

USE OF DOCUMENT MANAGEMENT SYSTEMS - A CASE STUDY OF THE FINNISH CONSTRUCTION INDUSTRY

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SUMMARY: *Triggered by the very quick proliferation of Internet connectivity, electronic document management (EDM) systems are now rapidly being adopted for managing the documentation that is produced and exchanged in construction projects. Nevertheless there are still substantial barriers to the efficient use of such systems, mainly of a psychological nature and related to insufficient training. This paper presents the results of empirical studies carried out during 2002 concerning the current usage of EDM systems in the Finnish construction industry. The studies employed three different methods in order to provide a multifaceted view of the problem area, both on the industry and individual project level. In order to provide an accurate measurement of overall usage volume in the industry as a whole telephone interviews with key personnel from 100 randomly chosen construction projects were conducted. The interviews showed that while around 1/3 of big projects already have adopted the use of EDM, very few small projects have adopted this technology. The barriers to introduction were investigated through interviews with representatives for half a dozen of providers of systems and ASP-services. These interviews shed a lot of light on the dynamics of the market for this type of services and illustrated the diversity of business strategies adopted by vendors. In the final study log files from a project which had used an EDM system were analysed in order to determine usage patterns. The results illustrated that use is yet incomplete in coverage and that only a part of the individuals involved in the project used the system efficiently, either as information producers or consumers. The study also provided feedback on the usefulness of the log files.*

KEYWORDS: *Document management, construction project, Internet*

1. INTRODUCTION

Electronic document management systems focus on facilitating the management of documents pertinent to particular enterprises, projects and work groups in computer networks. EDM systems tend to treat the documents they shuffle around as black boxes, just like the post office has little interest in what is inside the envelopes they keep shuffling around, as long as the mail gets to the right recipient in time.

Recently commercial EDM systems have started to use web technology as their implementation platform. Also there has been a clear shift from selling a software licence to offering an ASP service on the web. Many different names have been used by both service providers and researchers to denote such systems, including Document management system, Project Extranet, Project web, Project Bank, Project Specific Web site, Project information management system, Virtual Project. There are many cases of such systems being offered by independent “.com” companies, who often have been financed by venture capital. Quite often such systems have also been developed by design consultancies, copying firms, e-commerce companies, as a complement to their main products and services.

EDM in construction has not been the subject of as intense research as product modelling (Björk 2002), but it is a technology which currently is being introduced rapidly in practice. There are, however, still significant barriers to its introduction (Love et al, 2001), most of which are psychological and organisational. The benefits and costs of using such systems are often spread unevenly over participants and this causes additional problems for the introduction.

On the level of the industry as a whole there have been a number of recent general studies of IT usage. The most comprehensive study has been the Swedish IT-barometer study which has been carried out twice in 1997 and 2000, and included questions about the use of document management systems (Samuelsson, 2002). The way this survey was carried out did not, however, provide an answer to the question "in how many percent of projects is an EDM system used", which is the best indicator of overall usage. In figure 1 the percentages for Sweden represent the proportion of employees at such workplaces where EDM systems have been used in at least one project, as a percentage of the overall workforce in the industry. The percentages for Denmark and Finland on the other hand represent the proportion of workplaces where EDM has been used in at least one project. Thus large companies contribute more to the average in Sweden than in the other two countries. The sample was also much larger and more statistically correct in Sweden. The results for Finland are clearly higher than for Denmark, which might be explained with the choice of companies which were included in the survey.

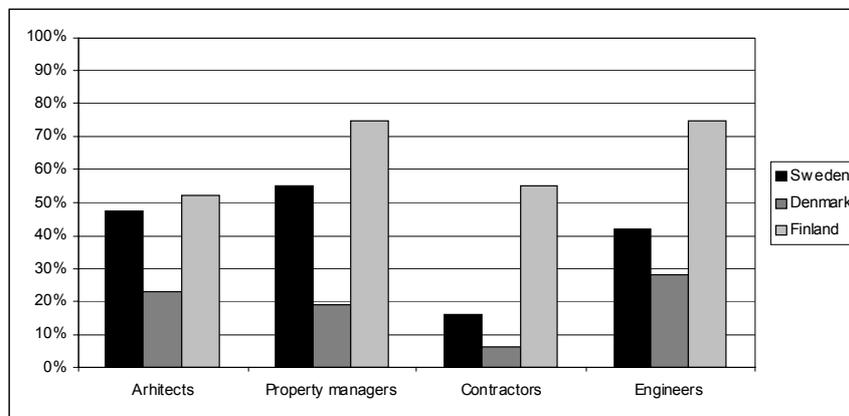


Figure 1. Proportion of employees (Sweden) and proportion of workplaces (Denmark and Finland) where an EDM system has been used in at least one project (Samuelsson, 2002).

In a recent study conducted by VTT a method for measuring the benefits of introducing EDM systems was developed and tested on projects in four countries (Sulankivi et al, 2002). The study showed that although the directly measurable cost savings that could be attributed to the EDM system were rather limited (less than 1 % of project cost), there were important other quantifiable and qualitative benefits.

An EDM system should be used as widely as possible in order to maximise the benefits of improved communication. The rate a system is used during a project is therefore naturally of a high importance, since communication by-passing the system diminishes the effect of the system. However the rate of use has not been studied much. Thorpe and Mead (2001) have studied the effect of EDM-systems on communication patterns in organisations by utilising social network analysis. Their study showed that the system took a central role in the projects. Howard and Petersen (2001) also studied communication patterns in a similar manner as Thorpe and Mead. However they took a broader approach by covering also other media. The project participants were asked to track all communication during a two weeks time. Neither of these studies have however analysed the full usage of an EDM-system during a complete project. Most of the studies focus on interviews and user perceptions rather than hard data on real usage. A more recent study by Andresen et al. (2002) analysed three different construction projects where an EDM system was used. The study charted actual usage by logging seven different actions done on the system. The study showed that the EDM systems in their case studies were implemented on a too short notice without properly defining common goals for the participants, which led to inefficient usage of the system.

Björk (2002) proposes a typology of research questions and methods for studying EDM-systems in the construction industry, including tracking actual system usage patterns using log files of EDM-systems. Since

most of the systems on the market use a thin web client, the projects will most likely have extensive standardized web-logs in one form or another. Also systems are likely to log different activities done by the users of a system for security reasons. Together all log files from a project could provide a comprehensive view of real usage of the system. A study of one construction project could not to a great extent be generalised to cover the whole construction industry. The results may neither show the benefits or limitations of all EDM-products on the market since only one product is studied. However, by conducting such a study, different problem areas, usage patterns, system limitations etc. could be recognized.

2. PURPOSE OF THIS STUDY

This paper reports on research carried out at the Swedish School of Economics and Business Administration, focusing on the use of Internet based EDM systems in the Finnish construction industry (Bäckblom and Björk, 2002), (Ruohtula, 2003). The research had a number of aims;

- to study the current rate of use of EDM systems, generally and as a function of project size
- to study the barriers to the rapid introduction of EDM systems
- to study the EDM service market and the business strategies adopted by the service providers
- to study usage patterns in an individual project

The research methods used was the combination of a survey on a statistical sample of projects, which aimed at producing material suitable for quantitative analysis, interviews with key personnel from half-a-dozen providers of EDM systems, providing qualitative data based on their experience of selling these systems to the industry, and quantitative data taken from the log files of a particular project. These techniques worked well in combination to provide a fuller and more reliable picture of the market under scrutiny.

3. LEVEL OF USE IN THE INDUSTRY AS A WHOLE

An existing commercial database of on-going Finnish construction projects was used as a starting point to establish a stratified sample of projects of different sizes (this database is typically for marketing). The sample had to be stratified by project size since there are few large projects and a multitude of small ones. The number of projects selected in the different strata was 10 (A), 20 (B), 40 (C), 30 (D). The letters refer to the size categories shown in figure 1 below. Key personnel from the projects in the sample were interviewed concerning the use (or non-use) of EDM systems in their project using telephone interviews. This technique was deemed feasible for the size of the sample at hand. 100 projects were selected and the response rate was 98 %. Clearly a much larger sample could have been handled using a paper or web-based questionnaire, but this would have led to very low response rates, and in the case of a email or web-based questionnaire to a clear bias, since users of EDM systems would have been more likely to answer than non-users. A clear benefit of the chosen telephone technique was also that in many cases it was only after a couple of phone-calls that it was possible to determine who the key persons were in the project, such as the project manager. This was not apparent in the data in the project database.

The overall result concerning use of EDM systems as a function of project size is shown in figure 2. Whereas none of the small projects (< than 50 Mill Fim) in the sample used an EDM system the penetration was almost 50 % among projects > 100 mill.

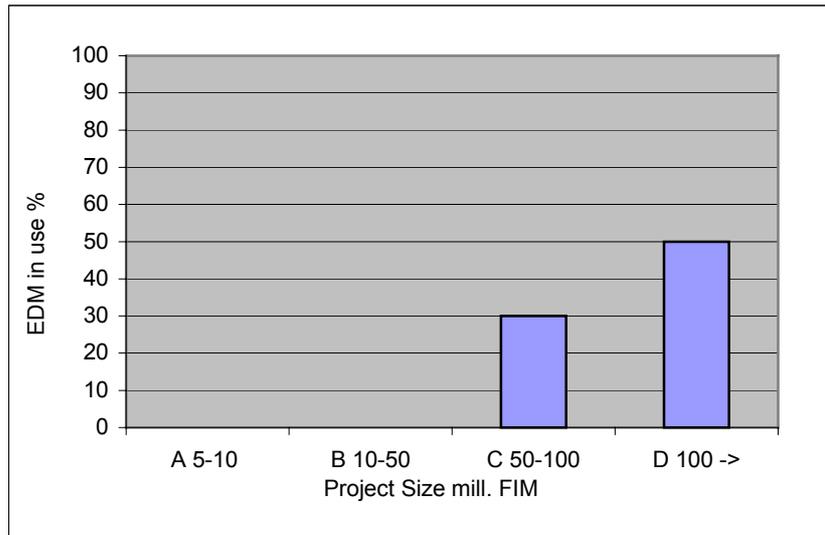


Figure 2. The use of EDM systems in Finnish Construction Projects as a function of the size of the project (1Euro = 5.94 FIM).

The respondents were also queried about the reasons for not using systems, in order to shed light on the possible barriers to the introduction of this technique. Systems were used in 27 of the projects. In only 9 projects it turned out that the respondent had no knowledge about EDM systems and what they can offer. In the other projects where systems were not used the reason given were (in order of popularity):

Table 1. Reasons given for why an EDM system was not used in a project

10	I have no decision power in the matter
10	Not enough benefit from an EDM system in this project
9	Cost too high, the systems are too expensive
8	Decision not yet made
7	The systems are too technical, difficult to learn and to use
7	small and simple project, no need for EDM system
6	I don't know enough about the systems
6	All participants local
4	I would like to use but I can't convince the other project partners
4	E-mail sufficient
3	clear-cut and simple project

4. BUSINESS STRATEGIES OF THE VENDORS

In addition to the short phone interviews a number of deeper interviews with representatives of system vendors were conducted. Each of the interviews lasted between one and two hours and the interviews were recorded and transcribed as a basis for the further analysis. A list of questions had been drafted as a basis for the interviews and provided a synopsis for each interview. As the interviews progressed the knowledge acquired during the earlier interviews affected the interviews in the sense that there was an increasing amount of dialogue between the interviewers and the interviewed experts. The EDM service providers had different sorts of business strategies and contexts, and it can be useful to describe these shortly here.

Kronodoc for instance has prices which are much higher than the other players (which they justify with the technical level of their software) and aim at selling software licenses to large clients in the process plant,

shipbuilding etc. industries. Due to their strategy of selling licenses to larger corporation they do not need to directly support their users with a call centre. For them the building construction industry is only a marginal market.

Similarly to Kronodoc, *Raksanet* is a company which is solely dependent on its income from the sale of its EDM services. Their product was, however, from the start targeted to the building construction industry, where a low price level was established in the late 1990's by vendors with a background in the copying business (figure 3). *Raksanet's* strategy entails providing their customers with good support, for instance a call centre, and by gradually including new value-adding modules to their system, such as a site diary and a maintenance service book.

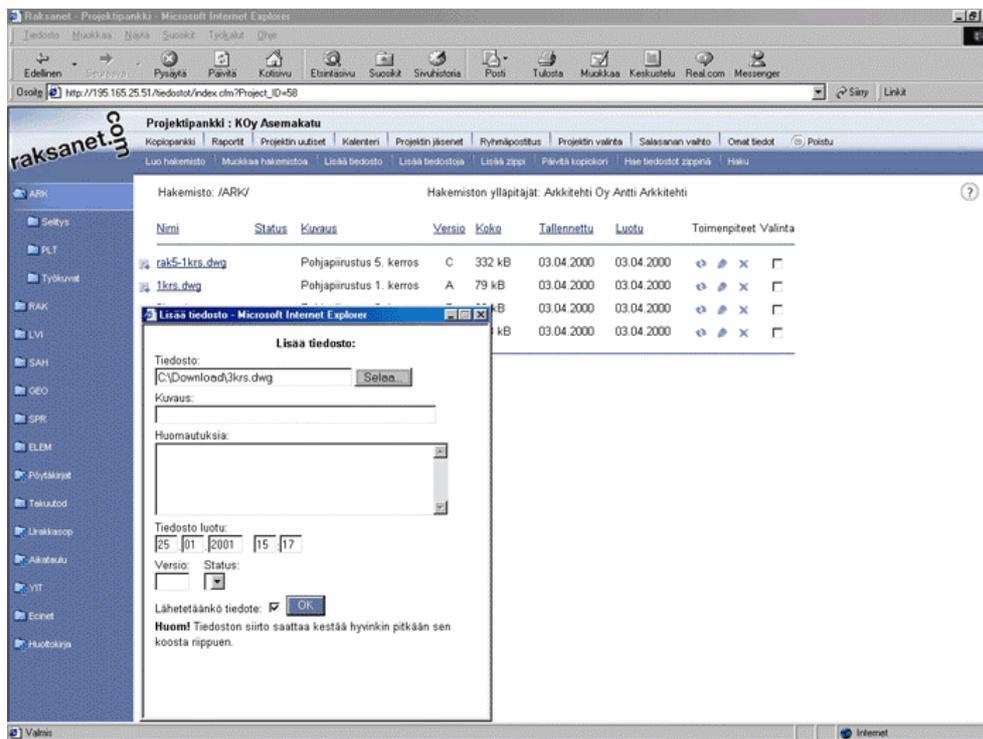


Figure 3. A screen shot from one of the Finnish EDM-systems (*Raksanet*)

Of the systems developed by copying companies *Sokonet* is the leading one (technically and in number of user projects). The price for using their system is very modest and the company claims to owe much of its success in raising its market share in copying services, especially in the Helsinki region, to the added value they have been able to provide their clients through their EDM system. The copying company *Valopaino* has also developed their own system, but the functionality is limited compared to *Sokonet* and it is not as prominent in their marketing.

Buildercom is part of a group of companies which have specialised in the development of software and ASP services for contractors, in particular for site operations and e-commerce. The scope of *Buildercom's* services is, however, more comprehensive, focusing on both design, construction and facility management and maintenance.

JP Terasto again is a building design consultancy and provide their EDM system for clients as part of their overall services. The interviews highlighted the fact that each service provider seemed to have a clearly different business models.

The following observations were made during several of the interviews;

- The overall price level for using a system is equal to or less than 0,1 % of the project's budget. This should be compared to around 0,3 - 0,4 % for copying services.
- Price is thus no longer a major barrier for the introduction of EDM systems, although a number of

respondents to the telephone query from smaller projects still listed this as a reason for not starting to use the systems.

- Neither is lack of technical infrastructure (computers, web connection) a major problem, at least in Finland. The degree of Internet connectivity is very high in Finland and the bandwidth is high enough for the retrieval of even large CAD-files.
- The main barrier for wide-spread adoption is psychological resistance from key decision makers. The decision process before a project adopts an EDM system can be quite complex (many people need to be convinced).
- Few sales of systems or services are done at the initiative of the users. Mostly sales are a result of several months of persistent personal work from sales-representatives involving demos etc. These systems do not sell through web-marketing.
- With the price level prevailing in Finland it will in the long run be difficult to generate enough cash flow only from the sales of an EDM service to the building construction industry. Those service providers which bundle the ASP service with some other services (copying, project management, e-commerce, detached house building) will have a clear advantage.
- Standardisation or industry practice guidelines in some form would be welcomed by several of the vendors. This would facilitate moving from one system to another. One possible area for standardisation could be the representation of metadata (for an attempt in this direction from Denmark see IBB 1999).

It is noteworthy that since the study was carried out Raksanet and Buildercom, both rather pure ASP-solutions, have merged.

In addition to the above more general conclusions there were some observations which emanated from single interviews;

- Designers in particular have fears that the efficient use of EDM systems creates “a big brother” watches situation, where clients have too much insight into the current status of the documentation. Thus it will no longer be possible to put the blame for delayed documents on somebody else.
- It has been difficult to get subcontractors to give bids to requests for tender which have to be “pulled down” from an EDM system. At least this was the case when the construction market was “hot”, when there were enough jobs to be had anyway without the extra bother involved.
- Although the individual homebuilders market per se would seem totally uninteresting due to the low prices that could be charged, there is an increasing number of builders or clients who in their work are very used to the Internet and who welcome the opportunity to supervise or just follow the progress of the building or their own home over the Internet. Thus vendors of package houses, project management firms etc. are likely to start offering this type of service as a value-added service to their clients.
- One of the key long term benefits of using a EDM system in the design and construction phases is the added value that this provides in the FM and maintenance phase. At the margin this can even effect the sales price of a property as it changes owner.

5. STUDY OF THE LOG FILES OF AN INDIVIDUAL PROJECT

The Buildercom company (mentioned above in the discussion of vendor strategies) provided log files from a large construction project in Jyväskylä that had used their system. The project was a 14-story office building called Innova, the landmark of Jyväskylä Science Park. The log files consisted of complete logs from the web-server as well as a data dump from the system database including contents of a table that logs user actions. The study did not try to quantify the success or failure of the use of the system, but rather develop the methodology of analysing the data and gathering the needed information as well as provide recommendations for conducting similar studies. The purpose was to see what information could be gathered from the files in order to chart the system usage during the project. There were no particular pre-set hypotheses that were tested and the study was more exploratory in nature. The log file from the web server had the following structure (Note that the IP-numbers have been replaced with X's due to security reasons.:

```
#Date: 2000-11-13
No data
#Date: 2000-11-14
05:52:20 XXX.XXX.XXX.XXX - 80 GET /tmt_torni/login.asp - 302 ⇨
Mozilla/4.0+(compatible;+MSIE+5.0;+Windows+NT;+DigExt)
05:52:20 XXX.XXX.XXX.XXX - 80 GET /tmt_torni/login.asp - 200 ⇨
Mozilla/4.0+(compatible;+MSIE+5.0;+Windows+NT;+DigExt)
05:52:20 XXX.XXX.XXX.XXX - 80 GET /tmt_torni/tyomaapk/tyomaapk.css - 304 ⇨
Mozilla/4.0+(compatible;+MSIE+5.0;+Windows+NT;+DigExt)
```

As the excerpt shows, the log file reveals the time a certain resource has been requested and the IP-number of the user. This data is enough to show top user- IP-numbers, most accessed resources, and the overall use of the system over different time periods, among others. The range of the file is 2000-11-13 to 2002-09-02, and its size is 22 350 kb with 171 712 rows of data. The other log file from the project consisted of a data dump from a table in the system database. This table contains a log of specific events tagged to individual users. The events include such actions as login, file manipulation, changes in user information etc. This log obviously exists for helping the system administrators when tracing errors or security breaches, as well as for having data of actions for possible legal reasons. The structure of the log file seems too limited for supporting complete reporting functions for the system users, since for example file downloads or viewing of files is not logged at all. The logs contain only data of changes made in the information stored in the system, not data from using that information.

The database log file has the following structure:

```
time, site, ip, userid, username, event, parameters
1.10.2001 11:50:48, tmt_torni, XXX.XXX.XXX.XXX, userid_1, username_1, ⇨ sisaankirjautuminen
1.10.2001 13:53:58, tmt_torni, XXX.XXX.XXX.XXX, userid_1, username_1, ⇨ sisaankirjautuminen
1.10.2001 15:22:19, tmt_torni, XXX.XXX.XXX.XXX, userid_2, username_2, ⇨
```

Note that the ip-numbers have been replaced, as well as the user-id:s and complete user names. The database log contains 5 488 rows, or events, and its time range is 2001-1-10 – 2002-9-9. Together both files give a relatively complete view of the whole project. With the time stamp and the ip-number the data from the both files can be combined.

During discussions with Buildercom a significant limitation with the data from the project emerged. The system was not used at all during the design phase of the project. The design phase was done on a separate system, and no documentation from that phase is included in the Buildercom system. The data does not either include work security documentation. The security inspections were done with PDA-devices. The data includes mainly the following information:

- Meeting agendas
- Notice boards
- Construction site diary
- Quality inspections

Since the amount of data was relatively large the proper method of analysis would have been running the log file

through an ordinary weblog-analysis program such as Webtrends (www.webtrends.com). This proved however to be impossible due to technical difficulties with the structure of the data. During the work with the log file, it also became clear that the format of the log file changed on 2002-02-07. The date and time no longer appear as presented in the earlier excerpt with the date on a separate row and log rows from that date with only timestamps. The date still appeared on a separate row, and a single row in the file started with a date-time-stamp, ie. 2002-02-07 14:04:55.

Due to these problems it was decided to load the log file into a database and run queries on the data instead. The file still had to be cleaned up so that unnecessary characters and information did not appear in the file. Also all the rows had to have the same format. Thus the date time differences had to be corrected.

The data was loaded into a database and analysed. The database log file was loaded in the same format as it was delivered. The weblog however had to be cleaned up in order to get it loaded into the database. The cleanup was done with a script that processed the file row by row and rewrote it in a new file. After the cleanup process the log file lost nearly 10 Mb, and shrank to 12 577 Kb. The data from the reformatted weblog and the data dump from the system logging were imported into a database in two different tables. After all of the data was loaded into an MS SQL 7 database a set of queries were run on it and reports generated.

The original research plan was to do the basic weblog analysis, and complement this data further with the database logs of the system. The weblog would have given a rather complete view of the overall system use and top visitor information. Using the IP numbers that information could have been tagged to individual users in the project organisation and thus it would have been possible to chart the system use based on all the organisations and different groups using the system.

Some of the reports from the weblog could basically be reproduced by database queries. These include Most Requested Pages, Most Downloaded Files and Most Downloaded File Types. The reports on accessed resources from the weblog proved out to be a problem. Basically every downloaded file is recorded in the log. The first problem was that file downloads are not done directly from a named folder tree. The download request goes to a page called `download.asp`, which redirects the browser to a path called for example `temp/182607103/Meetingminute135055.doc`. In other words the file is moved to a temporary directory with a unique name for each access based on the visitor session. So the same downloaded file appears in the log file with a unique name each time it is downloaded. Further there are for example 34 files called `poytakirja.doc` in the system which makes them nearly impossible to identify. When the `download.asp` page is accessed, the page also receives an item number over the header information. With this number it could be easy to track individual files. However the item number could not be tagged to a full path if there exists more than one file with the same file name. For example in the case of `poytakirja.doc` it is impossible to know in which context it exists. A report of file downloads was done though before the fatal disk error. The report contained a complete list of downloaded files that were identified according to the item number. On the second attempt it however became clear that this does not give a reliable and complete view of the downloaded files, since downloads are not done consistently. The system has apparently been changed during the project, and the item number does not appear from 2002-2-2 and forward. Also the naming convention for the file downloads is different and the unique number before the file extension does no longer appear.

The database log contains information that makes it possible to do some activity statistics. Though this data, as stated earlier, contains only logs of modifications in the data, not data on accesses. This means that it is rather difficult to attempt an analysis of an individual session, and the log file does not help with the access statistic problem in the weblog on file downloads.

6. RESULTS OF THE LOG-FILE ANALYSIS

Altogether there were 48 individual users of the systems, of which 28 represented individual roles in the project organisation chart. People in the organisation chart were coded with a letter identifying the company they represent, and a number identifying the person. So B is the main contractor and persons B1 and B2 are their employees. There were 8 users from Buildercom, which includes system administrators and test-user accounts. Three people marked in the organisation chart had not been given access to the system, or had not logged in at all. The database log has an event field which contains a string that describes the actions a user has done.

The table above gives a picture of what features in the system have been used. Information of users in the system include apart from basic user information the company the person represents and the type of the company. Users

can also be grouped. The system also has basic document management functions with file and folder uploading or creating, deleting and updating. News can also be published. The project organisation and timetables are independent images, and must thus be updated manually. A diary function exists also in the system as well as the possibility to accept contracts. Actions can also be created and they can be marked acknowledged. References can also be created.

Overall there were 2965 logins into the system by 48 different user accounts. The top 10 users based on login frequency are the following (table 2):

Table 2. Top 10 users based on login frequency

#	User	# of logins	Role
1	D1	459	Architectural design
2	L1	358	Project manager, Main constructor
3	C1	244	Clients project manager
4	C2	219	Clients project manager
5	E1	205	Structural designer
6	M2	143	HVAC manager, HVAC and electrical contractor
7	X1	133	?
8	G1	106	HVAC design
9	X2	105	?
10	G2	92	Electrical and telecom design

The users marked with a question mark in their role description are not included in the project chart, and could thus not be identified. As can be seen from the table the login frequency is relatively high for a couple of users, with only 9 users with over 100 logins. The majority of users (28) have logged in less than two times a month on average. 17 users have logged in less than 10 times in total. The whole log file spans 20 months from November 2000 to June 2002. When the users are organized according to the total number of actions logged, the top 10 include the following (table 3):

Table 3. Top 10 users based on logged events

#	User	# of events logged	Role
1	C2	870	Client's project manager
2	L1	629	Project manager, Main contractor
3	D1	466	Architectural design
4	C1	413	Client's project manager
5	M2	249	HCAV manager
6	X2	236	?
7	E1	206	Structural design, Consultants
8	L5	196	Technical office, Main contractor
9	L6	190	Construction site, Main contractor
10	X1	169	?

The people in the table organized according to logged events do not vary much from the login frequency table. However when the number of events logged is compared to the login frequency it can be seen that for example the construction consultants C1 and C2 have made on average 3,97 and 1,69 logged actions per login. While the architect was the most frequent visitor on the system, he has made just 7 logged actions when not counting the login event.

This pattern could be explained by the manner the system was used. There has clearly been a group of people visiting the site frequently and adding material to the system. Then there is another group that visits the system and downloads some material, which unfortunately does not show in the log files. Table 4 shows top 10 users organized according to the number of logged events per login.

Table 4. Top 10 users based on events/logins

#, User, #of Events Logged, #of Logins, Events/Logins, Role

1	X6	101	16	6,31	?
2	C2	870	219	3,97	Construction consultant
3	C3	118	45	2,62	Construction consultant
4	L5	196	80	2,45	Technical office, constructor
5	L7	59	26	2,27	Construction site, constructor
6	X2	236	105	2,25	?
7	L6	190	89	2,14	Construction site, constructor
8	L1	629	358	1,76	Project manager, constructor
9	M2	249	143	1,74	PHC leader, technical constructor
10	C1	413	244	1,69	Construction consultant

As the table shows, the events/login value does not give good information on user activity. The first user in the list is ranked high because he has updated his user information 29 times and company information 25 times, while only logging in to the system 16 times. But what can be seen from the table is how the architect, PHC designer, structural designer and electricity designer among others have logged in relatively often, while not doing much else. These are the users that have visited the system in order to get access to some information they need in their work.

The files in the system were charted by analysing the parameter field from the database log of the system. The parameter field includes in the case of a file upload the full path to the file in the system.

During the whole project 397 files were uploaded in the system. There were 20 delete-actions and 10 update actions. The file types of the 397 uploaded files were the following:

Table 5. File types of uploaded files

MS Word document	197
JPG Image	91
MS Excel document	77
Adobe PDF document	17
TIFF Image	11
GIF Image	4
MS Project document	1
PCX Image	1
Total	397

As can be seen from the table above, the majority of the documents are files from ordinary office programs. Since the system was not used for the design phase of the project no CAD-files or other design documents have been uploaded. The text documents within the system consist of meeting minutes and their attachments, memorandums and different field reports. This can be concluded from the file and folder names.

A large part of the files are images. The images are pictures of reference constructions and pictures taken during the construction. Also some of the images (the TIF-files and some GIF-files) seem to be image versions of text documents or some charts, such as timesheets.

The number of files from different meetings uploaded into the system were the following (table 6):

Table 6. Number of files from meetings

Contractor meetings	107
Design meetings	72
Construction site meetings	58
Meetings of the board of directors	28
Purchasing meetings	11
End-user meetings	11
Total	287

The rest of the files are timetables (4), images (91), project reports (12), construction site safety documents (2)

and one construction site plan.

Files had been deleted 20 times from the system. The majority of the file deletions actually appear to have been made directly after file uploads. For example one file has been uploaded two times and deleted two times before the final upload – all within minutes. The 10 file updates mostly seem to have been minor changes that were done during uploads. Around half of the updates have been made during the same session as the file upload was done. Overall the changes in files in the document management part of the system are minor.

The majority of the documents in the system are related to different meetings of the groups involved in the project. Further the files that have been uploaded have not been changed after the upload, apart from a handful of cases. Thus the system has served mainly as a place for file storage and distribution. No collaborative work has been done within the system.

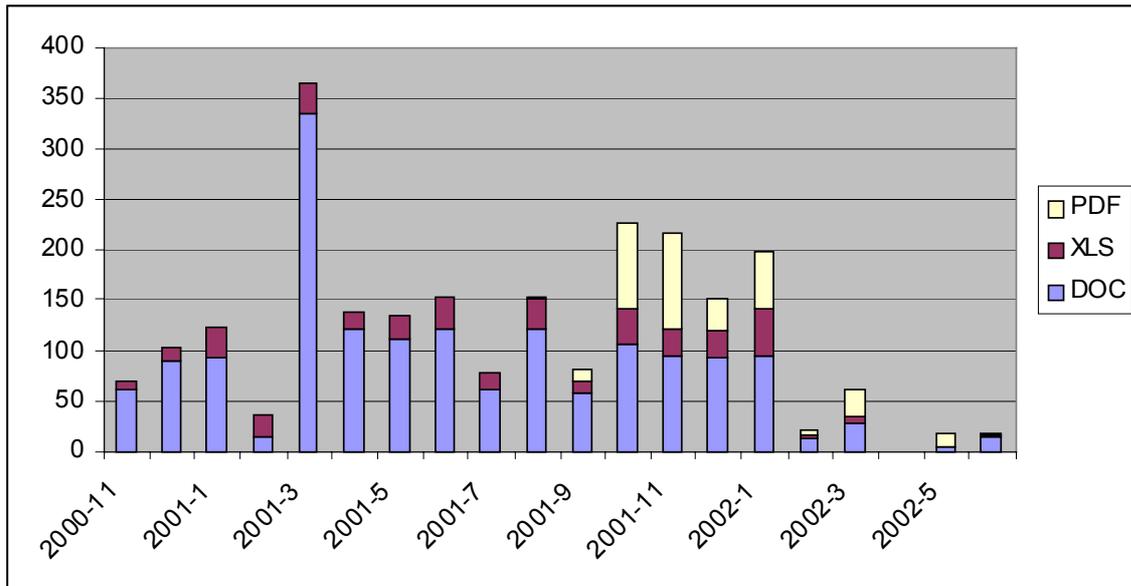


Figure 4. Total download frequencies of MS Word, MS Excel and Adobe PDF documents by month.

The overall system use was analysed from the weblog. Since the user activity has for most users mainly consisted of logging into the system and downloading some file, the file downloads give the best view of the overall activity. File download frequencies proved out to be the best activity measure in this case. The download frequencies can be summarized over different time periods since the document name and timestamp are logged in the weblog. The database log does however not include file downloads. As stated earlier, individual files could not be identified reliably, and thus the download frequencies can reliably be counted only based on the file extension. This gives just an overall download activity statistic. Further the GIF and JPG image files in the system are difficult to identify from the log file since every image an html-page contains is also logged in the same manner as when one of the images uploaded into the system is viewed.

The document download frequencies were calculated separately for MS Word, MS Excel and Adobe PDF-document. *The MS Powerpoint and MS Project files were not downloaded a single time!*. The download frequencies were calculated on a monthly basis, which in the projects means 20 months. The majority of files (216 of 397) in the system are MS Word files, so naturally the most frequently downloaded files consist of them.. The average download frequency per month is 83,1 with a standard deviation of 73,3. A peak in March with 335 downloads can be observed. Up to this point only 16 files had been uploaded into system, and nearly all of the files were related to the planning stage with meeting minutes from planning meetings and other specific design-documents or timetables. 12 of the uploaded files in March 2001 were MS Word documents.

During the project 81 MS Excel documents had been uploaded into system. The average download frequency is 19,4 and the standard deviation is 12,7. Most MS Excel downloads occurred during January 2002 with 44 downloads.

The system contained only 17 Adobe PDF files in the end of the project. The most active periods for PDF document downloads were October and November 2001. Only 9 PDF documents were uploaded into the system

until the end of November 2001. These files include two meeting minutes from the meetings of the board of directors. The rest of the files are meeting minutes and reports of the advancement of the project by the project managing organisation. The most popular document during these two months is a meeting minute by the project managing organisation uploaded 2001-10-24. The document has been downloaded 74 times during October-November 2001. The rest of the 11 meeting minutes from the project managers are MS Word documents.

After the problems with getting access to data from a project, and analysing the data some results could be produced. The results were, however, not as comprehensive as the original intent due to the problems with the input data. What can be concluded from the results is the following:

- The system was mainly used for storing meeting minutes
- The system was not used for concurrent work, only as a document storage point
- The system was not used widely in the project organisation. Only a few of the users were active.
- Active users consisted either of information producers who uploaded documents or information users who downloaded the needed information.

Since the nature of the system use was mainly storage and distribution of process specific documentation, the document flow was minimal – or non existent. Sulankivi et al. (2002) describe the redesigned workflow and state that for gaining maximal benefits from using an EDM system, it has to be used for creating a new way to work, rather than automating existing processes. In this case it seemed more like the system was used for easy storage and automating distribution rather than for creating a radically new and efficient way of working.

Even though the use of the system seemed to be rather limited, perhaps due to another system having been used for the design phase of the project, it still seemed to be a relevant tool for some users. The log files showed two types of active users; those who create and distribute information and those who access and use the information. The interesting part was that it seemed like the information users almost never produced information themselves.

The log files still proved to give a good overall view of a construction project. If a comparison between different projects would be made, more interesting information could be revealed. Since most of the systems use a thin web client, much of the information can be gathered from standard web logs. However the industry should develop the logging of activities within the system. In this case study the logging of the system seemed to be made only for tracking possible bugs. The information was far too limited for providing comprehensive reporting. Software developers and service providers should consider creating reporting tools that would show system use during the project. This information would be helpful for example in making the processes in the organisation more effective. Another problem with the system seemed to be that it is in constant development. Fundamental structural changes in the system had been made during the project, which created problems during the analysis of the data.

7. CONCLUSIONS

This study shows that the use of electronic document management is growing rapidly in the Finnish building construction industry and becoming commonplace at least in bigger projects. The results concerning overall use from this study cannot be directly compared with the results presented in the earlier IT-barometer study, due to methodological differences

The main barrier for wide-spread adoption is at this point in Finland psychological resistance from key players in the design and construction team. The price or the lack of technical infrastructure is no longer a significant barrier. Currently this psychological resistance can only be overcome with a sustained sales campaign involving personal visits. In the near future this situation may change, as more and more project participants already have (positive!) experience of using such systems, and as large client and construction organisation implement EDM as part of their company policies.

Fierce competition has lowered the price levels that can be charged for these services to the point where it is difficult to run such services on a stand alone basis. Partnerships with companies, for whose main business an ASP based document management service provides a clear value-added is therefore a likely trend in the near future.

The study showed that analysing log files can be a good way of getting an overall view of information flows

during a construction project. A prerequisite is, however, that the structure of the log files enables such analysis in a meaningful way and this study revealed some weaknesses which can be remedied rather easily. Combined the information from different logs gives probably the best single view of a complete project.

Analysing a single project does not however give any reference points, making the results just statements of facts. If two or more projects were analysed and compared, more interesting results could probably be found. Further the analysis method could be developed so that some sort of standardised method could be used. Also an analysis of a project by using log files should be supplemented with interviews. Since the information reveals the actions of an individual users, the interviews could be used for getting answers to why a user has used the system in the proved manner. Also interviews can reveal the overall workflow of the project and thus give answers to for example peaks in system use etc.

The following quote from an interview with a HVAC consultant (Ekman, 1999) illustrates the knowledge and attitude gap between older professionals, who often resent and fear taking into use new IT support, and younger practitioners, for whom IT is a natural part of working life and leisure.;

Electronic document management requires so much "brain power". Nowadays we no longer discuss HVAC problem during the coffee breaks. Such discussions have been replaced by discussions about IT technical problems.

Such differences in attitude and IT-literacy between different groups of users within single projects has also been discussed by O'Brien (2000). Overcoming this gap and getting the different groups on board is one of the key challenges in the comprehensive introduction of EDM in the construction industry.

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