax research preserves only the relationships of immediate proximity. Other topological relationships in a plan—such as those of boundary and enclosure —are removed from consideration. However, it is these relationships which come into play when we consider the hierarchical organization of plans. We have already seen that the clusters of rooms are spatialized entities: all the rooms of a cluster are defined, not only internally through a common circulation core, or a network of connections, but also through a distinct boundary.

As we introduce topology into the picture, we can identify further hierarchical structures: Mies has a tendency to organize the clusters themselves into larger entities, such as blocks, wings, or floors. But, again, at this level the organization varies considerably from house to house. It is at this level that geometry proper, dealing with properties of shapes and sizes, comes into play.

Here we can return to an unresolved issue: the seemingly "arbitrary" restrictions, which I had placed in my transformation, exercise, such as disallowing corridors and enforcing or relaxing convexity. These restrictions are actually not arbitrary. House plans done in the early 1920s—the Brick house, the Lessing house and, in all probability, the Concrete house—are all attempts to design a house without a corridor based circulation spine. In the Brick house, additionally, we can see an attempt to get away from cellular planning. These houses, however, all remained experimental cases and in the built schemes such as Lange and Esters houses, Mies resorted to the corridor-based plan. Only with his court-house schemes of the 1930s when he was able to allow the free planning ideas of the Tugendhat and Barcelona pavilion to distort the major public space of his house was he able to resolve the simultaneous presence of lack of corridor and freely flowing interior space. This background allows us to understand the nature of Mies's explorations. Programmatically, Mies approached each design with a scheme of clusters which could be spatialized only in a limited number of ways, since the rooms could not be reassigned to different clusters and the clusters themselves could interconnect in a limited number of ways. At the level of geometry, however, Mies could try different hierarchical combinations and introduce different types of organizational schemes, allowing or disallowing circulation spaces and distorting shapes of rooms.

The arguments presented here are, admittedly, somewhat speculative; detailed exploration is needed to show how the proposed hierarchical model was played out in Mies's work, and, more importantly , it needs to be shown how Mies's case may be generalized. However, the case does give a strong indication of how and at what level geometrical description may help us in understand designing. A geometrical description is involved with design at a cognitive level, in the same way that a graph is involved with the design at a sociological level. What the paper does is give us a hint as to what specific role geometry plays within the cognitive aspect of designing a plan, at least in part. The impact of geometry on a plan is to introduce progressive restrictions on a plan, or to borrow a phrase from Cassirer, to cause the gradual concretion of a plan. At the level of topology, this is manifested in the imposition of a classificatory schema based on basic spatial categories such as interiority-exteriority, inbetweenness, and adjacency. To spatialize, in short, is to classify. At the level of higher geometry, the impact is manifested in the fine-tuning of this classificatory scheme: in specifying the restrictions which will distinguish two equivalent topological schemes and help in the choice of one. In other words, rather than looking at topology as restricting the field of geometric possibility as we discussed at the end of section 1, it is better to see geometrical concerns as restricting the possibility of topological variations.

References

Drexler A and F Schulze (Ed.). (1986-1997).The Mies van der Rohe Archive. New York: MOMA. V. 1-5.
March L and P Steadman. (1971). The Geometry of Environment. London: RIBA. March L and C F Earl. (1977). 'On counting architectural plans.' Environment and Planning B: planning and design. 4: 57-80.
Hillier B and J Hanson. (1984). The Social Logic of Space. Cambridge: Cambridge University Press.
Hillier B, J Hanson and H Graham. (1987). 'Ideas are in things: an application of the space syntax method to discovering house genotypes.' Environment and Planning B: planning and design. 14: 363-385.
Hillier B. (1997). 'Why Space Syntax Works: when it looks as though it shouldn't.' London: Proceedings of the 1st International Space Syntax conference. Vol. II. pp. Peponis J. (1999). 'The logic of space and the reasons of design.' Brasilia: Proceedings of the 2nd International Space Syntax conference. (forthcoming).
Peponis J, J Wineman, M Rashid, S H Kim and S Bafna. (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.
Peponis J, J Wineman, M Rashid, S H Kim and S Bafna. (1998a). 'On the generation of linear representations of spatial configuration.' Environment and Planning B: planning and design. 25: 559-576.
Peponis J, J Wineman, M Rashid, S H Kim and S Bafna. (1997). 'Describing plan configurations according to the covisibility of surfaces.' Environment and Planning B: planning and design. 25: 693-708.
Rashid M. (1998). On the configurational studies of building plans from the viewpoint of a situated observer. Georgia Institute of Technology: unpublished Ph.D. dissertation.
Steadman P. (1983). Architectural Morphology. London: Pion.
Tegethoff W. (1985). Mies van der Rohe: Villas and Country Houses. New York: MOMA.

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