The Rehabilitation Design Process of the Bourgeois House of Oporto: Shape Grammar Simplification

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Abstract. *This study was accomplished in the context of a broader research to be developed in an ongoing PhD program in architecture. The purpose of this study is to give a perspective of the research progress and to present a shape grammar simplification that will be improved to assist the rehabilitation design process of the bourgeois house of Oporto.*
The typology of the bourgeois house of Oporto, built from the late sixteenth century until the early twentieth century, is dominant in the ancient fabric of the city and in need of rehabilitation. From the analysis of a representative sample of a moment of its evolution, it is possible to verify patterns and to define rules.
This first approach intends to validate the use of shape grammars as a tool, able to assist the architect in the rehabilitation design process of the bourgeois house of Oporto.
Keywords. *Design process; rehabilitation; shape grammars.*

INTRODUCTION

The overall goal of the ongoing PhD is the development of a tool able to assist the architect in the rehabilitation design process of the bourgeois house of Oporto, Portugal. The research described in this paper start this with the presentation of a shape grammar simplification focused only on the topology of rehabilitated or in rehabilitation buildings.

The old center of Oporto should be preserved not only for the knowledge and symbolism present in its built historic heritage, but also for its intrinsic material and economic values.

In this city, the Porto Vivo, SRU - Society for Urban Rehabilitation has recently been created and its mission is to lead the process of urban regeneration. This institution has replaced CRUARB (commission for the urban renewal of Ribeira/Barredo) restructuring their political action.

According to the Management Plan for the Historical Centre of Oporto, a strategic document created in 2010, a requirement of UNESCO, when it revised its classification program of world heritage sites, the historical center consists of 1,796 buildings, 443 in good condition, 649 in average condition, 575 in poor condition and 78 in ruins, with 51 being works in progress. The dominant function is housing, constituting 80% of the buildings (Loza, et al. 2010). The bourgeois house is the building type that predominates in this territory.

In the critical success factors in the report of the 2010 activities of the SRU, we can identify as weaknesses the extent of the territory and the complexity of the task and as strengths the experience, knowledge and results.

The report of the 2011 activities emphasizes the

experience gained during its seven years of existence. The report of 2012 given the economic context and the restrictions on access to bank credit estimates more constraints to the rehabilitation process.

At present the urban regeneration in the city of Oporto is seen as an objective in the medium, long term.

Architecture is an open work and should not be regarded as an achievement but as a process, it is never finished and is continuously used (Vieira de Almeida, 2008).

The bourgeois house of Oporto has been the subject of some interventions which resulted in the accumulation of a niche of experience. In the vast work still to be done it is important to understand how this experience can be used efficiently.

With the intention of supporting the rehabilitation design process of this buildings, a shape grammar simplification was developed based on the information extracted from a sample of rehabilitated or in rehabilitation buildings. This study validates the use of shape grammars in the analysis of the design solutions used for this buildings and in the creation of new solutions in the same language.

THE BOURGEOIS HOUSE OF OPORTO

The house is an elementary part in the conformation of the streets and in the fabric of the city as a whole. In Oporto the high narrow house (Figure 1), originated from the old borough, prominent in the old heart of the city and in the streets that radiated from him, continued the local tradition, assimilating successive styles and techniques (Oliveira and Galhano, 1992).

In Oporto there is an apparent lack of uniformity in their houses, different shapes, sizes and colors mark the first impression you may have.

A closer look identifies two fundamental types. The high narrow house with three or four floors, sometimes reaching the five floors with two or three openings was in origin a hybrid type. Congregating residence with commercial activity, belonged to the bourgeoisie, had stores, warehouses and workshops on the ground floor and housing on upper floors (Figure 2). Among them, rarer, large and low houses composed mainly of ground-floor and main floor with numerous façade doors and windows was the noble house with large spaces as a statement of prestige and power in the city (Oliveira and Galhano, 1992).

The two fronts bourgeois house set in a Gothic-mercantile lot has taken origin in the duplication of smaller lots of only one front houses. Those houses of the oldest part of the city, raised in narrow and deep lots, adherent to the existing relief, are an urban and architectural fact immediately associated to Oporto (Barata Fernandes, 1996).

These houses persisted in local tradition and followed the evolution of the city from the late sixteenth to mid-nineteenth century and kept some of their basic features to the early twentieth century.

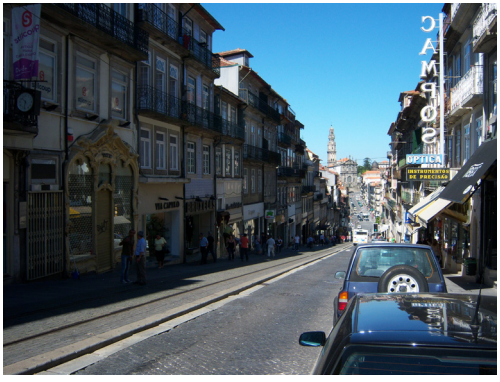


Figure 1
Street Clérigos (author's photograph).

Figure 2
Street 31 de Janeiro (author's photograph).

This type of house is not exclusive from Oporto and it is possible to establish relations with other European cities such as Genoa, Bologna, Pavia and Florence or even cities of northern Europe (Barata Fernandes, 1996).

The bourgeois house of Oporto for its dominance and symbolism presents itself as a key element in the rehabilitation of the built historical heritage of the city. Over time it becomes important to reevaluate their internal organization and uses, materials and building construction system, in a gesture to rescue the past and strengthen its basic features.

THE SHAPE GRAMMARS

The first publication of shape grammars goes back to 1972 and had as authors George Stiny and James Gips (1972). In an early stage, it was applied in the interpretation and evaluation of pictorial works. Later in 1980, with the publication of the paper "Kindergarten grammars: designing with Froebel's building gifts", George Stiny (1980) presents a grammar defined in the three dimensional space that was the initiator of the architectural grammars that followed.

Shape grammars can be defined as algorithmic systems for creating and understanding designs directly by computing shapes, instead of text or symbols. A shape grammar is a set of rules that are applied step-by-step to generate a language of designs [1].

Shape grammars are descriptive, analytic and generative: descriptive because they explain the formal structure of the designs that are generated, analytical because they can be used to tell whether a new design is in the same language, and generative because they can be used to create new designs in the language (Stiny & Mitchell, 1978).

In 1976, George Stiny demonstrated that shape grammars can be original or analytical when applied to the creation of new design languages or in the study of existing ones (1976). According to Terry Knight [1] this gesture was the basis for new approaches and an enhancer of its use in education and practice.

The analytical studies are based in a set of existing designs that represent the language - the corpus - used to infer the rules of the grammar, which is then tested by using the rules to generate designs in the corpus, as well as new designs in the language.

George Stiny (1981; 1992) has also shown that shapes, labels, and weights can be combined to form shape grammars that encode specific languages of designs.

The shape grammar simplification that will be presented follow the steps of the analytical studies and is based on the Malagueira simplification grammar of José P. Duarte (2004). It differs from this one because it not only aims to introduce a more complex grammar but also serves to explore, in a flexible way, different possibilities of developing the grammar for the rehabilitated or in rehabilitation buildings of the bourgeois house of Oporto. Unlike the Malagueira simplification grammar, the lots and the buildings have different dimensions and uses weights in a different representation to highlight future intentions.

THE CORPUS OF DESIGNS

The theoretical support for this research consists in the study of a moment in the evolution of the bourgeois house of Oporto since the late sixteenth century to the early twentieth century.

The bourgeois house of Oporto has been the subject of some interventions in the historic center and in parts of downtown. The collection of information led to the identification of five different house designs that constituted the corpus for the grammar.

This collection was made taking into account some examples of rehabilitated or in rehabilitation nineteen century buildings that in their origin were from the hybrid type, congregating residence with commercial activity, with warehouses and workshops on the ground floor and housing on upper floors.

Two fronts buildings, raised in narrow and deep lots, with four or five floors, three openings and yards with some variations. The central staircase was structuring in the internal organization, the ground

floor had a separated entering from the rest of the building. The functional organization of the housing part of these buildings, in their origin, was not specialized, with exception of the living room located in the front of the first floor and the kitchen that it was always placed in the back of the last floor near the roof (Barata Fernandes, 1996).

The buildings analyzed have been adapted over time to the needs of its dwellers, but they kept same of their basic features to the present day.

Over time, the bourgeois house of Oporto was able to adapt to new circumstances and techniques and became prevalent in the city (Oliveira and Galhano, 1992).

The five rehabilitation solutions studied, divide the buildings in small apartments that are organized respecting the location of the central staircase in a logic that separates the front from the back of the buildings. The ground floor with is own entering continued, in some cases, the commercial activity.

With the study of the rehabilitation designs of this buildings it was possible to verify patterns and to define rules in the definition of a grammar focused on the topology of the bourgeois house of Oporto buildings in the corpus.

THE SHAPE GRAMMAR SIMPLIFICATION

The bourgeois house of Oporto shape grammar simplification combines shapes, labels, and weights to encode different ways of seeing and describing designs.

This grammar is defined in the Cartesian product of algebras U12 V02 and U22 V02 in the two-dimensional representations of the different floor plans.

The decisions made in the organization of the lower floors can condition the generation of the upper floors, this dependency is encoded into the grammar through the use of sequential, parallel grammars, one for each floor.

The derivation of a design in the grammar goes through several successive stages defining each floor. When the generation of a lower floor finishes, the state changes, thereby activating the generation of the upper floor. Each of these stages, in turn, includes several steps, as locating functional zones, locating the staircase and dividing functional zones into rooms.

This simplification is composed by rules for the manipulation of simple geometries representing rooms by dissecting, connecting, extending and adding new shapes to them, as well as rules for assigning and changing functions associated with them.

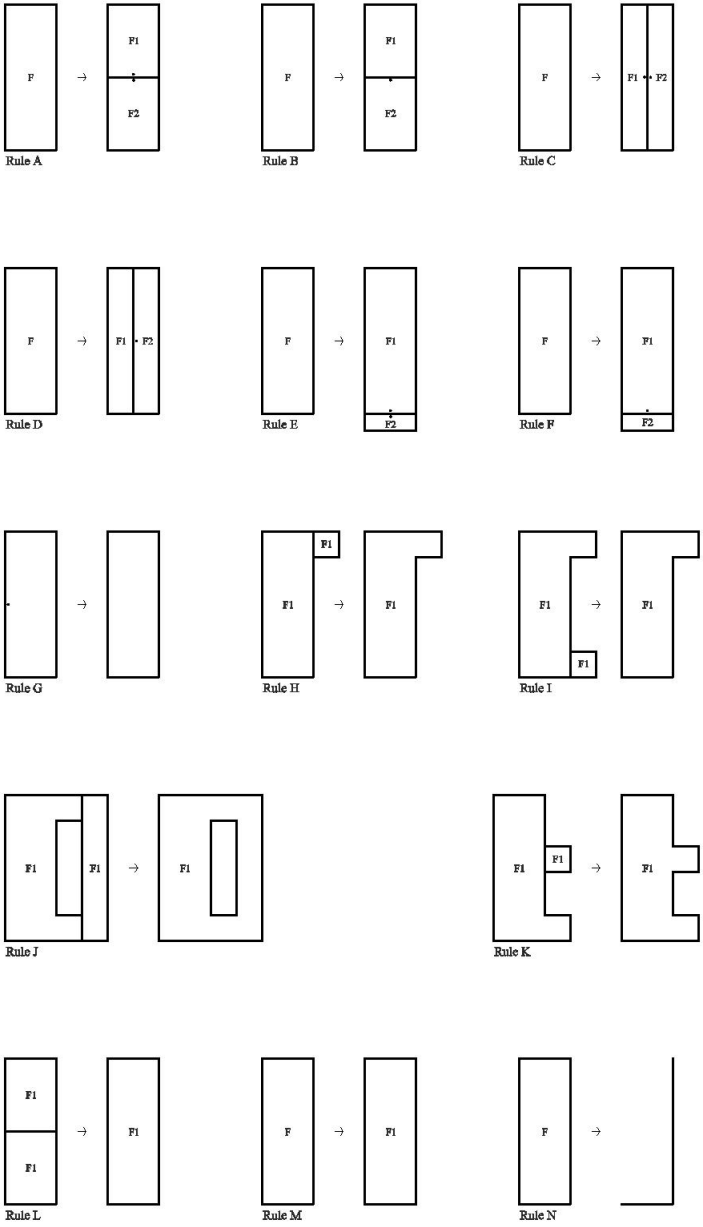
A very simplified set of rules will be presented only with the two dimensional information, where lines represent walls and shaded areas and labels represent the functions associated to the different rooms. The functions of the rooms that the shapes represent are indicated by the labels fn (n = 1, 2). The identification of the last line placed and the indication on which side the next dissection may occur is made by the label dot (•): on both sides (rules A, C and E) or only in one side (rules B, D and F). In rules A and B, dissections are perpendicular to the bigger edge of the rectangle. In rules C and D dissections are perpendicular to the smaller edge of the rectangle. Rules E and F add a new rectangle. Rule G deletes the label •, preventing further dissections. Rules H, I, J, K and L concatenate two adjacent shapes to form a larger room. Rule M assigns a function to a room. Finally, rule N subtracts two lines of the rectangle (Figure 3). The generation of basic layouts, obtaining different patterns, with these rules comprises three steps. In the first step, the lot is divided into different functional zones - yard, working, service, circulation, living and sleeping or living/sleeping. In the second step, the vertical circulations are located. In the third step the functional zones are divided into rooms to obtain the final layout.

A diagram in the form of a tree, in which it is possible to recognize the basic patterns behind the houses in the corpus is shown in Figure 4.

This diagram is composed by nodes representing the state of the design and by arcs representing the application of rules in the definition of the functional organization of the first floor.

A case study will be presented showing the several steps referred above in the first floor derivation of one building in the corpus.

Figure 3
Shape grammar simplification rules.



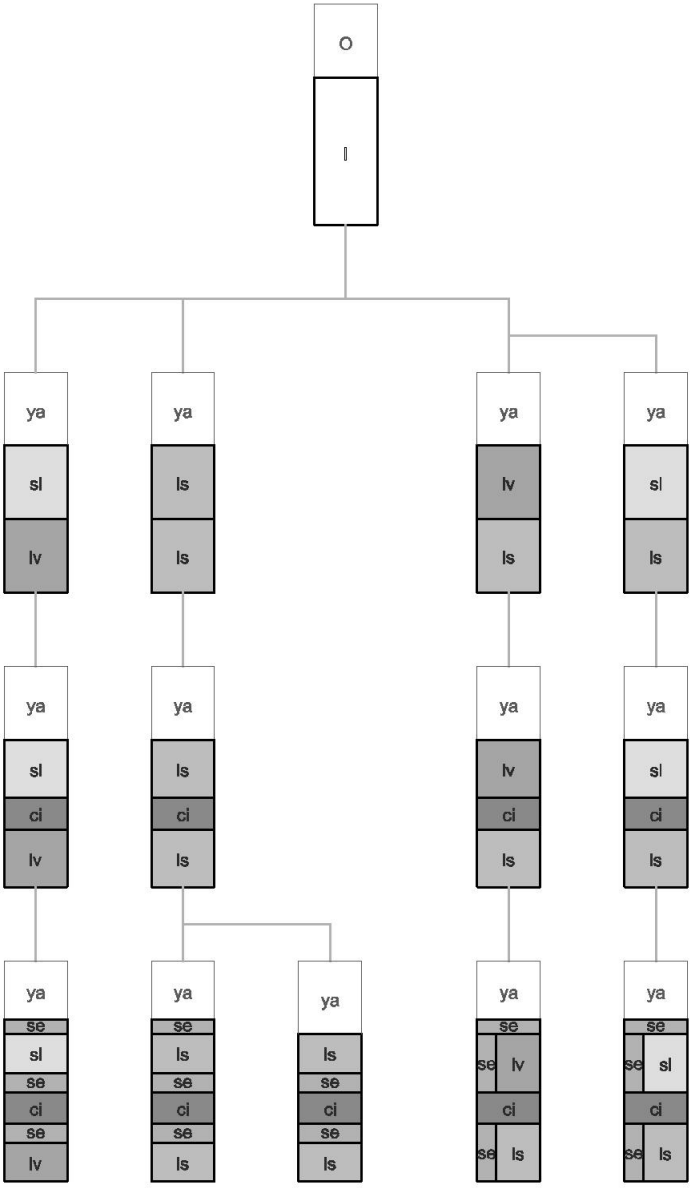


Figure 4
Tree diagram showing the definition of the functional organization of the first floor. I - inside; O - outside; lv - living zone; sl - sleeping zone; ls - living / sleeping zone; ya - yard; ci- circulation zone; se - service zone.

CASE STUDY

The example of an Oporto nineteen century building located in the Almada Street is presented (Figures 5, 6 and 7). The author of the rehabilitation design is the well-known Souto de Moura.

The existent layout and the design proposed by the architect for this floor are shown with the first floor derivation in Figure 8. This floor is organized respecting the location of the central staircase with an apartment in the front and other in the back of the building. Secondary vertical circulations are added. The back apartment also occupies a part of the second floor.

CONCLUSIONS

The purpose of this paper has been to present the first approach to the shape grammar for the rehabilitation of the bourgeois house of Oporto, explaining the reasoning behind this work in progress.

With the intent of supporting the rehabilitation design process of the bourgeois house of Oporto, being aware of the actual rehabilitation context of Oporto and based on "best practice" procedures in heritage conservation, this study not only reintro-

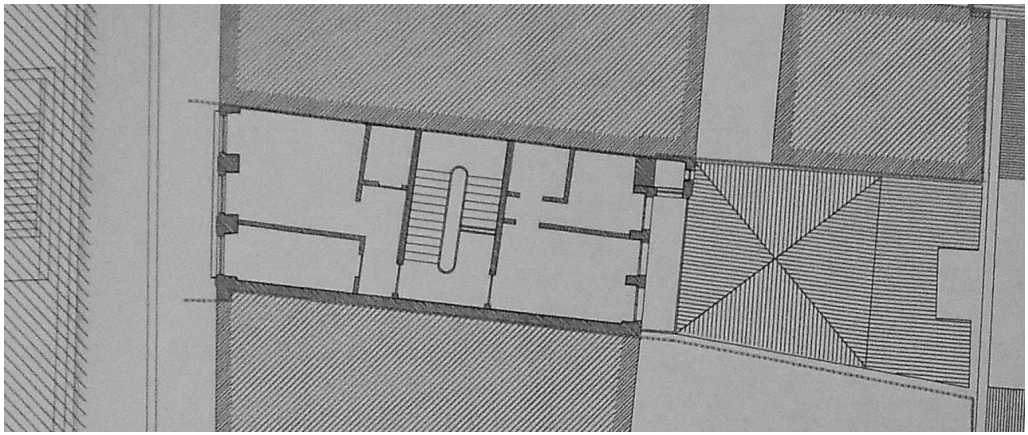


Figure 5
First floor existent layout.

Figure 6
First floor proposal layout.

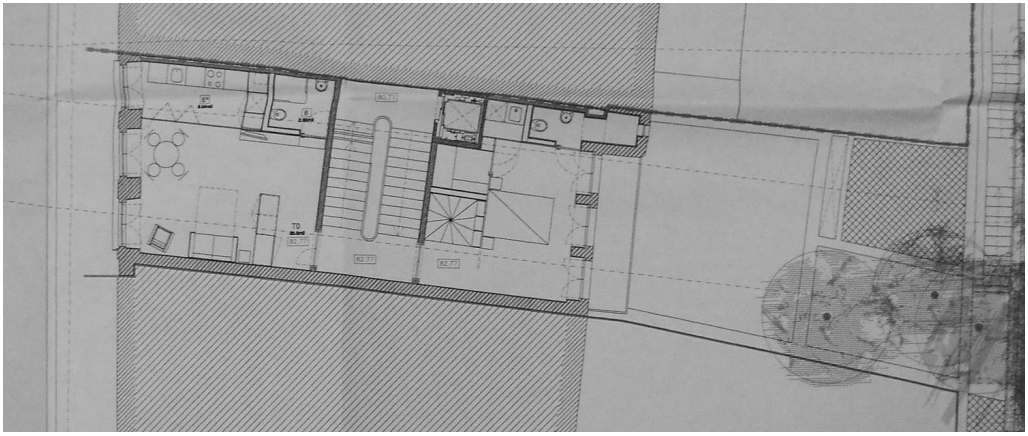


Figure 7
Second floor proposal layout.

duce the discussion of the design process in architecture but also serves to explore a more efficient way to assist the architect in the rehabilitation of these buildings.

This shape grammar simplification was based in the derivation of five rehabilitation proposals and was tested in two new designs in the language. The derivations were useful in the definition of the rules and in the viewing of the shape grammar future development. The new designs served also to update the grammar that is constantly evolving. This approach proved to be proficient in the study of the buildings topology.

A more complex shape grammar is now being developed. It will be parametric and will encode information on dimensioning, on function and on the building system.

This information can be useful to establish the link with BIM (Building Information Modeling). In this approach BIM represents the overall method of handling building information, and not the computer implementations. The possible combination of shape grammars and BIM is being considered.

A shape grammar for the rehabilitation of the bourgeois house of Oporto has been initiated, carving a path for the future development of a new approach to the rehabilitation design process of these buildings.

REFERENCES

Barata Fernandes, F (ed) 1996, *Transformação e Permanência na Habitação Portuense – As formas da casa na forma da cidade, Transformation and Remaining in Oporto housing, the shapes of the house in the shape of the town,* FAUP, Oporto.

Duarte, JP 2004, 'Towards the mass customization of housing: the grammar of Siza's houses at Malagueira', *Environment and Planning B: Planning and Design*, 32, pp. 347–380.

Loza, R et al. 2010, *Management plan, Historic center of Oporto world heritage*, CMP, Oporto.

Oliveira, VE and Galhano F (ed) 1992, *Arquitectura Tradicional Portuguesa, Traditional Portuguese Architecture*, D. Quixote, Lisbon.

Stiny, G 1992, 'Weights', *Environment and Planning B: Planning and Design*, 19, pp. 413–430.

Stiny, G 1981, 'A note on the description of designs', *Environment and Planning B*, 8, pp. 257–267.

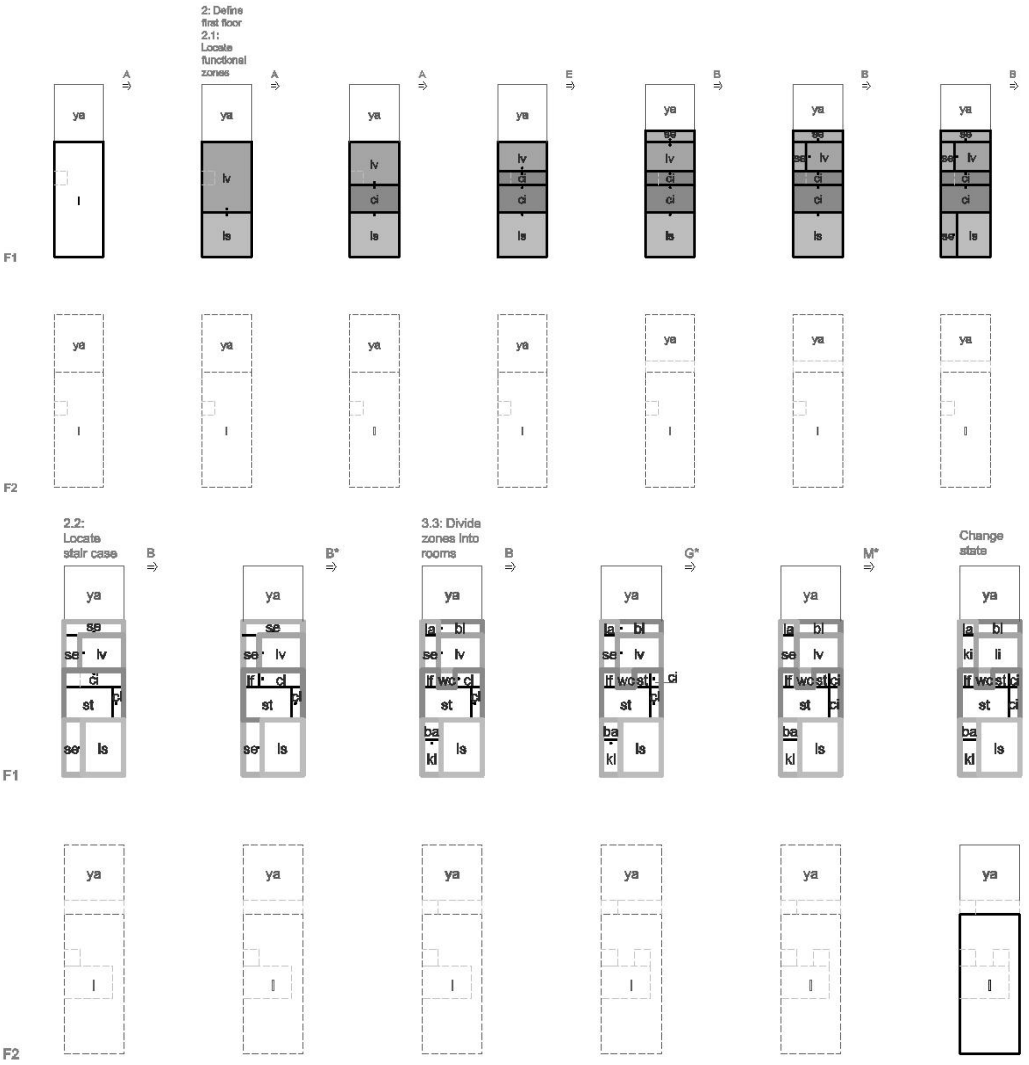
Stiny, G 1980, 'Introduction to shape and shape grammars', *Environment and Planning B*, 7, pp. 343–351.

Stiny, G 1980, 'Kindergarten grammars: designing with Froebel's building gifts', *Environment and Planning B*, 7, pp. 409–462.

Stiny, G 1976, 'Two exercises in formal composition ', *Environment and Planning B*, 3, pp. 187–210.

Stiny, G and Gips, J 1972 'Shape Grammars and the Generative Specification of Painting and Sculpture', *Freiman*

Figure 8
Derivation of the first floor functional organization. bl - balcony; ba - bathroom; cl - closet; ki - kitchen; la - laundry; lf - lift; li - living room; ls - living sleeping zone; st - staircase; wc - water closet, ya - yard.



CV Information Processing 71, Amesterdam, pp. 1460–1465. Republished in *Petrocelli OR 1972 The Best Computer Papers of 1971*, Philadelphia, pp. 125–135.

Stiny, G and Mitchel, WJ 1978, 'The Palladian grammar models', *Environment and Planning B*, 5, pp. 5–18.

Vieira de Almeida, P (ed) 2008, *Apontamentos para uma Teoria da Arquitetura, Notes for a Theory of Architecture*, Horizonte, Lisbon.

[1] www.mit.edu/~tknight/IJDC/.