UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

theoretical context

"When very large numbers of people are concentrated in one place, the resources needed to maintain the environmental quality of public and private spaces increase exponentially. Social interaction is more complex and more intense, and this has to be ameliorated by spatial and infrastructural design that maximizes qualitative as well as quantitative factors."

(Hensel, M., Menges, A., Weinstock, M. Emergence in Architecture. *Architectural Design*. May/June 2006)

Introduction

The theoretical context looks at the city as an emergent product of the lower-level activities of the city components. City components refer to the smaller elements which make up the fabric of a city like buildings, roads, inhabitants, cars etc. Lower-level activities refer to the interaction between these components, and will be investigated in order to define the consequential feedback into the city as a whole.

An understanding of these aspects of emergence will allow for the identification of tools and guidelines which will in turn be used as measuring criteria for design performance.

Ants, humans and self-organizing systems

A “composite animal”, is how the South African Renaissance man Eugene Marais describes the nature of the termitary: “[it] is a separate composite animal at a certain stage of development, and lack of automobility alone differentiates it from other such animals” (Marais 1970: 63). Similarly Marais explains that “the human body is composed of a number of organs, each connected by a visible or invisible thread to the central point, the brain. Each organ is in constant activity and has a separate purpose – at least that purpose appears to be separate and independent; but on closer observation we find that all the organs are really working for a communal purpose” (Marais 1970: 61). Examining his comparison of the termite with the human body illustrates the universal nature of any bottom-up or self-organizing system. However, what ultimately cripples Marais study is his futile search for the pacemaker. According to him the queen ant controls the activities of every individual ant in the colony. Later studies in the field, specifically the work of Deborah Gordon, Behavioural Ecologist at Stanford University, indicate that this is not the case. There is no pacemaker. The colony self-organizes out of millions of individual ants into an entity of which the qualities are far more than the sum of that of the individual ants.

Steven Johnson, author of *Emergence: the connected lives of ants, brains, cities and software*, explains that “in these systems, agents residing on one scale start producing behaviour that lies one scale above them: ants create colonies; urbanites create neighbourhoods; simple pattern–recognition software learns how to recommend new books” (2001: 18). Thus it would seem that we are surrounded, or rather integrally part of these self-organizing systems. In order to define a self-organizing system, four universal truths apply:

1. Self-organizing systems comprises of **smaller entities** with a variation of functions, yet acting towards a united goal. The system as a whole defines an environment for these smaller entities (the human body for example, acting as environment for the different organs).

2. The definition or character of the **smaller components is vastly different from that of the system as a whole** and in most cases can be defined as self-organizing systems within themselves (like ants within a termitary).

3. The system as a whole, as well as the smaller components, is subject to **external influences**, correlating to the respective scales.

4. The system as a whole is subject to **feedback** from the smaller parts, which is the driving mechanism behind changes within the smaller part's environment and evolution of the system as a whole.

The city super-organism

Cities comprise of smaller systems or components which are self-organizing systems within themselves. Included in this list of city organs, which are all vastly different in character and function but act toward the successful functionality of the city as whole, are roads, cars, busses, taxis, parks, inhabitants, commuters, neigbourhoods and buildings etc. Buildings for example are also self-organizing within themselves. Like the human body which comprises of organs acting diversely but toward a common goal; structural systems, ventilation systems, movement systems, etc are all different in nature and function yet they contribute to the successful functionality of the building as a whole.

It is thus possible to classify the nature of a city as a self-organizing system. The higher-level activities of a city is a product of the lower-level activities, or as stated by Johnson: "The city is complex because it overwhelms, yes, but also because it has a coherent personality, a personality that self-organizes out of millions of individual decisions, a global order built out of local interactions" (2001: 39).

As stated earlier, one of the defining aspects, and the source of evolution within any self-organizing system, is the constant feedback from the lower-level activities into the whole. An individual forager ant will, based on the amount of other forager ants encountered during the day, either keep on searching for food or change its behaviour. This is an instinctive "decision", based on the success of the colony as a whole. According to Gordon, "Ants can sense the difference between encountering ten foraging ants in an hour and encountering a hundred." She continues that "this particular skill is critical to the colony's formidable ability to adjust task allocation according to colony size or food supply – a local talent, in other words, that engenders global behaviour" (Johnson 2001: 76).

"Emergence is a classical concept in systems theory, where it donates the principle that the global properties defining higher order systems or 'wholes' … can in general not be reduced to the properties of the lower order systems or 'parts'."

Heylighen: Self-organization: Emergence and the Architecture of complexity

"We are everywhere confronted with emergence in complex adaptive systems – ant colonies, networks of neurons, the immune system, the internet, and the global economy, to name a view – where the behaviour of the whole is much more complex than the behaviour of the parts."

Holland: Emergence from chaos to order

Emergence

It is within this constant process of feedback that we find the evolutionary power within any self-organizing systems. In the case of a termitary, this is an instinctive process. Yet, with a city, feedback becomes much more reflective and thus increasingly complex. City inhabitants are aware of decisions made which changes their environment like a vendor setting up a stall or a corporation building new offices. There are, however, some decisions of which the feedback into, and change of the city environment is not so obvious. Johnson explains that this is because lower-level activity falls within a different time scale than that of the emergent higher-level product. He explains that: "Driving a car has short-term and long-term consequences. The short term influences whether we make it to soccer practice on time; the long term alters the shape of the city itself" (Johnson 2001: 98). He goes on by saying that if "perceived at that [the millennium time scale], the success of the urban super-organism might well be the single most momentous global event of the past few centuries" (2001: 98). This statement is backed up by the fact that urbanization has displaced half the population of the planet into cities and that "until the modern era less than 3 percent of the world's population lived in communities of more than five thousand people …" (Johnson 2001: 98). The success of the city super-organism is due to its emergent nature.

In his essay *Morphogenesis and the Mathematics of Emergence*, Michael Weinstock, director of the Emergent Technologies program at the Architectural Association School, explains that "living organisms can be regarded as systems, and these systems acquire their complex forms and patterns of behaviour through the interaction, in space and time, of their components." He further states that "the form of an organism affects its behaviour in the environment, and particular behaviour will produce different results in different environments, or if performed by different forms in the same environment" (Weinstock 2004: 12).

Genius loci

We find the same elements in a small town or village as we find in a city, yet there is a distinct difference in the character of a city compared to that of a village. Thus, the character of city or town cannot be deduced by the mere sum of the parts. The character is an emergent product of the interaction of these parts. The number of interactions between elements seems to increase as the system increase in complexity: A building in a city relates to a magnitude of other buildings in terms of proximity and scale; a city dweller's options of travel, housing and work are much more than that of a village inhabitant.

This emergent product of the interaction of components is the spirit of a place or the *Genius loci*: it is the product of interaction between the magnitude of city components (the lower-level activities) and the consequential feedback into the city as a whole. However, it is not a quality that can be attributed to the city inhabitants, buildings, roads or any other city component in isolation.

Chrisian Norberg-Schulz, in his book *Genius loci: Towards a Phenomenology of Architecture*, states that "from the beginning of time man has recognized that to create a place means to express the essence of being. The man-made environment where he lives is not a mere practical tool or the result of arbitrary happenings; it has structure and embodies meaning" (1980: 50). He goes on by explaining that any man-made environment, be it a house or a city, can structurally be defined in terms of built boundaries, which defines "enclosure" (1980: 58). The character of these boundaries comprises of the permeability or axis (be it physical or visual) through them. Furthermore, an enclosure has a three dimensional quality, with boundaries extending not only horizontally, but vertically as well.

"The main urban elements are centres and paths. A square

viously functions as a centre and a street as a path. As such they are enclosures; their spatial identity in fact depends upon the presence relatively continuous lateral boundaries" (1980: 59).

Norberg-Schulz explains the structure of the urban *genius loci* in terms of scale, dividing the city environment into urban districts, which, according to him, falls within the same category as a centre. He states that "a district, thus, is either defined by conspicuous edges of some kind, or at least by a change in urban texture which implies a boundary." (1980: 59) The fact that boundary and enclosure plays an eminent role in the structure of man-made places, the "character of man-made places is to a high extent determined by its degree of 'openness'" (1980: 63). This openness refers to communication between structure and user, as well as relationship between structure and structure, in other words, lower-level activities.

A prime example of *genius loci* in terms of closure and openness is the Kowloon walled city on the Kowloon peninsula in Hong Kong. Greg Girard, author of *City of Darkness: Life in Kowloon walled city* describes it as follows: "six-and-a-half acres of solid building, home to 33,000 people, the biggest slum in the world," (1993: 9). In 1993, under agreement of both Chinese and British governments, the Kowloon walled city was demolished. Despite valid arguments for and against the existence of the city (dirty, unhygienic slum life vs. the existence of a self-governing, self-maintaining environment with a strong spirit), the city clearly illustrates some guiding principles pertaining to a positive *genius loci.* The origins and evolution of form and performance of the city as a whole lie in the political history of Hong Kong. However, the *genius loci*, although influenced by these external, political forces, was mainly shaped by the fact that this was, in the word of Peter Popham, journalist specializing in architecture, "arguably the closest thing to a truly self-regulating, self-sufficient, self-determining

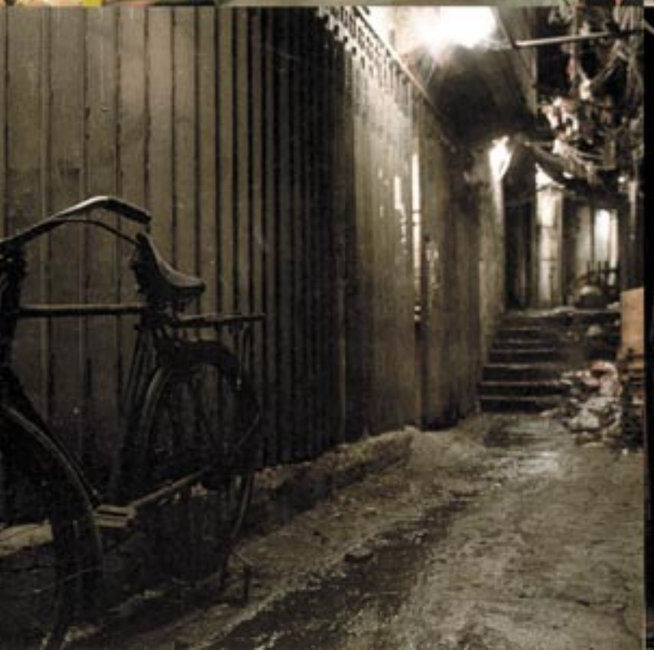
Page 42: figure 035 (top left): Kow loon City external façade.

Figure 036 (Top right): A boundary of houses. The southern façade of Kowloon City.

Figure 037 (Bottom left): Kowloon City on street parking.

Figure 038 (Bottom right): Service distribu tion.

Page 44: Figure 043: Kowloon Walled City, Kowloon Pininsula, Hong Kong



modern city that has ever been built" (Girard 1993: 9). It was within this self-organizing system that the full potential of emergence can be seen: a solid and well-defined spirit of place.

As mentioned earlier, the barrier or edge, and movement through the edge constitutes one of the main structures in the creation of man-made environments. Referring to figures 039 to 042, the edge of the outer wall of Kowloon defines it as a separate entity within its surroundings. Restricted movement through this barrier ensured the safety and unity of the community within the city. This enhanced the emergence of a very distinct spirit for the entire city.

When viewed in terms of a solid structure, the entire city becomes a block with movement patterns carving away the fabric, and daily activities carving space for living in. Like water forming a canyon over centuries of erosion, movement within a city defines form and creates possibilities for appropriation by the city inhabitants. Yet in order for this to happen, boundaries need to exist, albeit between different functions in a city or the city as a whole. This form of evolution is graphically explained in figure 044 on page 46.

Thus, it is within the way enclosure and openness, edge and access communicate with one another that we find an aspect of the spirit of a place. As derived from the above argument, the language for this communication consists of visual as well as physical access and openness. Yet in order to achieve such interaction, an enclosure is required, a distinct boundary to act as mediator between structure and structure, and structure and user.

Figure 039

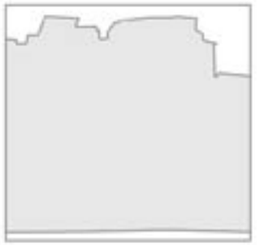


Figure 040

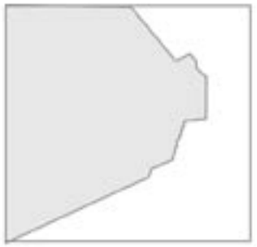


Figure 041

Figure 042

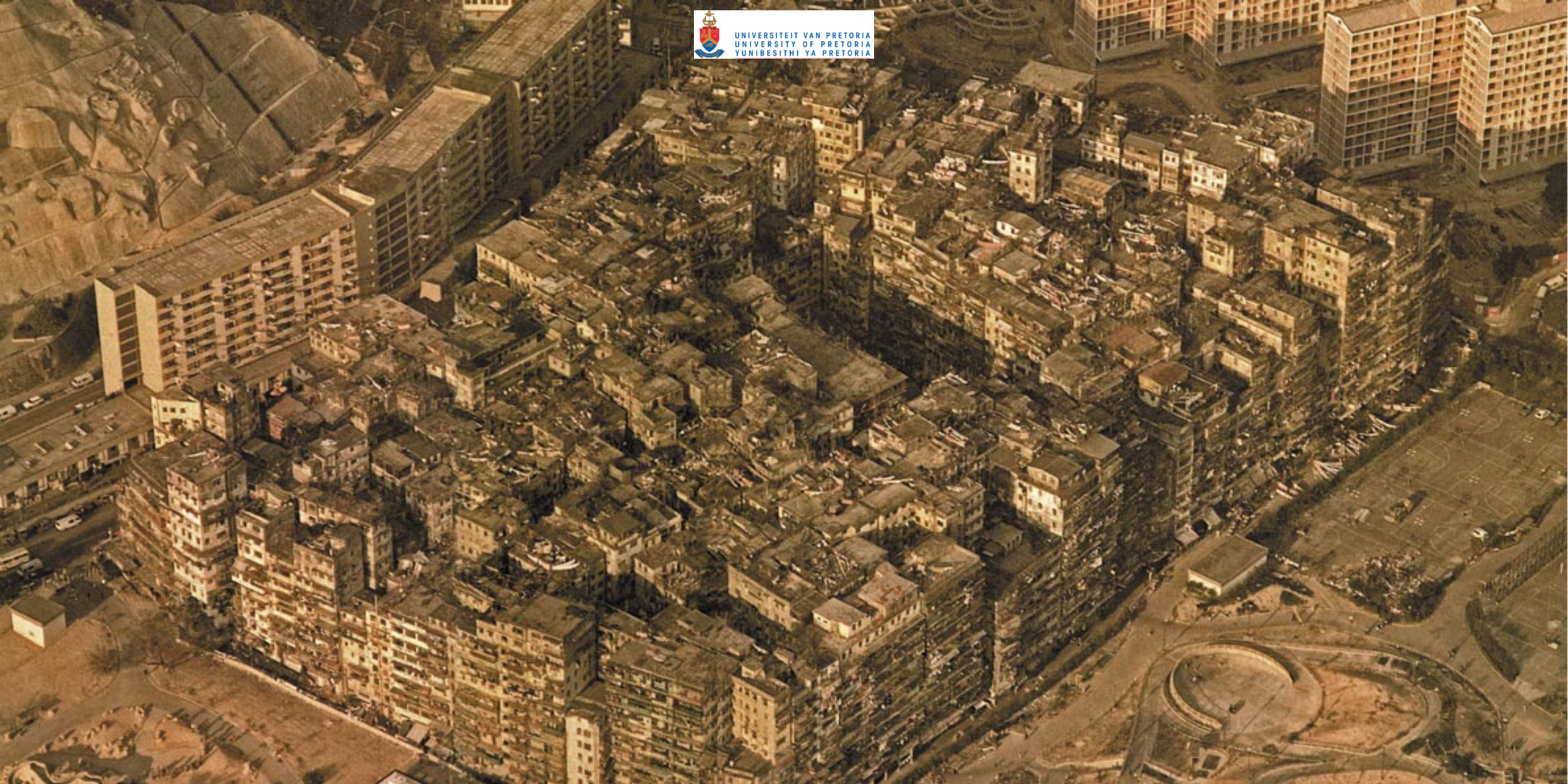

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Figure 44: Movement and city shape

Feedback

Feedback is a defining characteristic of any self-organizing system and is the main driving force behind the creation of complexity. It can broadly be defined as the parts interacting with the whole. As explained earlier, we find this quality brilliantly demonstrated by the individuals in an ant colony, where a number of encounters between foraging ants will determine the next action of the individual ants.

“A foraging ant might expect to meet three other foragers per minute – if she encounters more than three, she might follow a rule that has her return to the nest. Because larger, older colonies produce more foragers, ants may behave differently in larger colonies because they are more likely to encounter other ants.
This local feedback may well prove to be the secret to the ant world’s decentralized planning“ (Johnson 2001: 8).

The ultimate aim of any feedback into a system is to ensure the continual improvement of performance of such a system. In order to “learn”, the lower-level activities obliviously feed information back into the higher-level activities. This, likened to the process we find in the natural selection theory, is to ensure the ultimate survival of the system as a whole.

Movement as feedback

Movement can be considered as a ground level activity within the urban environment. Examining the structure and layout of our cities, it is by far the dominant determinant of how a city is planned. The reason for this is that it forms the primal feedback line from city elements to the city as a whole.

The growth of Athens from 600 B.C. to 287 A.D. illustrates this point. Referring to figure 045, it is clear that the growth of the city was determined by the movement of users along the Panathenaic Way, which stretched from the Dipylon Gate, up the slopes of the Acropolis and terminated at the foot of the statue of Athena. According to Edmund Bacon, “it served both as sacred way and as the main street of Athens. It was the central spine along which occurred the principle mercantile, industrial, and political activities which made up the life of the city. Indeed the position and size of the Parthenon are comprehensible only when it is viewed in relation to the entire Panathenaic sequence” (Bacon 1968: 53).

In redesigning the master layout for Rome, Sixtus V, …, saw the need to use movement as a basic organizational tool. He used nodal points (refer figures 049 an 050, page 49) to connect certain vital districts of the city. Between these points embodied by obelisks erected in open “squares”, movement paths were created. Consequently, Baroque Rome emerged from these points and around these paths. The two diagrams by Paul Klee (figures 047 and 048, page 49) illustrate the principle of nodal point orientation using movement.

Another diagram, a water-colour painting (figure 046, page 048), also by Klee, further develops the idea of movement systems. This shows simultaneous movement systems with the intersecting areas highlighted. The suggestion here is that the form and performance of a city is, in general, determined by the systems of movement.

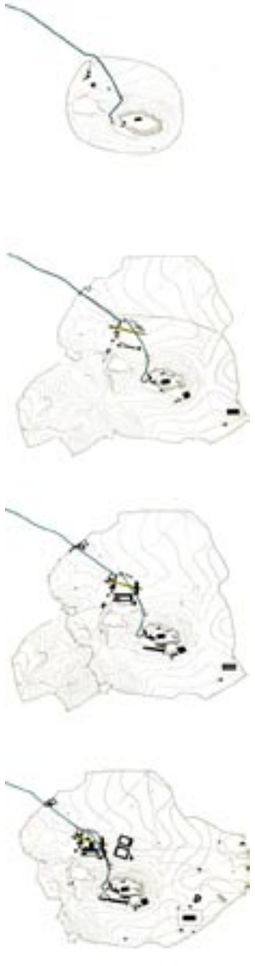
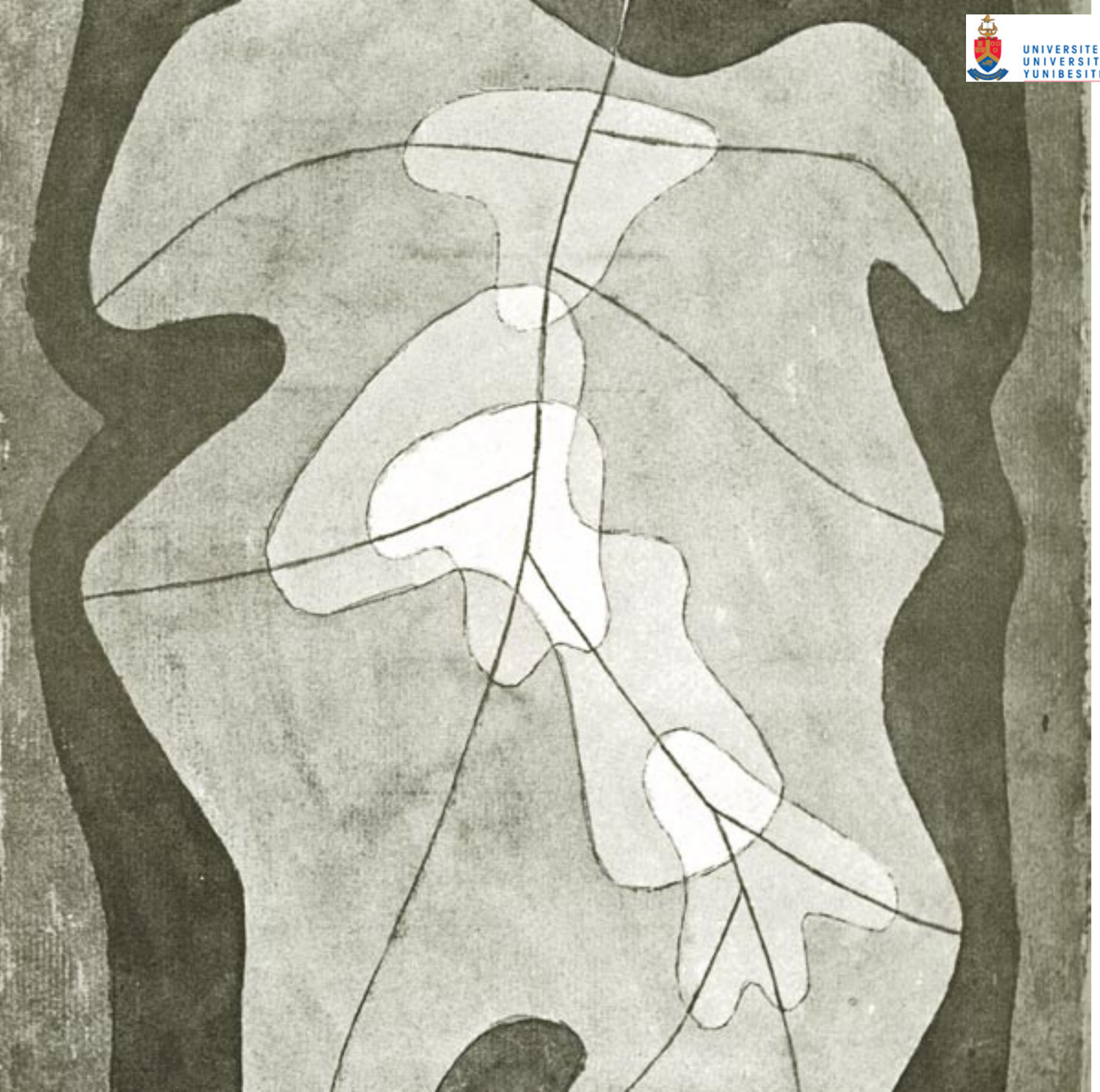


Figure 045: The growth of Athens around the Panathenaic Way.



“Since the veins of a leaf or the branches of a tree are comparable to the channels of movement of people and goods within a city, we see the parallel between organic structural form and the city movement system, their sequential effect on the sensibilities of the people who move over them, and the resulting effect on the appearance and character of the city adjacent to them” (Bacon. 1968: 114).

According to Bacon, there are three concepts which need to be taken into consideration when investigating simultaneous movement systems. These are the relationship of mass and space, the continuity of experience, and simultaneous continuities. Where mass and space can be understood as physical entities, and the relationship between them as a tool for design, continuity of experience and simultaneous continuities refer to a qualitative aspect of movement. Bacon states that “if one can establish a track through space which becomes the actual path of movement of large numbers of people, or participators, and can design the area adjacent to it to produce a continues flow of harmonic experience as one moves over that track in space, successful designs in cities will be created” (1968: 34). This establishes the simultaneous movement systems in a city as the primary feedback line, determining the form and performance of a city.

Top: Figure 47 and 48
Bottom: Figure 49 and 50

Page 48: Figure 046:
“Illuminated Leaf”

Building as feedback

As was mentioned earlier, one of the defining elements of the spirit of an urban environment is boundary. The creation of boundary defines space. The wall of a room indicates a certain relationship between the user and a space. This is however not limited to built space: The circle of light around a fire, or the canopy of a tree indicates just as clearly the notions of “inside” vs. “outside”. We find this perception of space not only on the individual room or building, but also on the urban scale: either ‘inside’ or ‘outside’ the city.

The relationship between user and space is defined in terms of scale, proximity, opportunity for movement and view, and need. The act of place making, or rather, the adaptation of space in terms of abovementioned factors, is defined as building, and is mainly informed by the need of the user. Need causes the changing of the environment through the creation of boundary. Thus boundary is the product of adaptation according to need. It is boundary that defines space, which in turn is made into place by the need of the inhabitant. Conclusively, the difference between the creation of space and place is that of time: Space is the initial product of boundary creation, where place requires user adaptation of that space. This adaptation will in turn create a new space, as the act of building includes the creation of boundary. Thus building falls within the scope of a feedback system: need creates boundary; boundary defines space; over time space becomes place; place making is informed by need, and need creates boundary.

This iterative process varies in scale: adapting a city block to the need of the community requires a more complex approach to boundary creation and a more public focused place making, compared to the more private place making and subtle boundaries in the adaptation of a residential unit. Thus the same is true for the creation of neighbourhoods, suburbs and city districts.

Building/moving

Since building constitutes the creation of boundary or edge, moving to or from a place will always be through these boundaries: walking to work requires moving through the semi-private house/street boundary, through the magnitude of neighbourhood/city block/ city district boundaries, through the public street/foyer boundary, and finally through the semi-public foyer/office boundary. Clearly these boundaries of different scale and accessibility (semi-public boundaries are more accessible than semi-private or private boundaries) exists simultaneously on different layers within the urban environment.

It is this multi-level nature which gives the urban environment its complexity and can be the cause of disorientation. However, the initial division of cities into districts, suburbs and neighbourhoods attempts to orientate the user and guide movement. As Johnson states: “A city is a kind of pattern amplifying machine: its neighbourhoods are a way of measuring and expressing the repeated behaviour of larger collectives – capturing information about group behaviour, and sharing that information with the group” (2001: 40). Thus the clear definition of barriers, the knowledge of leaving and entering space, constitutes a vital orientation tool when moving through an urban environment.

It is this awareness of ones location in place, the knowledge of position (inside this place, outside that place) along a movement system, which constitutes as continuity of experience, one of the principle considerations of movement systems. However continuity does not refer to repetition or rhythmically structured space. It describes clearly identifiable boundaries between places, and the awareness of location.

Community as feedback

The Oxford English Dictionary describes a community as (1) “a group of people living together in one place”, (2) “the people of an area as a group” or (3) “a group of people sharing a religion, race, or profession” (2006). Considering the diversification of communities not only in a urban environment (commuters moving through the area daily etc.), but also on the internet with Facebook and mySPACE communities growing daily, the above mentioned definitions seems outdated and does not adequately describe the multi faceted nature of a community.

Consequently the arguments for movement and building as feedback highlighted some aspects of the urban community. A person moving through a space is as an important role player in the adaptation to place as someone working there or living there. Thus the urban community will consist of a multitude of role players on different scales of involvement and the following breakdown will be used as client profile for the design:

1 **The daily commuter** does not work or live in the community district, yet contributes significantly. Place making along movement routes and through boundaries play a vital role in the open public landscape of the district or area. The need of public facilities and the opportunities for retail are determined by the amount of commuters along a movement route. This falls under the scope of place making, which, as described earlier, is a feedback system. Thus the amount of commuters influences the making of place, which in turn influences the amount of commuters.

2 **The patron** mostly visits the area over lunch hours. These users are more related to retail and dining opportunities and as such contributes to the community financially.

3 **The employee** forms an integral part of the urban community during office hours, establishing the area as a destination. They also contribute financially as most employees fall under the patron definition. In establishing the area as a destination, movement to and from work influences the movement systems.

4 **The vendor** can be seen as a unique employee, contributing to the daily street level activity of the urban community. They ensure an influx of patrons during lunch hours and play a vital role in the quality of experience of a space since the nature of street venting includes the adaptation of space to place according to need.

5 **The resident** is the only role-player described by the initial definition of a community. However, residing in one place might be a better description. This includes homeowners, home-renters and the homeless. They form the after hour custodians of the community and contribute to the more personalized place making activities. The homeless is in most urban areas the only true 24hour inhabitants of an area, with place making limited and nomadic, yet with a contribution to spirit and character.

"Cities have no central planning commissions that solve the problem of purchasing and distributing supplies…
How do these cities avoid devastating swings between shortages and glut, year after year, decade after decade? The mystery deepens when we observe the kaleidoscopic nature of large cities. Buyers, sellers, administration, streets, bridges, and buildings are always changing, so that a city's coherence is somehow imposed on a perpetual flux of people and structures. Like the standing wave in front of a rock in a fast-moving stream, a city is a pattern in time."

John Holland (Johson 2001)

Design tools and performance guidelines

Understanding a city as a self-organizing system complicates the identification of measurement criteria for performance or even tools for design. Even when considering Holland's statement, it becomes clear that there are no right or wrong interventions within the urban environment. The identification of tools for emergence within the city super-organism seems futile as this organism, per definition, is self-regulating its growth and evolution. However, from the argument for movement and building as feedback, certain guidelines can be highlighted to guide the iterative process of emergence within the urban landscape.

The first guideline is the **creation of boundary** in order to define space. The quality of a boundary should correspond to the classification of space it encloses yet still allow for juxtaposing of other boundaries (possibly of different qualities) on it. For example, a street level entrance might give access to a foyer which is used for both office and residential space.

Secondly, the possibility of adaptation of the boundary in order to **transform space into place**: where creation of space is determined by boundary, place making emerges from space over time. This adaptation must be possible in all the layers of an urban environment.

As illustrated by Sixtus V's master plan for Rome, movement takes place from or to a place. The **continuity of experience** between places can be seen as the third guideline. As described earlier, this continuity deals with movement through boundaries and the knowledge of orientation. It also describes the movement through the city districts, suburbs and neighbourhoods.