LOCAL VALUES in a NETWORKED DESIGN WORLD

ADDED VALUE OF COMPUTER AIDED ARCHITECTURAL DESIGN

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Information systems for the design and management of transformation in Dutch educational buildings

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Abstract

Following a period of little change, new didactic approaches coupled to social and technological developments have recently triggered several fundamental modifications in Dutch secondary education. These modifications have extensive consequences for the accommodation of secondary education. The majority of existing buildings is quite conventional in spatial terms and is characterized by limited flexibility and transformability.

The paper is a description of a modular yet coherent information system that supports decision taking concerning the transformation of existing buildings. The system consists of spatial and topological representation of a building and its brief, as well as a matching system that connects the two.

The purpose of the system is to support the management of the building transformation by providing appropriate input to design and decision activities, as well as by accommodating their output. This is achieved by providing a responsive context for the analysis and evaluation of design decisions from the major viewpoints and with respect to primary aspects. Continuity is a major consideration in this context: appropriate information and feedback should be available throughout the design and construction process but also after completion (in anticipation of further transformations, as well as for monitoring building performance).

Transformations in Dutch secondary education

The development of Dutch secondary education and its accommodation can be divided into two periods.[1] The first period, from 1800 till 1940, is characterised by the emergence and consolidation of classical education. The individual tuition made way for collective education with a blackboard. The main condition for this new way of teaching was silence. This meant that all the pupils had to be involved in the lesson.

The main task for architecture was allowing the teacher to have a permanent supervision over all the pupils simultaneously. The Dutch government developed a model which answered to this question. In 1863 a new law made it possible to choose subjects and the basic building type of the government from 1811 was progressively transformed into the *corridor type*. Different subjects were accommodated in separate classrooms.

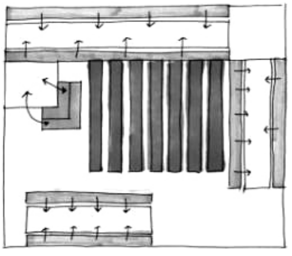

Figure 1.

End of 18th century.

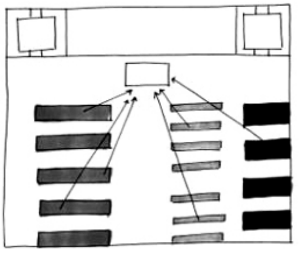

Figure 2.

Government model of 1811.

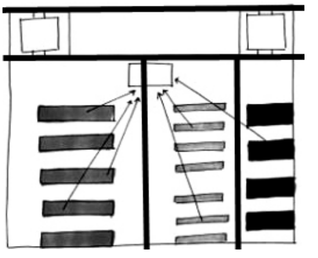

Figure 3.

Transformation of the model into the corridor type.

After the Second World War criticism on classical education increased and led to the gradual introduction of new educational concepts. In 1964, a new law was passed on that implemented a common first year and the choice of three levels. Then a period of little change came in the institutional and didactic framework of Dutch secondary education. During the last thirty years changes in the buildings for secondary education have been evolutionary in nature. The development of the *hall type* was a natural consequence. Further transformation of both the corridor and the hall types has lead to the *pavilion type*. A common characteristic of all three types is the presence of a large number of traditional classrooms (either connected by a corridor or a hall). This makes all three types predominantly appropriate for formal teaching, i.e. by a single teacher that lectures a group of students.

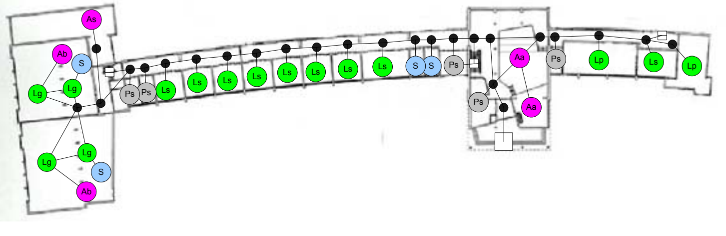

Figure 4. Segbroek College(Schamhart, The Hague)[2], corridor type.

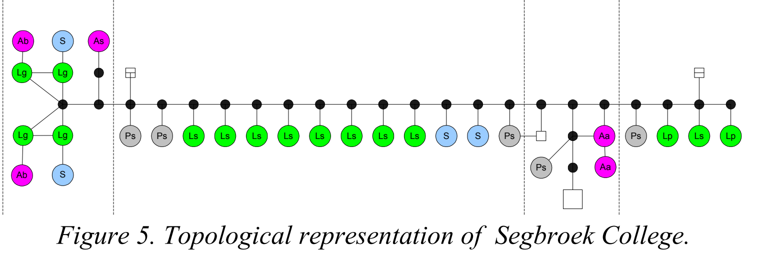

Figure 5. Topological representation of Segbroek College.

The corridor type takes up a lot of space because of the length of the building. The entrance can either be in the middle, cutting the corridor in two, or at the head of the building. The rooms for physical education are much larger in size and are usually situated in a separate volume.

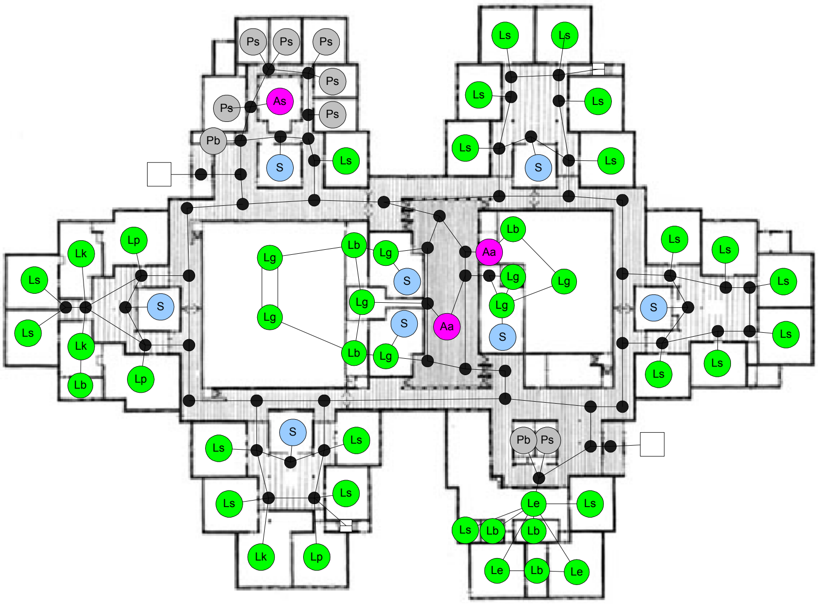

Figure 6. Kruisherencollege (Architectengroep E.D. Amersfoort, Uden)[3], hall type.

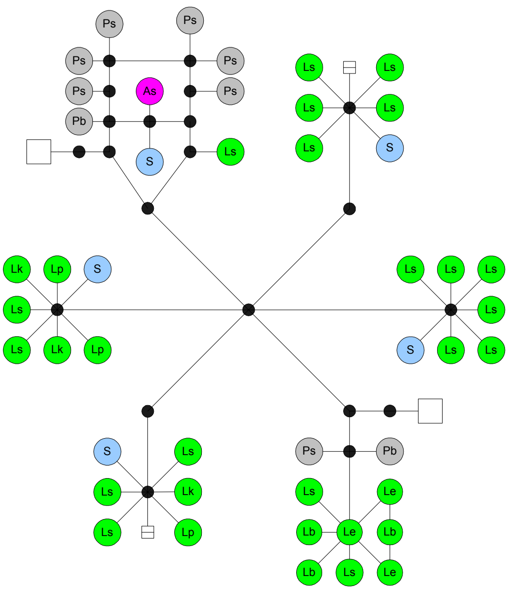

Figure 7. Topological representation of Kruisherencollege.

The hall type is much more compact and therefore takes up less space than the corridor type. The corridor is larger in size and can have several functions like workplaces or even a library. The gymnasium is usually a separate wing or building.

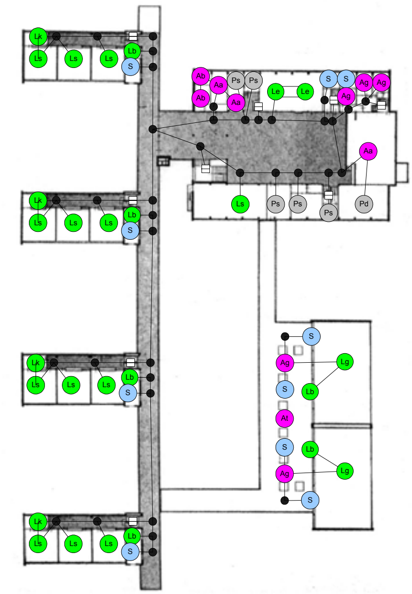

Figure 8.
Caland Lyceum (Kuiper, Gouwetor en De Ranitz, Rotterdam)[4], pavillion type.

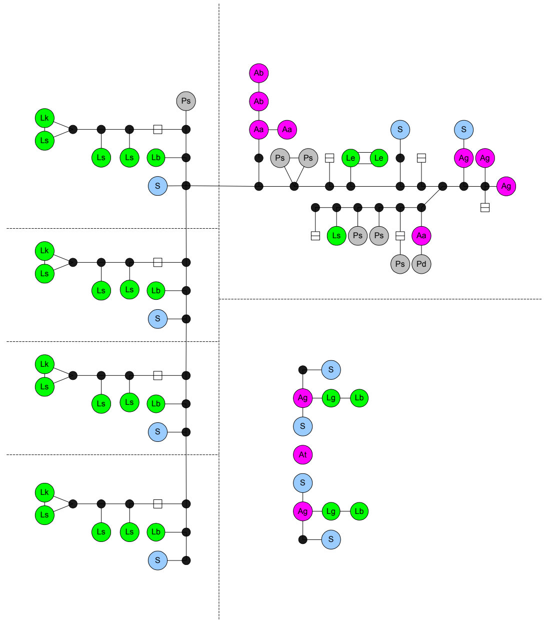

Figure 9.
Topological representation of Caland Lyceum.

The pavilion type is a combination between the corridor and the hall type. Each pavilion can have its own arrangement, depending on the activities that have to take place in the specific wing. The gymnasium is usually a separate pavilion.

The didactic approaches underlying these types were challenged by legal changes that started in 1998. Dutch secondary education no longer met the demands of the times. Knowledge gets out of date quickly, professions change continuously and employees switch jobs all the time. Lifelong learning and adaptation to new circumstances become conditions for which pupils must be prepared especially in secondary education. New didactic approaches put the learning process first, shifting from amassing knowledge to obtaining skills [5]. These approaches were coupled to social and technological developments such as the need for people with a broad education and yet specific skills and lifelong advanced computer-aided lessons[6].

These modifications appear to be opening further possibilities for educational innovation. They facilitate the import of a wide spectrum of new educational concepts such as the fusion of two existing directions in school for lower general secondary education into one. Also experimenting with new forms of learning like /21[7] has become not only acceptable but also a prerequisite keeping up with changes in society.

The consequences for the accommodation of Dutch secondary education have been extensive, especially with respect to the large variety of different ways of learning. The majority of existing buildings is quite conventional in spatial terms consisting mostly of identical classrooms [8]. Most spaces follow a classroom pattern (square spaces) and have a size of approximately 45-50 m^2. This is deemed appropriate for class education to approximately thirty pupils but otherwise is characterized by limited flexibility and transformability. For example, it is inappropriate for individual study or working in small groups.

An example of the impact changes in the educational system have had on existing buildings is the Segbroek College in The Hague, designed by Schamhart in 1955. The renewed didactic approaches together with an increasing number of students made the school implement a major modification. A new wing, almost the same size of the existing school, houses a large number of new large classrooms. In the area between the old and the new a zone for new ways of working is created. Thus they combined the need for more space with creating new workplaces based on the new educational concepts.

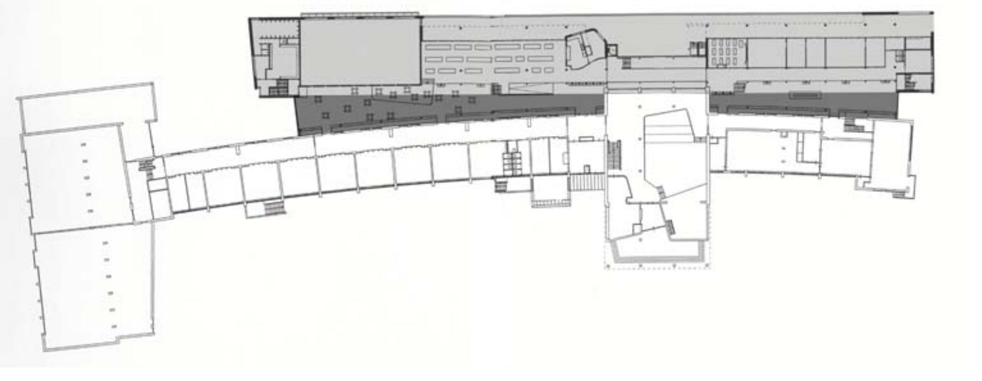

Figure 10. Segbroek College, extension.

Analysis of building and brief

The necessity to transform existing school buildings for Dutch secondary education so as to meet the new requirements is an urgent and cumbersome problem. This urgency and the extent of the transformation often obscure related problems, from demographic changes that influence the number of students to building maintenance and facilities management. Nevertheless, these problems generally form primary preoccupations in briefs ostensibly motivated by the transformation of Dutch secondary education. Less attention is paid to ways of anticipating further changes in the educational framework and related social or technological patterns.

Anecdotal evidence shows that the transformation of a building is a time-consuming and expensive operation. Many issues are handled from scratch or at the level of first principles. This means that results are frequently uncertain, with unanticipated problems emerging with the transition from one decision to another. Many of the problems encountered stem from the use of incomplete and implicit information. For example, building costs are frequently underestimated because the exact state of the building and its subsystems is vaguely known. As a result, the extent and focus of the transformation is frequently unclear and decisions are too easily deferred to later stages. A high concentration of deferred decisions frequently overloads the design and decision activities, with negative influences on the quality of both the process and the product. Even worse, feedback to earlier decisions is generally ineffective because of the lack of correlation between aspects.

An alternative is to begin with the transformation of a building for the secondary education with a comprehensive analysis of requirements and possibilities. This analysis concerns all levels and aspects of decision taking, from briefing and design to post occupancy, in a continuous process. Continuity, coupled to the comprehensiveness of the information and the availability of several abstraction levels in the resulting information system, facilitates the development of a responsive informational background for all actions and transactions concerning the design, evaluation and use of the built environment.

The information system we have been developing consists of the following modules:
1. Geometric representation (structured floor plan)
2. Topological spatial representation
3. Typological analysis and classification on the basis of (1) and (2). This refers to both the whole building and its discrete parts (e.g. wings).
4. Database of programmatic requirements focused on spatial / functional units
5. Topological representation of (4)
6. Matching system that compares (4) and (5) to (2) and (1) using (3) for decision guidance (heuristic) so as to identify the object(s) of the transformation

Geometric representation

The geometric representation we use derives from the conventional floor plan [9]. For practical reasons we have accepted the limitations of the two-dimensional description of built form, as in practice floor plans form the conventional background to the activities with which we are concerned. The third dimension is usually considered in relation to a small number of aspects such as acoustics or construction.
The main difference between our geometric representation and conventional floor plans lies in the fact that each relevant entity, i.e. spatial or building element, is described uniquely by an integral graphical object. This ensures that each room of the building is uniquely represented in the drawing. It also allows us to measure properties in relation to behaviour and performance (e.g. floor area, volume, day lighting or building cost). Each entity is annotated with reference to external information, such as the activities accommodated in a space or safety requirements. In most cases these annotations refer to other modules of the information system. For example, programmatic requirements are annotated to spaces through links to the brief database (described later in this paper). This makes it possible to compare e.g. the actual area allocated to an activity with the desired one but also to analyse complex patterns relating to global performance such as routing [10].

A small set of primary properties forms the basis for the classification of spatial and building entities into fundamental categories. These categories describe the major subdivisions of design entities, such as the load-bearing vertical elements on a specific floor level or spaces for teaching languages in a particular wing. Following the constraints of the two-dimensional representational basis, the floor levels form the initial classification property. The categories are implemented with elementary mechanisms that can be found in practically all CAAD systems, chiefly layers.

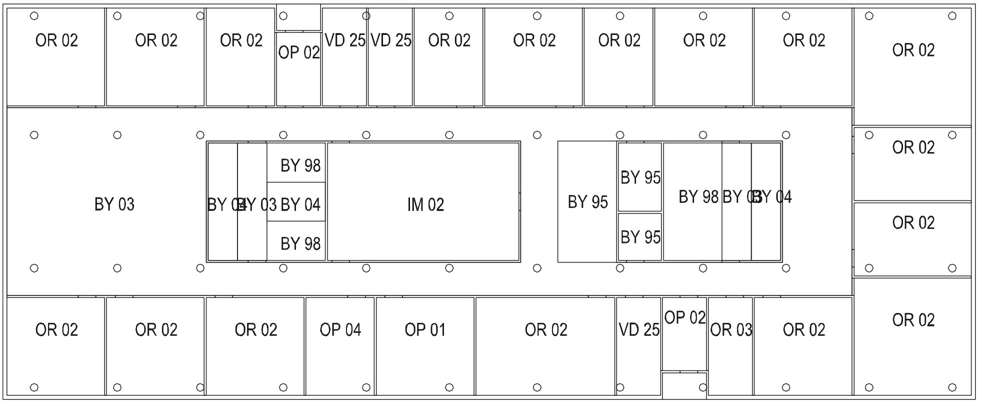

Figure 11. Geometric representation (Campman, Tennekes, De Jong architecten, Johan de Witt College, the Hague, 1991)[11]

Other properties as well as most relationships between entities are implicit in the representation. These are recognized automatically only if and when needed. For example, normative evaluations of day lighting refer to the ratio of the floor area of a space to the vertical area of its openings that give on to the outside. In order to perform such evaluations, the external openings of a space are identified automatically on the basis of adjacency, measured and compared to the area of the space. The recognized relationships are explicit in evaluation reports but may also be recorded in the representation as semi-permanent properties (subject to dynamic change), especially if the recognition is cumbersome or time-consuming.

Topological representation

The topological representation is complementary to the geometric one. By representing entities and relationships in a graph it is possible to describe explicitly relationships and patterns in the spatial and building structure. Our topological representation focuses on the spatial entities and on access between them as the main relationship. The resulting access graph [12] forms a basis for the description and analysis of spatial articulation at a higher abstraction level, as well as of dynamic aspects such as pedestrian circulation [13].

Of particular importance to our work is the ability to recognize the topological structure of building types. The types described previously have a clear topological basis, even though their topology is seldom described explicitly. By making it explicit we are able to study relationships between types (including the transition from one type to another) and identify the type of a building not only in whole but also in part. The latter is crucial for the study of transformation, as it helps identify typologically hybrid solutions and partial mismatches between accommodation proposals and the spatial articulation of a building.

The analytical power of the topological representation lies in its mathematical background, which facilitates transition from descriptive and qualitative statements to quantitative measurements. In addition, the abstraction of the topological level permits explicit and focused treatment of issues central to the programmatic, legal and other requirements on the building. The clarity of visualization in the topological representation also contributes to the transparent treatment of issues relating to e.g. type identification and analysis, matching of a design to a brief and interaction between users and the building.

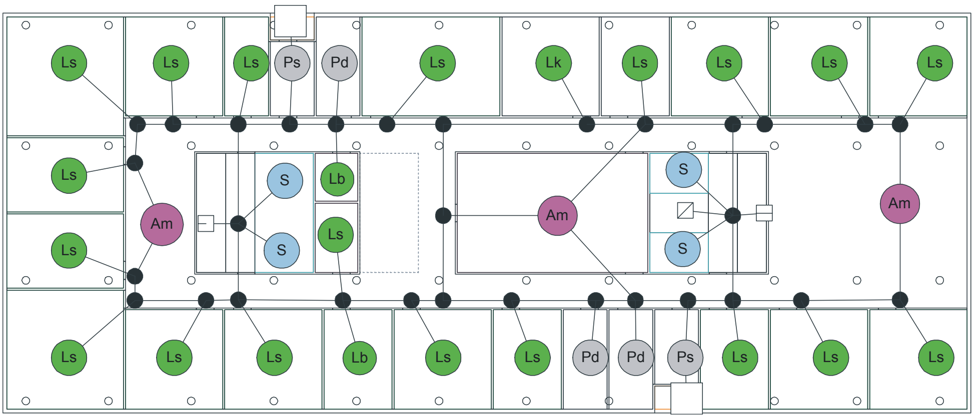

Figure 12. Topological representation of Johan de Witt College.

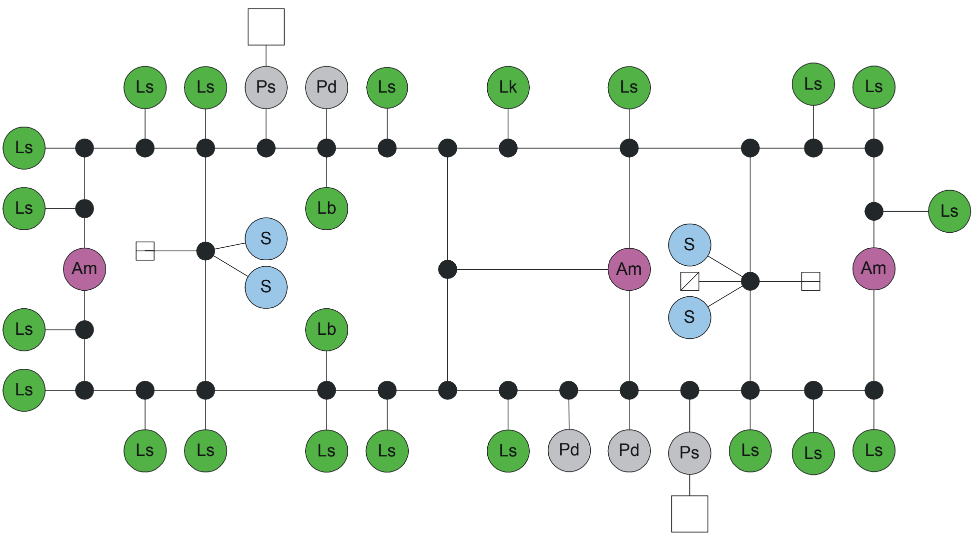

Figure 13. Normalized topological representation of Johan de Witt College.

Typological analysis and classification

The acknowledged building types described earlier form a departure point for our study of transformations in Dutch secondary education buildings. These types are described in the conventional manner by a number of salient features, but also analysed with respect to geometric and topological structures and characteristics that underlie these features. The results of this analysis suggest that the acknowledged types are essentially typological. The geometry of spaces, structures and wings appears to play a secondary role. One could argue that the topological structure imposes constraints for the geometric development of a design. These constraints determine the suitability of geometric forms for a particular type.

We believe however that the relationship between geometry and topology in a type is more intricate than mere deterministic, directed constraining. In order to study this relationship we employ the concept of zoning by which the building is subdivided into usually fuzzy and frequently overlapping parts with a readily identifiable formal, functional and performance character. This character derives from a combination of constraints, ranging from building structure and suitability to particular uses to geometric arrangement and circulation organization. The resulting zones integrate geometric, topological and functional characteristics into subdivisions of a building that frequently play a prominent role in a study of possible transformations.

In the case of Dutch secondary education school buildings we employ a basic zoning scheme consisting of three main type zones. The first is the *use zone*, consisting of spaces for the primary uses in the building. In school building this encompasses most classrooms, offices and study areas. The second type is the *circulation zone,* comprising both vertical and horizontal circulation facilities and spaces. The third one is the *service zone,* usually the most fixed part of the building with the least flexibility and adaptability. The circulation and use zones are normally more flexible and offer possibilities for transformation limited chiefly by the construction and external envelope of the building.

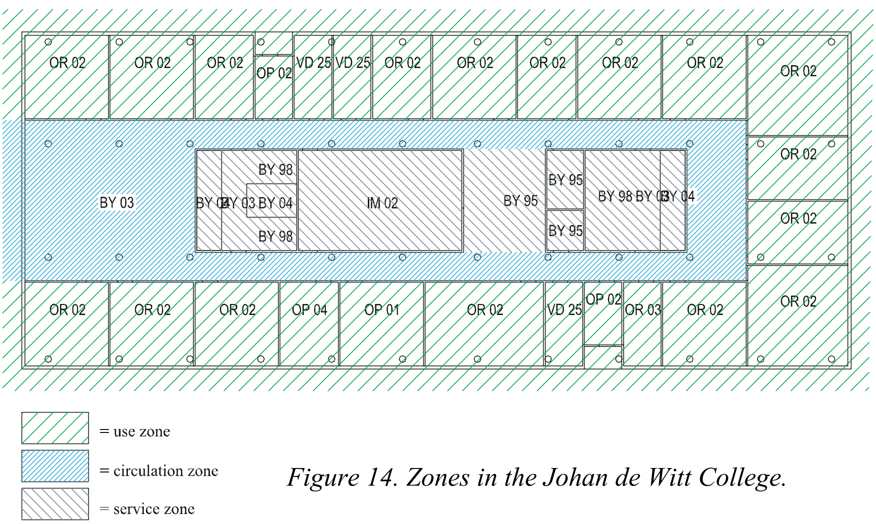

Figure 14. Zones in the Johan de Witt College.

The three zone types may be present in a building in a number of patterns that are closely linked to building type. For example, a three-zone pattern such as *use – circulation – service* is characteristic of the corridor type. A five-zone pattern such as *use – circulation – service – circulation – use* is common in buildings of the hall type.

Typological classification is an important instrument for our analysis of buildings and their transformations. It presents a coherent overview of situations and possibilities clustered in identifiable classes. These classes (rather than their specific instances) may act as departure for design and evaluation processes. This is particularly true of wider analyses of building stock but equally applicable to projects concerning a single building, where information on the type complements and structures information on the instance.

The typology also acts as a useful background to the formulation and use of transformation strategies. By correlating the sequence of steps in these strategies to the succession of abstraction levels in the typology we can match the specificity of decisions to that of building information. This supports smooth transition from one level or decision to another, but more significantly provides early identification of consequences. As a result we are able to anticipate the emergence of partial problems and defer decisions to later stages being fully aware of the extent and focus of transformation actions at these stages.

Brief database

Programmatic requirements are normally distributed into a number of complementary documents that specify behaviour and performance from different viewpoints relating to different disciplines or parties. The first step towards their correlation is a complete enumeration of stated and implicit requirements [14]. This is followed by integration on the basis of a common structure (backbone). Our choice of such a backbone is the list of activities to be accommodated in the new design. This list covers most aspects and issues and focuses attention on performance and user satisfaction. Programmatic requirements are translated into properties and constraints of the spaces that accommodate these activities.

The resulting multidimensional description of each activity and each corresponding space is sufficient for the treatment of local design problems but offers few possibilities for the recognition and treatment of wider issues (i.e. pertaining to larger parts of the design of the whole design). This is compensated by the flexible clustering of the activities. The initial clustering (default) reflects the kinds of educational activities that take place in Dutch secondary education. This can be altered into clustering on the basis of the kinds of users, the form of educational activities or any other aspect that is chosen as the departure point for a particular problem. The ability to modify the clustering allows for direct identification of common requirements and constraints that apply to different parts of the brief. These may be a determining factor in e.g. building costs or the flexibility of a building.

The brief database is physically implemented in four interconnected files. The first one comprises spatial requirements such as proximity, accessibility and flexibility. The second file accommodates functional requirements on e.g. thermal climate, acoustic comfort and visual comfort. Quantitative requirements such as required area, number of spaces and free height are collected in the third file. The fourth file describes the facilities required by the activities, e.g. the number of computers and the kind of furniture. The segmentation of the brief in four files reflects our expectations concerning the sources and target groups for different kinds of programmatic requirements.

This segmentation does not impede the selective compilation of requirements from all four files into customized descriptions on specific parts and aspects of the brief. The table on the next page, for example, is an integral description of spatial and functional requirements for the cluster *Languages* that are typically used in the early stages of an allocation process.

By means of dynamic links between computer applications each activity in the brief database can become an annotation of a space in the geometric or topological representation. This linking forms the basis for the analysis of proposals for the accommodation of a new brief in an existing building. This applies to both the requirements on a single space or activity and the distribution of particular constraints in the building (e.g. climatic or acoustic conditions).

Topological representation of programmatic requirements

The topological representation of programmatic requirements is generated automatically from the brief database by defining each activity and each (sub)cluster as a node and each access relationship and the belongingness to a cluster as links. This permits direct comparison between the brief with a floor plan both visually and mathematically. The comparison makes local and global problems explicit in the accommodation of a brief in a building.

The main difference with the topological representation of a building is that the topological representation of programmatic requirements does not normally contain circulation spaces. In the case of the building access graph these form the connecting tissue between the spaces. As a brief normally indicates circulation space as a mere percentage of the total floor area, the connecting tissue in the brief graph consists of abstract, cumulative objects that indicate the clustering relationship. This simplifies the matching of the graphs as it permits identification of sub graphs on the basis of stated clustering criteria.

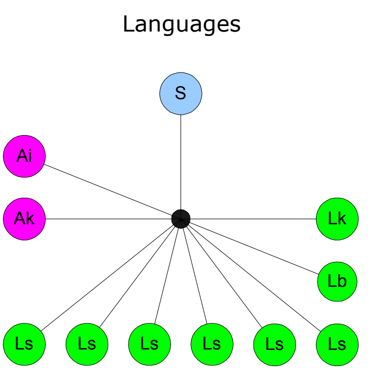

Figure 15. Topological representation of programmatic requirements for the cluster Languages.

Cluster Languages										
Cluster	Subcluster	Code	Name	Education type	Activities	# Users (max)	Free height	public/private	silence/noise	Accessibility
LA	01	Ls	Dutch	CGI*	teaching and learning Dutch	032	3000	depends on the schedule	talking	ST**
LA	02	Ls	English	CGI	teaching and learning English	032	4000	depends on the schedule	talking	ST
LA	03	Ls	French	CGI	teaching and learning French	032	3000	depends on the schedule	talking	ST
LA	04	Ls	German	CGI	teaching and learning German	032	4000	depends on the schedule	talking	ST
LA	05	Ls	Classical Languages	CGI	teaching and learning Classical Languages	032	4000	depends on the schedule	talking	ST
LA	06	Ls	Other Languages	CGI	teaching and learning other languages	032	4000	depends on the schedule	talking	ST
LA	21	Pd	department space		conferences, work (preparing lessons, marking papers, administration), tutoring	depends on number of teachers	2700	specific user	talking	T
LA	95	Lb	storage	-	storage of material of department e.g. books, tapes, tests and TV.	-	-	-	-	T
LA	98	S	lavatory	-	sanitary functions	-	-	permanentlyope n	-	STV
LA	07	Ak	education space for small groups	G	supervision of small groups, group work	010	3000	depends on the schedule	talking	ST
LA	08	Ai	individual workplaces	I	individual study	001	2700	permanentlyope n	silence	ST

Explanation of codes: C(lassical) G(roup) I(ndividual) S(tudents) T(eachers) E(mployee other than teacher) and V(isitor)

Each node in this representation is annotated by means of dynamic linking with the corresponding activity in the brief database where they become properties of the node. Changes in the brief database are automatically propagated to the topological representation either as changes to the properties or as structural rearrangements of the graph (re-clustering).

Application

The modules described so far can be used as interconnected but otherwise self-contained descriptions of a brief or a building. However, the potential of the connections can only be realized if the modules are treated coherently and consistently in the framework of the resulting compound representation and in relation to the architectural processes involved in the transformation of a building. The following sequence of steps is a schematic description of a typical application of the complete system.

Building analysis

The geometric representation of the existing situation of the building forms the usual starting point in the analysis of the building. It serves as a basis for achieving agreement on the current state of the building (no trivial task in practice), for identifying additional programmatic requirements that arise from factors distinct from educational changes such as demographic changes, as well as for quantifying the extent of problems and possible solutions (e.g. available floor area) [15]. [See figure 16, next page]

The topological representation that is derived from the geometric one supports further analysis with respect to the spatial type but also for functional dynamic aspects. These are of paramount importance in a building with a large number of mobile users whose activity patterns vary depending upon the typically unpredictable structure of school timetables. [See figure 17, next page]

The topological representation exists in two forms. The first retains the geometric position of spaces in the floor plan. It serves as a direct abstraction of the geometric representation that stresses entities and relationships. The second form is normalized and facilitates typological classification and comparison between buildings that may have completely different geometries. [See figure 18, next page]

Brief analysis and comparison

The basic brief for the transformation represents the main bulk of new requirements. This has to be adapted and augmented with additional requirements that express the approach of each school, as well as with constraints that derive from the school building. The resulting changes are generally limited to additional activities and a finer subdivision of clusters. Clustering is critical for the transparency and efficiency of the transformation process because it reveals the degree of matching between the educational approach (primarily at the level of daily activities) and the possibilities of the building. It also facilitates agreement with respect to the global accommodation of activities in the building and focusing on particular problems in parts of the brief or the building. [See figure 19, next page]

The topological representation of programmatic requirements permits a direct, visual comparison of the new brief with the existing situation in the building and consequently unambiguous identification of required adaptations and of possible strategies. In the example of the last four figures, the main difference between brief and building is that there is no provision for individual workplaces (Ai) or an education space for small groups (Ak). The existing classrooms are still needed, so they cannot be transformed into new working places. The emerging solution in this case is to expand the building and create new space for the new activities. [See figure 20].

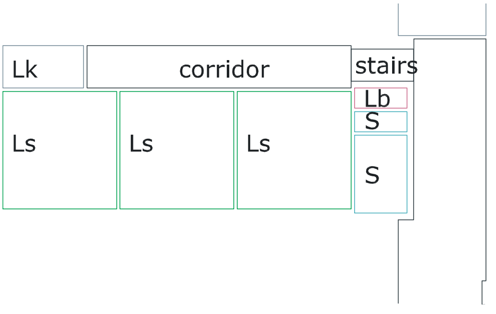

Figure 16. Caland Lyceum: geometric representation of a wing.

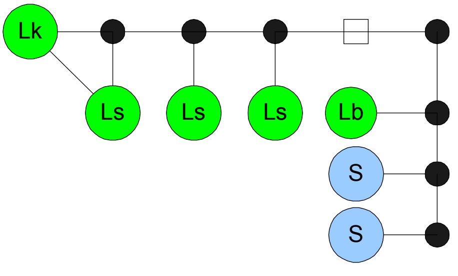

Figure 17. Caland Lyceum: topological representation of a wing.

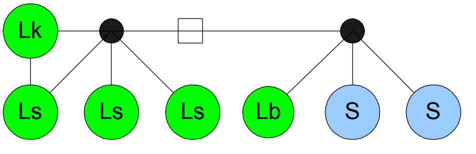

Figure 18. Caland Lyceum: normalized topological representation of a wing.

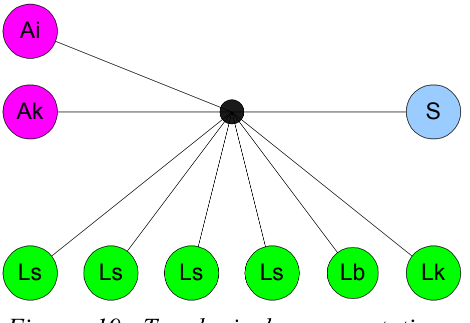

Figure 19. Topological representation of programmatic requirements for the cluster to be accomodated in the wing.

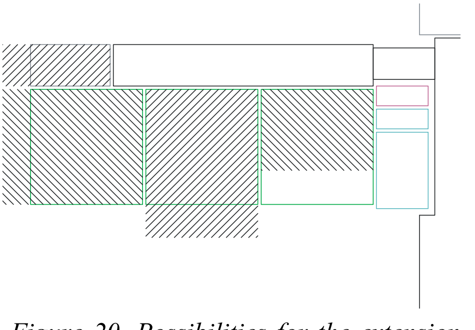

Figure 20. Possibilities for the extension of the wing.

Learning issues

The analysis sketched above describes one of the many cycles in the transformation of a Dutch secondary education building. The same procedures can be repeated at different stages of a design process and at different abstraction levels. Problems can be addressed at a global as well as at a local level, with respect to the existing building or to a new design at any development stage. The purpose of the analysis and evaluation performed by the information systems described in the present paper is to provide a stable, comprehensive and coherent background to design communication and guidance. However, communication between the information systems and their users is not one-sided. Every application should result into an augmentation of the knowledge incorporated in the system. This augmentation can take many forms, including:

- Extension of the brief with activities and requirements
- Fine-tuning of the representations with respect to the geometry and structure of buildings
- Registration of cases and precedents

The positioning of new knowledge in the information systems is determined by the distinction between problems or constraints common to more cases and ad hoc situations like variation in the number of students or the bad maintenance of a building. Common characteristics are added to the core modules, while the ad hoc information is retained in the case base.

Discussion

The information systems developed for the design and management of transformation in Dutch secondary education buildings derive from representations and analyses developed for other types of complex buildings [9; 15; 18]. Consequently, the technical side of the system is reasonably advanced for providing the desired capabilities of representation, analysis and communication, as well as adequate performance in handling large and complex buildings and briefs. The first stage of our research concerned the integrated development of the computational facilities on the basis of a small number of existing buildings representing the basic school types. Transformations that already have taken place are documented separately (as new states of the buildings) and used primarily for the fine-tuning of analyses.

After the first stage of the project our emphasis shifts to the relevance of the information systems for the resolution and management of design problems. The main focal points are:

1. The development of a database of cases and precedents: these describe design solutions and situations with known form, activity content, behaviour and performance. In addition they accommodate the history of design processes in order to support process management, e.g. allow us to anticipate problems.
2. The development of a typology of problems, solutions and briefs: this complements the building typology and is expressed in the structure of the brief database and the structure of the case base.

Such developments can only be achieved through the use of the systems in the framework of real transformation projects. Therefore the possibilities for further development is either to participate in design projects so as to achieve a coherent overview of all stages or to initiate large-scale analyses of building stock.

The underlying descriptive approach to designing and management [19; 20] means that the information systems operate in the background of human design and decision processes. They register design decisions and states and return unobtrusively relevant feedback that facilitates the definition and refinement of strategy. This makes the systems also appropriate for communication and cooperation between the different parties involved in a transformation process over the Internet. We consider this together with the analyses offered by the systems to be a major incentive for use in real projects.

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