MODELLING MULTIPLE VIEWS ON BUILDINGS

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Abstract

The building practice is characterized by its loose organization of the different participants, that each perform a specific role in a building project and have a specific view on the building project data. When modelling building information, it is useful to base the structure of a building model on these views. This can be done by the use of *aspect models*.

This paper presents an approach in which aspect models are used to store view specific information. The approach is illustrated with an outline of a building reference model. The building reference model consists of a general kernel and view dependent aspect models. This model is first worked out for one decomposition level, the space unit level. After that the model is extended with other decomposition levels.

1. INTRODUCTION

In a building project, each partner usually plays a specific role. This role follows from the partners primary interest, and results in a specific *view* on the building. A designer's primary interest is for example the spatial structure, a structural engineer's primary interest is the load bearing structure, while an energy engineer is interested in climate zones.

As a result of this, buildings and building parts are viewed differently by each partner: e.g. a wall is regarded by the designer as a 'space boundary', by the structural engineer as a 'load bearing element' or as a 'non load bearing element', and by the energy engineer as a 'climate zone separator', see figure 1. The figure can be extended with the views of the client, the contractor, the cost calculator, etc.

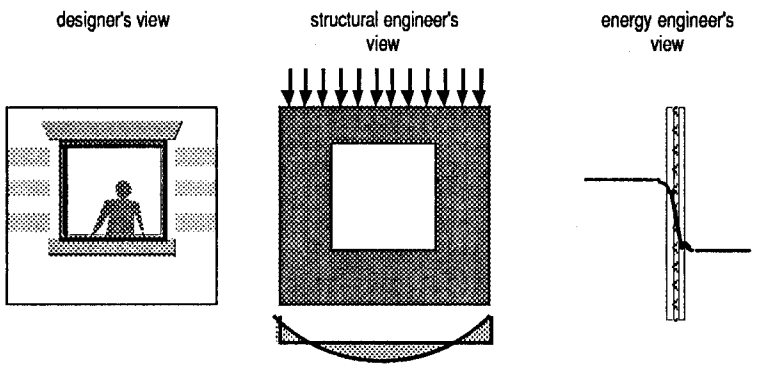

Fig 1. Different views on an outer wall

All these partners use a different description of the building, with different decompositions, relationships, even with different shape specifications. This explains for example the difference between a designer's drawing and a structural engineer's drawing.

2. VIEWS IN BUILDING INTEGRATION RESEARCH

The distinction of different views is a very important issue for the research on information integration in building. In this research area significant progress has been made by the use of the product model approach. An important reference model in this context is the General AEC Reference Model [1]. Other well known models are the AEC Building Systems Model [2], and the RATAS model [3]. These models have been presented at previous CIB / W78 meetings. In these models concepts like decomposition (part_of relations) and specialization (kind_of relations) have been worked out extensively.

The importance of view integration is also recognized in these models, but was not worked out to the same extent. As a result, these models are not yet suited very well to serve the needs of our industry.

3. ASPECT MODELS

A promising approach for view integration is the use of so called *aspect models,* each of which describes one aspect of the real world (e.g. the building). Following this idea we can develop an aspect model for every view on the building, e.g. an aspect model for 'spatial design', an aspect model for 'building structure', and an aspect model for 'energy'. In each aspect model the concepts of decomposition and specialization can be used independently. The result is a set of models, each of which describes the building from a different viewpoint. By applying this model structure, building information can be stored in a simple and clear way.

The next step is to define the relationships between the aspect models. For example, a wall can be modelled in a number of aspect models, each of which describes certain characteristics of the wall. But the fact that the information in the respective aspect models is concerning the same wall, should also be modelled. This can be provided by a model kernel, which describes view independent information, see figure 2.

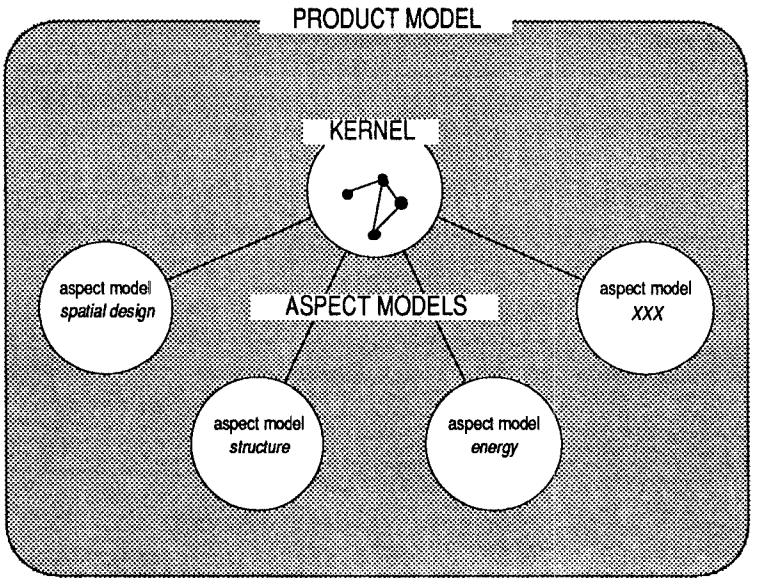

Fig 2. Structure of a product model with aspect models

In the following we describe how the aspect model approach can be applied. For this purpose an outline for a building reference model is presented. This is done first for the decomposition level of rooms, walls etc., called the *space unit level.* After that the model is extended, upwards and downwards, with other decomposition levels.

4. ELABORATION ON THE SPACE UNIT LEVEL

According to the product model structure as discussed above, general information about the objects on the space unit level (rooms, walls, etc.) is stored in the kernel, while view dependent information is stored in aspect models. In this paragraph is shown how this can be done, first for the kernel, then for the aspect models.

4.1 General Information on the Space Unit Level

Information about rooms, walls etc. which is view independent is stored in the space unit kernel. The space unit kernel which is presented here is based on the kernel of the House Model which is developed by De Waard and Tolman, see [4].

Figure 3. shows the general entities which are important on the room level, or more general on the space unit level. For this figure the space unit is considered as a black box, i.e. we do not look inside the space unit (according to [5]).

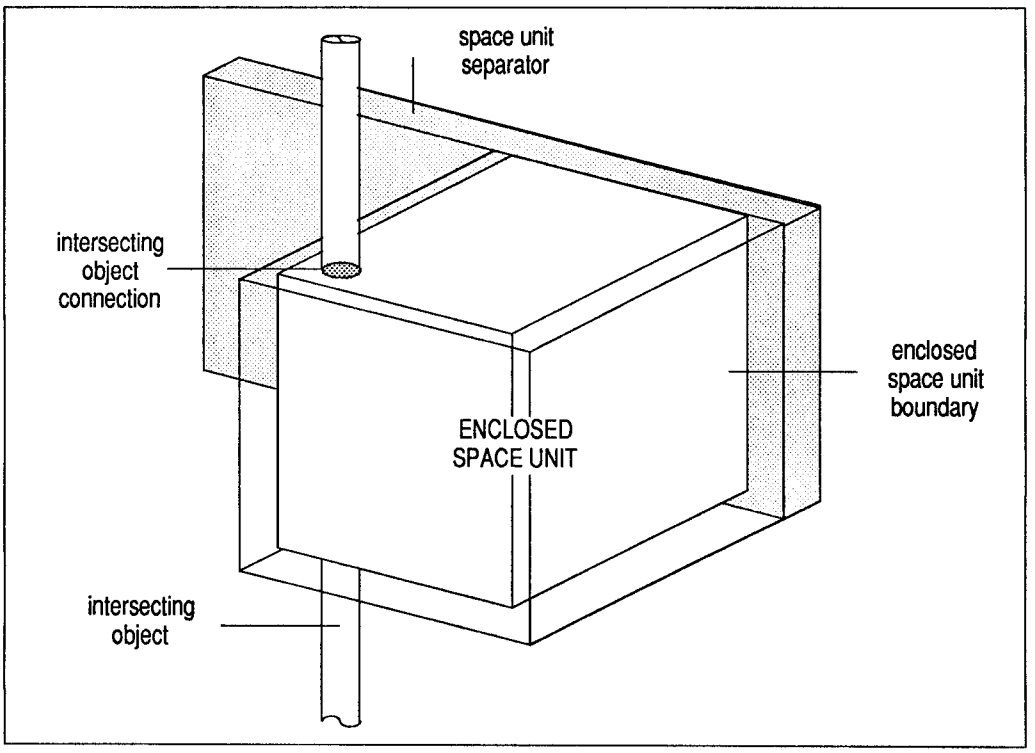

Fig 3. Sketch Enclosed Space Unit

The primary entities on this level are *enclosed space units* (e.g. a room), which are bound by *space unit separators* (e.g. walls), and which may be intersected by *intersecting objects* (e.g. columns or pipes).

The relation between *enclosed space unit* and *space unit separator* is described by an intermediate entity, called *enclosed space unit boundary*. The use of such an intermediate entity for a relation is very useful, e.g. to specify the finish of a part of a wall which is adjacent to a room. It provides also for situations in which an outer wall bounds several rooms (see fig 3), or for partly enclosed spaces. *Intersecting object connection* is also an intermediate entity, which describes the relation between *intersecting object* and *space unit separator*.

The following NIAM diagram shows the entities discussed here. For NIAM explanation see Nijssen & Halpin [6].

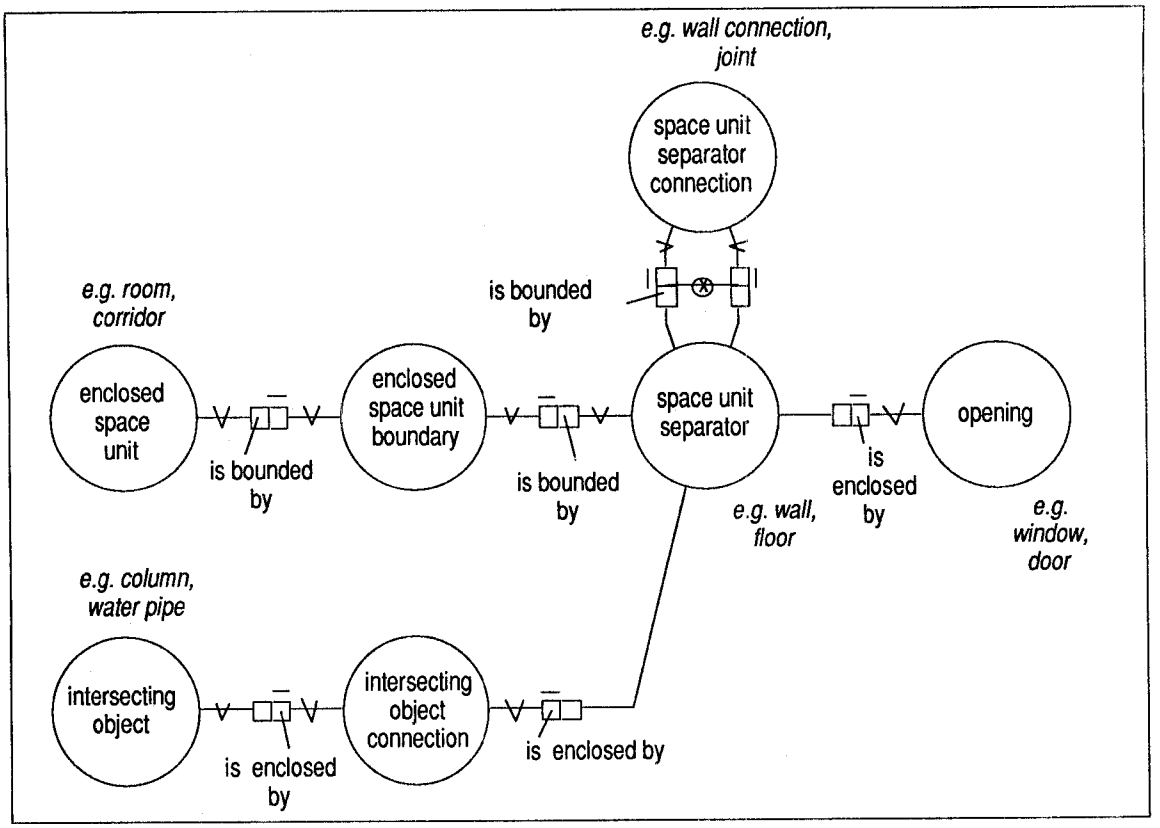

Fig 4. Space Unit Kernel

The relation between *intersecting object* and *enclosed space unit* will be specified on a lower decomposition level. This relation is specified here because the space unit is considered as a black box. Also entities for wall elements, wall element layers, internal spaces, etc. will become visible after decomposition.

4.2 Information on the Space Unit Level from a Function and Circulation View

View dependent information is stored in aspect models. On the space unit level aspect models can be developed e.g. for a *function and circulation* view, for an *energy* view and for a *flow systems* view. Aspect models for these views have been developed for the CEC project COMBINE [7].

The *function and circulation* view can be seen as the way one looks at a building in functional analysis, with bubble diagrams, etc.. If a single space unit is viewed this way, only two entities play a role: the *space unit* and the *space unit entrance* which provides for the connection with other *space unit*s, see figure 5.

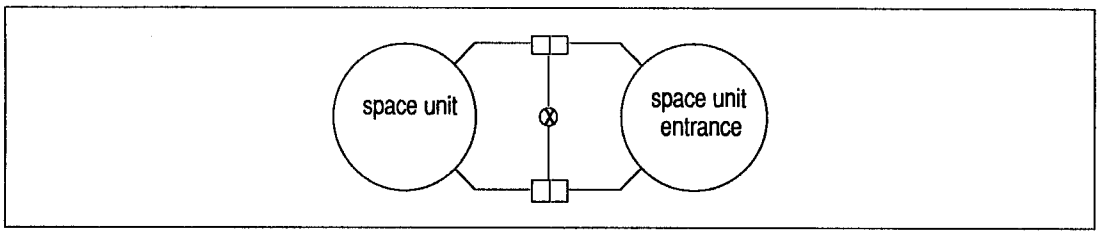

Fig 5. Aspect Model of Space Unit from the Function and Circulation View

Note that the aspect model does not contain information about separating elements, like walls and floors or about intersecting elements like columns. These elements are considered as not of primary interest for function and circulation.

The entities of the aspect model are *subtypes* of entities of the kernel. E.g. *space unit entrance* is a subtype of *opening*. The view specific information in this model is stored in the two relations and in the attributes of the two entities (not shown).

4.3 Information on the Space Unit Level from an Energy View

The *energy* view leads to a distinction of the building in thermal zones, thermal zone separators. The following diagram shows the entities of the aspect model for energy on the space unit level.

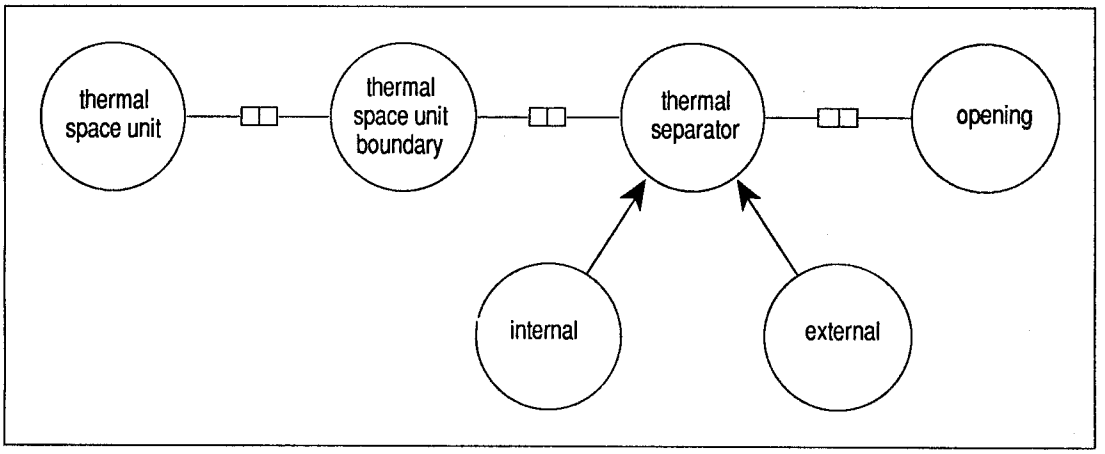

Fig 6. Aspect Model of Space Unit from the Energy View

These entities are again subtypes of kernel entities, to which view specific information is added in this aspect model.

For the energy view the distinction between internal and external is of course essential. But for other views, like function and circulation, or structural engineering, this distinction is not important. Therefore this distinction is specified in this aspect model, and not in the kernel.

5. DECOMPOSITION

Until now, only one decomposition level of the building is discussed: the space unit level. In this paragraph is shown how the relations with other decomposition levels can be included in the models. This will be done first for the kernel, and after that for the aspect models.

5.1 General Decomposition

The top of the kernel decomposition is the entity *building,* which decomposes in one or more *building blocks. Building blocks* decompose into *block parts,* which may be floors, zones, areas, etc.. *Block parts* decompose into the space unit entities discussed in 4.1.

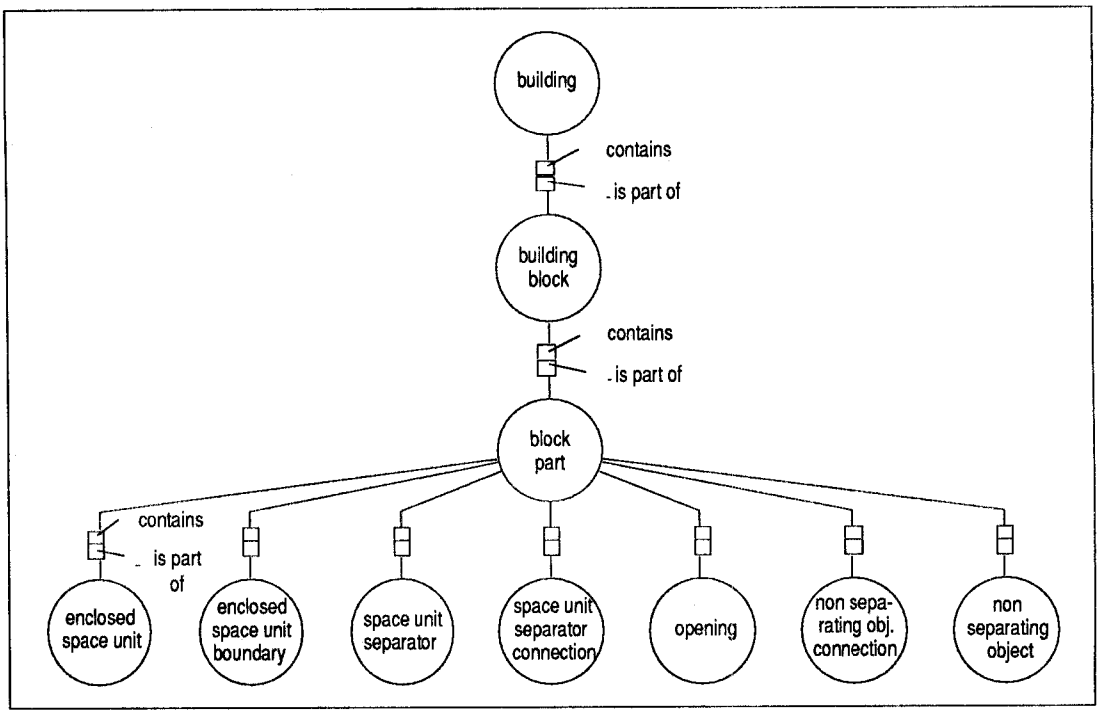

Fig 7. General building decomposition (upper levels)

Of course the decomposition process can be extended downwards several more steps. For instance an *enclosed space unit* may contain lower order enclosed spaces (i.e. a bathroom may include spaces for the bath tube and the washing stands), or *a space unit separator* contains one or more *separating elements,* which may contain *separating element layers.*

5.2 Decomposition from a Function and Circulation View

For each aspect model a view dependent decomposition can be defined. These decompositions differ from the general decomposition because of their specific view.

The aspect model decomposition for *function and circulation* is very much dependent of the building type. Therefore the decomposition is worked out for office buildings. A general decomposition for buildings is also possible, but will be very abstract. The following picture shows some high level entities of this aspect model. An *office building* contains one or more *office units* (belonging to different companies) and one or more *shared areas* (which may contain the building entrance, corridors, stairs, elevators, etc.).

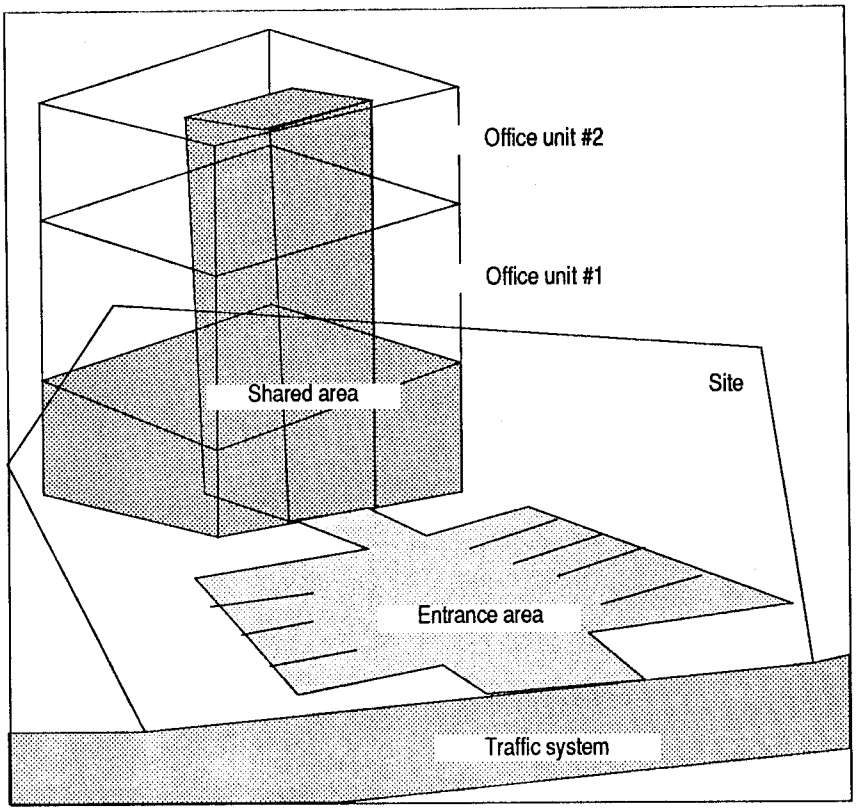

Fig 8. Sketch function and circulation on the building level

The decomposition for function and circulation is:

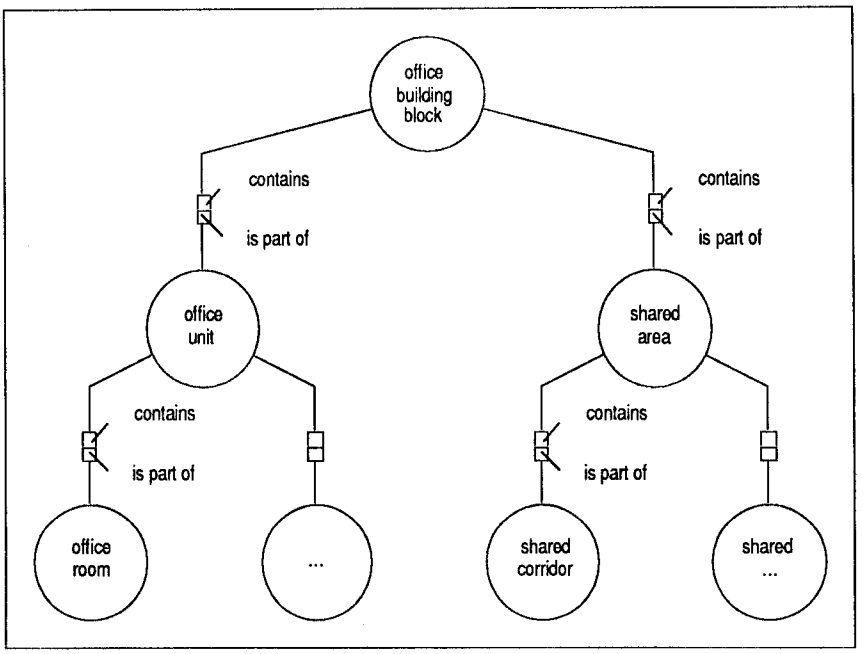

Fig 9. Decomposition for the Function and Circulation View (for office buildings)

Figure 9 shows that *office unit* decomposes into *office rooms* (and one or more private corridors, kitchens, toilets, storage rooms etc.). This decomposition level corresponds to the space unit level in the kernel. This means that the entities on this level contain information about enclosed space units from a function and circulation view.

The relations on the different levels can (and must) be specified in NIAM network structures (as is done for the space unit level in 4.). These networks will specify how spaces are connected, as in bubble diagrams.

5.3 Decomposition from an Energy View

The following figure shows some entities of the decomposition of the aspect model for *energy*.

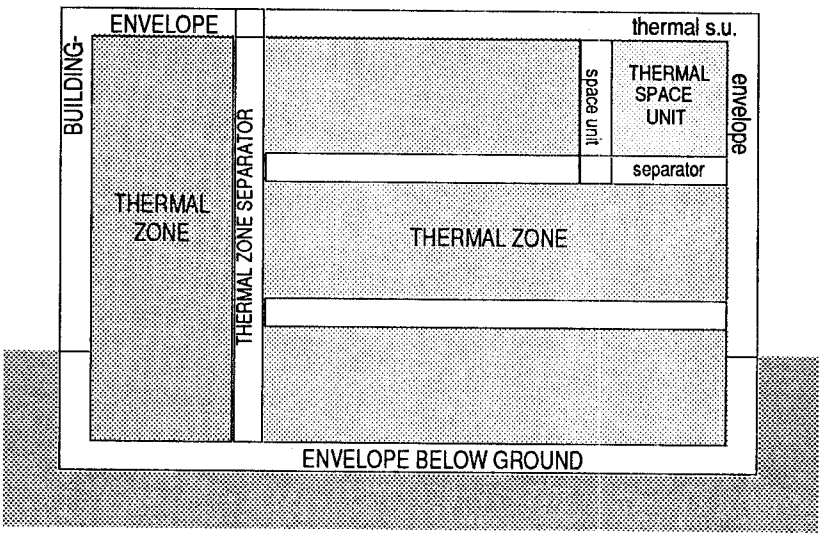

Fig 10. Sketch Energy View

The energy view leads to the following decomposition:

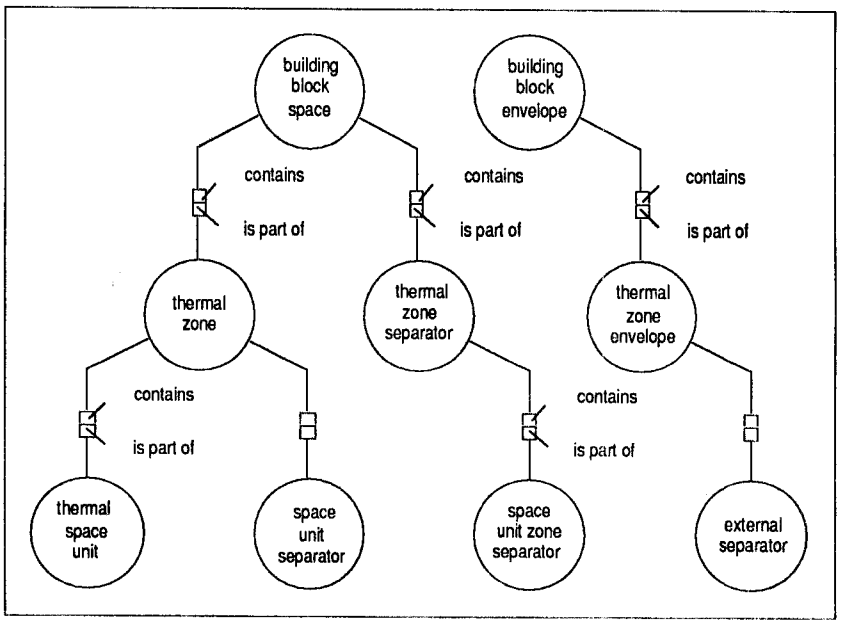

Fig. 11. Decomposition for the Energy View

The decomposition shows that the distinction between spaces and space envelopes can be found on every level: on the highest level (not shown) the entities are *building* and *building envelope*. And on the space unit level *thermal space units*, *space unit separators* (between *space units* of the same *thermal zone*), *space unit zone separators* (between *space units* of different *thermal zones*) and *external separators* are distinguished.

In the models on the space unit level also intermediate entities like *thermal space unit boundary* were applied. This kind of intermediate entities should also be incorporated in the decomposition levels. However, for simplicity we have left them out in this model.

5.4 Decomposition from a Flow Systems View

Finally a decomposition for a *flow systems* view is discussed. First a sketch of an example of flow systems is shown: a water system.

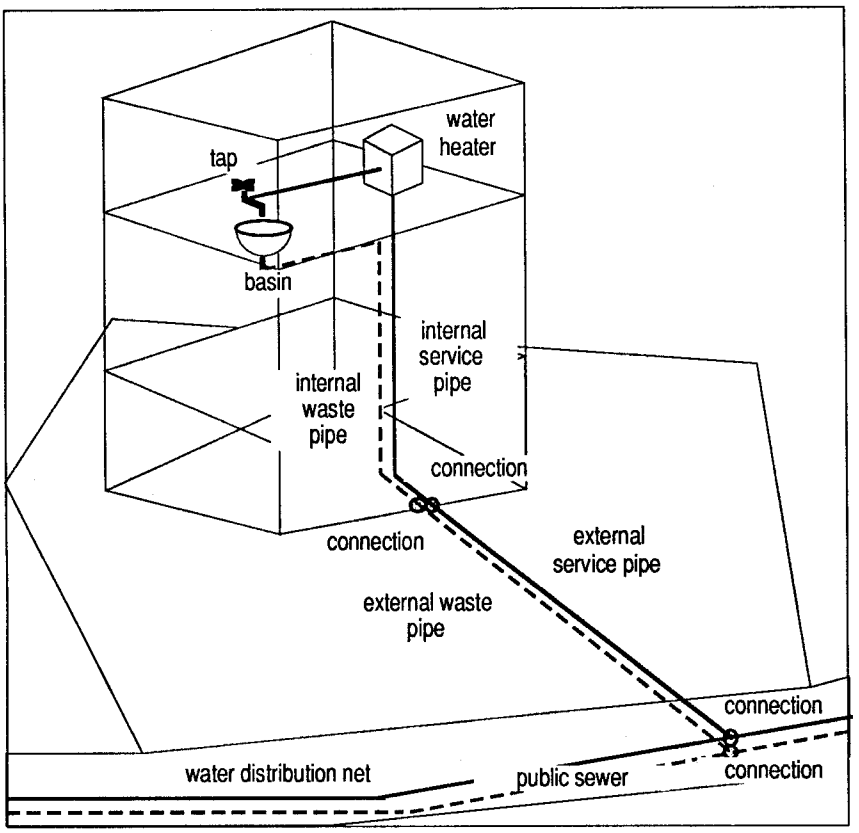

Fig. 12. Sketch Water System

The flow systems model is based on the AEC Building Systems Model by Turner et. al. [2]. According to this model flow systems decompose into *sources*, *paths*, *controls*, *measurements*, *storages* and *sinks*. When this decomposition is combined with the black box approach with the decomposition in buildings, building blocks, block parts etc., the following decomposition for flow systems is obtained:

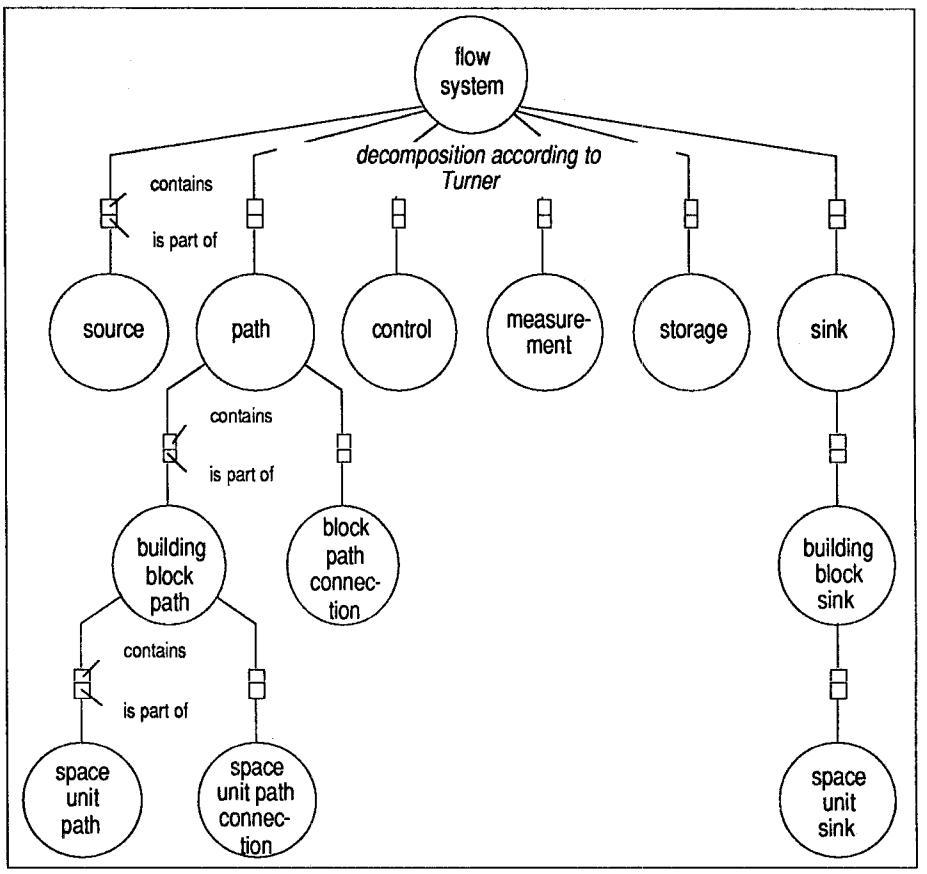

Fig. 13. Decomposition Flow Systems

The diagram shows that a *path* is decomposed into smaller *path*s when smaller building parts are considered. The *sink* entities in the different levels however do not specify smaller parts, but specify information about sinks in smaller *contexts*: on the highest level is stored that a sink can be found somewhere inside or outside the building, while on the lowest level is specified that a sink can be found somewhere inside a specific space unit.

6. EVALUATION

This paper discusses how multiple views on buildings can be modelled using aspect models. At this stage the models are of course rather simplified. E.g. the aspect model for energy is in fact simplified to a heat transmission model, without heat sources, without solar energy, etc..

But the purpose of this paper was not to present a complete building model which supports multiple views, but to show the approach taken However, the models as presented should be elaborated further to find out how useful the aspect model approach is in practise.

6.1 Further Work

It is our intention to elaborate the aspect model approach in more detailed models. Additionally, the developed concepts will be tested using the object oriented, graph based product modelling tools which are currently developed at TNO [8].

7. CONCLUSION

In this paper we present an approach to model multiple views on buildings using aspect models. This approach provides a simple and natural way to model building information. The models must however be elaborated to find out the real impact of the approach.

ACKNOWLEDGEMENT

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