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Thinking and designing with the idea of network in architecture

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Abstract

A spatial setup is designed considering the network of interrelations between its constituent units. This is a network significant for architectural discourse as it maps the interactions and social relations between users, defines the functional and latent routes, and indicates spatial proximities. Although design is subjective, design tools and methods provide objective criteria to interpret and iterate. Common tools of network thinking allow us to invoke scenarios that will lead us to visualize and exchange ideas about architecture, extrapolate up to date functional ratios, define ranges of proximities to bring forth spatial and potentialities of architectural program and test them within criteria.

This study focuses on the idea of networks in architectural design and discusses the use of graph theory based tools in the design process. It presents the possibilities of systematic mapping of relations among spatial elements through their neighboring and attracting qualities in the initial phase whereby the relational network is still dynamic and non-hierarchical. The topic will be expressed by presenting two examples, one from an academic setting, the other elicited from practice. The first describes a workshop on systems thinking demonstrated with a game called "İkidebir". The second is an iterative hospital campus design scheme in which functional and site specific relationships are modeled and animated with network modeling and assessment tools. Network-based thinking, graphs measurements, and the diagrammatic assessment of relationships between spatial organizations as a design exercise are valuable both for those who are in practice and in the education of architectural design.

Keywords
Networks, Architectural design, Relational thinking, Space syntax.

1. Introduction: Space as a networked artifact

Today, networks, which can be described as structural and organizational models, are pervasive in every aspect of our lives and range from genes to power systems and from social communities to transport routes. These networks are concerned with the structure of relations between things and are informative as they allow us to uncover those inherent principles and behaviors that regulate a variety of natural and artificial systems (Lima, 2011; Wigley, 2007).

In the field of architecture, the study of networks has emerged as an inspiring concept in the description of built environments. After all, the design of a spatial setting inherently implies the network of interrelated spatial units, and so we can view the practice of architecture as mainly involved in the creation of the specific configuration of this network. In other words, the outcome of an architectural design process is essentially a configuration (Nourian et al., 2013). Network relationships are thus tools that the architect utilizes to propose his/her perceptions. These relationships once regarded as a mutable also constitute the potentials of encounters for the users through connections and borders, including even new ranges and thresholds. Thus they make up the base for the interactions and social relations between users, defining both functional and latent routes, and indicating spatial proximities and neighbors. According to Dovey and Dickson (2002), the spatial dispositions of buildings constitute social organizations. They are not formal types or archetypes, but, rather, clusters of spatial segments structured in certain formations with syntactic rules of sequence and adjacency. Lawson develops this view by defining architectural and urban spaces as containers that accommodate, separate, structure and organize, facilitate, heighten, and even celebrate spatial behavior. He says that space creates settings that organize our lives, activities and relationships (Lawson, 2005). Hillier suggests that buildings carry social ideas within their spatial forms (Hillier, 1996) and spatial formations can be seen as visual symbols of societies. We read the space and anticipate a life-style (Hillier and Hanson, 1984).

To date, most of the research studies that set out to reveal the potentials of network systems have utilized graph theory, a theory that relies on the conversion of information into a network diagram that can be mathematically analyzed to determine the relative depth or significance of the nodes or edges that make up the network (Ostwald and Dawes, 2013). Architectural applications of this method have also been developed by several researchers (Alexander, 1964; March and Steadman, 1971; March, 1976; Steadman, 1983; Hillier and Hanson, 1984; Hillier, 1996). Generally speaking, these works discuss some of the concepts of mathematics and diagramming or graph theory based tools that have potential value in understanding architectural forms and spatial organizations. They primarily present the architectural designer with some mathematical methods of conceiving and manipulating the spatial configurations.

An analysis of utilizations of graph theory based tools in architecture suggest there are in three different modes: (1) to analyze existing spatial formation (Hillier et al., 1987; March and Steadman, 1971), (2) to generate spatial form, (Mitchell et al., 1976; Steadman, 1983), and (3) to evaluate architectural design (March, 1976; Hillier, 1998; Space Syntax, 2002). The first of these types of utilizations begins by exploring the intrinsic nature of the existing built environment and then decoding the underlying principles and meanings. The second group uses a series of predefined rules in a computerized, automated process to search for a desired spatial product. The last group provides tools that architects may use to evaluate their design proposals and also gives them opportunities to argue for the best performing proposals. The criticism leveled against these approaches mostly stems from the following questions: To what degree does an architect become involved in this cognitive process and how does he/she evaluate their designs considering desirable social implications rather than focusing on an automated evolutionary process? (Nourian et al., 2013). In the last decade an analytical approach, space syntax theory and its applications, has made great strides in showing architects the possible effects of their design solutions and have enabled them to learn from their design solutions (Dursun, 2007, 2012). In this way such utilizations constitute evidence-based design processes (Hanson, 2001).

Space Syntax theory is constituted on two hypotheses (Dursun, 2012): 1. The built environment functions as a spatial / social network. In this network the main interest is about relational characteristics of spaces rather than individual ones. Space is experienced through this spatial networks or relations. 2. Spatial networks create potentials of movement and describe a living pattern. Movement is the key element to decode man-space / man-man relationship. Based on this network structure spatial configurations embody social or cultural meanings and generate or inhibit social interactions, movement patterns in built environments.

Such analysis tools guide in the comprehension and depiction of the relational structures however there has been complicacies in the transfer of this research-based knowledge directly to design process. The design process is conventionally perceptive, experiential and subjective. The method to reference research based knowledge to the design process is a typically a matter of concern for most. Dovey tries to explain this contradiction by focusing on relation between phenomenological philosophy and Cartesian world. He describes these poles "lived space" (the realm of personal feelings, emotions and particulars) and "geometric space" (the space of plans, forms and universals) (Dovey, 1993). According to Dovey, geometric space is a representation of lived space with the meanings and values extracted. For him, geometric space is a universal language of spatial representation that has predictive value. How can one creatively externalize the spatial knowledge in a measurable, visible manner for evaluation for assessment and improvement even from the initial stages of the design process?

Design is a complex cognitive process that continuously engenders both problems and solutions (Lawson, 2003). It is a kind of experimental process that is largely learned and practiced through "making" (Schön, 1987; Al-Sayed, 2012). Rather than searching for optimal solutions (Simon, 1996), design is about experimenting and probing. Experiments lead architects to discover something, and then these help them to redefine their underlying concepts (Dursun, 2007). In network thinking the investigation focuses on systematically mapping relations among spatial elements through their shared and relative characteristics, in other words, neighboring and attracting qualities in rule-based dynamic network models. The "relations of the relations" and "the protocol between the rules," which refer to the order and the scale that the rules will be enacted during the design process, are of prime importance in these models. By observing the effects, the creative process can be interpreted as a kind of choreography, one in which "pace" is also interrogated for the elements of the parametric model.

It is possible to deduct that relational qualities that suggests life inside a spatial construct i.e. social interactions and the movement (form prone to flow patterns) and proximities are built up by formal qualities defined by rule sets i.e. distance close or far, vertical positions, below or over, and whether clustering or disparate. Dynamic network models suppose that spatial entities are in constant motion during the design process. Their exact positions are yet ambiguous, they hang in air, and sway, or jump from one location to another; they start to presume specific locations and concretize as their relationships among each other become more and more defined.

This study aims to explore following question: How we can use the idea of network in architectural design? By focusing on the experimental and intellectual characteristics of the design activity the study tries to examine how this kind of thinking can be used as a creative and informative tool in design process. In the scope of the study first, the main question is opened for discussion conceptually with architectural students by the help of a game, İkidebir. Secondly, the authors try to explore how this kind of thinking can be utilized in the design process by focusing on an iterative hospital campus design scheme from practice. Cross indicates that design has its own distinct intellectual culture and has its own ways of knowing, thinking, acting (Cross, 2007). Based on this idea this experimental study aims to open a discussion about how, a scientific and graphic tool, network thinking and modeling, could feed the design thinking and making.

2. Playing the systems game – "İkidebir"

Played by architecture students as a component of the Architectural Morphology class at the ITU Faculty of Architecture in 2014, "Ikidebir," is a game in which simple rules make up a network where the nodes are in motion until they asymptotically settle into a configuration that satisfies the rule for each individual. This game engenders a dynamic system in a given space, and has the following rules: (1) Players initially announce an avatar, a spatial entity in this case, they selected for themselves and represent it as a node; (2) each player then selects two other announced nodes in order to follow in discrete this time. (3) All players randomly position themselves in the confined space (game area). (4) Hearing the start signal the players try to stand at equal distance to the two nodes whom they have picked to follow (Figure 1). The students first write their selected spatial entities and later draw the relations that form on the board, (Figure 2). Then the system is opened for discussion with the students. After introducing some analytical tools, space syntax and other dynamic network models such as cytoscape to decode this relational structure, the authors re-evaluated the process by the feedbacks of the students.

Network can be described as a structure that is constituted by the links between nodes. These nodes can represent different entities such as individual person, object, space or concept. Both countable and non-countable entities can be interrelated. For example in the first series of the workshops for this game in the Architectural Morphology class between 2008 and 2014, the students selected fictitious avatars and that had caused a more concentrated discussion on the nature of networks. However in the last workshop students selected to represent spatial units. Thus the composed networks lead the players to question the adopted relations that provide typical configurations. Recorded sessions are revealed at the blog: http://ikide1.wordpress.com.

As soon as the game starts, players move in order to position themselves between their selected players. However as those players are also in movement, they continuously have to recalculate their target positions. This can be seen as a systemic flow, which sometimes accelerates and sometimes slows down. The simple rules create a dynamic set of nodes until the game settles into an arrangement that satisfies the rule for each player.

Discussions with the students yielded the following key aspects:

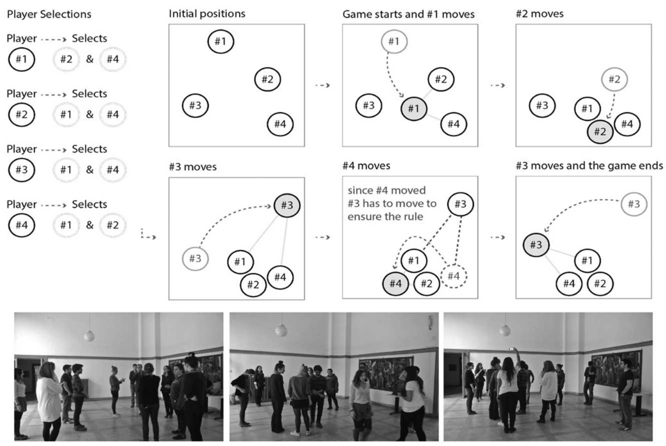

Figure 1. Ikidebir Game – A Demonstration of Game Evolution.

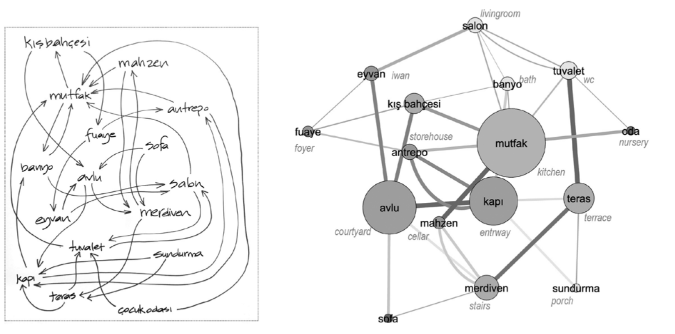

Figure 2. Choice of Spaces and Relational Characteristics Visualized by Cytoscape Program.

- The networked structure is informed by the choices made by the players.
- The rule that the relation between spaces must be equidistant to the selected two spaces both triggers and organizes the motion.
- The nodes, spatial entities in this case are fixed in terms of the links created whereas their geometric compositions are constantly changing.
- By default each player selects two other spatial entities; therefore everyone is plotted into the network.
- Only two spaces may be selected. This type of selection brings an important limitation for the interrelations among the nodes. Such that each space is connected by at least two spaces and remains linked with the whole. On the other hand some spaces are selected more than the others and this causes the system to lose homogeneity and leads it to a varied distribution.
- The nodes selected by more nodes tend to be key elements in the system, in the given case “kitchen, entryway, and courtyard”. Their positions / or fluctuations affect the whole group causing both accelerations and decelerations. Therefore these nodes are latent to change the form of the system.
- Some nodes – such as porch and sofa – are less significant to the system and thus they either may be selected by only a few players or even by none at all. Their actions do not create major changes.
- However, even though they may be less-selected, some nodes – such as the winter garden – may prove to be effective, especially so when they are selected by a single player who is selected by many.

By the introduction of graph theory based tools such as space syntax and cytoscape to analyze the network structure the students tried to make this network legible and accessible to reading and assessing (Figure 2). Based on mathematical and graphical data, following questions are put into considerations: How do the selected nodes (avatars) behave in that particular system? How do they interact? How many connections do they have? What do they share? Are they interactive or are they inactive? Is there any key connection among them? Are there any groups or divisions (clusters) between them?

The relational whole in the graphic and the calculated syntactic values, such as integration, connectivity, depth, choice, etc., rationally support the experience of the students’ perception of the choices (Figure 3). These explorations induce some valuable insights associated with the network structure:

- In order to play students made random selections from spatial entities as avatars. The choices are mostly relevant in a residential setting, defining a quality or a program inherent to that space, like living room, kitchen, bathroom, WC, entryway, terrace, or nursery, or a few less common spaces like a cellar. The game also includes spaces more typical of traditional Turkish architecture, like the inner courtyard, iwan (vaulted hall) and sofa (connecting hall or egress space).
- Hearing all the choices, students then selected two other two spatial avatars to be linked to from the available set in the group. These choices result in conventional relations such as sofa-courtyard, living room-kitchen, terrace-entryway, cellar-kitchen, kitchen-WC and some unusual relations such as liv-

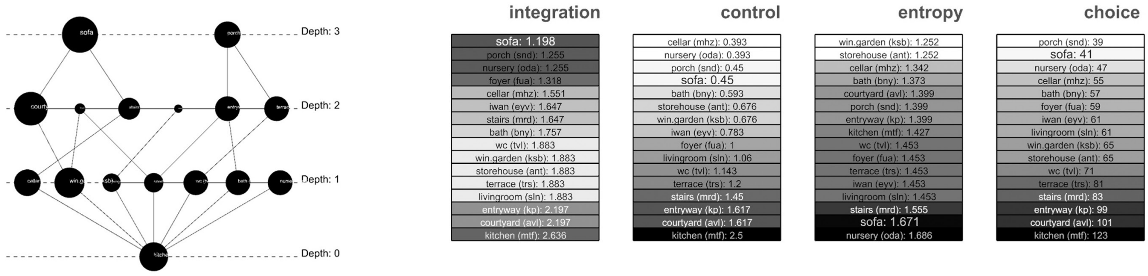

Figure 3. *The Relational Whole and Calculated Values Visualized by Space Syntax for Grasshopper - İkidebir.*

ing room-iwan, living room-bathroom, bathroom-kitchen, nursery room-WC. This allows the players to experiment on uncommon or secondary relationships.

- These selections provide enough information to analyze and figure out the key entities in the network are "kitchen, entry way and courtyard". These represent powerful nodes that have strong relations with the other nodes. The game also presented that these nodes initiated the motion and acted on the pace of the system. "Sofa and porch" tended to be inactive nodes. As they do not have strong relations with the other nodes, their effects on the spatial system are limited. Syntactic analyses clarify these characteristics. Integration values for the spaces reveal the following order: kitchen (2.636) > entryway = courtyard (2.197) > storehouse = winter garden = terrace = living room = WC (1.883) > bath (1.757) > iwan = stairs (1.647) > cellar (1.551) > foyer (1.318) > nursery = porch (1.255) > sofa (1.198).
- Networks do not need to link nodes specifically of the same genre. Students' selections included vague spatial entities like "entryway" as well as very defined ones like a "cellar".
- Networks by default defy physical dimension; however, discrete groupings suggest varying snapshots of spatial possibilities. Iterative playing out of the rule hints form possibilities including proportions, zones, interior and exterior build-up, etc. Specific network visualization layouts simulate part–to-part and part-to-whole relationships and spatialize the network in 2D (Figure 4). Visualizing the game with cytoscape, it is possible to visualize adjacencies and clustering possibilities, although the model is exempt of physical dimensions.

In this workshop network thinking in architecture have been opened to discussion a. through students personal experience b. through graph theory related tools that analyze the demonstrated network. In other words abstract spatial network that emulates a spatial construct is experienced by the students participation and then examined in a cognitive scientific platform. The study imparts the following potentials network thinking in architectural design process:

1. The spatial whole can be described as the relations among its constituent parts rather than as a sum of disparate units. The manner in which these relations are constituted may infer diverse connotations and there may be quantifiable aspects of these relational patterns.
2. The rules that construct the network (one space must be selected by at least two other spaces) and the rules that enact on the form or the

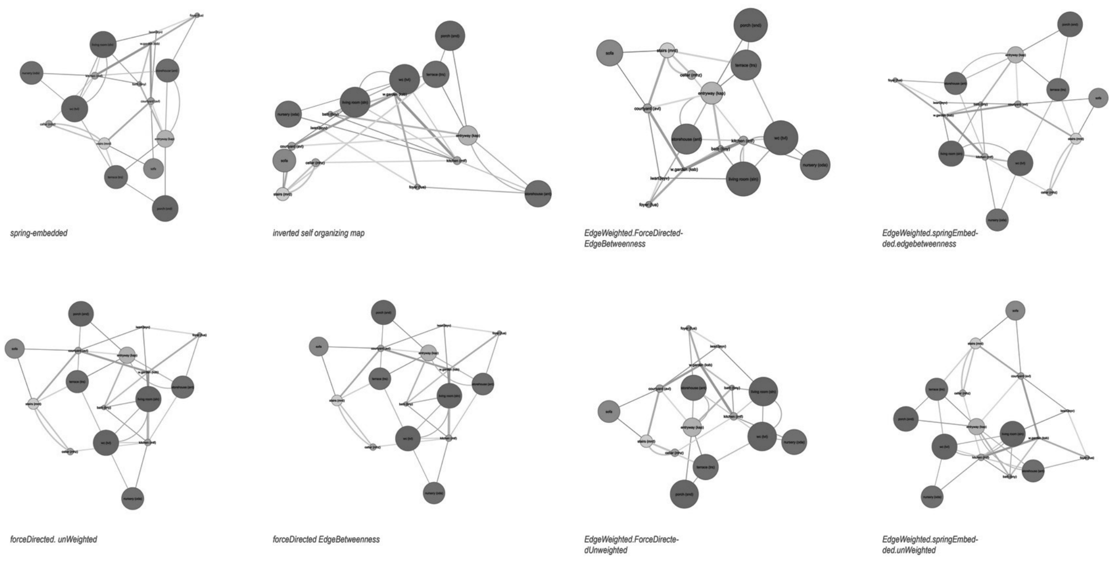

Figure 4. *Network from the Game Modeled in Network Visualization Program Cytoscape.*

configuration (the relation between spaces must be equidistant to the selected two spaces) conform the flow and the proximities between nodes, is therefore constrained. Actual design processes include more complex and varied relationships and rules. However in both cases specified rules for distancing and clustering are indicative for the propositions of form. To understand the implications of these rule sets and their implementation is significant for the designer.

3. Certain relationships tend to be prevalent and affect change to the whole, whereas other clusters of relationships are not at all effective to the whole, yet are dynamic in their groupings. It will be argued that this phenomenon relies on the designer and the brief. The game is a demonstration of the relational make-up and the dynamic quality of these relations when they need to attain spatiality. This conceptual visualization or modeling enables the architect to consciously model, through play, the bonds and proximities of spatial units and the site.
4. Concentrating on the idea of network in architectural design, space syntax helps designer to develop spatial awareness by transforming relational spatial structures into graphical, mathematical and scientific forms. It explains what does these relations mean and how does the system works. By making non-discursive characteristics of space discursive, it presents a language for thinking and talking about space (Dursun, 2007).
5. While space syntax provides a useful tool for architects in deciphering and assessing the relationship among spatial entities in terms of spatial accessibility and human flow, other dynamic network models such as cytoscape and customized parametric modeling reveals possibilities regarding on geometric-formal characteristics of this relational whole. In other words, these models visualize the possible formal end products of applied rules.
6. Relevant graph theory concepts and criteria, diagrams, and produced data sets based on effective representation of spatial systems lead to powerful instigation, management, and assessment of design phases. It is thus that, in contrast to convention, these tools have potentials to be tools with which we can think (Hillier and Hanson, 1997) during the morphological stages. These tools are creative and constitute an educational component within the research-based design. They also lead the designer to better understand the relationship between form and its use (function), while opening up new possibilities for design based on research results and generative principles (Schneider et al., 2013).
7. The experiment does not refer to the use of graph theory based tools including space syntax to extract potentials after the architectural form is solid rather during the initial stages of design. In this context it advances design thinking, enables interactive exploration of the effects of programmatic relations on form and suggests a method to structure correspondence of form and function.

3. Design Research: Method to design a campus

The second example is taken from practice and deals with a conceptual design scheme for a campus on psychiatry and neurology. Hospitals have been the subject of a great deal of research in the architectural literature, especially in regard to their functional and organizational structures. Human flow and way finding issues appear key concepts of these researches (Ünlü et al., 2005, Setola, 2009, Khan, 2012, Peponis et al., 1990). The aim of our study is to impart potentials of network thinking explored in developing this master design scheme. In parallel to existing research, this scheme also focuses on the human flow in terms of vehicular and pedestrian pace between specific subunits. The programmatic and site relationships and relations to the varied qualities of the site are modeled and animated by the use of custom-made modeling tools based on network thinking. Peculiar qualities of the site – such as emergency-prone segments along a major artery, or the more tranquil neighboring residential areas, and/or the security latent zones are represented as polar attractors. This design exercise incorporates interrelated positioning; programs are attracted (tied up) to specific zones or segments, and also to one another, as are the nodes connected to each other by the students' choices in the case of the game.

In the initial phase the separable programmatic units, regardless of their sizes, are scripted to move around an abstract container, pulling and pushing one another and the poles of the container in terms of their space/use related attributes. These disparate units are determined according to the administrative organization chart and the patient flow described by the clinical team. Attributed criteria to these units are urgency, security and privacy. Each program unit is specified with varying degrees of these attributes (Figure 5). "Urgency" pole attracts programs with emergency zones such as the emergency of the neurology hospital, privacy node attracted the acute psychiatric clinical program nodes, public pole pulled the outpatient nodes, and, finally, security node pulled forensic clinical nodes. By regarding these contained program units as a network, the script allows similar attribute grades to accumulate and the defined polarities to pull each other, and to move the groupings toward specified poles of the abstract container. The script also allows for negotiations among the varying degrees of these attributes.

In the second iteration, shown in Figure 6, the group formations are clustered in the layout to allow propagation to the actual site. In this case the rules for propagation are parameterized by diffusion, overlap possibility, and size. The rule implementation follows a hierarchical order. Certain program units link to others like their satellite, and certain units have priori-

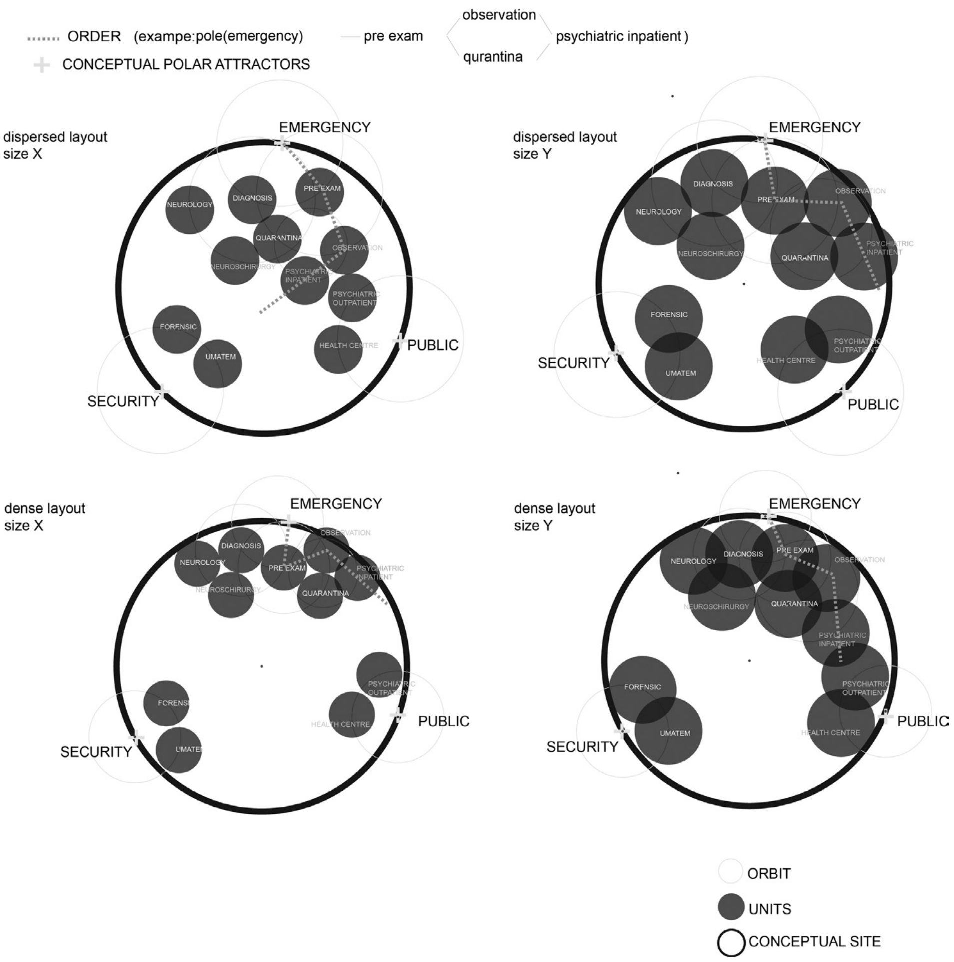

Figure 5. Conceptual Polarities Mapped in Relational Modeling among Program Units and Specific Attributes.

ty in maintaining proximity to the defined abstract polar zones. For example, the rehabilitation unit is a sub-unit orbiting the psychiatric clinics, bound by the everyday personnel and patient flow, which has been quantified as 300m walking distance. The emergency department has first priority to be in proximity to the main artery which is the main urgency pole (node).

These interrelations and hierarchy are plotted and evaluated on a table matrix. Size is derived from the "List of Requirements" as well as the height and floor space limitations as a work area serving both a group of patients and a health team: 20-30 patients to one floor, as in the case of the neurology inpatient building – up 100 patients in total. The floors of the building floors are limited to eight in total, suggesting a footprint area of 1500sqm depicted with a circle with equal area (Figure 6).

In the site implementation, the value sets and interrelated network are then mapped to the site directly referencing the preferred poles and axis to certain nodes. This 'machinic' diagrammatic exercise is modeled and run iteratively. The distances between units are defined in ranges proportional to time and the pace of pedestrian and vehicle reach (Figure 7). For example, the emergency pavilion for the three departments (psychiatry, neurology and neurosurgery) are located in the same spot; however, once a patient is to be transferred to an inpatient unit, the neurological unit is accessed via a flight of ramps and elevators, taking a total of ten minutes, whereas psychiatric patients are transferred by vehicle to the psychiatric inpatient clinic. One is vertical in positioning whereas the other is horizontal.

Each unit "behaves" and situates according to the specified rules, with emergency related units tending to prefer the artery neighboring zones, the inpatient units moving towards the residential borders, etc. The process is further rationalized with the use of a major axis for pedestrian and vehicular flow and its possible orientation on one hand and the variations provided by possible positions of a hypothetical center of the system on the other, certain units only following other units as satellites (Figure 8).

This exercise is repeated in iterations for assessment of the resulting configurations. Units that are directly linked to site poles and units that have more links to other units have greater potentials in defining the working configuration. The position of an emergency plateau close to the major road is a straightforward design decision; however the role of the diagnosis department and its location to the other departments is one example where probing is necessary. The process enables fine-tuning and easy reassessments of multiple possibilities.

The space syntax analysis also demonstrated that the diagnosis department is the key spatial unit in the network as it represents a powerful node that has strong relations with the other nodes. The rehabilitation block and inmate unit tend to be inactive spaces. Based on the syntactic analyses integration values for the spaces reveal the following order: diagnosis (4.435)

GROUP	Units	area	n o Patients	area	radius	n o floors	distance to mainGate-	distance to mainGate-	attributed for	attributed for public	attributed for
A	diagnosis	1200	10	20	20	3-4	200	500	-	+	+
A	neurology hospital	22320	160	84	84	6	100	200	-	+	+
B	psychiatric INPATIENT	36000	300	107	107	1-2	500	1000	-	-	0
B	rehabilitation block	3200		32	32	2-4	1000	2000	-	0	0
B	psychiatry outpatient units	8200		51	51	2-3	100	500	-	+	+
C	forensic clinical units	31200	200	100	100	3-4	1000	2000	+	-	+
C	inmate units	4800	40	39	39	5	1000	2000	+	-	-
C	AMATEM alchololic rehab uni	6240	50	45	45	3	500	1500	+	-	-
C	UMATEM addictions units	4800	60	39	39	3	500	1500	+	-	-

LINKS (distance max-min)	diagnosis	rehabilitatio n block	psychiatry outpatient units	forensic clinical units	UMATEM addiction s units
diagnosis					
neurology hospital	50-100				
psychiatric INPATIENT		100-200	100-200		
rehabilitation block					
psychiatry outpatient units	300-600				
forensic clinical units					
inmate units				100	
AMATEM alchololic rehab unit					100-200
UMATEM addictions units	100-500				

Figure 6. *Matrix of Relations of Program and Site.*

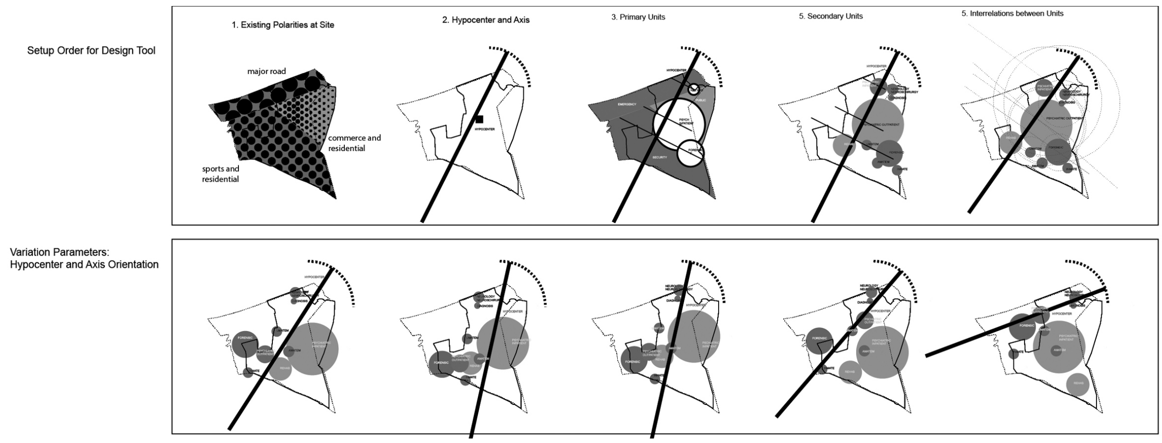

Figure 7. Setup Order for the Abstract Programmatic Polarities Diagram.

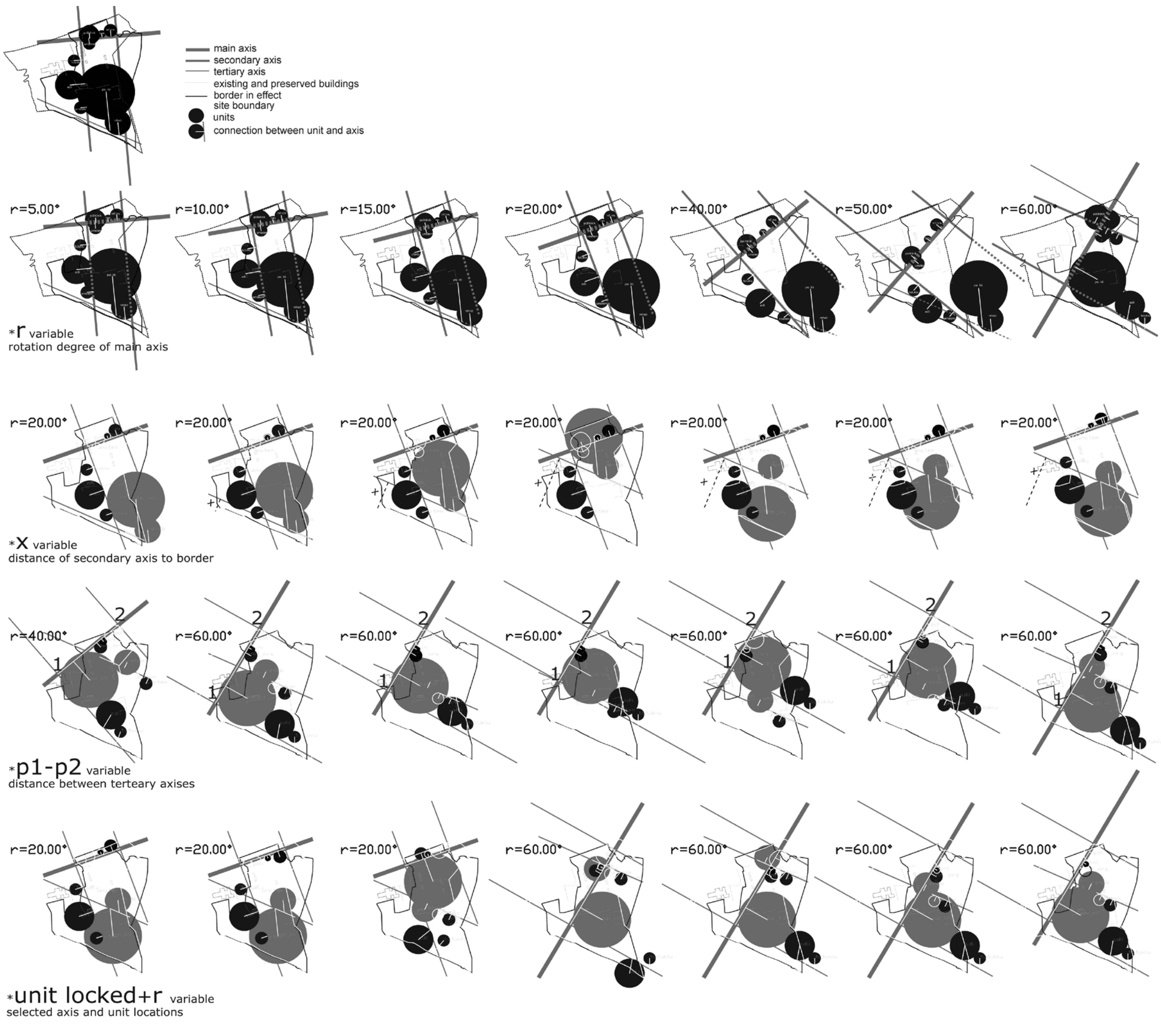

Figure 8. Relational Site Model in Iterations.

> psychiatric inpatient = umatem = forensic (1.267) > neurology inpatient = amatem (1.109) > psychiatric outpatient (0.986) > rehabilitation block = inmate units (0.634) (Figure 9).

The focus of these design research sessions is to be able to abstract and re-evaluate relationships regarding the program, and the site, and reconstruct corresponding layout options with their interrelation degrees in reference to specific attraction criteria. These attractions and repulsions, in other words the polarized units, hint at building/structure-prone units by their capacity to conjoin and to cluster as buildings around a courtyard, for example. Through a series of assessment, multiple layout potentials are derived and compared. The process gradually narrows into a discursive scheme and potentials for the master plan are extrapolated.

With the parametric configuration it was possible to convey the fact that the project model is only a snapshot of the possible set, and yet major decisions are more defined than others, and that there is room for development. It is thus a map for action (Figure 10).

While the project was actualized in 2009, it is still under discussion as the stakeholders continue to bear a great burden of existing patients and economical strain; however, it is important to note that the project has remained viable, despite the passage of time and change of certain personnel. This is mainly due to the fact that the project is in itself a tool that allows evaluation of site and program conditions, and has the potential to change in accordance with modification of the site and evolving needs.

The idea of network has been influential in the process o conceptual design scheme for this campus project. The clinical team asked for the project to correspond with the new understandings as well as the client required to evaluate all possible scenarios at the site. Both interests were met the project. The process imparts the following potentials of relational thinking in architectural design process:

1. Same as case one, here it is demonstrated that the spatial whole can be described as the relations among its constituent parts rather than as a sum of disparate units. The manner in which these relations are constituted may result is diverse consequences as to form and these relational patterns can be mapped in a quantifiable manner although they are based on concepts.
2. The rules that construct the network (common conceptual/spatial qualities that can refer to both the site and the functional units) and the rules that enact on the form or the configuration (the distances attributed between units as a function of pedestrian and vehicular motion) conform the flow and the proximities between nodes. Spec-

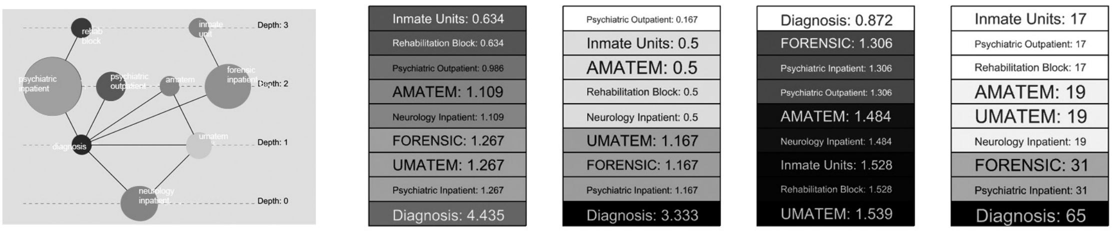

Figure 9. *The Relational Whole and Calculated Values by Space Syntax for Grasshopper – Hospital Campus.*

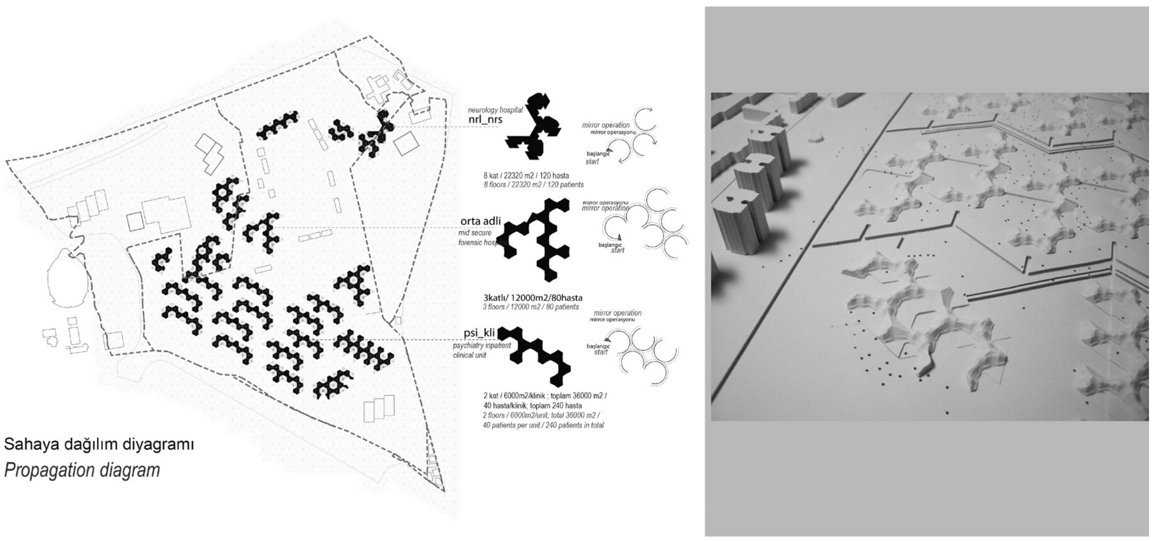

Figure 10. *Propagated Site Model.*

ified distances as well as clustering operations (orbiting, attraction to axis and positioning with hierarchy) are indicative for the propositions of form. To understand the implications of these rule sets and the order and the pace in which they are implemented are of value for the designer.

3. Certain nodes and links (relationships) are more effective to change the whole, whereas other clusters in the network are not at all effective to the whole, yet can be active in their local groupings. It is important to note that the designer takes his position rather than an automated generation of form in orchestrating the relational model. Also in relational models enable to demonstrate peculiar qualities of networks such as an overlooked unit linked to a major node has equal effect on the system, and therefore may act on the design discourse equally.
4. The project made use of custom-made parametric models that animated the network of both subjective (based on functional qualities) and objective (based on functional size, distance and orientation) relations. This enables to link attractive qualities with their corresponding spatial abstractions. This is made possible by the advance in the now ubiquitous digital tools that enable live change and tracking of parametric relational models. Thus it is possible to have variations as well as breeds of solutions to a brief.
5. This process requires a sustained assessment strategy for the variations arrived by the modeling. Space syntax or network visualization and assessment with software like cytoscape enable the assessment of the relationships among spatial entities in terms of spatial accessibility and human flow, as well as other network measurements like closest path, clustering, etc.
6. The process involves iteration: restructuring the initial relational setup, remodeling, and reformulating the physical ties (distances and ratios), reassessment of the order of rule enactment. It is crucial to the process that the model is remade up after the initial run which serves more as a prototype to the machine-like dynamic model.
7. In this project case, the units were thought of as clustering similar attributes of spatial concepts like public/private together. However the pattern to distribute and propagate the units at the site could have been different then clustering the likes. The model only allows the designer to apply his design decisions in a prototypical manner that he can observe exceptions, derivatives, and possible modifications live on the model.

4. Conclusion

Architectural design is ultimately about the configurations, connections, shape, and orientations of physical forms (Do and Gross, 2001). It deals with designing connections, borders, new ranges and thresholds in the space. Two case studies (one derived from architectural education and the other from architectural practice) are valuable both in terms of their effort to conceptualize the idea of network in design and to use this idea to trigger production of space in design process.

Networks are dynamic forms in which relations are alive, in that they are in states of constant change. By exploiting this way of thinking in early stages of architectural design, it becomes possible to keep the negotiation alive, which is important for a creative process. This approach also provides informative tools for architects as it permits designers to see different potentials and possibilities in design and constitutes mediums for experimenting and probing.

This study mainly concentrates on the idea that a critical understanding of the network in spatial constructs can inform, shape, and enhance the design. To exemplify the discussion, the authors first engage architecture students in a game designed to explore how a space paradigm can be conceptualized through a process of dynamic network rules. Secondly, the authors also try to explore how this kind of thinking can be utilized in the design process by focusing on hospital campus design scheme from practice.

The first example aims to trigger the architecture students to develop the idea of spatial network in design by the help of a system thinking game in which all the students are actively involved. Network thinking in architecture is opened for discussion conceptually in order to decipher the potentials of the space and make its un-discursive, intangible characteristics discursive and tangible. This experiment constitutes a conceptual ground that permits the designer to understand the dynamic interaction among the design parameters, and also permits evaluation of the relationships and their meanings in the design. Here network thinking appears as a powerful tool in order to underline the notion that design activity is neither a closed box nor an automated process, but is rather an intellectual process in which the architect plays an active role as a spatial choreographer.

The second sample concentrates on a design practice, one in which programmatic and site relationships are modeled and animated by customized modeling and assessed by graph theory based tools such as space syntax. The main aim here is to explore how relational thinking can be integrated into the architectural and urban design process. This example is important as it regards a need for a dynamic design instrument that can satisfy the changing needs in a long-term process. The architect can use the resulting parametric work and relational thinking to reveal and/or meet the requirements.

In networks, nodes are not constituted from the same genre. They can be structured with different components including not only spaces, but also design criteria or concepts. This is an opportunity to link tangible with non-tangible qualities in a cognitive process.

In terms of network thinking, the two experiments in this study are structured through three main stages: (1) Description of the relational structure, (2) Analysis of this structure and (3) Application of a rule-based design. The first process concentrates on achieving an understanding of how the networks are constituted and reveals the linking filter that organize these complex sets of relationships. The second process deals with the analyzing or decoding potentials of the constituted networks. The third introduces a phase in which definite metric design rules are applied to the network of nodes. In this way, relational structures are transformed into spatial form from which the design proposals emerge (Figure 11).

In the first stage of the game main determinant is the choices of the students. The constituted network can be referred to as a conceptual and nonhierarchical one in principal. In the example from practice however the spatial relations are structured by the clients preferences and through data arrived from user questionnaires. Therefore in this case the network is not only a mental construct but also has physical impositions, yet they are also nonhierarchical in terms of their networking. In the following stages in both cases, the spatial potentials of the structured networks are expedited by network assessment and graph theory based tools that include space syntax. In the process space syntax imparts flow, transition, integration among spatial units whereas other dynamic network modeling whether analogue or digital set forth clustering, neighboring conditions and their meanings. Such graph theory based tools including space syntax appear as informative and creative tools to think, talk about and engage in space and spatial constitutions. In the third stage we can denote that form is designated by the enactment of the geometric rules. The operative rule is “to remain in the median axis of the other chosen two” in the game described in the initial sample, and in the next sample it is the distances designated for the units to satisfy in reference to one another. It is possible to say that design process is the iteration between these stages, i.e. the assessment of the “fixed” form and its consequences in the third stage are examined and tested with tools mentioned in the second stage. Therefore the process continues with the feedbacks of the second stage reconfiguring rule sets of the third stage and rerunning these relational metric rules.

Network thinking equips architects with data regarding space and enhanc-

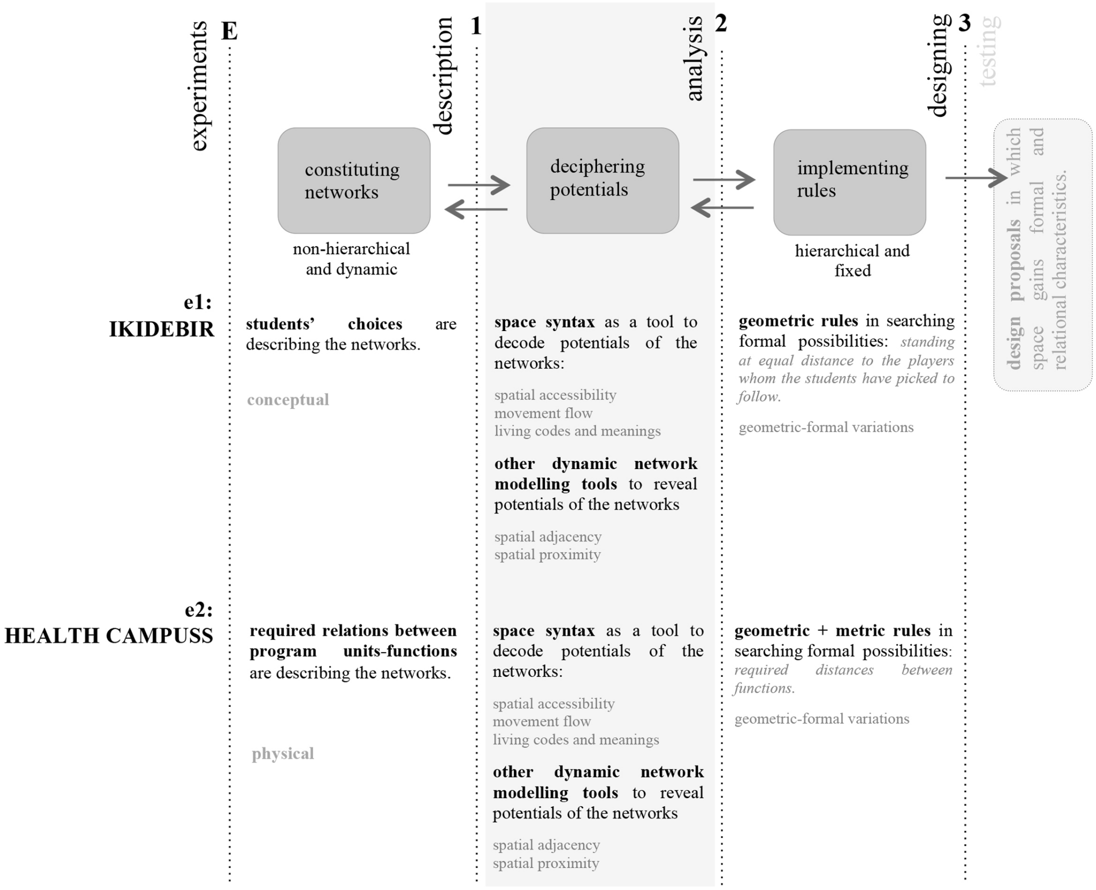

Figure 11. *Talking about Two Experiments.*

es their spatial awareness. Mathematical and graphical tools render previously invisible characteristics of space visible, measurable, and discursive. In respect to other generative tools for design network modeling in architecture can thus be transformed into a design tool with which the designer can freely think, play and model.

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Mimarlıkta ağ düşüncesi ile düşünmek ve tasarlamak

Bir mekan kurgusunun tasarımı onun parçaları arasındaki ilişkiler ağının düzenlenmesi ile ilgilidir. Bu ağ yapısı mimarlık söyleminde kullanıcılar arasındaki sosyal ilişkileri, etkileşimleri resmettiği, mekanda fonksiyonel ve potansiyel rotaları deşifre ettiği, mekansal yakınlıkları gözler önüne serdiği için önemlidir. Mimari tasarım öznel bir süreç ise de kimi tasarım araçları ve metotları tasarımcıya tasarlananı değerlendirmek, öğrendikleriyle yeniden üretmek için nesnel kriterler sunar. Ağ düşüncesi içeren mekan kurma ve ölçme araçları mimarlığa ilişkin düşünceleri görselleştirme ve tartışmaya açmaya, verilerden mekansal ilişkilere dair yeni oranlara ulaşmaya, mimari programa yönelik potansiyelleri ortaya çıkaracak çeşitlilikleri tanımlamaya ve kriterlerle test edebilmek için senaryolar geliştirmeye olanak verir.

Bu çalışma mimari tasarımda ağ düşüncesinin kullanılmasına odaklanır ve tasarım aktivitesinin deneysel ve zihinsel özelliklerine vurgu yaparak bu tür bir düşünme biçiminin tasarım sürecinde yaratıcı ve bilgilendirici bir araç olarak nasıl işlevselleşebileceğini araştırır. Çalışma, kural temelli dinamik ağ modelleri içindeki komşuluk ve çekim özellikleri yardımıyla mekanı oluşturan elemanların ilişkilerinin sistematik haritalanmasına yönelik araştırmalar sunar.

Mimarlıkta ağ düşüncesine odaklanan çalışmalar incelendiğinde temelde üç amaçla kullanıldığı söylenebilir. (1) Var olan mimari biçimi anlama (Hillier ve diğerleri, 1987; March ve Steadman, 1971), (2) Mimari biçimi üretme (Mitchell ve diğerleri, 1976; Steadman, 1983), (3) Mimari biçimi değerlendirme (March, 1976; Hillier, 1998; Space Syntax, 2002). İlkinde varolan mekansal biçimlenmelerin kendilerini oluşturan dinamiklerin keşfi için analiz edilmesi hedeflenir. Tanımlayıcı ve açıklayıcı yönleri ön planda olan bu çalışmalar mimarın mekana ilişkin bilinç düzeyini arttırarak tasarım sürecini besleyecek bilgi birikimini çoğaltır. İkinci grup çoğunlukla bilgisayar odaklı, mekanik bir süreç içinde ve önceden belirlenmiş kurallar bütününde istenen mekansal biçimi aramaya niyetlidir. Burada çoğunlukla üretilen biçimin nasıl bir yaşam biçimi kurguladığı sorgulanmadan tüm olasılıklar tasarımcının gözü önüne serilir. Son grup çalışmada ise tasarımcı üretilmiş mekansal kurgular arasında istenen kurallar, sınır şartlarına uygun en iyiyi seçme görevini üstlenir. Burada kritik olan ve çokça eleştirilen konu tasarımcının bu bilişsel sürece ne denli dahil olabildiği, mekanın belirli bir kural setini aramak ötesinde ürettiği olası yaşam senaryoları ile ne denli değerlendirilebildiğidir (Nourian ve diğerleri, 2013). Nitekim son donemde mekan dizimi çalışmaları tasarımcıya tasarladıkları mekansal kurguların nasıl yaşandığını göstererek, kendi tasarımından öğrenmesine, önerisini yeni düşüncelerle geliştirmesine olanak sağlamaya, bilgi temelli tasarım sürecinin de özünü biçimlemeye niyet etmiştir (Hanson, 2001; Dursun, 2007, 2012). Bu noktadan hareketle bu çalışma mimarlıkta ağ düşüncesinin tasarımcının birebir dahil olduğu bir interaktif araştırma süreci içinde tasarımın ilk evrelerinde, yaratıcı bir araç olarak nasıl kullanılabileceğine odaklanmaktadır.

Yazıda bu olgu biri mimarlık eğitimi diğeri mimarlık pratiğinden seçilmiş iki deneyim üzerinden tartışılmıştır. Bunlardan ilki mimarlıkta ağ düşüncesinin kavramsal olarak sorgulandığı "ikidebir oyunu"dur. Bu atölye çalışmasında amaç, öğrencilerde ağ düşüncesine yönelik bir kavrayış ve farkındalık geliştirmektir. Mekana ilişkin oluşturulan karmaşık ağ yapısının ne tür potansiyeller ürettiğinin, ağın karakteristik özelliklerinin, bu ağ yapısının nasıl görünür, tartışılabilir ve de değerlendirilebilir kılındığının öğrencilerle birlikte irdelenmesi hedeflenmiştir. Sentaktik ve grafik-teorik araçlar oyunda kurgulanan ilişkiler ağını analiz etmek için kullanılır. Bu deneysel çalışmanın amacı mekan tasarımının belirli kurallar çerçevesinde parçalarının, parametrelerinin karşılıklı ilişkide olduğu bir sistem kurmak olduğunun soyut bir model üzerinden altını çizmektir.

Yazıda tartışılan ikinci örnek ise yerleşim ve programa ilişkin kararlarının dinamik ağ modelleme araçları ile değerlendirildiği bir hastane kampüsü tasarımıdır. Bu deneyim söz konusu kavrayışın yani mimarlıkta ağ düşüncesinin, mekanı kurarken, tasarlarken nasıl kullanılabileceği ile ilgilidir. Burada temsil edilen yerine deşifre edilerek aranan, potansiyelleri sınanarak geliştirilen bir mekansal kurgudan söz edilebilir. Benzer şekilde sentaktik ve grafik-teorik araçlar da mekanın potansiyellerini çözümlemek için kullanılır. Bu deneysel çalışma doğrudan, üretilen bilgi ile sürecin beslendiği bir mekan yapma pratiği ile ilgilidir.

Mimarlıkta ağ odaklı düşüncenin mekansal organizasyonların ölçülmesine ve bir tasarım araştırması olarak kullanılmasına yönelik olarak ortaya konan deneysel çalışmalar mimarlığı öğrenen ve gerçekleştirenler için değerli olacaktır.