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Characterization of Bubble Diagram in the Process of Architectural Form Generation

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Abstract

A bubble diagram is understood as a graphic medium which bridges program and plan in architectural design process. The role of a bubble diagram is either to generate or to explain a plan in relation to its program. Despite the explicit role of a bubble diagram in architectural design process, what a bubble diagram indicates exactly is very ambiguous. Here I attempt to reveal the nature of the bubble diagram more sharply. My main argument is that the ambiguity of a bubble diagram results from the fact that it is used to range two different types of representational formats. Reviewing the theories of shape recognition and shape representations in vision science, I will also argue that the procedural description of architectural design process should be criticized and that the focus of design method research has to be shifted into the representational format of form description in architectural design process.

Keywords: design process, bubble diagram, shape representation

1. INTRODUCTION

In architectural design, a bubble diagram is understood as a graphic medium which bridges program and plan. That is, a bubble diagram is derived from a program in order to develop building plans from it. Or a bubble diagram is abstracted from a building plan in order to show visually how the plan meets the requirements of its program. Indeed, a bubble diagram, as a true intercessor between program and plan, can be formulated in either direction to make generative or explanatory graphics.

The role of a bubble diagram is either to generate or to explain a plan in relation to its program. Despite the explicit role of a bubble diagram in architectural design process, what a bubble diagram indicates exactly is very ambiguous. This is not only because the term diagram covers a large range between linguistic sentences and photographic pictures but also because deliberate efforts are rarely made to define a bubble diagram in architectural discipline. Here I attempt to reveal the nature of the bubble diagram more sharply. My argument is that the ambiguity of a bubble diagram results from the fact that it is used to range two different types of representational formats.

In this paper I will first review the development of design process research in light of form generation and argue that the focus of design method research has to be shifted from the operational rules of form transformation into the representational format of form description. The origin and the role of bubble diagram in architectural design process will be examined and the representational format of bubble diagram will be specified in the course of examining both programmatic approach and typological approach in form generation.

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2. DESIGN PROCESS AND FORM GENERATION

'What is designing? 'This question keeps recurring in the design method movement. The underlying purpose of this question was, of course, to place the focus of attention on the design process rather than on its end product, that is, architectural design. The theoretical interest in architectural design process had been traditionally neglected primarily because the value of an architectural design was commonly assumed to be appraised independent of its design process.

However, it must also be noted that both mythical and practical attitudes also contributed to the indifference to architectural design process. Many assumed that architectural design process is a 'black box' mystery not just because it closely intertwines with the brain but also because it concerns creativity which they fancifully believed to be left susceptible to manipulation, but not to analysis. In addition, every practicing architect knew that the outcome of architectural design process research must be very limited in terms of practical knowledge. The outcome could not lead to the scientific and objective recipes by which an architectural design is automatically derived from the client's design brief.

Architectural design process naturally attracted attention when Alexander outlined an ambitious proposition for the systematic process of designing a physical form which answers a complex problem.[1] He argued that because the functional requirements of a physical thing get very complex, designers no longer intuitively grasp the order which the requirements call for, so they need a way of representing the requirements which makes them easier to solve. Alexander introduced a mathematical tool for the hierarchical decomposition of a set of functional

[1]) See, Alexander C., Notes on the Synthesis of Form, Harvard University Press, 1964.

requirements.

Alexander's main idea is that the design of a physical form should not be made directly from functional requirements but via another level which is one step further away from the actual world, as shown in Figure 1. The direct synthesis from complex requirements to the design of a physical form is beyond the designer's control because designers cannot grasp the order which the requirements need. In contrast, he argued that the derivation of the diagrams (F3) from the program (C3), though still intuitive, is. "out in the open, and therefore under control".[2]

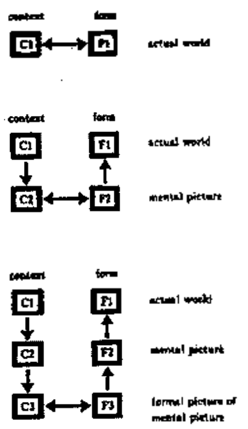

Figure-1. The Relation between Form Diagram and Context Program

What he means is this. When the interacting and conflicting relations of functional requirements are hierarchically decomposed into the successively nested sets of functional subsystems, designers can cope with the original complexity of functional requirements by dealing with each small independent set of requirements step by step. The invention of a diagram, that is constructing an abstract pattern of physical structure which resolves each small independent set of functional requirements, can be achieved, although the diagrammability may depend on the physical implications of the requirements of a set. Independent diagrams are put together through addition to form a larger diagram. The path from the diagram (F3) to the design (F2) was considered purely as a matter of local detail. Thus, Alexander argued that the form's basic organization is born precisely in the constructive diagrams which precede its design.

This systematic analysis-synthesis approach was radical not just because it aimed to demystify the design process but also because it disregarded the conventional system of appraising an architectural design, that is visual or expressive qualities and the meaning of the form. Instead, the approach assumed that a design can be appraised by explicitly relying on the concept of fitness to purpose. The analysis-synthesis approach was soon severely undermined because it became widely accepted that the requirements of a design in general are an 'ill-defined' problem in the sense that the information used and the criteria for evaluating the solution are not well defined. As the appraisal of an architectural design became more fragmented, a new viewpoint of architectural design emerged as a social project. When architectural design is considered as a social project, a new issue arises separate from the appraisal of an architectural design: that is user participation in the design process.[3]

As far as architectural design is concerned, design process research has to address the question of how the physical form is generated. That is, form generation should be the main subject of design methods. However, in the verbal process of user participation practiced by the design method movement, debate concerning diverse issues and opinions became the main subject and form generation was simply deserted. It is hardly surprising that this verbal process attracted little attention from architects as it seemed anti-professional and irrelevant to the architectural design process. My main point here is that form generation does not naturally follow from verbal discussions.

This discussion hinges on the inherent difference between two types of information: pictorial information such as drawings or physical models and linguistic information such as words or numbers. The linguistic result derived from approximating the diverse opinions expressed in verbal discussions among participants is shapeless in the sense of the arbitrary connection between signifier and signified. On the contrary, pictorial output in the design process depicts the building naturally through drawings and physical models.

Through reliable techniques of social science, important issues such as area, security, privacy, cost, etc. may be identified, negotiated, and/or agreed upon. It is possible to check, discuss, or even agree upon whether a design meets all these intangible considerations; however, it is theoretically impossible to specify the operations of generating a form from intangible considerations. For example, once a design is completed, the area of its shape can be logically calculated or participants may vote on different aspects of the design. However, in a given area, the unique choice of a shape cannot be made logically because there are so many shapes which meet the area requirements.

Without both physical components and the rules of arrangement which naturally result in form generation, lay users do not know what to do simply because they do not know what the components are nor how they should be arranged. Therefore, in the actual practice of user

[2]) ibid, p.78

[3]) Horst Rittel argued that user participation in the design process did not arise from the deontological argument but from the logical argument because the designer cannot claim his knowledge is superior to lay users because of the ill-definedness of design problems. However, I disagree with him because the primary purpose of designing is not to understand the design problem but to produce possible design solutions. See Rittel H. "Planning Problems are Wicked Problems" in The Development of Design Methodology, edited by N.Cross 1984, pp.136-144

participation, form generation made by lay users is essentially controlled by the architect. Normally the architect has to provide the framework in which users generate a form.[4] In other words, the scope of user participation is confined to the dependent part of a form and the dominant part of a form is left to the architect. I would thereby argue that architectural design process with user participation should be characterized as 'controlled collaboration' rather than 'equalized cooperation'

It is very interesting to see the design method movement come back to the traditional view of architectural design process, that is the generate/test cycle, because the movement started from the assumption that the traditional architectural design process was no longer capable of dealing with the complexity of a design problem.[5] In contrast with the previous two views of the design process, the generation/test cycle puts form at the center of focus. In the generation/test cycle, nothing impedes form generation. It is not exaggerating too much to say that this third generation of generate/test cycle is proposed in order to eliminate the erroneous tenets which hamper form generation in both systematic and verbal processes.

There are two key questions in architectural design process research. One is what a form is. And the other is how it comes up in the design process. The second Question cannot be answered without answering the first one. However, we also cannot answer the first without mentioning the second. I would argue that the crucial problem in design method today is that operational rules of form transformation become the sole subject and the description of a form is not attempted .

This may be attributed to several advantages of investigating operational rules versus describing a form. First of all, it is technically much easier to focus on the operational rules. Any transformation can be formulated as a combination of simple and generic geometric operations such as scaling, translation, rotation, reflection, etc. Any transformation can be encapsulated in the simple logic of production systems and can be readily computerized. Secondly, it is clear that the operational rules are also useful or may be more valuable in generating a new form. Inventing a new form can be described as a sequence of operations. Thirdly, it seems to me that the value-laden emphasis on the 'procedure' plays a significant role in blindly focusing on operational rules. The objective description of a form has to be essentially the other half of design method.

4) In the much publicized case of Lucian Kroll's buildings for Louvain Medical School, the architect had to provide flexible partitions and modular grids and rules by adopting SAR methodology. It must be also noted that the form is already divided into two, support and infill, and that users cannot exercise any control over support design. See Lucian Kroll, "Anarchitecture" in The Scope of Social Architecture, edited by R. Hatch pp.167-181, 1984.

5) Broadbent argued in "The Development of Design Methods" that the design method movement proceeded into a third generation, taking the Popperian view of designing, that is first generating a design conjecture whenever possible and testing the design conjecture as rigorously as possible. He pointed out that the conjecture/analysis is drawn from the parallel between methodology of science and methodology of design by Hillier et al., in the article "Knowledge and Design". Two articles of architectural design process research ("The Primary Generator and the Design Process" by Jane Darke and "Cognitive Strategies in Architectural Design" by Bryan Lawson) support this generate/test framework.. The above four articles are reprinted in The Development of Design Methodology edited by Nigel Cross.

3. PROGRAMMATIC APPOACH AND TYPOLOGICAL APPROACH

In postwar modern architecture, there are two different theoretical approaches to form generation in the design process. One is the programmatic approach in which a form is newly constructed from the given program and this approach proceeds inherently in a bottom-up manner. The other is the typological approach in which a form is borrowed from preconceived classifications of existing forms and this approach follows proceeds inherently in a top-down manner. The critical review of those two approaches serves well in the investigation of the method of form generation in architectural design.

In the sixties, Argan renewed the theoretical discourse of the type by proposing it as a starting point floor the architects working process.[6] For Argan, the working out of every architectural project has this typological aspect. He thus argued that following the succession of the architect's working process, formal architectural typologies will always fall into three main categories: complete configuration of buildings--plan, major structural elements--structural system, decorative elements--surface treatment. It seems sensible to infer that the memory of an example or the image of its abstract construct is used as a starting point for the design process. In this respect of using some kind of mental image as the structure of a whole, typological approach is quite convincing in a practical sense.

In a typological approach, a plan is generated not from the program but from the type. The question thus lies in the first place on what a type is and then the process of generating a plan from a type can be explained. Argan made an explicit comparison of a type to the iconographic and compositional treatment of themes in figurative arts and he also agreed with the general belief that a type must be treated as a schema of spatial articulation which has been formed in response to a totality of practical and ideological demands. Because Argan made it clear that a type is not a categorical concept but a prototype, it seems obvious that a type .can be described explicitly. However, it is only Possible to gain a metaphorical sense of Argan's type because he did not give any description of a type and because what he describe as the formation of a type defied the explicit description of a type.

Instead of describing what a type is, Argan explained the

6) See "On the typology of architecture" by G.G. Argan in Architectural Design, December 1963.

process of forming a type: "Type is never formulated a priori but always deduced from a series of instances···· In the process of comparing and superimposing individual forms so as to determine the type, particular characteristics of each individual building are eliminated and only those remain which are common to every unit of the series. The type therefore, is formed through a process of reducing a complex of formal variants to a common root form."[7] This text may be understood in the metaphorical sense that when individual forms, for example plans, are superimposed in front of our eyes, their similarity can be recognized. It must be noted that without specifying what the elements are, the common characteristics of plans cannot be extracted by simply overlapping one plan on the top of the other. This naive and faulty argument is due to the fact that Argan overlooked the real difficulties of formulating a coherent system for specifying similarities and differences between shapes which are not identical.[8] I would argue that Argan failed to describe the formation of a type at the methodological level because he never examined the format of the representation.

It is important to note that typological theory is closely related with the perceptual theory of recognizing a familiar object. This perceptual theory is normally known as the constructivist paradigm of visual perception.[9] The essence of the constructivist paradigm is that visual perception is a cognitive process explained as the coupling mechanism of hypothesis formation arid corrigible testing although the process is unconscious. Appropriate knowledge interacts with sensory input to create a stereotyped hypothesis of psychological data. The hypothesis is advanced to predict and to make sense of a particular object in the world. In other words, an individual object is recognized first by identifying its stereotyped structure, that is a schema, and then by noting a number of features that identify the object more specifically.[10] In this explanatory framework, perception is thought of as an indirect, inferential process which is schema-driven in a top-down manner.

Argan's argument about the thinking and working process of an individual architect is that design process is to be construed in terms of the relation between type deduction and artistic creation if a type exists in our brain from past historical experience. It seems clear that what is sought in type formation is the perceptual schema and that Argan's method of finding it is not accountable. In order to ground a theoretical argument on the methodology of form generation, Argan has to describe what a type is. Without knowing what a type is, no one can follow the typological approach of form making, that is the process from a type to a form. Argan did not give any real example of a type. For example, Argan refers to historical types, such as centrally planned or longitudinal temples or those resulting from a combination of the two plans without showing what he indicates by them. My argument is simply that Argan did not propose the typological approach of form making in a methodological sense because a type is not described, although the functional role of a type is defined in relation to its subsequent form.

The programmatic approach of form generation cannot be correctly understood without the knowledge of what the program is in the first place. The program here refers to a description of the spatial dimensions, spatial relationships, and other physical conditions required for the convenient performance of specific functions.[11] The main argument of the programmatic approach is that because an architectural design is tested by its functional requirements, the form of an architectural design has to be generated primarily from a rough configuration that adumbrates this eventual pattern of repetitive human activities. The idea of the 'bubble diagram' is central to the programmatic approach of form generation.

A bubble diagram has been frequently associated with the functional parts and their relationships in a machine in an analogous sense. And it is often mistakenly assumed that a bubble diagram arises somehow as a by-product of machine design. Nevertheless, I here would argue that a bubble diagram appears not as the result of machine design but by factory layout. However, factory layout designers treat a factory as an individual product because each layout plan is fundamentally unlike any other.[12] In this sense, the

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[7]) ibid.

[8]) In order to see the sheer difficulties of shape discrimination and classification, refer to the attempts at the Psychophysics of shape in Perception, by J. Hochberg, 1978, pp.132-134.

[9]) See Ian Gordon, "Empiricism: Perception as a constructive process" in Theories of Visual Perception, John Wiley & Sons, pp.122-145. See also "Is Computational Psychology Constructivist?" in Artificial Intelligence in Psychology, by M. Boden, MIT Press, 1989

[10]) According to Hochberg (Perception, second edition), the term schema was first used by a physiologist to refer to the context that embeds all experience. Hochberg defines schema as the structure by which we encode and generate the shape information of an object. An individual object is recognized first by identifying its schema, and then by noting a small number of features that identify the object more specifically and set it off from other examples of the schema to which it belongs. In cognitive psychology, the idea of a schema is not restricted to shape information but usually conceived in a much wider sense. Schema normally refers to the memory structure which is pertinent to the task. In other words, a schema is a particular bind of knowledge packet, that is a stereotyped response to the problem at hand. See Cognition and Cognitive Psychology by A. J. Sanford, 1985, pp.194-225, See also Cognitive Psychology by Ulric Neisser, 1967, pp.286-292.

[11]) See John Summerson, "The Case for a Theory of Modern Architecture" in The Unromantic Castle, Thames and Hudson, 1990, pp.257-266.

[12]) In order to be wholly supported, this argument may need vast evidence and elaboration which is certainly beyond this paper. Here, I just want to point out three supporting facts. First, the elements in a bubble diagram indicate void spaces like areas in a factory, not solid materials like parts of a machine. Second, the relationships between space elements in a bubble diagram indicate not only the automatic flows of physical substances but also deliberate human activities. However, the functional chart of a machine design is only confined to the automatic flows of physical substances such as information, force, power, energy, and/or materials. On the other hand, the functional chart of a

task of architects is more similar to that of layout planners than the task of machine designers.

It can thus be argued that the idea of using bubble diagrams originates from an industrial engineering concept of facilities planning, more specifically, layout planning. The underlying premise of facilities planning is that the efficiency and productivity can be enhanced by properly planning facilities and activities, One of its critical processes is allocating areas for equipment and activities, which is called layout planning. The goal of layout planning is to systematize the process of producing a proper layout alternative. In 'systematic layout planning' (SLP) which exemplifies the programmatic approach, a space relationship diagram (SR-diagram) is used as a generative mediator to arrive at layout alternatives as shown in Figure 2.[13]

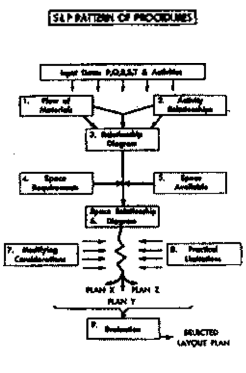

Figure-2. The Procedure of Space Layout Plan Derivation

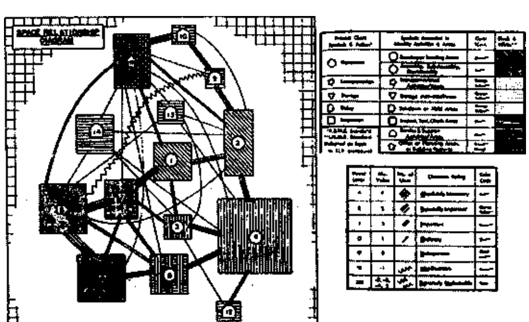

Figure-3. A Representation of Space Relationship Diagram

The SR-diagram as shown in Figure 3 carries two different kinds of information. One is the information about the space elements and the other is the information about the spatial relations between space elements. The format of the representation of the SR-diagram is not pictorial. The shape information of space elements is not present in the SR-diagram although the size is naturally indicated by the area template in which two different symbolic signs of activity and area categorizations are present The spatial relations between space elements are specified in the symbolic signs of closeness rating. An SR-diagram has the abstract constraints of a plan but not the shape information of a plan.

In the SLP procedure, space layout plans are generated directly from an SR diagram. Although Mutter provides some practical suggestions of using unit-area blocks, building feature units, and strips of several machines, he does not propose any systematic procedure to generate space layout plans from an SR-diagram. Muther argues that "as soon as Box 6 (SR-diagram in Figure 2) is put together, the bottom drops out of it. The planner finds himself adjusting, modifying, integrating, blending and massaging the diagram to get an acceptable layout."[14] As far as the procedure from SR-diagram to space layout plan is concerned, Muther's argument that plans are generated from an SR-diagram naturally and instantaneously is void in a methodological sense because he does not specify how space layout plans are derived from an SR-diagram.

Two different methods of programmatic approach have been developed for spatial synthesis in computer aided building design. Each method specifies the process of generating space layout plans from an SR-diagram. One may be named a quadratic assignment method and the other an adjacency graph method.[15] In the quadratic assignment method, a grid is imposed on a site and the areas of space elements are divided into the same modular units. The task is to assign the modular units of space elements to the grid locations of a site in such a way that the linear objective function, such as minimum circulation cost or some directly analogous measures, is optimized. The closeness rating of the SR- diagram has to be quantified into the interaction matrix of circulation data and the boundary of a site such as the building boundary is outlined.

Despite the technical problems, the quadratic assignment method may be very useful for fairly restricted floor plan layout for buildings such as warehouses and industrial plants, where circulation efficiency is the primary determinant of space layout. However, the space layout plan cannot be determined sorely by the circulation efficiency, which may be a constraining factor. Aside from the practical limitations caused by the correct circulation data, there are serious flaws in the theoretical assumption that the actual configuration of the plan should reflect only the circulation flow volume. Because the quadratic

factory layout deals with both material flows and human activities of operating and service supporting. Third, machine designers usually create specifications and written requirements for a product to be made in lots and batches.

13) See Richard Mutter, Systematic Layout Planning,1973

14) ibid., p.9-1

15) This distinction is borrowed from Mitchell's quadratic assignment formulation and adjacency requirement graph formulation of architectural spatial synthesis problems. See Computer-Aided Architectural Design, by W. J. Mitchell, Van Nostrand Reinhold Company, 1977, pp.426-436. Similar distinction is made by C, M. Eastman "The Scope of Computer-Aided Building Design" in Spatial Synthesis in Computer-Aided Building Design edited by C. M, Eastman, Halsted Press, 1975.

assignment method is meant to solve only its own narrowly defined objective, it fails to provide meaningful assistance for architects.

In the actual design process, architects frequently use the space adjacency diagram (SA-diagram) which has many different variations as shown in Figure 4. The SA-diagram is equivalent to the SR-diagram in the sense that both diagrams use the same format of representation. Like the SR-diagram, the SA-diagram has two symbols, The space elements are indicated in terms of area templates and the spatial relations of adjacency requirements are indicated in terms of topological connection. A space layout plan is produced from a topological graph via dual graph relationship in the adjacency graph method.

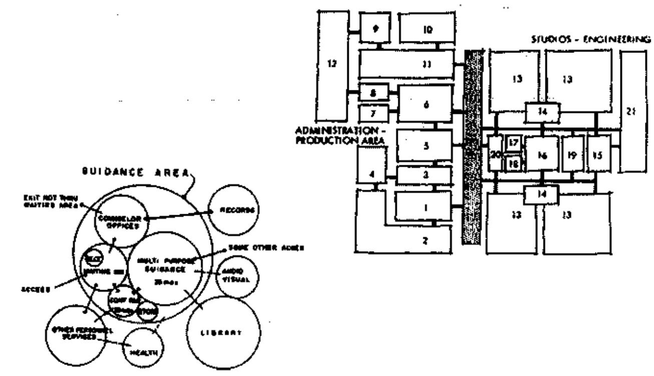

Figure-4. Two different examples of Bubble Diagrams

Compared with the quadratic assignment method, the adjacency graph method is more appropriate for form generation in architectural design both because it relies on the constraints rather than an objective and because the SA- diagram specifies the topological structure rather than the system's performance. It is thus possible for an architect to position the space elements and also to manipulate their areal quantity and shape while keeping his eye on the topological constraints of the SA-diagram. The SA-diagram is mostly known as the 'bubble' diagram. The nature of bubble diagrams can be easily understood when an SA-diagram is contrasted with a jigsaw puzzle. In a jigsaw puzzle, the boundary of each piece is rigid. On the contrary, the boundary of each space element in the SA diagram is flexible.

The adjacency graph method can also be understood in comparison with the process of solving a jigsaw puzzle. Solving a jigsaw puzzle is the sequence of operations of finding the unique connection between two adjacent pieces. Because the congruent boundary connection is unique, the strategy of finding each adjacent piece one by one must work. In this 'piecemeal strategy', what matters is the local details about the congruent boundary connection between two adjacent pieces. The global structure of the rough locational relations along pieces need not be figured out in solving a jigsaw puzzle; in fact, the rough locational information hampers rather than facilitates the finding operation. On the contrary, the shapes of area bubbles and their spatial relations are not found but formed in the adjacency graph method.

The piecemeal strategy which shapes two adjacent area bubbles without considering other space elements is a blind search in the following two respects. First, the piecemeal strategy may end in a dead-end situation in which the constraints of a SA-diagram cannot be fully satisfied. Second, the piecemeal strategy deals only with the particular pair relations which are formed in the sequence of shaping area bubbles. In other words, the piecemeal strategy does not evaluate a space layout plan as a whole but only in a very partial way. What matters in a space layout plan should be the totality that is formed by all space elements and their spatial relations. Therefore, the adjacency graph method has to take the 'global/local strategy' where all area bubbles are roughly located and then the area bubbles are solidified as the subsequent modification of local details proceeds.

It must be noted that the plan (line drawing plan) is one thing and the space layout plan is another. The lines in a plan are material elements while the lines in a space layout plan are not necessarily material elements. The space layout plan is different from the plan in terms of the format of the representation. The plan is a planar picture while the space layout plan is the arrangement of space elements. The space elements of a space layout plan are made explicit in the sense that the boundary line of each space element is fully enclosed. On the contrary, the space elements are not made explicit in a plan because the segregation of space elements is not definite. A plan can be described as the composition of line elements in addition to the arrangement of space elements.

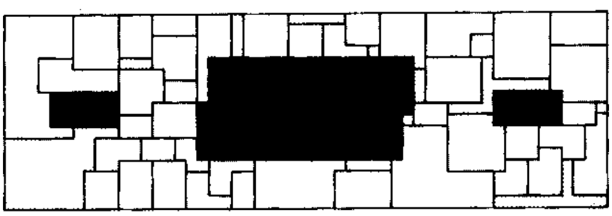

Figure-5.1 a Space Layout Plan of an Office Floor

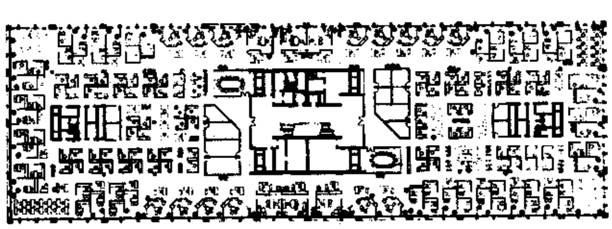

Figure-5.2 a Detailed Plan of an Office Floor

4. THE REPRESENTATIONAL FORMAT OF BUBBLE DIAGAM

The bubble diagram conceived by Freedman as shown in Figure-6.2 is meant to connect the topological graph of Figure-6.1 with the plan of Figure-6.3.[16] Enclosed by the flexible outlines, the area bubbles of Freedman's bubble diagram look very pliable and fluid, like the area bubbles of the SA-diagram. However, they are not area templates which are the symbolic signs, but shape primitives which contain adumbrated shape properties such as elongation, bending, or tapering. Unlike the topological links in the SA-diagram, the spatial relations in Freedman's diagram are not indicated by symbolic signs but depicted by the metric locations in the drawing. Freedman's bubble diagram is very different from the SA-diagram in terms of the representational format. Freedman's diagram has to be understood in terms of pictorial representation while the SA-diagram has to be understood otherwise.

Despite the differences of external appearance, SA-diagram is much closer to the topological graph in terms of representational format. The point in the topological graph is simply replaced by the area template in SA-diagram. Thus, an SA-diagram can be derived logically from its topological graph as the areas of space elements are normally given in the program. However, a Freedman's bubble diagram cannot be uniquely derived from its topological graph as the shape of each space element as well as its spatial locations are not specified normally in the given program.

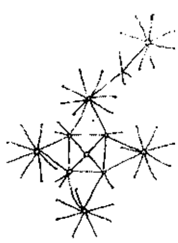

Figure-6.1 A Topological Graph of a Library Ground Floor Plan [17]

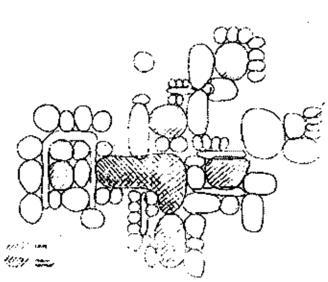

Figure-6.2. A Bubble Diagram of a Library Ground Floor Plan[18]

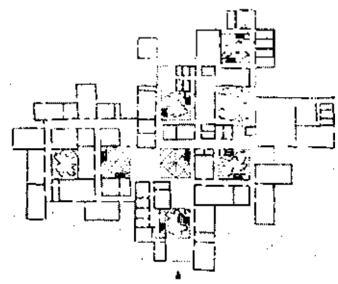

Figure-6.3. a Library Ground Floor Plan sketched by an Architect[19]

Freedman's bubble diagram is certainly different from the plan in terms of representational format because it cannot be read as the composition of lines, that is, a planar picture. Because Freedman's bubble diagram is the arrangement of space elements, it is identical with the space layout plan in terms of representational format. Like the space layout plan, the space elements in Freedman's bubble diagram are depicted by areal shape primitives and their spatial relations are specified by their relative locations in the drawing. It is very important to note that the distinction of Freedman' bubble diagram from both SA-diagram and plan is based solely upon representational format which raises two fundamental questions: which primitive symbols can be found in a diagram and what kind of relations among them can be specified?

On the other hand, Freedman's diagram appears very different from the space layout plan because of the inherent implications of two different outline types. The curved and adumbrated outline of the space element in Freedman's diagram looks fluid to a certain extent while the straight outline of the space element in the space layout plan seems rigid. What is implied in the apparent relation of the space layout plan to Freedman's diagram can be characterized as the transformation process of schematization. Freedman's diagram is a 'schematic' plan in the sense that the schematic areal shape of each space element in the plan is made explicit. Because Freedman's diagram can be differentiated from the space layout plan despite their affinity in representational format, Freedman's bubble diagram is herein designated a 'space scheme'.

The ambiguity of bubble diagram results from the fact that it is used to range both SA-diagram and space scheme each of which is described differently. SA-diagram, SR-diagram and space scheme are normally considered as bubble diagram in a wider sense.(see Table-1) The representational format of SA-diagram is different from that of space scheme in the following two respects. First, the space elements of a space scheme carry shape properties while those of an SA-diagram do not carry shape property but areal quantity. Second, the spatial relations between space elements in a space scheme are metric while those in a SA-diagram are topological.

[16]) See "Communicating with Users", in The Scope of social Architecture, pp.153-160.
[17])ibid. p.158
[18]) ibid. p.158
[19]) ibid. p.159

Two things must be noted in relation to the idea of space scheme. First of all, space schemes denote not only Freedman's bubble diagram but also the descriptions which can be differentiated from SA-diagrams, plans and space layout plans. I merely use Freedman's bubble diagram as an example to show what a space scheme might be. Second, a space scheme cannot be logically derived from an SA-diagram unlike Freedman's argument that his bubble diagram can be derived naturally from his topological graph through the programmatic approach.[20]

In the process of concretizing an SA-diagram to a space scheme, the space templates of the SA-diagram has to be changed into the space primitives of the space scheme each of which has its own shape information, and the topological relations between space templates has to be changed into the metric locations between space primitives. The space primitives and spatial relations in a space scheme cannot be specified based solely upon the information of its SA-diagram without considering additional information. Thus, the process of concretizing an SA-diagram into a space scheme is an open-ended transformation as different instances can be enumerated infinitely. On the contrary, in the process of abstracting a space scheme into an SA-diagram, the space primitives of various shape properties are logically replaced by the space templates of a single kind and the metric locations by the topological relations of predefined kinds without any additional information. That is, the process of abstracting a space scheme into an SA-diagram is the algorithmic transformation through which a unique result can be derived.

By the same token, a space scheme can be uniquely derived from a plan although a plan cannot be derived uniquely from a space scheme. The derivation process of a space scheme from a plan is the process of schematization in that the overall shape information should be made explicit while the detailed boundary shape information should be made implicit. The overall shape characteristics of space elements could be specified in terms of elongation, tapering and proportional modules.

In order to avoid an exhaustive comparison between space schemes, the representational format of space scheme should include an organizing method of forming a part/whole hierarchy in which space elements are grouped into successively larger containing modules according to common properties of space elements. If a space scheme is not represented as a part/whole organization of space elements, it is hardly possible to distinguish certain groupings of space schemes from others. As a unique space scheme can be derived logically from an architectural plan, the similarities and differences between various plans can be analyzed in terms of the comparison between their space schemes.

	Representational format	
	Space element	Spatial relation
Functional requirements (Program)	Numbers and verbal descriptions	
Topological graph	point	Topological link
SA-diagram	Area template	Topological link
SR-diagram	Area template	Weighted topological link
Space scheme	Shape primitive	Metric location
Space layout plan	Shape primitive	Metric location
Plan (Form)	A construct of material elements and a composition of space elements	

Table-1. The Representational Formats of Five Different Pictorial Outputs in the Process of Architectural Form Generation

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Lucian Kroll, "Anarchitecture' in The Scope of Social

[20]) I doubt that Freedman recognized the nature of space schemes as it has been characterized in this paper because, if Freedman knew the nature of space scheme, he could not have insisted that his lay participants generate his bubble diagram. See "Communicating with Users" and "Commentary on Lycee David" in the Scope of Social Architecture, pp.153-162.

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