Ordering systems in architectural design and planning

A discussion of classification systems and practices

Kjeld Schmidt
IT University of Copenhagen
schmidt@it-c.dk

Ina Wagner
Vienna University of Technology
iwagner@pop.tuwien.ac.at

1 Introduction

A salient feature of cooperative work in modern work settings is that multiple actors so to speak interact 'through' a large collection of artifacts of various kinds. An actor may for example place a document in a location where others can see it and use it. The actor may place it there for his or her own later use, but at the same time others may access it too, or the actor may place it there deliberately for the benefit of others. Perhaps the identity of the others cannot be known in advance, perhaps it can. Anyway, whatever the reason for putting it there, since other actors have access to the document, those others may retrieve and use it at some point in time, perhaps for purposes or in contexts that are quite different from those of its origination. It may also be the case that another actor may change the content of the document, change its location, rename it, delete it, etc. Such practices are ubiquitous in cooperative work.

The location of the collection may be a particular shelf, rack, room, or building, or the collection may be distributed over a number of shelves, racks, rooms, and buildings. The collection may comprise digital artifacts as well as paper and other physical artifacts. The items in the collection may be documents such as books, reprints of scientific papers, technical reports, invoices, design specifications, software code, blueprints, etc. Or the collection may contain parts and sub-assemblies, zoological or geological samples, forensic evidence, etc. Or the collection may be a heterogeneous assembly of such artifacts. However distributed and heterogeneous the collection may be, in their cooperative activities actors will (in some ways) interact and coordinate their activities through this collection, by changing its state.[1]

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1 Such collections of artifacts have been termed 'common information spaces' (Schmidt and Bannon, 1992) with a rather problematic choice of words. The main culprit here is the term 'information', which is not only nebulous and overworked; it is outright misleading, as it gives the impression that the term 'common information space' denotes something like a 'shared understanding' or a 'shared culture' or a cooperative work environment in general (such as a process plant). The originally intended focus on the practices concerned with large distributed collections of discrete artifacts is lost when the term 'information' is used as the key term.

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That is, in the practices we are focusing on here, actors not only interact by changing the state of some part of the world (which is characteristic of cooperative work in general), they interact in a highly distributed manner by changing the state of discrete items in vast heterogeneous and physically distributed collections. What is most striking is that actors manage to interact in this highly distributed and mediated manner without succumbing to disorder and utter chaos. In fact, they manage to interact an orderly fashion without (1) access to the effortless and continual recovery from misunderstanding that characterizes 'face-to-face' or collocated work settings, and (2) without the agency of a specialized and putatively omniscient and omnipotent central agency such as professional librarians or an overseeing committee (as in the case of bibliographical databases).

How do they do that?

The simple answer is that this is accomplished by means of a large variety of very sophisticated coordinative practices and concomitant coordinative artifacts.

Typically, complexes of interrelated coordinative practices and artifacts form what can be termed *ordering systems*: In administrative domains one will for example find ordering systems comprising calendars, clocks, agendas, minutes, files and folders, archives, standards operating procedures, organizational charts, etc. In production industries one will find many of the same ordering systems as well as specific complexes comprising drawings, bills of materials, process cards, routing schemes, etc. The challenge is to understand these coordinative practices and artifacts in their complex interrelationship.

What we are interested in here is, of course, the ordering systems required for the organization of large-scale distributed collections. Of these the following are of particular importance:

1. Validation practices: When accessing an artifact produced by somebody else, the actor retrieving it will somehow have to assess its relevance, validity, veracity, etc. Actors will here, among many other factors, rely on their knowledge of the procedures of origination, that is, the procedures according to which items are originally submitted and selected (e.g., the review procedures of scientific journals, the acquisition procedures of museums, etc.). Also, in some domains of work more or less sophisticated procedures of validation are developed and enforced (e.g., journalism, accounting, criminal investigation, experimental science, historiography).

2. Naming conventions: When accessing an artifact produced and submitted by somebody else, the actor who may need to retrieve it will have to be able to recognize its specific relevance. The item thus has to be named so that a potential user will know 'what' it is. This may involve a more or less elaborate convention for naming items (e.g., a nomenclature).

3. Standardized format: For others to be able to make sense of and use the items in the collection, their form must be standardized according to certain criteria. If the artifact is a text, the document must be formatted according to a certain standard (e.g., the different standards for formatting scientific papers in the different disciplines, or the conventions for formatting agendas or minutes of meetings). In manufacturing, parts

and sub-assemblies are produced to meet strict specifications as defined by 'templates' such as drawings.[2] In geological or zoological collections, for example, samples are treated according to standard procedures of conservation, etc.

4. Classification systems: For an actor to be able to contribute an item to the collection in such a way that others — in more or less foreseeable relevant situations — may be able to find it or even cannot avoid finding it, requires that the collection is organized according to some relatively stable and generally agreed-to scheme. In simple cases, a specialist (e.g., a librarian, custodian, etc.) may be able to impose a classification scheme. In many if not most cooperative work settings, however, this is not possible at all. New classes are created or discovered; existing classes are discontinued, or merged, or split into two or more classes. The domain may change too rapidly for an external specialist to maintain the classification scheme, or the domain may be too complex, uncertain or heterogeneous for any central or external agency to be able to cope with it. In such cases, the classification scheme must be developed and maintained cooperatively, in a distributed manner.

In this paper we focus on the practices underlying the use of classification systems, based on a long-term study of architectural practice. The choice of architecture as a case is motivated by the fact that architectural design and planning involves numerous distributed actors and thousands of distributed documents and other artifacts. Developing and maintaining ordering systems for these collections of items is part of architects' everyday work. We studied architects' ordering systems by analyzing a variety of representational artifacts and the practices surrounding them. We use this material for understanding the nature of classification systems and their role for cooperative work in complex settings. We first briefly describe the complexity of modern construction and planning to then give a detailed description of some of the ordering systems 'at work'. The conclusions we offer are preliminary.

2 Terminological digression

The concepts of classification and categorization are victims of enormous confusion, especially due to cognitivism's intellectualistic notion of cognition. Some comments on terminology is therefore called for.

1. When I look out the window and see sky, clouds, trees, birds and so forth, I do not thereby *categorize* or *classify* these phenomena as sky, clouds, trees, birds and so forth. I just *see* them. Categorization, by contrast, is a linguistic operation of applying *signs* to phenomena. Talking about phenomena, however, is not necessarily categorizing them, although talking involves the application of categories (signs representing kinds of things, actions, species, etc.). To categorize is to make what Wittgenstein would call a grammatical proposition ('red is a color').

In categorizing what I see as trees and birds I emphasize certain aspects of the world while abstracting from others, for instance that the trees and birds may all have green

2 The term 'template' has been suggested in (Turnbull, 1993).

colors or that clouds and leaves may all be moved by the wind. An act of categorization cuts the world into pieces in that it emphasizes certain features as the expense of others (‘*x* belongs to category *y*’).

In themselves acts of separating objects are not acts of categorization, as they are not necessarily linguistic operations. Peeling onions or removing dirt from one’s body by means of soap and water are acts of separation but not acts of categorization, although they may be subjected to acts of categorization, for instance when one is instructing children in how to do it. Similarly, when sorting the garbage (putting paper in this container, potato peels in that container) one may, or may not, be following instructions involving categorizations.

2. *Classification*, in turn, is a special practice of categorization, involving pre-established and systematic systems of signs. That is, classification is a linguistic operation of applying a *classification scheme*, i.e., an ordered set of signs that is pre-established according to (a) some general principles and criteria of ordering and (b) some procedures of identification and naming. In short, an act of classification is an application of a classification scheme. *Classification systems* (such as thesauri) can thus be seen as instantiations of classification schemes.

3. Classifications and categorizations are both convention-based practices and equally so. But classifications are convention-based in a quite specific sense. In the case of categorization there are no pre-established principles for determining the correctness of an act of categorization. With acts of classification, however, such pre-established principles exist, in that they specify relationships between items in terms of, for example, class/membership, part/whole, composition, cause/effect, origin/fate, function, ownership, value/risk, location, or state. Accordingly, an actor applying a classification scheme in a particular case can be held accountable in terms of the principles, criteria, and procedures of the classification scheme. Classification schemes are normative constructs.[3]

4. Classification schemes vary according to degree of abstraction, systemacity, and accountability. They may, as in the case of certain scientific classification systems, be sophisticated and rigorous theoretical constructs (e.g., cladistic classification in biology). Other professions such as architects use classification schemes that, although not strictly speaking theory-based, draw upon engineering and aesthetic frameworks and methodologies and yet, at the same time, have strong elements of common-sense or practical sense.

5. Classification schemes are institutionalized conceptual, linguistic, and procedural constructs that are part of the practices of professional communities (accountants, biologists, engineers, architects, etc.).[4] Classification schemes are developed by and for

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3 As normative constructs classification schemes may of course reflect and express interests, systems of ethics and morals, etc. However, to claim that ‘categories have politics’ (Suchman, 1993) would be a category mistake, in as much as ‘politics’ is a category of state power and not of social order in general.

4 The term ‘profession’ is here used in the Continental European sense of a community defined in terms of certain competencies, skills, methods, values, etc. One does not have to be a card-carrying member of a professional association to belong to a profession and to behave professionally.

these communities and members typically learn how to use them competently at schools and universities or in the course of their practical training.

6. Specific classification schemes are often expressed by a particular *notation*, 'a set of graphic units with its own structure' {Harris, 2000 #1796, p. 114}.[5] The relationship between a classification system and a nomenclature is often mediated by a notation: the classification of an item as expressed in the notation is taken as the name of the item, and *vice versa*: the name is a direct expression of the classification.

7. Classification systems are often used as *indexation systems* but the two concepts are not identical. An indexing system is a special kind of ordering system that gives the location of an item. The obvious example is the index in a book: an alphabetical list of selected names or terms with associated page numbers.

Indexes may be more or less elaborate. The primitive form of index is a simple pointer, as can be found in the form of links in millions of web sites: 'To read more about *x*, click here'. The meaning of the pointer is here given by the sentence in which it is situated. In database systems, indexes are based on sets of keywords, sometimes just a simple list of terms. Sometimes, however, the index is organized as a classification system, that is, as a set of terms ordered according to some semantically meaningful principle.

While indexes are not necessarily based on classification systems, classification systems may be devised and used for other purposes than indexation, as in the cases of the systems of classification of stars, elementary particles, and biological species, or in the various mythological, metaphysical, religious, ideological systems of classification. On the other hand, however, classification systems developed for other purposes may of course be applied as indexation systems in the organization of artifacts of interest to the related communities of practices (photos, papers, samples, art work, sacred relics).

In any event, for classification systems to be able to serve as indexation systems in the handling of large collections of artifacts in cooperative work, the classification system must be inscribed upon some artifact or system of artifacts (sheets, cards, binders, rolodex, catalogue, shelves) with an associated 'syntax' (list, matrix, hierarchy, map). Without inscription, the classification system will decay unstoppably.

What we are interested in here are classification systems used for purposes of indexing collections of artifacts in cooperative work.

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5 'Notations exemplify a type of structure which, far from being confined to writing, is one of the most basic structures in the domain of signs. It is the structure characteristic of any set of items fulfilling the following conditions. (1) Each member of the set has a specific form which sets it apart from all others in the set. (2) Between any two members there is either a relation of equivalence or a relation of priority. Thus every member has a determinate position with respect to all other members in the set. (3) Membership of the set is closed. Such a structure constitutes what in integrationist terms is an emblematic frame. The very simplest emblematic frames comprise just two members: examples are an on-off switch with only two possible positions and a red-green traffic light where the two colours alternate but never show simultaneously.' (Harris, 2000, p. 106)

3 The complexity of modern construction and architectural planning

Architectural planning and building today face increasingly complex demands. New materials and the possibilities of pre-fabrication require the development of technically sophisticated solutions for joining elements and materials (component design). The ecology of materials and techniques is of growing importance and connected to requirements such as energy efficiency and renewable building materials. Cost-consciousness has increased, and planners need to consider maintenance costs, special services for users, and changing social uses from an early stage on. Also, architects need to develop new ways of achieving flexibility and variability, and of combining neutral spaces with specific qualities. For companies and politics alike, architecture has grown into an important marketing factor. Buildings as well as urban structures represent and create images. Their conceptualization and representation requires novel visual strategies.

The ‘density’ of parameters that have to be taken into account in planning requires that architects expand their networks of consultants. In most cases the architect has the responsibility for the planning process and the overall quality of the design. S/he coordinates the planning process with external consultants, local authorities etc. who each fill in their bits and pieces. Searching for and negotiating technically and economically feasible solutions for a large number of details implies managing a large network of relations of power and dependencies.

Increasingly entrepreneurs not only act as general contractors but as ‘cultural actors’, thereby undermining the universalist role of the architect. At the same time the demands of planning give rise to specializations. This creates a dynamic which, while threatening the received division of labor, also contains a potential for innovating planning practices and for widening the solution space for architectural design.

<table>
<tr><td>USERS
Bring in their ‘Corporate Identity’
Define requirements</td><td>CLIENT
Formulates ‘room program’
May contract architect and technical consultants</td><td>GENERAL CONTRACTOR
Moderates and controls the planning and implementation process</td><td>LOCAL AUTHORITIES
For different aspects of the building
Control, authorize</td></tr>
<tr><td colspan="3"></td><td>JURY
Sets criteria, evaluates, authorizes</td></tr>
<tr><td colspan="2">CONSULTANTS
Construction engineer, heating and ventilation specialist, building engineer, traffic specialist, specialist for facades, lighting designer, etc.
Give technical advice
Cooperate in design of details and call for tender
Formally approve of design details</td><td colspan="2">ARCHITECTURAL OFFICE
‘Artistic director’ - responsible for overall design
Coordinates planning process</td></tr>
<tr><td colspan="2"></td><td colspan="2">PARTNER OFFICE
Supports costing and call for tender, survey implementation at construction site</td></tr>
<tr><td colspan="2"></td><td colspan="2">COMPANIES and other building professionals
Provide products, materials, skills etc.</td></tr>
</table>

Table 1: Example of a network for a large building project

4 The architects’ ordering systems[6]

Imagine an architectural office. It consists of several interconnected large rooms, each with several desks, each of these with a workstation. Most of these desks are covered with materials – plans, sketches, notes, photographs, faxes, books, samples. On shelves are large collections of binders for each of the current projects. In the entrance area a collection of scale models and on the walls 3D visualizations, sketches, photographs, and newspaper clippings from previous and current work. The walls close to people’s workspaces too are used as an exhibition space and decorated with materials from current work.

6 We here report on fieldwork carried out in ‘Architekturbüro Rüdiger Lainer’. The artifacts that have been selected for this paper have their origin in a large building project - *Pleasure Dome,* an entertainment center in the Gasometer area in Vienna.

Figure 1. The office

The process of design and planning is individual, team-based and multi-disciplinary, enlisting multiple professional competencies and perspectives, at the same time. It is organized into (legally defined) stages with defined products: Pre-design, design, construction planning, etc. Each stage is concluded with the respective set of CAD drawings for submission, construction, etc. In practice stages overlap a great deal. In this process, a principally unlimited solution space becomes more and more focused to be finally fixed in plans representing the artifact-to-be-built.

A great number of material is created in this process, much of it crossing boundaries several times in different media. Print-outs of drawings will be made, photocopied in A3, discussed, modified (on layers of transparent paper), annotated. Copies of material may be sent by fax to a consultant for commenting and return with suggestions and calculations, to be discussed and further annotated. Files are exchanged via email. Consultants will extract those layers from a CAD drawing that matter for their work, do their own drafting, and send the file back to the architects' office to be viewed, copied into their central CAD drawing or drafted. In parallel the architects communicate on the phone, call for an ad-hoc meeting, send an email etc.

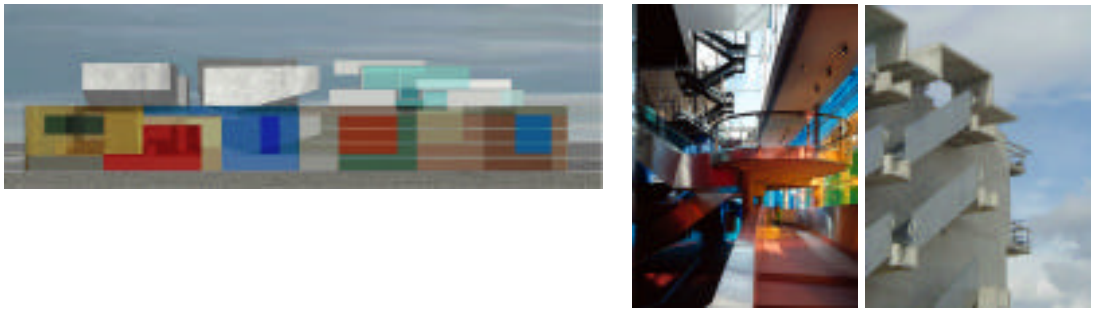

Figure 2. The project: Pleasure Dome

The artifacts that are produced, exchanged and worked on are different representations of a complex system. Due to the diversity and sheer amount of materials (and the design parameters they represent), maintaining order is a crucial problem.

The architects use several ordering systems in parallel:

- Binders – these contain all the paper material (letters, faxes, plot-outs and copies of drawings, minutes) in an order that reflects the architects' main 'working fields' and, hence, work relationships (to client, consultants, companies and other professionals, local authorities, etc.)
- The desktop (on the central server) – with a similar order and mail in/mail out folders plus attachments
- Excel sheets and Word lists for keeping track of the handover of drawings, maintaining an overview of design details, etc.

All these ordering systems build on classifications schemes. These schemes are aspects of architects' profession. The following sections describe several of the architects' ordering systems and the practices involved in their use.

4.1 The binder system

The physical filing system mirrors the web of people, tasks and materials that are activated, performed, and produced in the course of a project. In Figure 3 we can see most of the binders for *Pleasure Dome*. The labels which have been printed out reflect the 'working fields' of the project on the one hand, the professions and particular types of documents that are associated with them on the other hand.

The label 4.1.B stands for 'Consultant: Building engineer'. It contains catalogues of building elements and the legally required proofs concerning heat and sound protection.

The label 5.6.A/1 stands for 'Company: Escalators. Approved plans, Correspondence'.

The two pictures below show that many binders are created and labeled ad-hoc on the one hand, and that there are always things that remain outside the classification in use.

Figure 3. The binders for *Pleasure Dome*

4.2 The layer organization

In a large building project, different people work on different parts of the building and on different problems. Typically, such a building is made up of 15-20 sections and about 30 drawings altogether, including 11-12 floor plans, have to be drafted and coordinated.

In a project of the size of *Pleasure Dome* around 580 drawing versions have been plotted out and distributed. There are different drawings for different stages of a project and different purposes (e.g. submission plans, construction plans, etc.).

Plans have a particular trajectory. The first version is produced at an early stage. As planning progresses the drawing becomes more and more detailed and also specialized, with the different external actors filling in their expertise, which is evaluated and taken into account by the architects. This is a procedure in many loops. It entails numerous design changes. The central CAD drawing witnesses the projects' trajectory. It absorbs and mirrors the decisions taken and changes made, with the different actors copying versions and layers for different purposes, thereby extracting and adding information. In so far it is fine example of a boundary object (Star, 1989;Star and Griesemer, 1989).

Essential for coordinating the successive detailing of plans is a uniform layer organization. Layers reflect the organization of a building, which again is associated with different professions. Layer structures vary widely, between the involved professions as well as from office to office. They also depend on the CAD system in use, with AutoCAD inviting a proliferation of layers (due to the fact that it does not allow varying colors and line thicknesses on one and the same layer).

The layer structure has been tailored to a particular division of labor. The construction engineer, for example, only receives those layers that are relevant for his work.

A typical plan for *Pleasure Dome* consists of about 160 layers. The layer organization builds on a particular mix of codes for functions and materials. The most important layers have been defined in an ADAC prototype drawing. A layer name consists of four parts - the layer group (infrastructure, solids, existing, etc.), text, building element, and scale. At-f100 means: Ausbau (extension) text – window scale 1:100, 2-sol-beton: SOLID concrete, etc (Figure 4).

LAYERLISTE

NAME	INHALT	FARBE	FARBNR.
HILFSLAYER			
0	ACAD-Basislayer	WHITE	7
1-bgf	BRUTTOGESCHOSSFLÄCHE	RED	1
1-f-m2	POLYLINE; FLÄCHEN	RED	1
1-h- ...	HILFSLAYER	WHITE	7
1-pk-100	PLANKOPF, M.1:100	WHITE	7
1-pk-200	PLANKOPF, M.1:200	WHITE	7
FLÄCHEN SOLIDS/HATCH			
2-sol-253	FLÄCHE GRAU	grau	253
2-sol-254	FLÄCHE HELLGRAU	hellgrau	254
2-sol-abbruch		gelb	50
2-sol-beton		grün	90
2-sol-betonstein	SOLID-FLÄCHEN	türkis	111
2-sol-gips	(Einreichplanung)	orange	40
2-sol-staender		rosa	21
2-sol-ziegel		rot	10
2-hat-beton		WHITE	7
2-hat-staender	HATCH-FLÄCHEN	WHITE	7
2-hat-ziegel	(Polierplanung)	WHITE	7
2-hat-erde		WHITE	7
SONDERZEICHEN			
3-fw	FLUCHTWEGE	WHITE	7
3-ba	BRANDABSCHNITT	GREEN	3
3-filename	FILENAME	GREY	8
3-grstgr	GRUNDSTÜCKSGRENZE	YELLOW	2
3-widmung	WIDMUNG	WHITE	7
3-bfl	BAUFLUCHTLINIEN	rot	10
AUSBAU			
A-e	EINRICHTUNG	RED	1
A-em	EINRICHTUNG MÖBEL	GREY	8
A-es	EINRICHTUNG SANITÄR	RED	1
A-f100	FENSTER 1:100	BLUE	5
A-f50	FENSTER 1:50	BLUE	5
A-o	AUSBAUTEN OBERHALB	MAGENTA	6
A-stahl	AUSBAUTEN STAHL	BLUE	5
A-stie	AUSBAUTEN STIEGE	MAGENTA	6
A-stie-h	AUSBAUTEN STIEGE HINTEN	MAGENTA	6
A-t	TÜREN	MAGENTA	6
A-u	AUSBAUTEN UNTERHALB	MAGENTA	6
A-zw	ZWISCHENWAND	YELLOW	2

Figure 4. The layer structure

Developing a standard notation for layers and their sequencing is a recurrent concern within the office. It is an issue which is taken up at the start of each new project, with people looking through and discussing practices and experiences from previous work. However, with up to 19 people working in parallel, maintaining the disciplined use of standard notations, turns out to be extremely difficult.

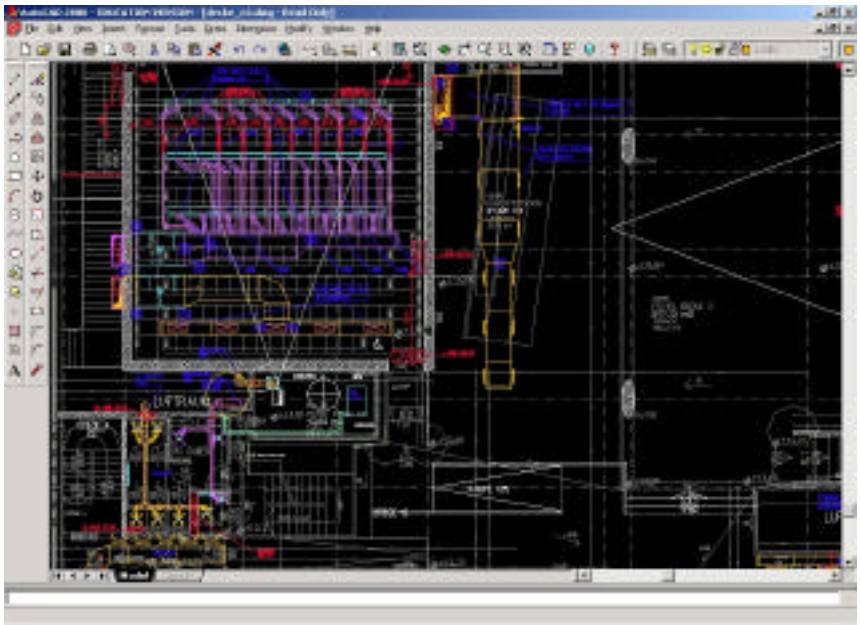

Figure 5. Section of a detailed CAD plan

Colors are used for highlighting different parts of a particular section or functional part of the building. In addition, the architects use a color code for line thickness. This code originates in the technology preceeding CAD programs At that time architects used specific pencils – 'Rotringstifte' – with a particular color coding with e.g. white standing for 0.25 line thickness, yellow for 0.35, green for 0.50. In the beginning, CAD systems used this color code but then free choice of color became an option and one can now choose between 30-40 colors and the respective line thickness, with the first six line thickness in black/white. Architects do not only want to plot out the right colors but see the same colors on their screen. There is general internal agreement about the color code in the office. The line thicknesses have been defined in a file which is normally forwarded together with CAD files to those external consultants that need to plot out and work directly on the file. Each architectural office does its own color coding and other professions (e.g. the geometer) use different conventions. A general norm (ÖNORM) concerning the submission of CAD drawings is being developed in Austria.

Uniform use of a specific layer structure and notation, although desirable, is not achievable in practice. For several reasons:

- Parts drafted by an external professional, let's say the heating specialist, are copied into the current plan, although based on a different layer structure (which then is added to the one in use in the office).
- Details that can be imported from another project (e.g. a glass railing) or have been drafted separately because of their complexity (e.g. the bridge between *Pleasure Dome* and the *Gasometers*) are also copied and inserted (respectively cross referenced to).
- People define their own layers for drafting (e.g. 'Mike's layer').
- There may be good reasons to preserve the history of some detail (e.g. the new seat arrangement for the movie theatres has been drafted on the appropriate layer with the old arrangement being preserved in another color).

4.3 The plan number

Each drawing is numbered. The plan number reflects the cooperative and distributed nature of the planning process. At the beginning of the Pleasure Dome project an elaborate plan numbering system was developed. It is an example of a composite or facetted classification. The architects here use a mix of codes - for the building, the process, the people involved, and for particular features of the plan. For example,

PW – 1- M – E1 – M2 – 103 – V1

would read: Design (Entwurf) – produced by architect – mall – level 1 – scale 1:100 – ground plan No. 3 – first pre-plot.

P: Project acronym

W: Stage of the building project (Entwurf, Einreichung, Leistungsverzeichnis, Polierplanung, Gewerberechtliche Einreichung, etc.)

1: Author: architect, consultants (construction engineer, specialists for infrastructure, facade, etc.), referring to a (hierarchical) classification of building professions

M: The subdivision of the building into functional parts (garage, mall, cinemas, bridge, staircases, etc.), grounded in classification schemes of architectural objects

E1: Level of building

M2: Scale, reflecting different purposes of use

103: Type of drawing and number: perspective (ground floor, cross section, front) and/or special provisions within the building (Fluchtwege, Brandabschnitte)

V1: Version, reflecting the status of planning.

This classification provides a procedure for giving names – a unique identifier for each drawing. It helps keeping order in the repository of drawings and supports accountability – the tracking of plans and their trajectory through the network of consultants, client, and local authorities. So has the classification been rearranged for use in an Excel sheet which helps keep track of the handovers of drawings to particular people.

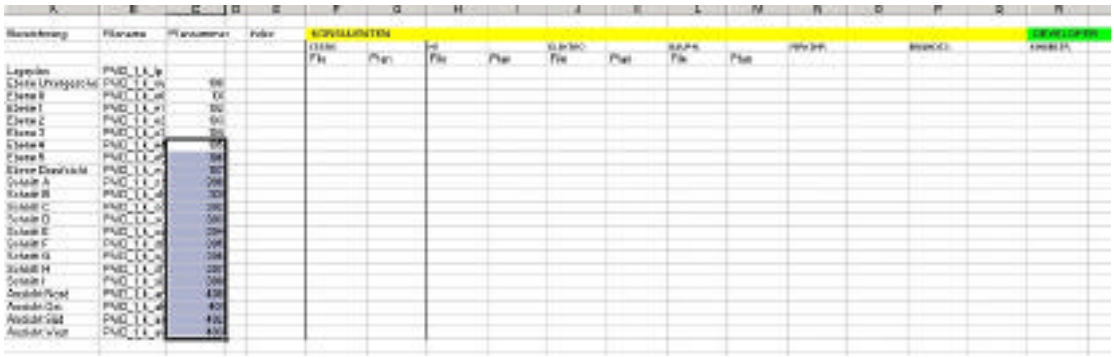

Figure 6. The plan circulation list

Word documents may be created from this Excel sheet which give an overview of which plans have been sent to or received (with annotations, changes or approval) from e.g. the construction engineer or the local authority responsible for fire protection.

4.4 The list of details

As planning progresses, more and more details have to be specified and filled in. A large building contains hundreds of details, which can either be left open to be decided by the construction company and/ or craftspeople, or carefully designed. Much of the aesthetic quality and individual character of a building depends on these details.

There are two types of details. A building consists of a large number of joints between building elements and materials, many of which may be specifically designed.

Furthermore, components such as the façade of a building, are made of different parts. The architect may wish to design a specific assembly of parts and materials.

Most details are drawn by hand, the main reason being that the software requires a level of precision, which does not take account of the 'inexactness' of the building materials. Also, detail drawings are of a scale of 1:5 or even 1:1, and cannot be fitted into a construction drawing.

The plan for producing a catalogue of components for *Pleasure Dome* was discussed in an internal project meeting (Figure 7).

R: Planning of details – who has got an overview? – G. is in charge.

R: To have a list of details would be important, including, what is relevant when? – I would like to have a 'Gesamtliste' and one 'actual list'.

I also would like to have references to 'detail principles' included, e.g. for stairs – Hütte Klosterneuburg, for railings – Absberggasse [references to previous projects].

We need such a list for achieving clarity concerning the details, e.g. everywhere closed metal sheets for the stairs outside – how does this fit with all the other stairs? – Or, we do have so many balustrades, some with glass, others …

The point is to coordinate the details in one's head.

The main purpose was to generate a complete list of all elements and components, which then would be used for mass and cost calculations and for the call for tender. At the same time the list should help to ensure conceptual consistency - that the same design principles and materials were used in different parts of the building on the other hand.

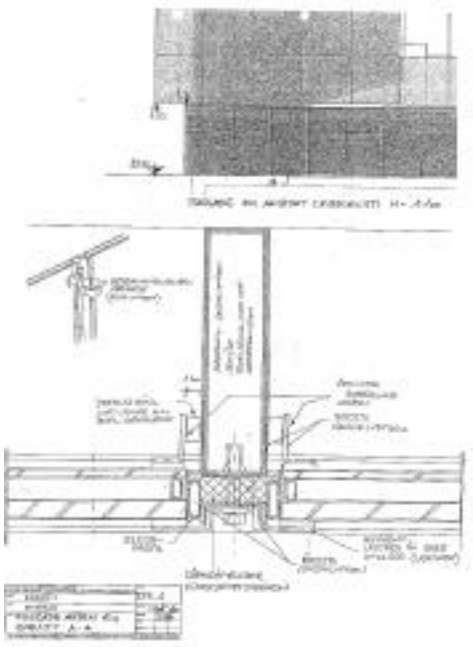

Figure 7. The detail drawing for a 'joint'

After the meeting, G. (the architect in charge) started building a Word document (Figure 8) that lists all the elements and components ('Aufbauten') to be used in the building – (inner and outer) walls, ceilings, floors, roofs, stairwells, balustrades, etc. This Word list, which was compiled in the office, went through several cycles of discussion and annotations, involving construction engineer and building engineer. Small sketches were made, showing the design principles for some components.

The final version of this Word document (to the right of Figure 8) is purely textual. Components are described according to a specific notation:

- Code AW 05 (interior wall), descriptive name, measurement for the whole component
- A list describing parts of component in sequential order (indicating the order in which they will be assembled), preceded by a measurement.

The parts may be standard elements or designed ones. Some are briefly described, for others the architects use names of products. Important remarks are added in red color, such as ‘new’ or for a designed detail also sometimes ‘approved 22.03.00’.

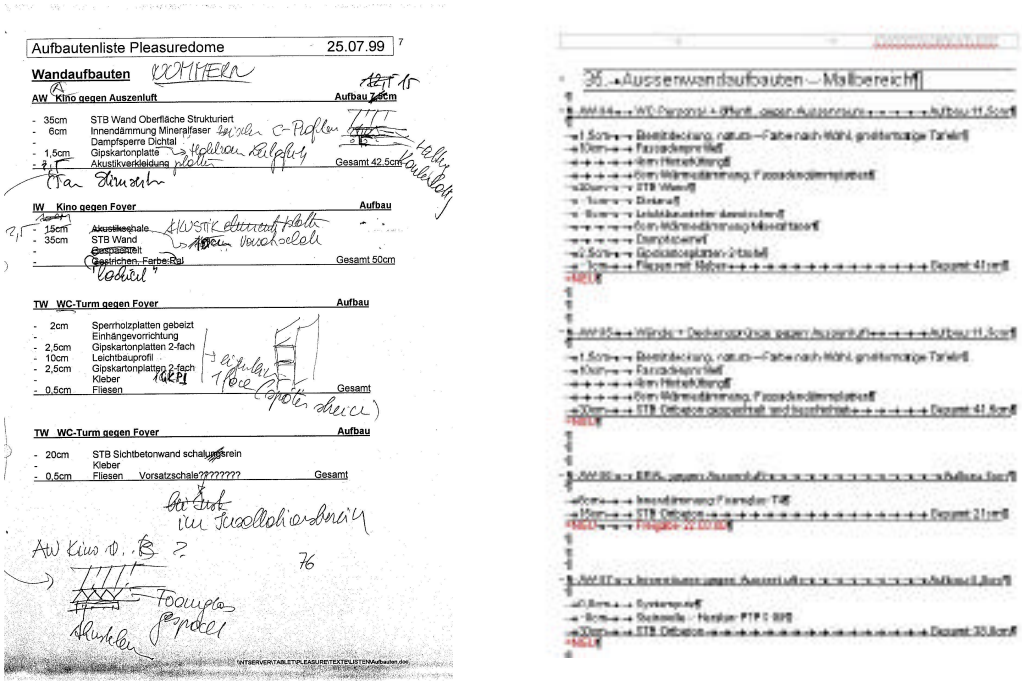

Figure 8. The list of components – draft and final version

In parallel, the architects started drawing details. The second document relating to details is an Excel sheet. It contains a hierarchical classification of design details. Function and material are overlapping classification principles.

- A 3 digit detail number in which the digits refer to: type of detail (e.g. interior glass elements), part of building (e.g. mall), and element or component (e.g. door to projection cabin)
- Name of (a) a particular class of elements and (b) the list of drawings that belong to this class (e.g. ‘Doors to projection cabins’ lists 4 drawings)
- Scale (e.g. M: 1.20), Date, Format (e.g. A3), and modification date.

One of the sources for the detail number was ‘Leistungsverzeichnis Hochbau’, a standard classification of ‘deliverables’. It contains a coherent numbering system for building elements and the people who produce or deliver them. However, the architects developed their own numbering system, based on a list of detail from a previous project.

An example are doors that come in many different types. When e.g. 10 stands for doors, all the different types have been assigned consecutive numbers. The detail number for G10 fire doors (‘Brandschutztüren’) reads as follows: 0 (Overview), 1 (Steel door), 2 (Wooden door), etc. G10/10 (Overview of all steel doors). G in this example stands for ‘Garage’. As people in the office were mainly working either on the Mall, the cinema, or the garage part of *Pleasure Dome*, a rule was developed to the effect that when a detail was particularly relevant for one of these parts, e.g. the garage, it should

be referred to under ‘G’. There may be G10 elements in other parts of the building though. The details for ‘Bridge’ (B) were added as an additional class (No 31).

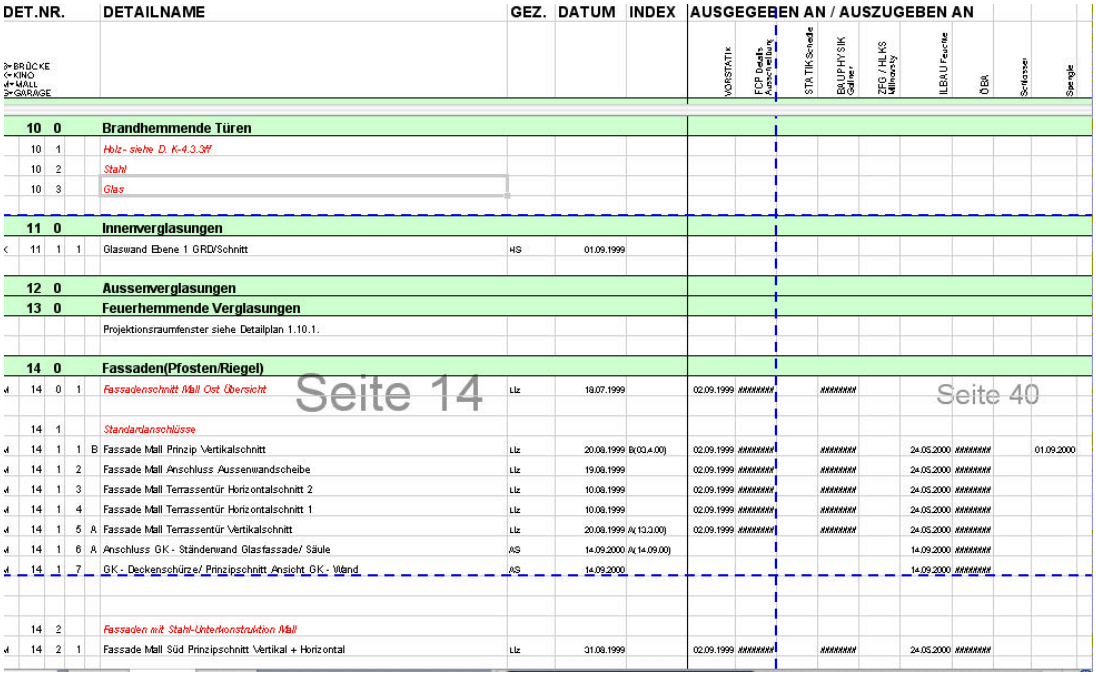

Figure 9. List of detail drawings

The list of detail drawings contains information about completion and modification dates and helps maintain an overview of the circulation of drawings within the network of people involved in planning and building. People can see on the list which detail needs to be sent to whom, either for comments or for approval. The sheet also tells who received a particular detail drawing. Moreover, details are referred to within CAD drawings by their number and framed (Figure 10).

Figure 10. References to detail drawings in a CAD plan

Most importantly, the Excel sheet provides an index to the detail drawings which are kept in a binder. The detail list and the detail drawings are used together. The binder is located centrally in the room, which is shared by the people working on the construction plans. Whenever someone needs information about details, s/he walks over to the table, searches for the documents, takes them out for photocopying, and places them back in the binder.

5 Discussion

What is immediately striking in this case is the multiplicity of coordinative practices and artifacts in use here: the binder system, the file system of the computer system, the layer organization of the CAD system, the plan number notation, the list of details, the detail naming notation, the list of detail drawings, the detail drawing naming notation, etc.

It is obvious that these practices and artifacts form what we call ordering systems (comprising, for example, a set of artifacts, a classification scheme, a notation, a nomenclature). Table 2 give a schematic overview of the ordering systems we have identified.

Ordering system	**Component artifacts**	**Key categories of the classification system**	**Main purpose**
Binder system	Binders with numbered labels	Professions and their 'domains' Types of documents	Provide an overview of all paper documents and print-outs
Layer organization	CAD drawings with layers, layer list, color codes	Function, building element, material, type of drawing, level, scale	Organize distributed drafting and reading
Plan identification system	Plans, code for numbering plans, plan circulation list	Stage of project, part of building, author, function, type of drawing, level, scale	Provide identifier for each plan and maintain overview of circulation
System of components and details	List of components, detail drawings, list of detail drawings	Type of building element, material, type of drawing, scale	Provide identifier for and index to detail drawings, connect them with CAD plans and list of components

Table 2. Ordering systems in architectural practices.

On closer inspection it also becomes clear that the classification systems in the different ordering systems show certain family resemblances; they are clearly based on the same general principles. The fact that the classification schemes and notations follow similar principles, is not accidental but the expression of wider ordering systems, linked to professional and industrial practices in so far as these principles are part of the training of architects and expressed in handbooks and thesauri. The commercial databases in the area of architecture and construction use particular classification

systems which in turn are based on one of the thesauri in the field. Furthermore, each CAD system comes with its predefined layer organization which then can be adapted to practices within the office. And, most importantly, instantiations of classification systems are available from the architects' previous projects and there are ongoing conversations within the office, as well as with external consultants about the naming and organizing of the many documents that are produced. The regularity is a manifestation of a professional culture.

What we also find is that the ordering systems at the office are exposed to dissipating forces, so to speak. Their scope is limited in that they only apply to certain stages in the project or to certain a scale or level of detail. Furthermore, classification systems are subverted by the particularities of the planned building (different structural elements imply different classificatory concerns and principles). Multiple professions and other stakeholders are involved in different capacities, all of them introducing heterogeneous principles of classification into the ordering systems of the office. Finally, for obvious reasons, the architects reuse part designs from previous projects and thereby introduce other sources of disintegration.

These observations are, of course, very much in line with what Bowker and Star have been arguing (Bowker and Star, 1991, 1999). We would like to take the analysis a bit further.

In cooperative work the individual activities are interdependent and they therefore have to be integrated. This can often be accomplished effortlessly, through ongoing mutual alignment and occasional negotiations. With the increasing scope of cooperative work, however (in this case, for example, due to the complexity of modern buildings and emerging issues such as planning for the life cycle of the building including its eventual demolition), the network of interdependent activities is expanded drastically to include myriads of interests, practices, issues, and concerns that are not integrated conceptually.

This requires ordering systems. At the same time, however, interests, practices, issues, and concerns will perpetually undermine the ordering systems. There is an inescapable tension between the need for global ordering systems and the enduring or emerging local concerns and issues.

This makes it important to distinguish between the practical categorizations inherent in everyday speech and the systematic and coherent classification systems based on writing systems.[7] Quite often this distinction is completely ignored or sometimes even directly denied by anthropologists and sociologists when they, in their analysis of social practices such as kinship systems or mythologies, naively presume that their models of these systems somehow exist 'out there' (e.g., Lévi-Strauss, 1962). In Jack Goody's words:

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7 Or, in general, between the 'natural attitude' and the attitude of the scientific observer. As pointed out by Alfred Schutz, the actor in the 'natural attitude' of everyday routine activity does not seek certainty or abstract conceptual coherence but merely to get the job done. 'As we normally have to act and not to reflect in order to satisfy the demands of the moment, which it is our task to master, we are not interested in the "quest for certainty". We are satisfied if we have a fair chance of realizing our purposes, and this chance, so we like to think, we have if we set in motion the same mechanism of habits, rules and principles which formerly stood the test and which still stand the test.' {Schutz, 1943 #1439, p. 65}

> ‘The trouble arises from applying a crude written technique (the table) to a complex oral process, then claiming one has the key to a culture, to a symbolic system.’ (Goody, 1977, p. 67)

Goody’s astute observation has later been developed significantly by Bourdieu:

> ‘It […] took me a long time to understand that the logic of practice can only be grasped through constructs which destroy it as such, so long as one fails to consider the nature, or rather the effects, of instruments of objectification such as genealogies, diagrams, synoptic tables, maps, etc., among which, thanks to the recent work of Jack Goody (1977), I would now include mere transcription in writing.’ (Bourdieu, 1990, p. 11)

> ‘Intellectualism is inscribed in the fact of introducing into the object the intellectual relation to the object, of substituting the observer’s relation to practice for the practical relation to practice. […] There are few areas in which the effect of the outsider’s situation is is so directly visible as in analysis of kinship. Having only cognitive uses for the kinship and the kin of others which he takes for his object, the anthropologist can treat the native terminology of kinship as a closed, coherent system of logically necessary relations, defined once and for all as if by construction in and by the implicit axiomatics of a cultural tradition. Failing to inquire into the epistemological status of his practice and of the neutralization of practical functions which it presupposes and consecrates, he considers only the symbolic effect of collective categorization, […]. In doing so, he unwittingly brackets the different uses which may be made in practice of sociologically identical kinship relations. The logical relations he constructs are to ‘practical’ relations — practical because continuously practised, kept up and cultivated — as the geometrical space of a map, a representation of all possible routes for all possible subjects, is to the network of pathways that are really maintained and used, ‘beaten tracks’ that are really practicable for a particular agent. The family tree, a spatial diagram that can be taken in at a glance, *uno intuitu* and scanned indifferently in any direction from any point, causes the complete network of kinship relations over several generations to exist in the mode of temporal existence which is that of theoretical objects, that is, *tota simul*, as a totality in simultaneity.[8] It puts on the same footing official relationships, which, for lack of regular maintenance, tend to become what they are for the genealogist, that is, theoretical relationships, like abandoned roads on an old map; and practical relationships which really function because they fulfil practical functions.’ (ibid., pp. 34-35)

Now, in our investigations of ordering systems in cooperative work in modern Western economies, we are dealing not only with ‘complex oral processes’ but also, and most importantly, with *members’* using the ‘crude written techniques’ Goody is referring to organize their work. Thus, if we, without discrimination, conceive of our analytical models of member’s (oral) categorizations and the same members’ own normative (written) constructs as identical phenomena, we are in even deeper trouble than the anthropologists and sociologist Goody and Bourdieu are criticizing. A community’s inscribed, publicly available classification systems involve completely different practices than the categorization practices of which an analyst may build a model in the form of a inscribed, publicly available classification system.

The function of classification schemes and ordering systems in general is to integrate distributed activities and thus, in certain respects, align or unite what is otherwise different local practices. — This is not as innocuous as it may seem and needs to be discussed further:

According to Bourdieu,

> ‘It’s only because the successively performed practices are only apprehended successively that the ‘confusion of spheres’, as the logicians call it, resulting from the highly economical but necessarily

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8 Bourdieu is referring to Descartes: ‘the synoptic diagram enables one to apprehend simultaneously and in a single glance, *uno intuitu et tota timul’* (Bourdieu, 1990, p. 83).

> approximate application of the same schemes to different logical universes, is able to pass unnoticed. No one takes the trouble to systematically record and compare the successive products of the application of the generative schemes. These discrete, self-sufficient units owe their immediate transparency not only to the schemes that are realized in them but also to the situation apprehended in a practical relationship through these schemes. […] Since it is very unlikely that two contradictory applications of the same schemes will be brought face to face in what we must call a universe of practice (rather than a universe of discourse), the same thing may, in different universes of practice, have different things as its complementary term and may therefore receive different, even opposed, properties depending on the universe of practice.' (Bourdieu, 1990, pp. 86 f.. – The translation has been corrected)

However, in a cooperative work setting the whole point about the application of ordering systems is exactly to 'systematically record and compare the successive products of the application of the generative schemes'. The individual activities of a cooperative effort are not 'discrete, self-sufficient units'; to the contrary, they are interdependent in different ways and to different degrees. In the 'universe of practice' of a cooperative work arrangement, the 'discrete, self-sufficient units' are interdependent and 'two contradictory applications of the same schemes' must be 'brought face to face', even if they would not meet otherwise. Members therefore actually 'take the trouble to systematically record and compare' how schemes and procedures are applied.

For the architects their classification systems are not just a resource for naming things but a vital support for complex practices across multiple 'universes of practice'. These practices reach from keeping track of and retrieving a great number of physically distributed artifacts to maintaining the relationships between artifacts (such as between detail drawings and the list of components or between the central CAD plan and detail drawings) and to supporting cooperation between the professions involved in planning. Indeed many of the ordering systems reflect this division of labor. The internal structure of artifacts such as CAD plans is such that the different disciplines can extract information that is relevant for them and insert it in the appropriate layer. Binders, for example, refer to professions, their standards (e.g. norms, legal provisions) and resources (e.g. catalogues, databases) and the material that has been exchanged with them (e.g. correspondence, plans).

In cooperative work, the tension between global and local, between the coherence of the classification system and the contingencies and urgencies of practice, is inexorable. Members are both practitioners and analysts, natives and theoreticians. Maintaining ordering systems involves ongoing work of conceptualization and reconceptualization which is not required if local practices exist as separate (temporal, spatial, cultural, etc.) spheres.

Moreover, developing and maintaining these different classification systems for different purposes is done cooperatively and in a distributed fashion. There is a strong cost-benefit aspect to reclassification.[9] Not just in that that looking through previous

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9 As noted by Bourdieu, 'practical logic' 'presupposes a sacrifice of rigour for the sake of simplicity and generality': 'symbolic systems owe their practical coherence […] to the fact that they are the product of practices that can fulfill their practical functions only in so far as they implement, in the practical state, principles that are not only coherent […] but also practical, in the sense of convenient, that is, easy to master and use, because they obey a "poor" and economical logic.' (Bourdieu, 1990, p. 86).

project materials and discussing classification practice takes time. Changing a cumbersome notation may become impossible after a short time, since each CAD plan has cross-references to others. Also, external consultants have to be mobilized and convinced to use the architects' naming conventions and structures.

What is particularly noticeable is how the architects flexibly combine a variety of such schemes for different uses. We found a clear and very simple example of this flexibility in the layer structure for a virtual model of the cupola of the ETH Zürich, which was built by students. The structure distinguishes between levels in the building, components (from the floor to the spiral staircase), parts (from column to balustrade), and material or texture (concrete, glass, wood, gravel, steel, etc.). Architects' classification systems, although partly theory-based, have strong elements of common-sense, and they are used in a rather pragmatic way. Also they combine different principles of classification. The layer structure for constructing the ETH *cupola*, for example, uses two different relations of part/whole (levels as well as components/parts) and material as principles. Other classification systems mix function with material and the professions involved in planning.

The need to merge, simplify, add to, etc. existing classification systems is something which is easily coped with in practice. The architects have developed different ways of retrieving materials and tracking its circulation that compensate for the insufficiencies of their classification systems. An example are the parallel archives of binders and 'desktop' on the one hand, of plan circulation list (an Excel sheet) and the folders with in- and outgoing Email plus attachments on the other hand.

Classifications such as those on which the layer organization is based, although increasingly chaotic and 'exploding' with new categories in the course of a large building project, are still intelligible. For example 'Mike's layer' can clearly be identified as provisional and temporary: the layer on which Mike experimented with a design change before inserting the drawing on the proper layer. However, there are many problems involved in keeping track of ad hoc naming and people's ingenuous ways of handling material on the one hand, to maintain present the common and agreed schemes of classifying on the other hand. So was the document defining the plan number not easily retrieved, although everyone knew that it existed and tried to follow the rules.

In sum, classification schemes are used for building and maintaining large networks of dependencies between large numbers of distributed artifacts on the one hand, the people involved in producing, reading, annotating, and approving them on the other hand.

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