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Electronic information processing in archaeology - A key to progress?

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The paper appear as read with minor corrections to grammar and language.
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The structure of Danish Archaeology

Denmark is a small country. With its 43.000 square kilometres and 5 mill. People, its archaeology should be of a size easy to survey by its community of archaeologist. In fact it is not. There are basically two reasons for this: the organisation of Danish archaeology is decentralised with an anarchistic touch, and the density of archaeological remains is high.

In the beginning *was* the National Museum. A hundred years ago it was the only professional archaeological institution in Denmark, and it tried to keep every other institution from the share. Its director even travelled around collecting from other museums, what he liked to have at the National Museum (Glob 1971: 20-21). After the Second World War, The National Museum found itself severely weakened politically, while all over Denmark, local museums prospered on a wave of interest in the past.

Today the local museums *are* Danish archaeology. There are currently 49 museums certified as responsible for the Danish archaeological heritage, and the number is growing. Thus ten years ago the number was 38. The National Museum has national obligations concerning "finds of precious objects" and in addition a "free licence" to carry out investigations in the country as a whole. The 48 local museums have each their "jurisdiction", within which they are responsible for all excavations carried out, but they also have the obligation to excavate under the legislation of rescue archaeology. In addition it is an obligation to store and take care of all information and material from the excavations. Indeed all excavated material must end up in a certified museum.

What then about an archaeology department at the university? Surely it can go out and do research excavations at will, and take care of the excavated material themselves? No, it has to seek permission to excavate from the local museum "in charge" of the site, and in advance it has to be agreed upon which museum has to take care of the material. It need not be the local one, but it has to be a certified museum.

The size of the local museums varies considerably, and so do the size of their "jurisdiction". There are museums with a permanent staff of 3-5 archaeologists and a fairly large area to cover (up to the size of a county), but most of the museums are very small with only one (possibly part time) archaeologist, and an area of only a few or even only one municipality. Yet in a good year a small museum may have an excavation budget exceeding that of the larger museums. This happens for instance if a new motorway passes through its area. Then the mobile force of unemployed archaeologists and archaeology students moves in, and a temporary excavation team is created. In such cases large and very important finds may end up in even the tiniest local museum.

The jurisdiction of the individual museums is granted by a board of archaeologists under the presidency of the State Antiquary. The Archaeological Board currently consist of nine members including the State Antiquary, who is also the director of the National Museum. Three of these come from the local museums, while the rest are from the universities (2), the National Museum (2 + the State Antiquary) and the Department of Environment (1). Currently there is a motion to increase the representation of the local museums.

The Archaeological Board also hands out part of the money used for rescue archaeology (the major part comes directly to the museums from the public authorities responsible for damage to the archaeological record), and it sets the overall rules to which the individual museums have to abide. Among these rules is the obligation to report all finds to the National Sites and Monuments Record (SMR) held at the National Museum, and to deliver a copy of all excavation reports to The Archaeological Board. These copies are subsequently stored at the National Museum.

Despite the overall control exerted by The Archaeological Board, the museums have a high degree of individual freedom. Recommendation for the general structure of an excavation report is available, but it is only a recommendation. This standardised report contains Level II data, and no more (Carver 1985: Figure 4 - with reference to the Frere report). There are no demands or recommendations for the structure of the recording systems used at the excavations. Consequently, there is a bewildering variety of recording practices. Some museums record and number features and layers separately, others consider layers to be merely descriptive properties of features and drawings, and yet others record only layers and not features as separate entities. Objects may be recorded in sequences unique to the excavation, or they may be recorded as sub sequences unique to features and/or layers.

Thus the Danish Archaeological Heritage is kept in custody at close to fifty different localities. The written reports on the investigations are kept in lockers at the same fifty institutions with a copy at the National Museum. A short description is placed in the National SMR to facilitate access to the data.

The richness of the Danish archaeological record and the conditions of research

Denmark is a lowland area with a stable, highly productive environment. This has led to a dense population from the Mesolithic and onwards. Denmark has also a strong tradition for an interest in its past, and an intensive archaeological research to match this interest. The combined result of these two factors is a very large and coherent archaeological record. The National SMR currently holds roughly 130.000 entries with a yearly accession of approximately 2.000 sites (Hansen 1992: 26). As a reasonable

comparison one may take the 60.000-70.000 sites known from Holland (Roorda & Wiemer 1992: 117), or the roughly 40.000 sites known from the Rheinland in Germany (Schollar 1992: 97).

Planned, systematic, professional excavations have been carried out in Denmark as in most other European countries for more than hundred years. Up to the Second World War the extent of the excavation programme was modest, and almost all excavations were carried out by the National Museum. For a researcher to keep track of the available data was fairly easy. The amount was limited, and the major part was stored in The National Museum. Even if far from all material was published, it did not matter, as all professional archaeologists were situated at the National Museum, or in Copenhagen at least.

A university education of archaeologist was initiated in Copenhagen in the thirties and in Aarhus late in the forties, but until the late fifties the number of students was limited, and the number of people receiving degrees even fewer. In the sixties the number of students grew radically, however, and at the same time professional positions began to turn up all over the country at local museums. Within a couple of decades the complete landscape of Danish professional archaeology was turned upside down.

As the number of researchers grew, the amount of data produced grew equally. The number of excavations carried out yearly is currently around 5-600, and although many of them are small with insignificant results, the turnover in terms of data is staggering.

The dispersal of the archaeological community at the many local museums combined with the above described jurisdiction system results in an atomised data material situated at 49 different locations. Where previously far the largest part of all data ended up at the National Museum, today only 1-2 % goes there.

There is no easy way to access the data. Each year The Archaeological Board publish a book giving a short entry on every excavation in the country, and from this you may get an idea of what is available. There is of course also the National SMR, but this has so far, for various reasons that I shall return to below, not been easily accessible. If you want to study a specific topic thoroughly there is only one way. You have to go around to all the odd forty-nine locations where the material is kept. Equally if you want to keep detailed track of a specific topic, you have to make a yearly journey to a number of these institutions. The researchers, who should do this, are themselves employed in various places around the country, and generally have very little time, or money for this kind of travelling. Only occasionally, accompanying a Ph.D. project or an other specific and often externally financed research project, are these types of travels realised. It is thus difficult for researchers to utilise the data produced at the various excavations in Denmark.

One way of solving the problem would be to publish the excavations properly. However, even if publications occur as never before in Danish archaeology, they hardly do more than scratch the tip of the iceberg. The problem is that there is no time nor money available for the data processing and analyses necessary to put together a publication (To create the level 3 and 4 data of the Frere report - Carver 1985: Figure 4). The whole idea of rescue archaeology is homed at the idea of saving the archaeological record for future study. All available money is defined into the field activity and the formal documentation for the archives. None of it is available for the publication process. If those responsible at the museums insisted that an excavation should be published (by themselves for instance), before a new could be initiated, the whole rescue archaeology system would crash, and a significant number of archaeologists living out of rescue excavations would be unemployed.

The problem, now known as "the bottleneck problem", with masses of information created through rescue archaeology, virtually inaccessible for further research, is a serious one, and has attracted some worried comments in recent years. Thus the Danish Research Council for the Humanities in a Plan of Strategy (1991: 70-71) has phrased its deep concern, yet unable by its own moderate means to solve the problem. Instead they pleaded with the Danish National Research Foundation to take on a responsibility backed by its superior financial means, but in vain.

If the problem is left alone, archaeology truly can be accused of irresponsibility. I view the excavation as the key research area within archaeology, where a process that involves knowledge as the most important research tool creates data. If the excavators' knowledge is based on outdated information - if it does not reflect what is potentially available, then the excavation is inefficient and in part a waste of time. If archaeology keeps on creating information without using this information to guide the creation of further information, then archaeology moves itself into a very dangerous position. What would archaeology do if the public started to ask unpleasant questions? Would all archaeologists stand up and lie? Would they all say, don't worry; we are currently just saving the record for the future? In a hundred years from now, when there is no more to save, we will return to our *objective* registrations and find out what they were all about.

Obviously I am pushing the point to extremes. There is a feedback, and there is an accumulating knowledge among the archaeological community, but it is slow, and the utilisation of the potentially available data is very unsatisfactory. All things considered, we must do something to solve the bottleneck problem. Even if our society will allow us "same procedure as usual", we cannot ourselves be content with this. *The information created on archaeological excavations must be made generally available for research - all of it*. The problem is only how? Certainly we must reorganise and certainly we must

provide resources for processing and analyses of the information coming out of the excavations. But should we also let this work conclude in a printed volume? Is the printed volume a desirable mean for the dissemination of data from archaeological excavations?

The problem with printed information

The organisation of a good story generally includes a "red thread" along which all events and information are ordered in a well thought out sequence. Excavation information lends itself very badly to this treatment. It mainly consists of individual items of information linked through statements of association. In the archive files most of this information is placed in long lists, properly cross-referenced (or they should be at least). It is the closest you can get to proper documentation in paper files, and it is by most standards unreadable.

In a proper excavation report a strategy for organising the information into a coherent story is necessary. This inevitably leads to information loss, and the more complex the excavation information is, the more pronounced becomes the loss. If we insist on a high degree of precise documentation the report by necessity convert towards the archive file and towards unreadability.

The closer the structure of a printed report is to its archive counterpart the easier it is to make. With a growing clarity and readability of a report, a growing amount of work has to be invested. Much of this work is invested in analysis, producing lots of new data (level 3 data) used in the formulation of the report. These data are mostly not documented in the report, as they would obscure this in the same way as the detailed excavation information does. Neither are they kept with the archive files, as these are only meant to document the excavation (level 2 data). Mostly, they remain in custody of the author of the report and eventually become lost.

If we insist on access to all documentary data a radical solution would be to publish everything: the archive files; the data coming out of the intermediate analyses; and the final, formal and readable report. It may be thought of as an ideal solution. From all practical views, however, it would be a hopeless solution. Paper, or perhaps worse, microfiche would swamp us, and very few would ever touch the documentation material. Most would stick with the formal report, as the work needed to digest and analyse the excavations from the printed lists of primary information would be prohibitive.

Publications including site reports appear in archaeology as never before. Due to the limited audience they are very expensive, and today only few institutions can afford to have a reasonably complete collection of relevant literature. If we for a moment pretend

that everything was published in ordinary printed publications, who then has the money to buy them? The average market in Denmark for each publication could well be as low as 10-20 copies.

There is a further problem with printed publications. Whereas a book is a nice thing to read, it may be a very awkward place to seek information. A book is a physical entity in itself, and any search system for information (e.g. indexes) is limited by its boundaries. To seek information on a specific issue mean searching across several books. As the number of books grows, the search for information becomes increasingly tedious.

There is no doubt that seriously we have to consider to let electronic information replace printed information. As I shall point out in the following chapter, some of the weaknesses of printed information is substituted with points of strength if we convert to electronic information.

Some useful properties of electronic information

Electronic information has many useful properties. In the following I shall deal with five of these, all of which are beneficial when compared to the correspondent properties of books:

1) It is extremely cheap to produce and distribute;
2) It can be structured to a high degree of complexity;
3) It is *live*;
4) Access to even large and complex sets of information can be extremely fast;
5) Physical location is in principle of no consequence.

Ad 1. I often recall the first PC I worked with 11 years back. It used 360 KB floppy disks at a price of approximately £ 5 each. Today a CD-ROM, which can be read just as fast as many hard disks in an older generation of PC's, holds 640 Mb at a production price of approximately £ 2-4 each (excluding the master). Without problems a CD-ROM can hold the information from an archaeological excavation complete with graphics. The production price of such a publication could be kept at £ 2-3.000, and the shipping cost world wide at £ 1-2 per copy. If price is your only concern, electronic publication on CD-ROM is a must. A traditional printed publication cannot in any way compete in price with the electronic publication, and while the book becomes increasingly more expensive, the price of electronic media's is bound to drop further.

If we consider on-line electronic information, this is currently also very inexpensive. In fact most users experience the Internet as completely free of charge, as the costs are covered in part by their institutions and/or by central agencies in their countries. This

may not last, but it will probably remain a very cheap way of communication, as the type of packaged information exchange used on the Internet is highly efficient in terms of throughput per channel. What may in the end turn out to become expensive is the services offered and requested at the various nodes of the net.

Ad 2. The physical property of a book permits a coherent, one-dimensional, sequential structure only, and not a complex, multi-threaded one. Therefore the author has to decide the sequence for the reader, when (s)he structures the content of a book, and information not fitting this structure has to be left out. Even if we can understand the complexity of a given set of information, and even if we can outline the structure of this complexity, the physical limitations of the book do not allow us to represent the full complexity of the data.

Information in an electronic form has to be filtered through a program that presents the information in a structured sequence to the reader. If the electronic information is kept in a simple sequential form, as typically is the case with information entered into a word processor, nothing is gained in terms of structural complexity. The author decides the sequence and the reader has to accept this.

However, it is possible to keep information in electronic form with a structure that goes beyond the simple sequential. For instance using an Entity-Relationship modelling approach to the reality we want to describe, we may set up a structure in a relational database system that holds the information in a complex multidimensional structure. If we simply "dump" the content of this structure in a printed format all we get are masses of tables with bits of information and pointers to positions in other tables with bits of related information. This is a representation that is completely impossible for the human brain to asses the content of. A filter (a query and report program) applied to these interrelated bits of information makes it possible to get a coherent, sequential version.

Indeed, depending on the qualities and properties of the specific filter applied, it is possible to get many different sequential extracts and versions of the information. If the author chooses one such version of the information to print as the "official" information, then we have a traditional publication, with only a partial representation, and the rest of the information in the database lost to the receiver of the product. Only if the electronic information in its complete relational structure together with a filter program is distributed to the end user do we make the total amount of information available to research. Any use of such a filter will always result in a limited, one-dimensional, sequential extract of the multivariate complexity. We can never escape this information reduction. By supplying the data and the filter, however, the individual researcher can experiment with various extracts of the data to gain a fuller understanding of these.

Ad 3. The notion that electronic information is live should also be seen in relation to the traditional printed publication. Whenever you wish to analyse information available in a printed publication, you have to perceive that information as data and physically put it into an analytical context (today this is very often the same as saying you have to computerise it) before you can do anything with it. In other words to analyse printed information formally, you initially have to make it operational. In an electronic context with structured information the data are already operational, and in a state of potential comparison with other data. The data need not be perceived as such, and made operational before they can be analysed. They already have their qualities defined as part of the structure and format that makes them accessible on the electronic media. To use information in an electronic environment to extract further information is thus mainly a question of applying analytical applications to already defined data structures.

Ad 4. Originally, the two main characteristics of computers were considered to be their abilities to perform calculations, and their abilities to store and retrieve information. Most archaeologists today have a PC, but for neither of the above two reasons. To most the PC is a very advanced typewriter, and just that. Surely some years back the PC was not too well suited for the purpose of information retrieval and presentation. The hard disks were small and slow, the processor speed was slow, and the programs to structure and retrieve the data were not easy to use. All this has changed, however. The speed of accessing data from various types of storage media's has increased considerably. The same is true with the capacity of the storage media's, where we now start talking in Gigabytes instead of Megabytes. The processor power has increased markedly in recent years. Pentium processors are beginning to become standards, and we are just about to see RISC-processors entering the main stream PC-market. Standard off the shelve software provides us with very powerful easy to use applications in a windows-based environment. All together it means easy and *very fast* information retrieval. Below I shall deal with the Danish national SMR database, which may be taken as a very good example to illustrate this development.

Ad 5. Networking of computers means that information becomes increasingly shareable between different locations. Various types of electronic networking have been with us for some time. Earliest the *terminal-mainframe* solution, later the *server-workstation* solution, and latest the *peer-to-peer* solution. In a PC dominated environment it is the two later ones, and especially the third one that are of interest. There are two types of uses of the networking facilities that should be heeded. One is distributed databases, the other is distributed computing.

Distributed databases are with us right now. It is fully possible today from one PC to access data on another PC or a number of other PC's within the range of a network, and

use these data on your own PC running a database application. The conditions are of course that the application program you are running knows the structure of the distributed data and the path to them.

Distributed processing is on its way, but not yet implemented in full at the PC level. It is known from UNIX-based workstations in peer-to-peer networks, and it is beginning to appear on the PC level as well. The idea is that a PC seeking information in a database at another PC can ask this PC to do the search. The benefit is that only the resultant data of the search has to pass the slower network link instead of the whole database file to be searched. This can become a very time saving feature, when distributed databases become the rule.

As the communication infrastructure and the networking possibilities between institutions improve, the physical location of data becomes of less importance. It is possible to envisage a situation where electronic information at the many Danish archaeological institutions mentioned earlier in this paper can be shared between them all at will, and with only those seeking the information needing to work for it.

Towards an integrated, analytical, electronic information environment in archaeology

Provided the structural problems of (Danish) archaeology, the growing masses of undigested information, the inherent problems with printed information, and the potentially useful properties of electronic information, what then can we expect to happen? Indeed, what sort of solutions should we work towards?

As stated in the heading of this chapter, I believe that we will and should be working towards an integrated, analytical electronic information environment in archaeology. To elaborate on this I will look at the use of electronic information for site recording purposes in Danish archaeology, as it has developed with the National SMR, and on planned developments within a new project concerned with recording and analysis of excavations.

The Danish national SMR has a tradition going back to 1873, where systematic surveys of the country were initiated (Christoffersen 1992: 10). In 1982 a computerisation of the record was initiated. Because of the complexity of the archives at the National Museum in Copenhagen, where information can be found in several different sets of files, it was decided that the transfer to electronic format should be coupled with a total revision in order to include all available information in the new system. It was estimated that the total process would take about 10 years (Christoffersen 1992: 12). The current estimate is that it will take at least 20 years. However, one part of the project that was carried through first thing was to digitise the geographical

position of all sites and monuments in the record. This allowed for a computerised production of overlays to the ordnance survey maps with points and reference numbers, even if the information associated with the points had not yet been entered.

The registrations in electronic format started on CP/M based microcomputers, but was soon moved to a UNIX based mini computer with several terminals attached. This was an acceptable solution for the entering of text data into the database, but it had some drawbacks in other contexts. Entering of a new point for instance meant finding the correct Ordnance Survey map, place and calibrate it on a digitiser, and digitise the point. Another problem was that a search for data on the computer tended to lock this up, delaying those entering data. For this reason all major searches were done exclusively as batch jobs at nighttime, and the base was never opened for researchers to do interactive searches (which would have been difficult anyway as you had to be able to write SQL statements).

The solution favoured to solve these problems was PC-based data entry as well as PC-based searches on copies of the database. As the PC-program should be used for both updating and searching a database with geographically organised data, it was imperative that the main interface to the database was map based. In 1990 a first version of the program was ready (Sjøstrøm 1990). It had a vector-based map of Danish coastlines, lakes and administrative boundaries. You could place new points on the map and have them automatically “digitised”, or you could query the database for information on existing points on the map. It worked very well except for one detail, there was no visible information on the screen to guide you to a particular location, where a new point should be placed, and indeed if you were searching in areas inland, where there were no lakes, etc., you would quickly get lost in screens with only points and no landmarks.

The suggested solution to this problem was to show “real” maps as a background to the points. These maps should come from an analogue laser disk, and be merged with the digital screen signal using a special and quite expensive video board. An unmanageable patchwork of pictures each showing small areas of only a few square kilometres would be the result. The project was temporarily beached.

The final and workable solution was to scan the 1:25.000 ordnance survey maps with 32 colours at a resolution of approximately 260 DPI (one dot equals 2.5 meter). These maps were placed on 5 CD-ROMS taking up a total of approximately 2.5 Gigabytes. At the same time the SMR database was transferred to Microsoft Access, and an independent application for Microsoft Windows was written to interface the database with the maps, and to act as the main user interface. A beta version of the program was released early 1994, and it is truly an amazing achievement.

One notable thing is the speed with which it works. It takes only a few seconds to find and transfer map data to the screen, and scrolling of the map is instant with only the slightest hesitation. Even more impressing is the access to the database. Even if there is 150.000 locations taking up 130 MB of space in the base, it takes less than 10 seconds for any area of the map shown on the screen to have all the points plotted on it, and the full information on each point available for inspection. The PC on which we run the beta version is current top of the line (Pentium processor, SCSI and PCI bus) but all the same the performance is impressive. Seven years back English Heritage implemented a similar solution on a network of UNIX-based SUN workstations (Clubb 1988). It says something about the technological development that this very expensive system appeared to be intolerably slow even then (to me at least when I saw it).

Even more promising, however, is the architecture of the system. The database of the SMR is kept completely separated from the application(s) that operates it. You can have the database(s) placed on any computer accessible within a network (or even split between more computers), and one or more applications accessing it from any other computer in the network. Further the map based user interface is an independent application, not at all part of the applications that access the data. This user interface application communicates with the database applications through Microsoft Windows standard Dynamic Data Exchange channels. To the degree that these channels can cross from one computer to another, as is currently the case with Microsoft Windows for Workgroups, we have in effect distributed processing.

A further development is currently taking place. After some years of discussing a general model for excavation data (Andresen & Madsen 1992), Jens Andresen and I have succeeded in raising money for a three-year project (starting 1994) to create a system for recording and analysis of archaeological excavations. The project has three parts:

1. During the first year the basic database will be established as well as input and output routines for its textual parts. The goal is to create a system that can produce an electronic equivalent of the textual part of an excavation report.
2. During the second year symbolic and graphic representations in two dimensions are introduced. The goal is a system that can produce an electronic equivalent of the complete excavation report.
3. During the third year symbolic and graphical representations of items not present on drawings will be added, as well as the third dimension; if possible, will be added to the graphics. The goal is a system with analytical capabilities to help scientific analysis and publication.

We intend to be able to cover most of the diversity of the current registration practice in Danish archaeology, and from this to produce standardised excavation reports as specified by the Board of Danish Archaeology. We are convinced that we will be able to subsume the very different attitudes towards registration under on single logical structure of archaeological excavation information. The user interface may vary considerably with different traditions, but not the basic structure.

The electronic recording system is the foundation, but it is not the ultimate goal. The reason for investing time into the matter is not the ability to print an excavation report at the touch of a button. If this were all, it would be easier to type everything directly into a word processor (as many do), and print it from there. It is also a system that aims at a formalised approach to excavation analysis, and indeed one where the analyses are integrated with the data recording. An inspiration here is definitely the system created by Dominic Powlesland in connection with the West Heslerton project (Powlesland 1991). We do not believe that within three years we can create anything quite comparable. Only, perhaps, that we can create something a little more akin to the peculiarity and diversity of Danish archaeology.

The system is currently being set up in Microsoft Access, and as with the SMR, the data will be kept separated from the applications that access it. Further when we come to the analytical applications these will be kept separate from the database applications, communicating through DDE channels. The concept rests on modulisation with a flexible communication structure between the modules. Whenever the SMR displays a site, where excavation information is available in electronic format, then ideally this information should be no more than buttons push away, no matter where the information may be placed within networking reach. The default way to access the excavation data should be geographically, through a display of the excavation plans, working in much the same way as the interface to the SMR. Indeed you could claim that going from the SMR level to the excavation level is only a matter of changing the map scale. Further, analytical applications should be tightly integrated with data. Thus if a set of stratigraphic relations are extracted from the base the default way of displaying these should be in terms of a Harris matrix (a graph) rather than a table.

An impossible dream? Certainly not. No one, who has seen the new PC-based interface to the Danish SMR, nor has seen Dominic Powleslands' GEOBASE system will doubt that this is *the way* things will move. We are on our way to an integrated, analytical, electronic information environment in archaeology. It may take time before archaeology in general gets there, but eventually it will happen. Will we also, however, see publications in electronic format replace traditional printed publications? Does the recording and analysis of the data in electronic format mean that very soon everything

will be disseminated in electronic format, and the book will die? Indeed, is this a development we should seek or avoid?

Can we entrust our data to an electronic media?

There is much grieving, complaint and mistrust associated with electronic information. Much of this is associated with an outspoken dislike of reading information on a screen. I can follow this aversion to a certain degree, but we must realise that much has to do with habits. Once I had to write everything on paper with a pen. Today I cannot write anything unless I do it on the screen in a word processor. I still have difficulties reading proof on the screen, but increasingly I do so, especially after I have acquired a top quality high-resolution screen. This kind of objections against electronically kept information is not relevant, really.

What should concern us are more technical matters. In our libraries we have books from the preceding century. Many of these are still good value. The book is a solid, well tested, repository of information. The same is not obviously true with electronic media's. I have a tape rolled out from a mainframe computer at the university computer centre 10 years ago. The computer with its particular operating system has ceased to exits a “long” time ago. Who can read the tape today? In my cupboard are also a few floppy disks belonging to the first PC we acquired at the institute. The machine was one of those that turned out to be a dead end in the development of PC's, and some years back it went to the broker. Who can read those floppy disks today? If we are - no - as we are stepping onto the steep road of electronic information, we should worry about one thing only, how do we ensure that what is electronic information today remains a stable and permanent source of information tomorrow as well?

An electronic publication today would probably mean a CD-ROM with a hypertext structured content including many illustrations of both vector and raster type. At least three Achilles' heels can be spotted here. Firstly, for how long can a CD-ROM of today be read in the CD-ROM drives of tomorrows standard computers? Secondly, hypertext demands a program to read and display it. For how long will a program dedicated to a piece of hypertext released today be available to show it, and indeed, if the program is distributed together with the text, then for how long will the operating system to run the program be available? Thirdly, the graphics will pose problems of exactly the same type as those associated with the hypertext. Then, what will the lifetime of a CD-ROM publication be under these conditions? Ten years at the most, if we heed our present experiences. This is more than sufficient for engineers or physicians, but it certainly will not do for archaeology.

What should we do? Abandon all attempts to publish in an electronic format? Or should we go ahead and just do it no matter what? Frankly, I do not think we will ever be given the choice. These things have their own inertia, a significant part of it being the retail price of the product. So we will go ahead and publish in electronic format and the publications will be short lived. However, we will not be the only ones in this dilemma. Our society at large is on the hook. Vital information is transferred to electronic media's all over, information that has to survive. It is of course a special problem to archaeology and a few other disciplines that we would like a formal publication to last a hundred years or more, but there is nothing special about our wishes that the information itself should exist at least that long, this is true in all parts of the society. I do not consider this to be a particular problem to be solved by archaeology. Rather it is a problem that has to be solved as part of the changing infrastructure of society.

To return to my questions of how to read those outmoded media's that lie around me? The answer is, I do not need to read them. As the technology changed, I transferred the electronic information to the new systems - *I kept it alive*. In my opinion that is indeed the only solution. We have to keep the electronic information alive. This means among other things that a publication on a CD-ROM cannot be considered the final act of preserving the information. On the contrary it is only to be considered an *ad hoc* "dump" to a convenient, cheap and workable media. The information itself has to be kept alive on a system somewhere else, moving from machine to machine and from operating system to operating system as the technology develops.

If we think of an electronic publication the same way as we do of a printed publication - as a repository for information to be handed down to future generations of archaeologists, then the electronic publication on for instance a CD-ROM cannot replace the book. The readability of the electronic publication depends on more than our eyes, and the understanding of the alphabet and language used.

Currently these additional factors are labile and beyond our control. For this reason the printed publication will still be central to our discipline, and the electronic publication will remain an add-on, probably with increasing popularity, and usability, but not as a place where information ends up for good.

We will, however, see our data, and not least our primary data from the excavations, increasingly be entrusted to electronic media's. Even if for many years we will produce paper "backups", a growing amount of information will exist in electronic format only. As the infrastructure of the information society, and hence the safety of electronic information kept live on computer systems, develops, and as efficient means of accessing our electronic data from the computer systems develop, we will find a diminishing need for publications, whether printed or electronic. Indeed if the printed

publications cease to have a role as a repository of information, and become a mean of conveying ideas to others only, then the electronic publication may well take over the leading role.

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