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Architecture as a Second Nature

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The paper suggests a new sustainable approach of building design. This approach makes architecture welded into nature. It functions in the same way as ecologies. The functional concepts in the fields of biology and ecology are used to suggest the techniques to create a new architecture. Mimicking the organism systems and processes in nature using new cybernetic technology are the new techniques for "bio- interactive buildings". The resulting "Modern Ecologies" based on a "second nature" unify the natural and the artificial into one entity. This ecology would be a continual dynamic relationship between matter, energy, and information in a specific medium (environment). It would be hard to separate what is life and what is matter. These smart buildings, in some ways, would "come alive".

Keywords: *ecological approach, biomimicry , sustainable architecture, passive architecture, interactive architecture.*

1. Introduction

Environmentalism has come a long way since its inception in the era of the industrial revolution. Mainly, there were two types of environmental movements in the west: the Naturalists or Preservationists who are concerned with the preservation of species of plant and animal life and the Conservationists who are concerned with the efficient utilization of natural resources. The aim of the Conservationists is the proper use of nature in the interest of the humankind; whereas the Preservationists sought the protection of nature from humans and they advocate the idea of separating wilderness areas from civilized areas (Naess,1999). The common thread running through the Conservationist's perspectives is their focus on intelligent and informed management of the environment to fit man. They feel relatively free to trade-off environmental quality for economic benefit (Glow, 1992). Their viewpoints embody the western faith in the mastery of nature: as nature is something to exploit in a way that should last as long as possible. On the other side, the Preservationists believe in the importance of ecological species but they consider human species separate and harmful to nature. According to the Preservationists, the human should physically be separated from what they call "wilderness".

In this paper a new approach towards the relation between human and nature is suggested. The new approach should emerge with an explicit rejection of the idea of man's supposed separation from and possibly domination over nature. This new perspective should come from the ecological trend that considers man as one of the species in the ecosphere, part of and dependant on the rest of nature. And the goal is to focus on how to live in harmony with the rest of the other species and live in peace with nature. This perspective promotes a more radical analysis of the industrial society itself. The current trend of using technology is to go against nature to control it. If the philosophy of this industrial society is responsible for a general disruption of the ecosphere, which is detrimental, then the problem is more than inefficient practices of exploiting nature. The problem lies in the deep relation between man and nature.

Human should see themselves as part of nature. Every technological invention and innovation should be inspired and work in harmony with nature not against it. Similar to the way that all the systems in our body work in harmony, any invented system should be part of the whole nature. That philosophy will make a substantial difference in resolving environmental problems.

2. How can we imply this perspective to our buildings?

2.1. Goals for a new design

The suggested new ecological approach should lead to a new architectural model to rebuild the relation between architecture and nature. Starting with a historical view, I'll show how architecture evolved independent of nature since the industrial revolution. Lately, however the relation between architecture and nature started to rebuild itself. Truly interested in this above mentioned transition, I will attempt to discuss the potential and critical path from the past to the present.

The scientific revolution made a crucial change on the whole way of approaching the world. Architecture which usually reflects the philosophy of its period faced a major change. After the modern revolution the classic way of ornament (which was part of the classic architecture theme) was considered an arbitrary beauty (Freigang and Kremeier, 2003).

C. Perrault in the seventeenth century distinguished between the arbitrary beauty and the positive beauty. He argued that positive beauty comprised three factors: richness of material, precision of execution and symmetry. C. Perrault meant rational, geometric, largely orthogonal order. His universal beauty became the basis for Neoclassic, which we now see to have been the ultimate origin of a technologically rational, gridded architecture. In 1908 A. Loos published his famous essay "ornament and crime" in which he wrote: "Modern ornament has no forbears and no descendant, no past and no future, it is joyfully welcomed by uncultivated people to whom the true greatness of our time is a closed book and is after a short time rejected." This stricture against the invention of ornament went to the degree they considered ornament is a crime (Gans and Kuz, 2003).

In 1924 L. Sullivan published his book "A system of architectural ornament According to the philosophy of man power". In his book he advocates the idea of geometrical figures. Design became a tool to redesign the whole society to be more materialist and to express the triumph of the man upon nature. The shape of the building should follow the functions inside the building and no other meaning should be embedded "the form is inherent in the specific task" (Sullivan,1967).

In the sixties of the 20th century a new argument started to take place about the cultural dimension. The architecture of our cities should search for a meaning and nothing exists in isolation. To summarize this emerging movement as Hegel sees it: "symbolic art seeks the perfect unity of form and content that classic art finds and romantic art transcends" (Ameriks, 2002).

The social crisis of industrialization leads to new investigations searching for a holistic cultural vision. Building as a part of the context, (the place and the time), became part of the design principles for the post-modern architecture.

2.2. Strategies

Context. Our main strategy is to change the meaning of context and how to deal with context.

The traditional meaning of context. Post-modern architecture started to reflect the spirit of the place, which is represented by the surrounding buildings, and the spirit of the time. Architecture, from the sixties of the last century, sought to work as part of the city style. It worked in harmony with the urban context. The meaning of the context was limited to the human achievements and cultural values. The broader world with its nature was neglected. The built environment was the focus and the human needs were the aim. That was the basic assumption for the meaning of context. The environmental crisis lately forced people to rethink this trend.

The suggested new meaning of context. A need for new attitudes towards "nature/earth" became urgent. New visions started to emerge concerning our relation with nature. A new way of viewing and valuing nature started to develop. The earth is a super-natural place that embraces many life-forms living harmoniously. Architecture which represents the man made environment should respond to its natural milieu, implying "appropriateness" and "harmony" within the larger context. Better to build systems connecting the outside natural world with the inner life by making the inner part of the outside. By this we exceed the traditional meaning of the city as context for our new buildings by another meaning for context which is the entire natural world around. We replace the goal to satisfy the human needs by a larger goal to satisfy all the natural species on earth. This is a new holistic approach with a new assumption.

Nature as a guide. Design should be approached as a way of risk taking instead of reducing the risk. "Our ideas we have had and evaluation we have made are free for recycling" (Gans and Kuz, 2003). Let us be opened to make a total change to our prevailing concepts. We should create a balanced world where the built environment works in total harmony with nature. Instead of superimposing form, the architect's responsibility would be to let the form unify with the whole context. In order to reach that, the new system should work similar to the natural world not alien from it. It is better to start with conceiving, then transforming, the natural systems with its complicated processes. From that we can move to initiate new architecture. This new "digestive building system" would function to support the ecosystem. This way we are exceeding the traditional green building practices and similar efforts. The goal of traditional green practices is to look for less harm that is done by an alien, juxtaposed system, while our goal is to create buildings that function like nature.

This natural philosophy conceives of the universe as an organism and the work of architecture as an organic operation. The organic approach here is a mode rather than a model, as a program rather than a form. Forming here is a dynamic process. In this dynamic process of forming the "architectural form", we create a best and stable relation between built and natural environment. This new architecture is welded into nature and the whole is a single body animated by a single spirit.

Architecture is a form that includes the pattern of human behaviour, which is natural and can work in unity with the rest of nature. In this context there is continuity between object (architecture), environment and behaviour. We can call this architecture a "second nature".

Flowing from this "second nature", a new design approach termed bio-mimicry has a highly promising design mechanism.

2.3. Design techniques

Biomimicry. Biomimicry is the imitation of the models, systems, and elements of nature for the purpose of solving complex human problems (from bios, meaning life, and mimesis, meaning to imitate) is a design discipline that seeks sustainable solutions by emulating nature's time-tested patterns and strategies, e.g., a solar cell inspired by a leaf (Biomimetics..., 2014). The term organic, first appears as dynamic rather than static concept of nature in artistic and scientific terms. And what distinguishes organism is the evolving, developing processes."The gestalt of an organism accounts for the complexity of its life cycle as it gradually develops yet somehow retains its identity" (Gans and Kuz, 2003). According to the Oxford dictionary, the term "organism" is directly related to the term "organization". There is a long tradition of defining organism as a self-organizing being. In multi cellular term, "organism" describes the whole hierarchical assemblage of systems. In biomimicry, we look at Nature as model, mentor, and measure (Evans, 2014):

Model: biomimicry is a new science that studies Nature's models and then emulates these forms, processes, systems, and strategies to solve human problems – sustainably.

Mentor: biomimicry is a new way of viewing and valuing nature. It introduces an era based not on what we can extract from the natural world, but what we can learn from it.

Measure: biomimicry uses an ecological standard to judge the sustainability of our innovations. After 3.8 billion years of evolution, Nature has learned what works and what lasts.

The bio-mimicry "helix" will be introduced here as a continuous model illustrating two integral products of the bio-mimicry process - organs and organisms (Benyus, 2011). This metaphorical approach to the definition embellished the primary goal of bio-mimicry – to visualize man-made systems and products as natural processes. The concept of biomimicry is often oversimplified into a linear process to create a design emulating the observation or the shape only. Bio-mimitics is also typically mistaken for biotechnology as it does not exploit "bio-assisted" processes such as using green algae to treat waste water.

According to E. Royall (2010), as natural systems evolving continuously to meet dynamic changes, biomimicry is considered to be a spiralling, continuous process, taking nature as inspiration to generate "organs" (individual products) or "organisms" (systems and processes) for the purpose of integration into a sustainable system. The "helix" model of biomimicry reflects a number nuances. Primarily the model is spiral. This represents the idea of biomimicry as a continuously evolving process, infinitely seeking a closer fit to the fluctuating environment. This model reflects continuous feedback and repeated fine-tuning required to adapt "organs" and "organisms" to the environment. Organs include singular products like photovoltaic cells or fibber optics, while organisms are systems such as smart grid or cities (Royall, 2010).

Biomimicry differs from other "bio-approaches" by consulting organisms and ecosystems and applying the underlying design principles to our innovations. This approach introduces an entirely new realm for entrepreneurship that can contribute not only innovative designs and solutions to our problems but also to awakening people to the importance of conserving the biodiversity on Earth that has so much yet to teach us. A sincere search effort for principles from this forming model should make moot the distinctions between organic and inorganic. This technique leads to a harmonious environment.

Others think that the larger medium – ecology – can lead to better environmental solutions.

Design Ecologies. Recently new terms entered the field of architecture to describe the ability of the new architecture to meet changing needs with respect to evolving environmental demands.

Some of these practices called Responsive Architecture which describe the new buildings that measure actual environmental conditions (via sensors) to enable these buildings to adapt their form, shape, color or character responsively via actuators (Wigginton and Harris, 2002). Responsive architectures distinguish themselves from other forms of interactive design by incorporating intelligent and responsive technologies into the core elements of a building's fabric. For example: by incorporating responsive technologies into the structural systems of buildings, architects have the ability to tie the shape of a building directly to its environment (Responsive..., 2014).

Other practices and research went step further to what they call Interactive Architecture. Interactive architecture signifies a field of architecture in which objects and space have the ability to meet changing needs with respect to evolving individual, social, and environmental demands. The convergence of embedded computation and kinetics in architectural form with the intention to involve human and environmental responses creates an architecture that could be termed interactive or responsive, but can also be cybernetic. Such systems must utilize a definition of interaction as circular, or they are merely "reacting" and not "interacting". According to L. Bilung (2000), reactive systems are unlike the transformational systems: "unlike transformational systems which operate on inputs available at the beginning, reactive and interactive systems maintain an ongoing series of interactions". Reactive systems follow a pace dictated by the environment. The environment determines when the systems must react and provides inputs. The systems respond to the inputs by possibly sending outputs to the environment (Bilung, 2000).

The new concept in interactive architecture – cybernetics – is to make people interact with architecture; the relation in this model is dialectical, as the building adapts itself to the environment and to the human needs, while the building at the same time changes the user behaviour. The people who use these buildings should not be thought of as "users" but instead as "participants".

M. Novak uses the term transactive intelligence, to define architectural intelligence that not only interacts, but that transacts and transforms both the user and itself (Silva, 2005). In the 1980s and 1990s, an explosion of development began to take place within the field of computer science. Out of this, fields such as "intelligent environments" (IE) were formed to study spaces with embedded computation and communication technologies, creating spaces that bring computation into the physical world. Intelligent environments are defined as spaces in which computation is seamlessly used to enhance ordinary activity (Tilder and Blostein, 2009).

The advantages of the digital realm. "Life adds "information to matter" to make adaptable shapes and systems" (Benyus, 2011). The same concept should be applied to the human industry and human constructions. Smart buildings, able to make decisions, actions and evolving at the same time, can be developed from this application. Some research had been done in this respect to get a human-like reaction. Collective behaviour started to take place in the digital realm. Actually in parallel to advances in ecological design, the digital realm has proliferated, becoming ubiquitous as our prosthetic extension to the world. During its first half-century the digital realm has generally been a top-down system. According to P. Hasdell (2006), the potential of the digital – as complex autonomous systems that behave in ways more akin to living things in the natural world – is only now beginning to be actualized. As the digital realm evolves, new forms of distributed computing are employing cognitive, sensory, and interactive abilities, such as inbuilt feedback mechanisms and predictive and collective behaviours. The overall characteristics of our digital technology more closely approximate, and are able to interact with, human and natural systems. As N. K. Hayles (1999) points out, essential decision-making processes in complex systems have developed in ways that now require both human and computer input. In this concept the natural and the artificial are increasingly united. The developing second order of cybernetic theory has a big role in this respect. The development of distributed cognitive environments in which humans and computers interact in hundreds of ways daily often unobtrusively has transformed data and information into a flow independent of its material base and creating the possibility for a new condition that links data and computer networks with human networks. N. K. Hayles (1999) speaks of this condition not as dichotomy between the real and virtual but rather as space in which the natural and artificial are increasingly entwined. The 2005 United Nations International Telecommunications Union report, "The Internet of Things", outlines an increasing degree of embedded computing within our everyday environments, a proliferation of computing to the extent that interactions between multiple embedded parts may in the near future, outnumber actual human-computer interactions. This ubiquitous distributed computing will impact our notion of the environment and the interaction between entities (artificial or natural) within those environments (Hayles, 1999; Hasdell, 2006; Tilder and Blostein, 2009).

This conceptually is related to the field of cybernetics or more precisely "new" or "second order" cybernetics in its rediscovery and redefinition in the 1970s. In the 1970s, new cyberneticians emerged in multiple fields, but especially in biology. The ideas of H. Maturana, F. Varela and H. Atlan, according to J. P. Dupuy (1982), "realized that the cybernetic metaphors of the program upon which molecular biology had been based rendered a conception of the autonomy of the living being impossible*"*. Consequently, these thinkers were led to invent a new cybernetics. Chilean biologists F. Varela and H. Maturana defined the term auto-poiesis as a conceptual mechanism:

"An auto-poietic is a machine organized, (defined as a unity), as a network of processes of production (transformation and destruction of components which (i) through their actions and transformations continuously regenerate and realize the network of processes (relations) that produced them and (ii) constitute it as a concrete unity in space in which they (the components) exist by specifying the topological domain of its realization as such a network." Auto-poiesis or "self-creation" describe the cybernetic or regulating systems that give rise to and maintain biological cells and living systems within this concept (Glow, 1992). The flow of energy and matter (molecules) is considered integral to the overall autonomy of the system as is the systems processes of cognition. Because H. Maturana's and F. Varella's cybernetic theory of auto-poiesis refers to closed or bounded biological systems – in other words an organism's capacity to make and maintain itself – it allows innumerable parallels to a more biological definition of ecology (Gans and Kuz, 2003).

More specifically, as computing develops, employing cognitive, sensory, and interactive attributes as inbuilt feedback mechanisms, the overall behavioural characteristics of a digital system are increasingly able to engage the complex dynamics of both human and natural systems. Emerging fusions of the natural and the digital are only just beginning to engage issues of biomimesis, emergent properties, environmental responsiveness, autonomous behaviours, and artificial ecosystems, in which a truly hybrid natural and digital environment, a "second nature" arises. Second nature as it is commonly understood is an acquired behaviour practiced long enough to become innate or "natural". It is also a learned physical or emotional response that modifies our relation to the world and allows us in this case to access both the natural and digital. Emerging fields of research on morphological, digital and media ecologies are beginning to extend the concept of ecology beyond the natural biotope.

Recently, some researchers started to consider ecology as not the exclusive domain of the biologist. Ecology can share commonalities and relationships facilitated by increasingly open "meshwork" between the physical and the virtual, the nature and the "second nature" and make them one unity. Ecology in this meaning includes nature, second nature, and the virtual world.

2.4. Examples

M. Wigginton and J. Harris (2002) in their book "Intelligent Skin" give a good practical example of design ecology. It highlights an exciting new approach to the area, where the shell of the building responds to external changes and internal demands similar to the animal's skin. The prime objective is to control internal environments through a responsive building fabric rather than by an energy consuming building services systems. The authors examine the potential for integral intelligence which is similar to the brain when it is connected to the building envelope-skin. They are suggesting an architecture model with flexible movable skin (giving some wall sections as a model for skin) working through a computing system. In his model there is a continuous exploring and evolution of information technology and smart materials which have allowed a new category of bio mimicry design to be created (Wigginton and Harris, 2002).

The Eastgate Centre in Harare, Zimbabwe, typifies the best of green architecture and ecologically sensitive adaptation. The country's largest office and shopping complex is an architectural marvel in its use of biomimicry principles. The mid-rise building, designed by architect M. Pearce, has no conventional air-conditioning or heating, yet stays regulated year round with dramatically less energy consumption using design methods inspired by indigenous Zimbabwean masonry and the self-cooling mounds of African termites (Atkinson, 1995; Doan, 2012; Pearce, 2014). Termites in Zimbabwe build gigantic mounds inside of which they farm a fungus that is their primary food source. The fungus must be kept at exactly 30.56 degrees Celsius, while the temperatures outside range from 1.67 degrees Celsius at night to 40 degrees Celsius during the day. The termites achieve this remarkable feat by constantly opening and closing a series of heating and cooling vents throughout the mound over the course of the day. With a system of carefully adjusted convection currents, air is sucked in at the lower part of the mound, down into enclosures with muddy walls, and up through a channel to the peak of the termite mound. The industrious termites constantly dig new vents and plug up old ones in order to regulate the temperature (Doan, 2012).

The Eastgate Centre, largely made of concrete, has a ventilation system which operates in a similar way as shown in figures 1 and 2. Outside air that is drawn in is either warmed or cooled by the building mass depending on which is hotter, the building concrete or the air. It is then vented into the building's floors and offices before exiting via chimneys at the top. The complex also consists of two buildings side by side that are separated by an open space that is covered by glass and open to the local breezes. Air is continuously drawn from this open space by fans on the first floor. It is then pushed up vertical supply sections of ducts that are located in the central spine of each of the two buildings. The fresh air replaces stale air that rises and exits through exhaust ports in the ceilings of each floor. Ultimately it enters the exhaust section of the vertical ducts before it is flushed out of the building through chimneys (Doan, 2012).

The Eastgate Centre uses less than 10 percent of the energy of a conventional building its size (Pearce, 2014). These efficiencies translate directly to the bottom line: Eastgate's owners have saved 3.5 million $ alone because of an air-conditioning system that did not have to be implemented. Outside of being eco-efficient and better for the environment, these savings also trickle down to the tenants whose rents are 20 percent lower than those of occupants in the surrounding buildings (Atkinson, 1995; Doan, 2012).

Who would have guessed that the replication of designs created by termites would not only provide for a sound climate control solution but also be the most cost-effective way for humans to function in an otherwise challenging context (Doan, 2012).

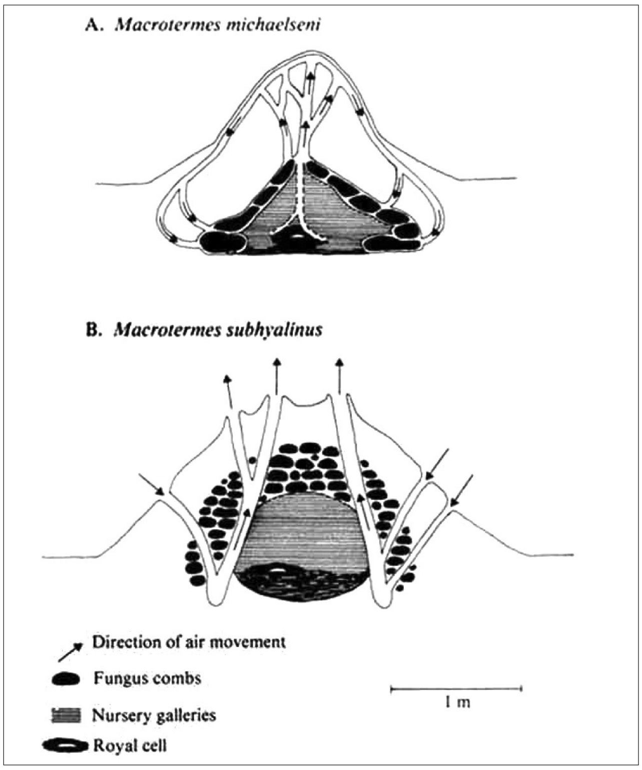

Fig. 1. The self-cooling mounds of African termites (Doan, 2012)

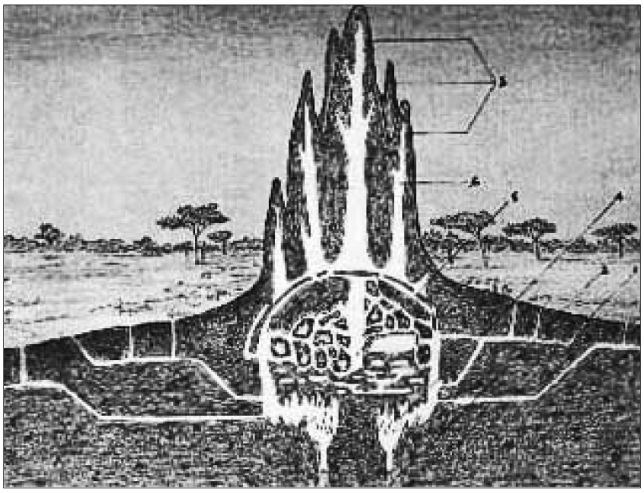

Fig. 2. The concept behind Zimbabwe passive design (Doan, 2012)

Another approach was that of MIT's Intelligent Room project directed by M. Coen, which was created to experiment with different forms of natural, multimodal human-computer interaction (HCI) by embedding computational smarts into everything with which the users come in contact. The goal was to allow computers to participate in activities that have never previously involved computation and to allow people to interact with computational systems the way they would with other people (Atkinson, 1995). The developments in IE were essentially fuelled by the concept of "ubiquitous computing" (a term coined in 1988 by M.Weiser as a post-desktop model of human-computer interaction) (Brooks and Coen, 1994).

Ubiquitous computing can be defined as computation thoroughly integrated into everyday objects and activities, and is often regarded as the intersection of computer science, behavioural sciences, and design. In ubiquitous computing, a user engages many computational devices and systems simultaneously in the course of ordinary activities, and may not necessarily even be aware that they are doing so. M. Weiser described this as "the age of calm technology, when technology recedes into the background of our lives" (Atkinson, 1995).

Another example can be seen through founder T. d'Estree Sterk and partner R. Skelton. They are working on shape-changing "building envelopes" using "actuated tensegrity" structures – a system of rods and wires manipulated by pneumatic "muscles" that serve as the building's skeleton, forming the framework of all its walls. Sensor/computer/actuator technologies are used to produce d'Estree Sterk's intelligent envelopes and structures that "seek fresh relationships between the "building" and "use"", according to Interactive Architecture organization. The buildings are covered by skins with the ability to alter their shape as the social and environmental conditions of the spaces within and around each building change. By connecting the skeleton to embedded, intelligent systems, d'Estree Sterk and his crew are creating smart structures that are light, robust and capable of making extensive shape changes without consuming a lot of energy (Butcher, 2006).

2.5. The suggested model

This paper is suggesting an integrated model that is connecting all the above designing techniques while adding new dimensions.

We aim to create a real continuity between object-architecture, environment and human behaviour as the main three bases for which is called a "second nature". We are looking forward for architecture that can keep a symbiotic relation with nature and humans. We talked and expanded about how architects can design a building to work like an organism. It may have systems of senses, bones (structure), muscles (moving parts), skins (shell) and a brain (digital) that know how to respond. Also this adaptable architecture can satisfy the human needs too. This arises from the building's ability to predict the behaviour and needs of the inhabitants by having observed them over a period of time. This building, instead of being programmed to perform certain actions, essentially programs itself by monitoring the environment and sensing actions performed by the users. At the same time these buildings have an effect on the users' behaviour. There is a strong connection between the two, buildings and inhabitants.

Architecture should work similar and in total harmony with nature and humans. Connected deeply through a "multiple-loop" system in which one enters into a "conversation": a continual and constructive information exchange between nature and human. That goes to the degree that it becomes part of that natural entity and it is hard to know the edges between the three. The relation in this model is totally dialectical; it goes further than mimicking. These smart buildings, in some ways, would "come alive" and may do more. I will call this ambitious architecture a "Smart Dialectical Architecture".

3. Conclusion

This paper demonstrates that all the current environmental trends come up with only partial solutions. They started from the assumption that there is a separation between human and nature. This artificial separation works mostly for the human advantage. A new ambitious environmental approach is suggested. This trend should start based on a new interactive philosophy between human, architecture, and nature. The core of this approach is: human is part of this ecosphere and should work in harmony within the ecosphere. The relationships are symbiotic where all entities are contributing to the whole ecosphere. Coming from this philosophy, the paper suggests a new model of building design that makes architecture work in total harmony with and welded into nature. It functions in the same way as ecologies. The functional concepts in the fields of biology and ecology are used to suggest the techniques to create a new architecture. Mimicking the processes in nature using new cybernetic technology are the new techniques for "bio-interactive buildings". The resulting "Modern Ecologies" based on a "second nature" unify the natural and the artificial into one entity. This ecology would be a continual dynamic relationship between matter, energy, and information in a specific medium (environment). The relationship in this design model is totally dialectical going further than just mimicking. It would be hard to separate what is life and what is matter. These smart buildings, in some ways, would "come alive".

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