# A prototype-based knowledge based system for design and planning of sustainable cities

## 1 Introduction

Experts in computer science do not care about problems that mankind should face urgently such as overpopulation, water (scarceness and pollution of surface water and aquifers), energy, pollution, health, residue treatment, urbanization, violence and terrorism, migration, cultural shock, “sex war”(homossexualism and so on). An ecodesign model was created to cope up with the need to stop the human entropic behaviour towards Mother Earth, biodiversity and the selforganization of a true human society able to move against the gradient of entropic forces associated to the second law of thermodynamics.

## 2 The domain dependent model

This ecodesign model entitled The Model of Primary, Secondary and Tertiary Waves for design and planning of sustainable cities characterizes the domain dependent model of a knowledge based system. It triggers off all phases of the design and planning processes insofar as the architectonic artifact defines the ecosystem and is defined by the ecosystem. It grasps the gist of design and planning emphasizing their intrinsic undivisible reality. Using a metaphor, it mimics the nature of light. It is particles and waves. From the artifacts stream forth the rays of planning (figure 1).

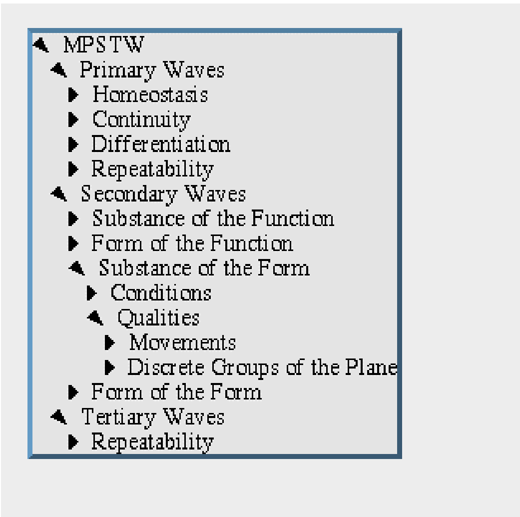


Figure 1. The object “Model of Primary, Secondary and Tertiary Waves in Self.

It exhibits both horizontal and vertical layers of integration. The subeco-systems are the figures (prefix, root, sufix) of the architectonic language. Their composition shapes a word. Likewise the subeco-systems play the role of the elements of the architectonic design namely, activities, structural systems, environmental comfort, hydraulic and sanitary installations, built systems and so on. Together they shape the architectonic artifact or the eco-system with hyphen. The sum of the eco-systems with hyphen shapes the urban ecosystem. Thus the subeco-system behaves neither as a whole object nor a part of it, although it enfolds information that mimic a closed set, when it unfolds as form especially it must cross-cut several different subeco-systems.

## 3 The computational model

Its implementation demands open computational systems that mimic its autopoietic and hermeneutic nature. It calls for a different notion of order: the *implicate order* [Bohm92:179]. This means to start working with an indivisible whole and the task of science is to derive parts through the abstraction of the whole, explaining then as approximately separate, stable and recursie but externally related elements consisting of relatiely autonomous subtotalities better described in terms of an *explicate order.*
This requires a flexible programming system that may not only adapt to the new emerging patterns of the domain dependent model enabling its endless evolution but also its extension by other computational methodologies.
Prototype based object oriented programming that can be embellished by reflective metalevel architectures exhibit a substantial capacity for expressiveness, metamorphosis and expansion [Foot92]. A prototype based object oriented programming language Self was chosen to implement it [US87].
It is possible to identify three steps in a lifecycle of a prototype based knowledge based system for designing and planning of sustainble cities:

1) Enfolding of information concerned with the subeco-systems (implicate order) consisting of three phases for each subeco-system ranging from the architectonic artifact to the urban design:
   a) an initial prototyping phase
   b) an exploratory expansionary phase
   c) and a consolidation phase.
2) Unfolding of information (explicate order [Bohm92] or production of full-fledged architectonic artifacts exhibiting vertical integration of subeco-systems
3) Planning of the urban ecosystem grown out of urban design.

A full-fledged knowledge based system to accomplish the three steps would require open distributed systems [Lang98] as well as collaboration-based design methodologies [SB98]. Of course prototype based systems can accommodate these methodologies easily.

## 4 The initial phase of prototyping

To illustrate the initial phase of prototyping, the design of an apartment for a middle class adult who prefers to live alone is implemented in Self.
An ecoDesign model was created to manage all its objects (figure 2). It plays the role of the globals in Self.
To capture the essential nature of design, besides concern with the enfolding of information to deal with the plane of the function the MPSTW entails also the need for unfolding the plane of the form. Here image performance (sketch phase) and image processing (drawing phase) must be outlined. Paper has zero processing capability, yet it is the medium of choice for conceptual design.
As a solution to this problem the object screenMorph to sketch what one wants is introduced. The ecodesign model engages in a conceptual graphical conversation with the screen, emphasizing the shift of paradigm in computing technology orbiting around the unifying concept of interaction [Wegn97] so well captured throught the prototype based

architectures. During this conversation there is a continuous dynamic play between the development of the concept which is a white box in the ecodesign model (figures 4,5) and the external movement of the screen. This is an inherent graphical facility created by my collaborator Jecel Mattos de Assumpção Jr from the Laboratory of Integrable Systems – USP. Scale and grid were added to the Self objects to help to position the graphical

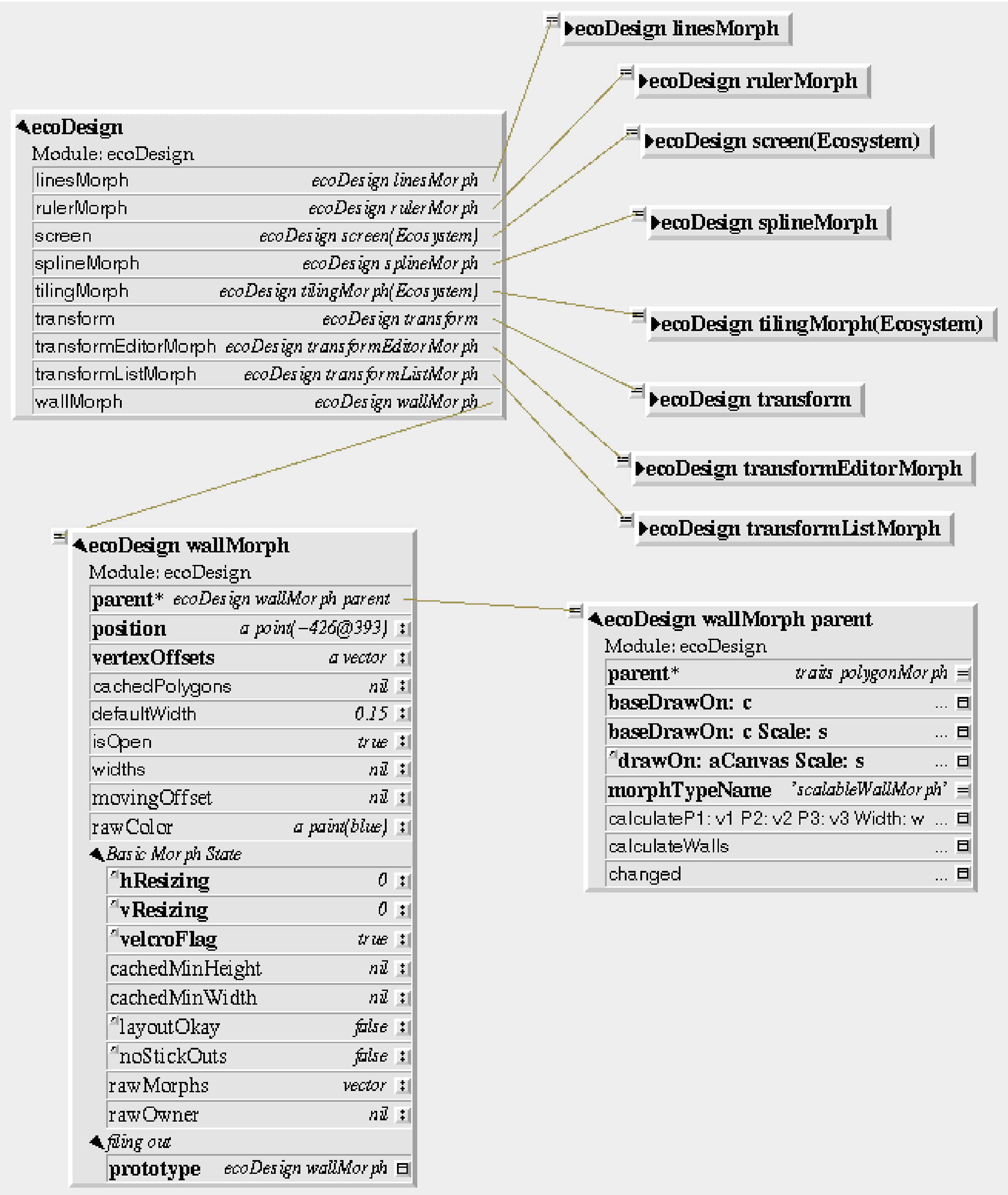


Figure 2.An ecoDesign object plays the role of the globals object in Self

elements of the plane of the form (figure 3).
A series of objects was created such as linesMorph, polygonMorph, splineMorph

rulerMorph, wallMorph which know how to draw themselves according to the screen where they are. They draw respectively lines, polygons, splines, rulers and parallel lines to represent walls.

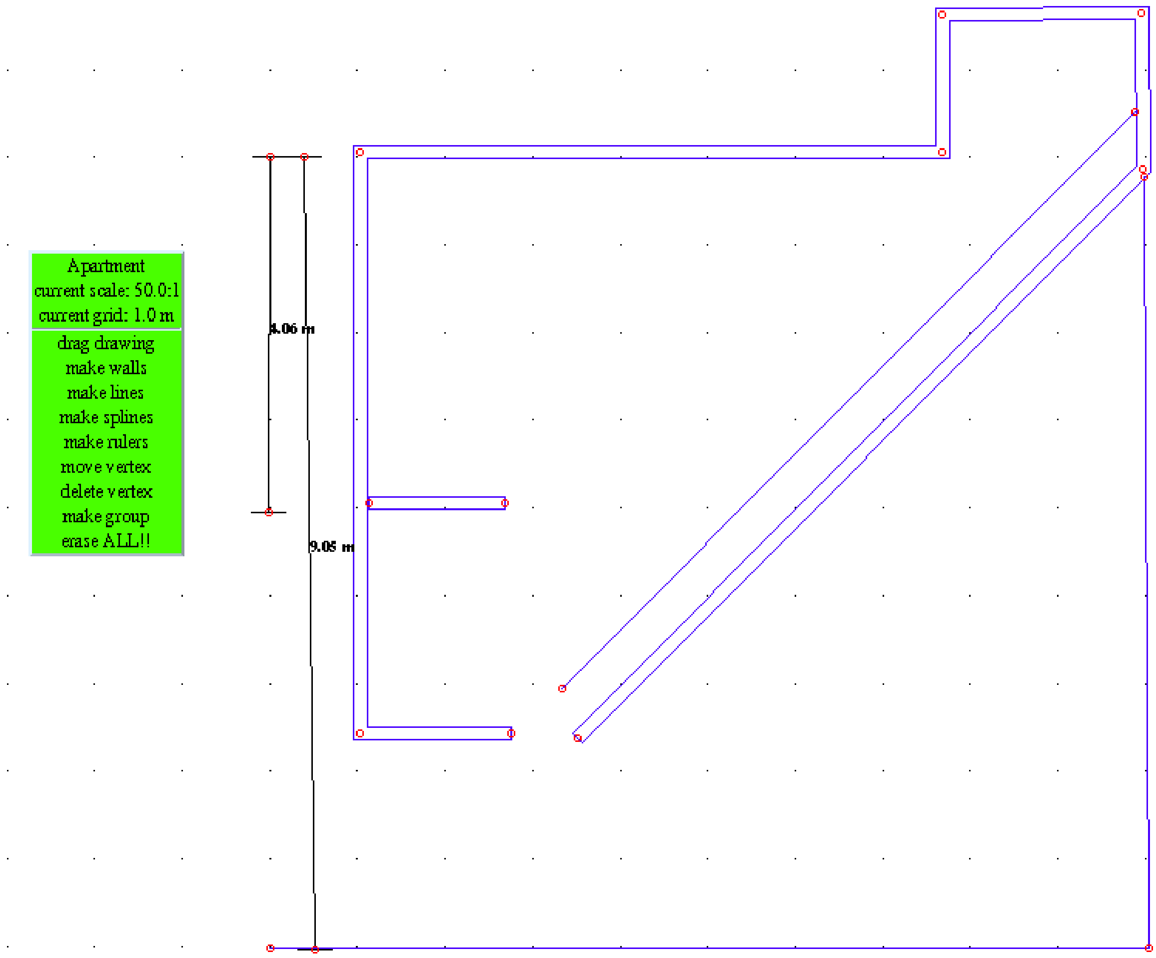


Figure 3. Clicking on the green menu one can change scale, execute the commands promptly.

This screen supports both performance and processing of the image. However the latter is not dealt with in this paper. The sketch phase is supported by the corresponding processes of the ecodesign model enabling thinking and diagramming as a one-to-one mapping. In the elaboration of the traditional designer, this mapping is one-to-many. His/her diagram contains several elements that the thinking seems unable to express due to its black box nature.

This ecodesign model is human-centered. The field of knowledge of ergonomics or human factors models the environment in which behaviour happens according to the intrinsic needs of human beings in their relationships with themselves, the others and the environment.

Hence the process of homeostasis of the element activities translates the description of characteristic activities of the human being such as to sleep (d), to clean oneself, to eat, to circulate, to work, to play and to organize and maintain the place to anthropometric measures adjusted to the activities. In the relationship of the human beings with themselves, homeostasis is in close relationship with the design process called substance of the function. In the relationships of the human beigns with the others, the design process called *form of the function* accomplishes this possibility ( Figures 4, 5).

| | | | |
|---|---|---|---|
| d-to sleep | h – to clean oneself | c – to eat | p – to circulate |
| t – to work | l – to play | o/m – to organize and maintain the place | |
| red – independence | | green – contact | blue – need of help |

Figure 4a. The symbols of the diagram.

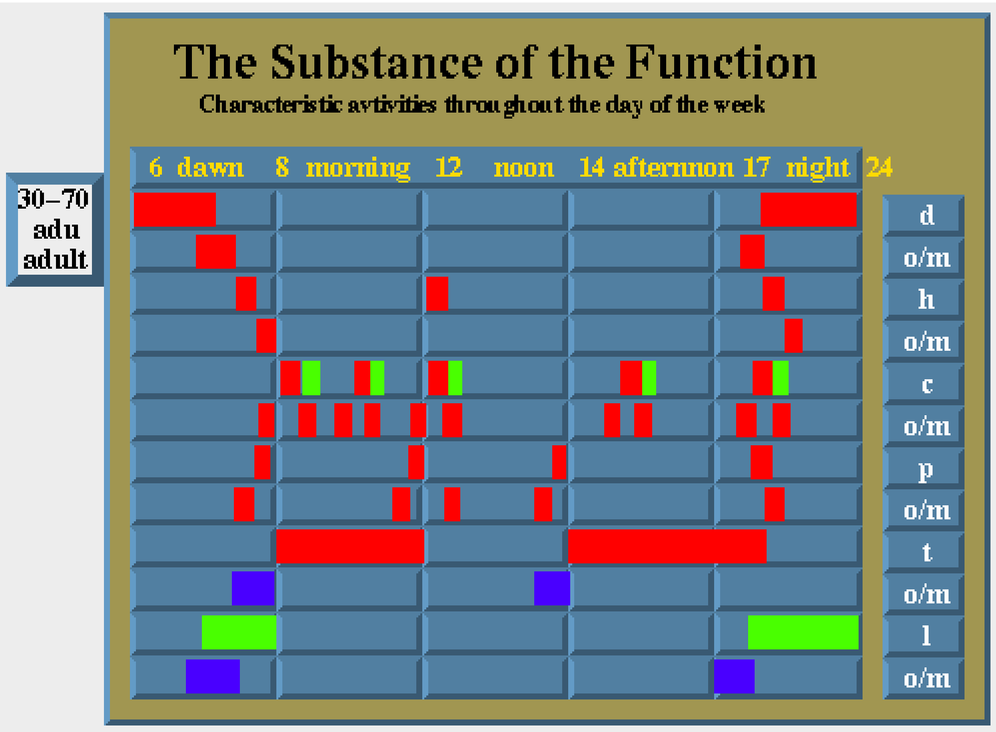


Figure 4b. The planes and stratas of the architectonic language. Source: [Lour88]

To illustrate the initial phase of prototyping, one generates the free plan of an apartment for singles who want to live alone. Here the element activities is partially implemented. This mimics the nature of the cognitive processes of design. One can always improve the first inspiring idea step by step incorporating more and more features.It representes the core of the design process. The homeostasis process invokes the ergonomic dimension and transform it in one of the pillars of the ecodesign. It helps to generate really free plans, as it is shown.

This information about the behaviour of the human being through the furniture becomes the basis of the design of the free plan. One drags the furniture to the screenMorph and one strives to mimic human behaviour now translated in terms of the form through the layout of the home furniture. It is time now to dress the free plan with a free form (figure 6).

Likewise one also outlines the topological relationships among several environments and the relationship of several environments with nature (figure 7).

| | | | |
|---|---|---|---|
| Ad-adulto | am – friend | aj – maid | |
| d-to sleep | h – to clean oneself | c – to eat | p – to circulate |
| t – to work | l – to play | o/m – to organize and maintain the place | |
| red – independence | | green – contact | blue – need of help |

Figure 5a. Symbols used in the directed graph.

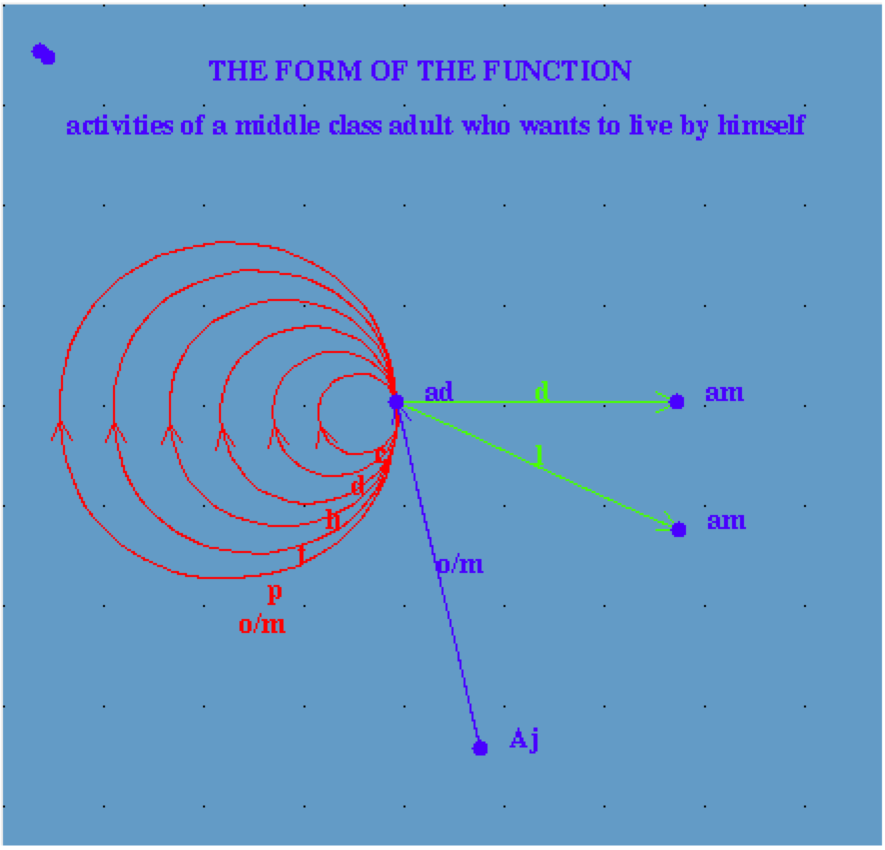


Figure 5. The planes and stratas of the architectonic language. Source: [Lour88]

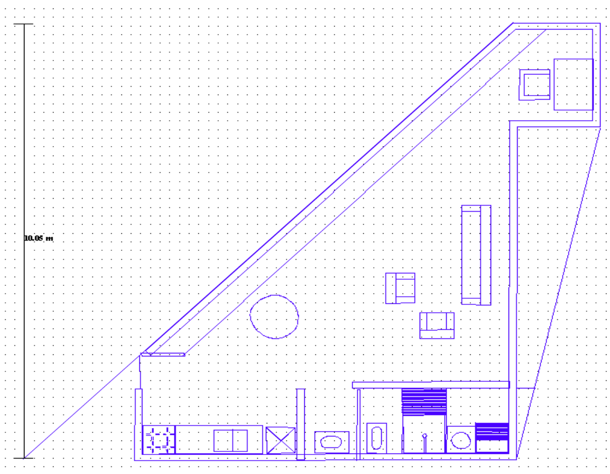

Figure 6. A free plan of an apartment for singles.

Figure 7a. Symbols of the graph.

B – biodigestor    bc – biofuel    C – eating area    Co – corridor    D – adult sleeping area
E – sport area    Eg – sewage    Es – ladder    Et – entrance area    F – sand filter
fr – fertilizer    H – local agricultural area    ir – irrigation    J – garden
Ja – greenery in wall    L – lavabo    Lg – lake    Lz – leisure area
N – nature    o/m – organization and maintaining area    P – circulation area
Pg – gasoline station    Pn – natural or built wetland    Pu – cattle    S – social area
Se- living room    Su – supermarket    Sv – laundry    T- working area
Tc – agricultural land    Te – terrace    V - varanda

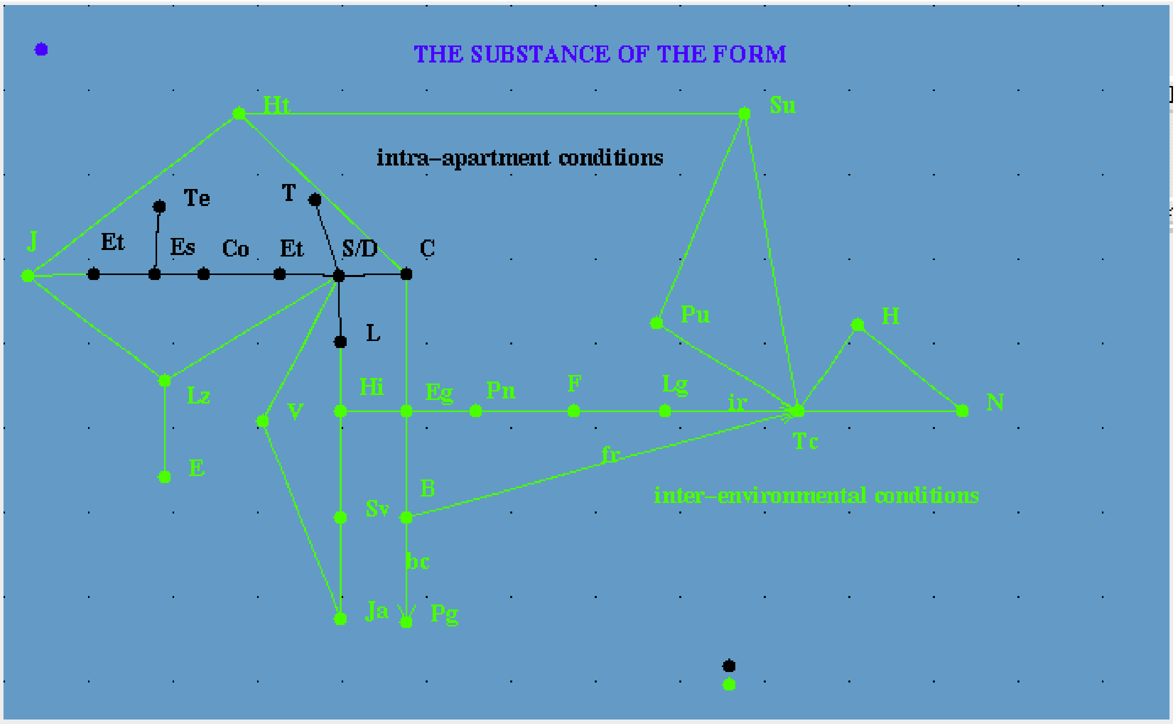


Figure 7b. The planes and stratas of the architectonic language. The topological relationships among different environments and nature. This calls for integration of urban and rural areas. Source: [Lour88]

The screenMorph was modified to draw nodes and arcs instead of lines and walls of a graph resulting in a new object called graphMorph.

The ease with this was done is an example of the advantages of prototype based programming. It also shows how flexible the MPSTW is.

It is important to create hydraulic walls, Obviously one must reflect the created apartment along the axis of the hydraulic wall and look for the crystallographic which respects this condition. The symmetry group of the square $D_4$ accomplishes this condition when it is translated in two directions along the plane. The outcome is the crystallographic group p4m. From this, all the other discrete symmetry groups of the plane that fit within the square lattice are derived. Due to its importance it was chosen to illustrate the approach [Lour98] (Figure 8).

The other phases will be dealt with in my postdoctoral research at the Laboratory of Integrable Systems, USP.

## 5 Conclusions

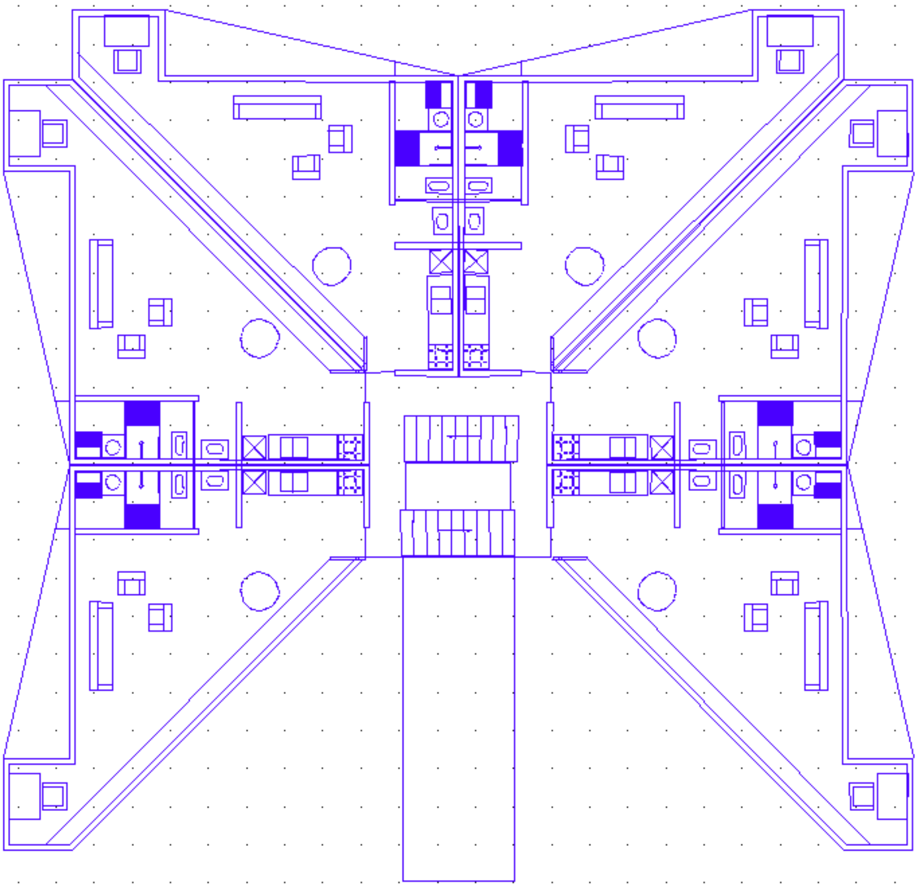

Figure 8. The symmetry group of the square $D_4$ was applied to the apartment for singles.

If the implementation of this prototype based knowledge based system in Self is successful, I shall be introducing a new technique in artificial intelligence based on prototypes in the context of the new emerging branch of hermeneutic computer science [Lour97].

**Acknowledgements**

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