

Document management – a key IT technology for the construction industry

Bo-Christer Björk,
Professor of Information
Systems Science,
Swedish School of
Economics and Business
Administration,
P.B. 279 00101 Helsinki
Finland
Bo-Christer.Bjork@shh.fi



The author has a twenty year long track record as one of the internationally leading researchers on computer integrated construction. Before his current position he worked at the Technical Research Centre of Finland (VTT) and the Royal Institute of Technology in Stockholm .

Summary

The IT infrastructure of today offers excellent opportunities for the construction industry to work more efficiently by managing its documents in a digital form on the Internet. Nevertheless IT has so far had more effect on the production of documents than on their efficient transfer and retrieval. In this paper the historical developments in construction computing over the last decades are outlined; how technical innovations such as photocopying, the fax, the personal computer, local area networks and finally the Internet have effected the production, storage, duplication and transfer of information. Key features in current web based document systems are shortly described, with special emphasis on alternative search methods such as hierarchical folders or meta data repositories. The integration of document management systems with other Internet based ASP-services in vertical construction industry portals is also discussed. The paper finishes by outlining some current trends, which seem to be leading towards the survival of a few dominant systems.

Key words: Construction, document management, Internet, ASP

1. Introduction

The effective management of the vast amount of information needed to design, construct and maintain buildings is a formidable challenge. The impact on overall construction costs of out-of-date, missing or contradictory information, causing delays, mistakes and expensive re-building, is well known both to practitioners and researchers. Despite the future promises of product data technology, the effective management of traditional documents, such as drawings, specifications, bills of materials etc., is still today for most companies the main priority. Today the widespread availability of personal computers and the “information superhighway” created by the Internet provide the necessary infrastructure for efficient computer-aided document management. What is still needed is a new business culture for collaboration on the Internet.

Construction documents have not undergone major changes since the middle of the 20th century. Plan drawings, sections and elevations, bills of quantities, specifications etc. look much the same as decades earlier. The technology for producing, managing, duplicating and distributing such documents has, however, undergone a number of fundamental changes.

The first important step was the introduction of photocopying in the 60's, which significantly lowered the cost for duplicating information. This development spawned a great number of dedicated copying firms, which handle the large sizes typically needed in the construction industry in a cost-efficient way. Today copying firms sell around 200 mill FIM worth of copying services to the Finnish construction industry, representing some 0,4 % of the total value of the projects they cater to.

The second wave of technological innovation occurred during the 80's and involved the proliferation of personal computing. Even before the emergence of the PC some larger design



consultancies used minicomputer-based CAD-systems, but it was the affordable applications like Autocad that started to raise the share of CAD-produced drawings dramatically towards the late 80's. The production of documents was of course greatly facilitated by word-processing and spreadsheet software. The transfer of the information was, however, still mainly done as paper copies in the mail or using couriers. At best diskettes were personally handed out so that the receiver could reuse the information in digital form.

The fax became a popular data transfer method in a very short time during the 80's. It spread as fast as the Internet or mobile phones some years later, due to the network economics of this type of innovations, where its value to the individual users becomes bigger for each new user who joins the network. The fax was superior for handling offers, quick changes, and small scale graphics, but not good for large drawings and absolutely useless for reuse of the data in digital form at the receiving end.

In the late 80's and early part of the 90's, computer networking, both in the form of local area networks, as well as using point-to-point bilateral lines and modem call up, made possible the use of document management systems for project documentation. The effort to set up the connections and of teaching the personnel involved how to use the systems often offset the potential benefits and the use in the construction industry was limited to isolated pilot projects only.

Since around 1996 the widespread use of the Internet also in the construction industry has radically enhanced the possibilities for data transfer and management. Today document management is one of the fastest growing IT-applications in our industry. In a survey conducted in Sweden in 1998, the IT-barometer, companies named document management as the technology, which they were most likely to invest in during the next two years [1].

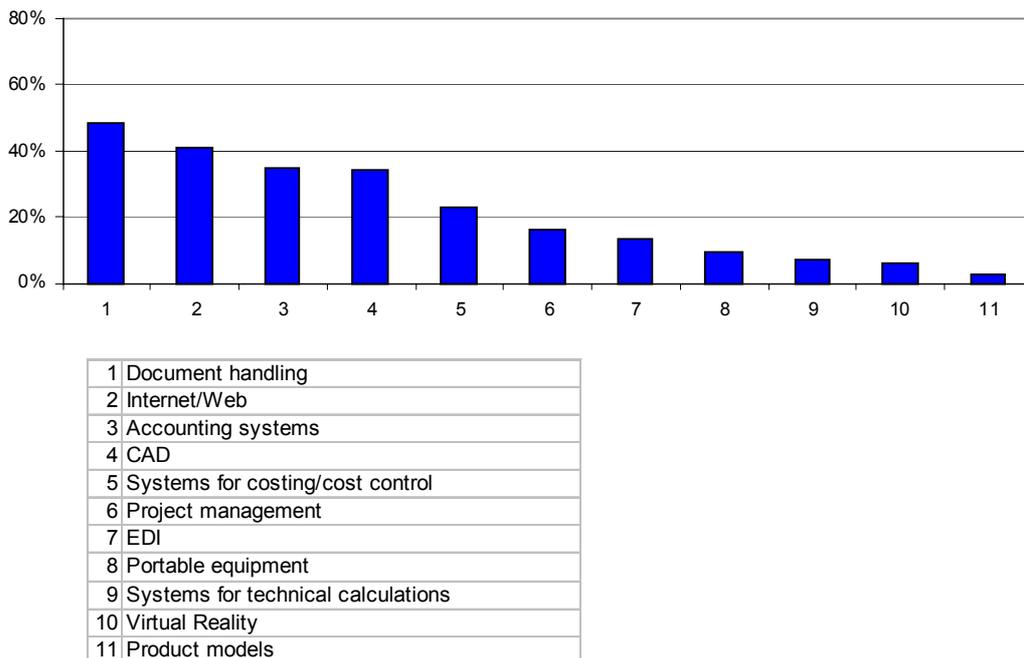


Figure 1. In a comprehensive survey conducted in the Swedish construction industry in 1998 (the IT-barometer) companies named document management as the top priority for IT-investments during the next two years.

The barriers to use such systems were significantly lowered by the shift from expensive and often complex software, which needed to be installed on the computers of all project participants, to subscription-based software which is located on servers only and used through ordinary web browsers. At the same time a clear trend is away from in-house solutions, typically provided by one

of the dominating project participants such as the architect or the main contractor, towards outsourcing of document management to third party application service providers.

The current situation in the construction industry is that a mixture of different generation methods is used for managing the documents (figure 2). Hardly any documents are today produced by hand, but many are transferred by printing them out and sending them to the other parties by mail or couriers, often using copying companies as intermediaries. This is in particular true for the handling of the request for tender documentation in the tendering phase, since this is a phase where many companies which haven't yet established working relationships are in contact. A slightly more sophisticated method is that documents are produced digitally and transferred digitally as e-mail attachments. In terms of document management, this hardly offers any improvement over the current situation since finding a document in another person's personal computer may be even more difficult than in his shelves. Retrieving a document may often as a last resort require asking a person to deliver it.

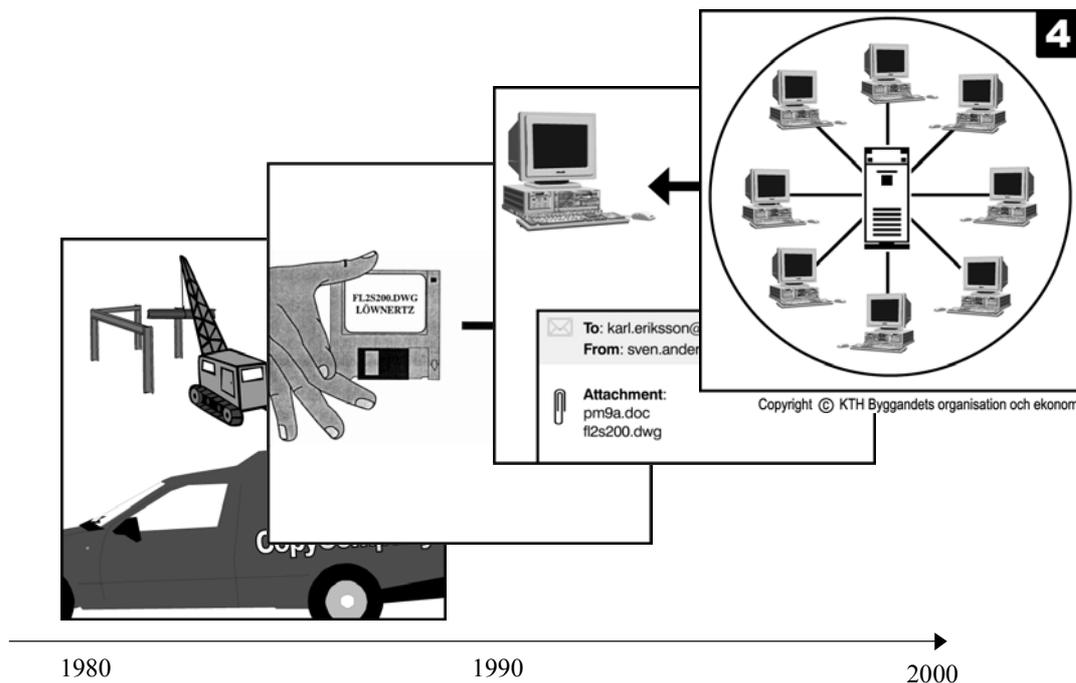


Figure 2. Today's document management practice is a mixture of technologies dating from the past few decades.

Finally there are the integrated document management solutions proper. The key characteristic of these is that only one master copy of each document is kept somewhere on a server and that it is possible to search for the required document using some classification or meta-information. This has aptly been described as a shift from just-in-case delivery to just-in-time retrieval [2]. Also within this category there are several options. Earlier systems tended to be customised applications, where a copy of the application needed to be installed on each workstation that was using the system. The last few years the trend has been towards solutions based on Internet technology where all that is needed is a standard web client (Netscape, Explorer) and passwords.

Systems on the market differ in technical functionality. An on-going study by VTT called ProCE has systematically been studying what features systems have, comparing them with the requirements of companies [3]. A questionnaire was sent out to document management companies in both the Nordic countries and the USA and 18 companies have provided detailed answers. Features found in most systems included:

- A main retrieval mechanism based on either hierarchical folders or metadata

- Handling of revisions and change management
- Viewing of CAD-files using special purpose software

Features found in only a few systems were for example:

- Electronic authentication of user identity (i.e. smart cards)
- Full text search capability
- In-built virus checker

In the following we will discuss one of these features more in detail, namely the main search capability. An efficient but at the same time user-friendly search mechanism is quite central to the success of a document management system,

2. Main retrieval mechanism – hierarchical folders vs. metadata

A larger construction project may eventually result in the production of tens of thousands of documents and a system must provide users with some easy to use method to find the appropriate document. Technically there are several ways in which this can be done [4], [5].

Documents can be hyper linked by hand, a technique used a lot for www-pages. This can be quite useful for static information, like the information typically found on company homepages of intranets, but doesn't work well for the typically rather dynamic document sets used in construction projects. Also you have to first open a document and actually view its content to find the hyperlinks.

Another option would be to use full text search. This works much the same as the general web search engines and the results are equally unpredictable. An additional difficulty is that drawings are a very important document category in the construction industry and are difficult to include in such searches.

The two currently mostly used options are using a hierarchical folder structure or using meta data as a basis for searches. The hierarchical folder structure is very easy to understand for end users, since it works exactly the same way as the folder structure in the windows operation system. The drawback of this is that usually one particular view on the total document base is enforced. In many systems the folder structure has been predetermined by the system vendor, whereas other systems allow the users quite a lot of freedom in creating a folder structure of their own. More rare is a solution which allows two or more alternative folder structures superimposed on the same documents.

This latter multiple solution is in fact a step in the direction towards meta data based search. By meta data (or reference data) we mean certain pieces of information which describe essential attributes of a document as a whole. In meta data based systems the data is placed separately from the documents in a data base, which provides a versatility for automated searching which the hierarchical folder structure doesn't have. For instance the information given about the literature references in the references section of this paper is meta data. Such meta-data enables other researchers or practitioners to retrieve the document through library services. If key words have been used to describe the document's contents (which is the case for this paper) they may also find out about its existence through a bibliographic data base.

In the case of construction documents meta data is related to attributes such as type of software with which a document was created, engineering discipline, phase of the construction process, part of the building described, scale (for drawings), revision etc. This type of meta data is in fact already included in traditional documents in the form of drawing headers et.c., but not in a computer searchable form (figure 3).

In view of the fact that there are several competing document management systems on the market and that companies may need to switch between different meta data from project to project, it would make a lot of sense to develop standards for the meta data needed for construction document management. This would increase the interoperability between systems and would for instance facilitate the automated transfer of large document repositories from one system to the other. Such standardisation was suggested in the early 90's by this author [6] and an early attempt to formalise the central meta data needed is shown in figure 4 below [7]. Such standardisation has also recently

been made into a work item by ISO committee TC10/SC8 [8]. In Denmark the Association of IT-users in Construction IBB has also suggested a neutral format for the exchange of construction document meta data [9].

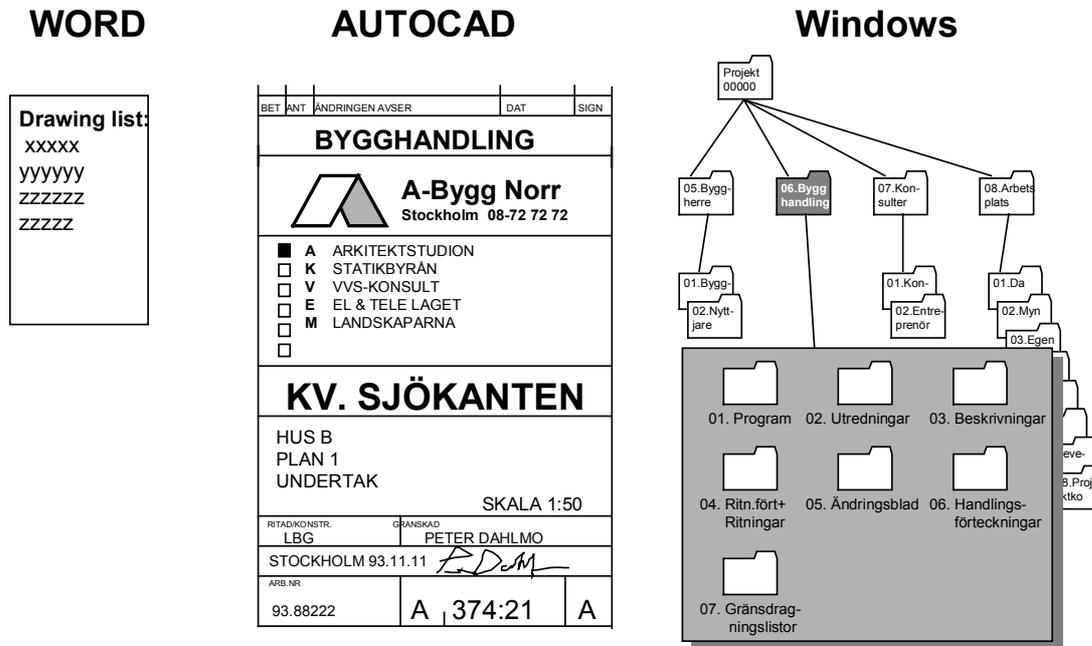


Figure 3. Meta data about construction documents is handled already in today's practice, in drawing lists and headers, the organisation of folders etc., but this information is not searchable using data base functions.

Many practitioners dislike having to fill in forms with meta data, despite the obvious advantages for later users who wish to retrieve documents. In practice the easy to use folder structure is much preferred to filling in meta data for each document to be uploaded. One possible solution could be to develop software, which automatically creates as much as possible of the metadata, based on contextual information.

3. Additional services

The new emerging web based application services (ASP) are governed by much the same rules as any commercial services. The potential customers in the industry often have a need for several types of the emerging Internet services (plain document management, bidding, information about building regulations, GIS, materials databases, e-commerce) and it is very cumbersome for them to learn new login routines and user interfaces for each separate service. Also they don't want to have separate subscriptions for each new service required. Thus much like ordinary shoppers who prefer shopping malls to individual scattered stores all around the city, or telephone users who are comfortable with one single phone bill for all different types of calls, users of Internet-based software services will prefer virtual shopping malls (or virtual department stores), from which they can find all the services they need. This sort of rationale is working very heavily in favour of the emergence of so-called vertical Internet portals, that is multiservice sites concentrating on a particular branch of industry. Either such portals will be set up as comprehensive efforts from the start, or they will

result from so-called dotcom companies creating alliances or being swallowed by each other.

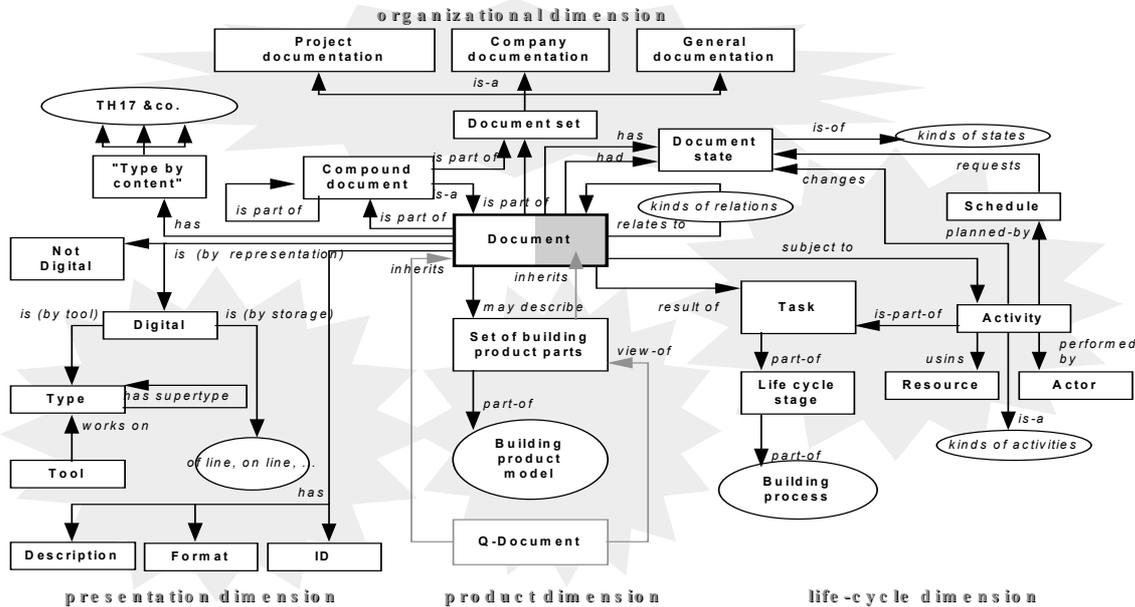


Figure 4. An international standard for construction document meta data could be very helpful to increase interoperability between commercial systems. The figure shows a conceptual schema of such information.

In 1999-2000 there was a lot of excitement about the setting up of such dotcoms. At a conference organised by CIFE at Stanford University it was reported that more than a hundred dotcom companies for construction had been set up in the States and that these had attracted venture capital for more than 1 Billion USD [10]. With the recent backlash on the stock market a lot of the early enthusiasm has vanished and now the situation has turned more into a survival game, where the strongest players will eventually emerge and get a dominant market position due to the critical mass effect.

One particular type of additional services that complements a document management service very well is tendering management. If documents are managed electronically during the design stage it would make a lot of sense for the building client to also manage the distribution of the requests for tender and the incoming bids using the Internet. Why should they pay for the expensive copying of drawings and specifications to be mailed to several potential bidders, many of whom never will bother to put in a bid, when today it is possible for them to just upload the documents on the Web and then just email the web address to companies they want to consider bidding, even providing temporary access rights to a document management system. If the document management service is directly linked with a copying company, it is then very easy for the prospective bidders to request the documentation needed in paper form, at their own cost.

A company which goes even further in their service is EU-supply, which provides a forum for on-line bidding (www.eu-supply.com). Here selected companies are allowed to enter bids into a secure service during a given time slot, in such a way that the other bidders see what the currently lowest bid is but without disclosing the identity of the lowest bid. EU-supply claims savings to the client in the order of 8-30 % compared to the traditional blind bidding process. The charge for the service is a percentage fee of the lowest obtained bid, which makes sense if the clients can be convinced of

savings which exceeds this fee.

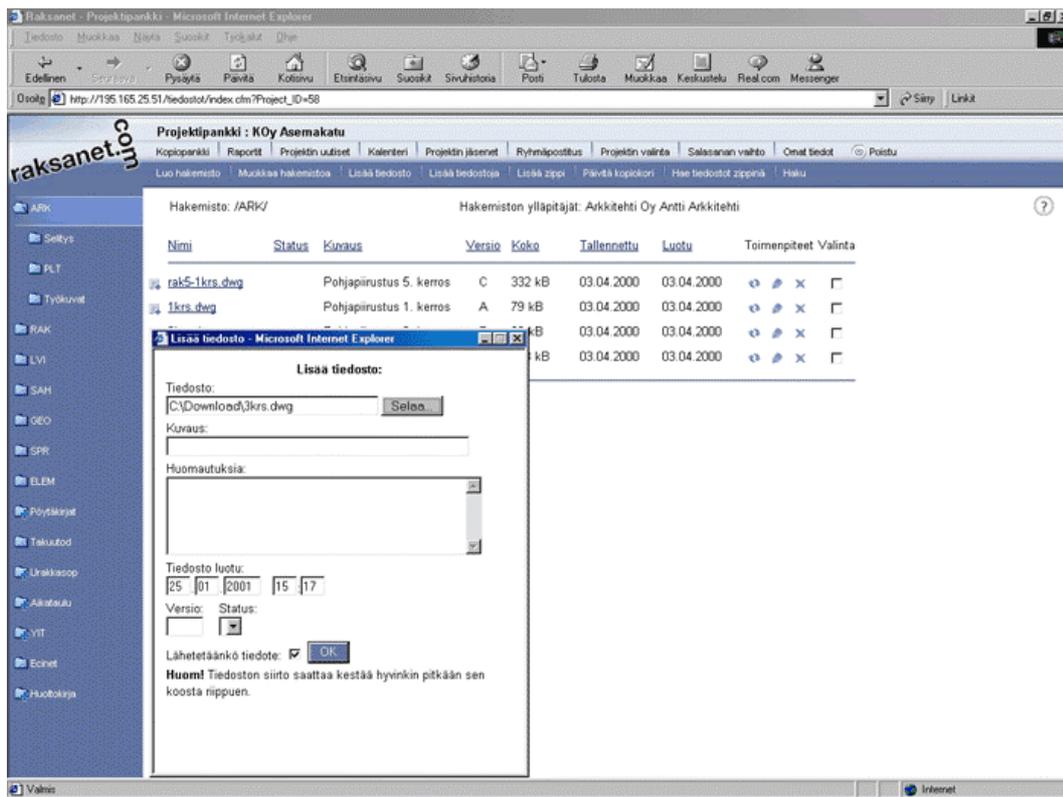


Figure 5 The Finnish Raksanet (www.raksanet.fi) is an example of the third party Internet based document management service. The screen dump shows how a user is up-loading a document to the server.

4. Conclusions

Currently the use of Internet based document management services, after a few years of pilot use, is getting into the steeply rising part of the S-curve, which the adoption of new technologies tends to follow. The situation in terms of market saturation is comparable to the CAD-market in the mid 80-ies. After an initial period of in-house customized systems, often based on software that needed to be installed on each client separately, the trend is now towards pure ASP solutions, which only require a basic web browser on the client end. Economies of scale and ever-changing project collaboration relationships give third party services a clear advantage compared to in-house solutions. During the last 3-4 years a large number of such services have emerged, either national or with operations in several countries. In the Scandinavian countries alone there are around a dozen such systems [11], [3].

In the longer run it will be interesting to see how the two currently contrasting techniques of building product modelling and document management could co-exist. Building product modelling has been the subject for quite intensive research and standardisation for the past 15 years, recently in the form of so-called Industry Foundation Classes, but has not yet started to have any significant impact on practice. Some early attempts to develop hybrid systems which could bridge the gap between these two technologies have for instance been done in the European CONDOR project [12].

Before web-based document management can achieve a major breakthrough in the construction industry there are a number of issues to be solved:

- Practitioners need to be convinced of the short and long-term benefits of this new way of doing business. Immediate savings in the form of lowered copying costs are easy to understand, but the savings in the order of 5-10 % of total project cost which vendors claim are possible, need to be demonstrated in a reliable way in numerous pilot project.

- Issues related to authorisation of documents, security, digital payments etc. need to be resolved, both on the legal level and by establishing industry practice guidelines that take into account the new virtual way of working.
- The attitudes of the practitioners who will be required to use the systems need to change, to overcome some initial resistance. This can best be achieved by developing systems which are easy to use and which provide all participants with features which made their personal work easier than before.

Although it is difficult to predict the future development of construction document management it is possible to identify some current trends. One trend, support by the logic of the business, will be for document management services to integrate with other ASP services (bidding, e-commerce, facility management information) to form larger vertical portals catering to the construction industry as whole. Another trend, which the recent downturn in the stock market strengthens is for the survival of the fittest only, since it is currently more difficult than a year or two ago to get new capital and companies will have to survive on operating income, not promises of future growth. And perhaps most importantly it is in the end users' interest to see only one or a couple of dominating systems win, and they will vote with their subscriptions once they perceive that some systems are likely to come out as winners in this game.

References

- [1] Howard, R., Kiviniemi, A., Samuelsson, O., "Surveys of IT in the Construction Industry and Experience of the IT Barometer in Scandinavia", *Electronic Journal of Information Technology in Construction (ITcon)* Vol 3, pp. 45-56, <http://itcon.org/1998/4/>
- [2] Turk, Z., "A Framework for the Engineering Information Technologies", Paper presented at the international conference on concurrent enterprises, University of Nottingham, 8-10 Oct 1997.
- [3] Lakka, A. Sulankivi, K., Luedke, M., Working material from the ProCe project, Technical Research Centre of Finland, 2001, <http://www.vtt.fi/rte/cmp/projects/proce/indexe.html>
- [4] Löwnertz, K., Johansson, C., Lindgren, N., Björk, B.-C., "Datorstödd hantering av dokument i bygg- och förvaltningsprocessen". Rapport, Byggandets informationsteknologi, Kungl tekniska högskolan, och CITB, Chalmers tekniska högskola, Stockholm, 1995
- [5] Löwnertz, K., "Change and Exchange – Electronic Document Management in Building Design", Licentiate Thesis, Dept. of Construction Management and Organisation, Royal Institute of Technology, Stockholm, Sweden, 1998, http://www.recm.kth.se/bit/doc_thesis/kurt_lic/abstract.htm
- [6] Björk, B.-C., Huovila, P., Hult, S., Document level integration of construction information, In: Brandon, P. and Betts, M. (eds.) *Integrated construction information*. E&FN Spon, London. 1995
- [7] Turk, Z.; Björk, B.-C.; Johansson, C.; Svensson, K. Document Management Systems as an Essential Step Towards CIC, In: Hannus, M. and Karstila K. (eds.) *Preproceedings of the CIB W78 workshop on Computer Integrated Construction*, Technical Research Centre of Finland, Espoo, Finland, 22-24.8.1994
- [8] ISO Technical Committee 10/Subcommittee 8/ Working group 13: Computer-aided design (CAD) technique - Use of computers for the preparation of construction documentation, <http://www.iso.ch/meme/TC10SC8.html>
- [9] IBB, "Dataudveksling via projekt web". Publikation 7, 1999, IT-brukere i byggesektoren (IBB), Teknologisk Institut, Taastrup, Denmark.
- [10] CIFE, "E-Commerce and E-business in Design and Construction: Getting Started and Staying in Business", Conference organised by the Center for Integrated Facilities Engineering, Stanford University, 8.4.2000, <http://www.stanford.edu/group/CIFE/ecommerce.summit.html>

- [11] Degerstedt, A., "Inventering och utvärdering av elektroniska dokumenthanteringssystem i byggprocessen", M. Sc. Thesis, No. 386, Dept. of Construction Management and Organisation, Royal Institute of Technology, Stockholm, Sweden, 2000, <http://www.recm.kth.se/bit/thesis/386.htm>
- [12] Rezgui, Y., Cooper, G., "A proposed Open Infrastructure for Construction Project Document Sharing", *Electronic Journal of Information Technology in Construction (ITcon)*, Vol 3, pp. 11-24, <http://itcon.org/1998/2/>