External Memories: Hypertext, Traces and Agents

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Preamble

'External memories' raise a question about context: 'external to what?' *External memory* is a technical term applied to everything that can be memorized in an individual's environment. As a general rule I have decided to retain the technical terms that characterize the area of the topic under discussion. It was Ted Nelson who coined the word *hypertext* in 1967 to signify non-sequential writing as well as a computer technology that allowed the user to move about freely by means of software links. I shall use the term *software* to mean computer programs. Electronic publishing started with the Xanadu system developed by Nelson. At the lowest level a hypertext is a system for managing databases that allows the user to connect together information screens using links. It is a collection of texts interconnected by means of interactive switches. This dynamic presentation of non-linear texts could not be printed on a conventional page. Hypertext allows the origin of a piece of information to be traced. In this article traceability is synonymous with explanation: 'Why was this equipment designed in one way rather than another?' It is about discovering the route of the design process that led to the eventual idea for the equipment. The necessary explanations are often required long after decisions were made, and this is why traceability is a matter of memory. The term *agent* is often used to mean those members of a community that act on its behalf. There are agents for a company or public department. There are biological agents. In a non-technological world traceability is ideally carried out by human agents who explain to other human agents. The term agent has been extended into the computer world to mean software to which the user delegates, sometimes unwittingly, tasks of varying complexity. These are then called software agents. In this article I refer to agent in its wider meaning, to be understood as an *actor* or an entity able to act in a limited context and having a quite specific role and appropriate resources.

Introduction

I remember those evenings in the 1960s by the fire in the Quercy countryside. The women would be knitting. The men would be cleaning their shotguns after the hunt. The children played horses, a very popular parlour game in the area. I used to listen to the talk – about the day, the elections, the problems of the harvest that year and all the usual topics. There was backbiting, running down the neighbours, while drinking herb tea. I recall sayings such as 'red sky at night is a shepherd's delight', because people needed to know

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whether they were going to work in the fields tomorrow or carry on with their jobs in the stable. Those country people used the arts of memory in a natural way, without benefit of theory. Everything seemed to be integrated. It worked very well. Long after those events from my childhood my thoughts return to those old women who used to chat about their recollections at the evening get-together: they were the community's memory. Nothing was written down. There was no need. That memory was alive because it was regularly discussed. It is true that its reach was limited, but it was very deep. Each person had their own knowledge about a certain area. It was well known that Jérémie knew a lot about vines and their diseases, he had experienced the mildew that had ravaged the vines at the beginning of the century. People were aware that Constant was an unrivalled hunter, and even though he kept fairly quiet about the hares' nests he had come across that year, we hoped he would pass on his secret tips for hunting hares. It was known that so-and-so was a fund of information about such-and-such, people would go and ask. Everyone played a part in this external memory, which anyone could access whenever necessary. Those country people were unaware of industry's division of labour, hierarchical organization and urban isolation. They were obliged to help one another, cooperate and coordinate certain tasks such as threshing in order to achieve reasonable efficiency.

Thirty years later the countryside has emptied of people and the Internet has arrived. In my house in this ancestral region of my childhood I am connected to the world. I read my emails. I send a message to a friend because I know he is well acquainted with the topic I am working on: I am finishing off a report for a project dealing with the automation of an aircraft pilot's control panel, and I have to include acceptability studies based on a group of users. My friend is a sociologist specializing in the development of new technologies and the emergence of new practices. I am using this new means of communication within a community that is now called human-machine interaction. This is one of my villages. These villages are made up of men and women, naturally, but also software agents via the Internet. These software agents are computer programs that mean, for instance, that one can do a rapid information search. Putting men and women on the same level as software agents may seem shocking, but the development of current computer techniques forces me to perform this daring juxtaposition. These software agents are modern technological slaves, which are more or less well developed, whose behaviour we more or less understand and which can make their users' lives easier when they are used well. These software agents' interactive character, which is of course artificial, together with huge documentary databases, makes the Internet an external memory similar to what the memory of the inhabitants of the Quercy village used to be. I am going to attempt to explain how villages like this, which are virtual because of the computer technology that supports them, are in fact real in terms of the knowledge that is exchanged through them.

There is a considerable factor of scale separating these two types of external memory. Nevertheless, human cognitive capacity is still just as limited. Access to the external memory was frequently better in the ancestral village, because the men and women who held it were available. Without prompting they might even suggest solutions that made it unnecessary to launch complex searches. The people living in the village had learnt to make tools for cognitive searches in order to explore and exploit their external memories. We shall call these tools cognitive maps that allow an articulation of information

exchanges between searchers and holders of knowledge. Nowadays, with the use of the new information and communication technologies, new kinds of cognitive maps are emerging. In the ancestral village getting access to useful information and acquiring cognitive maps were facilitated by the older people, those who had knowledge and knew how the system worked. In today's virtual villages processes for managing access to relevant information are available, even though they need to be improved. These processes consist, for example, of search engines or portals.

The new information and communication technologies have introduced external memories whose medium is hypertext. Hypertext technology was developed from a cognitive model of connectivity based to a large extent on the notion of extending human cognitive capacities, particularly associative memory. Systematization of these external memories has given rise to new possibilities of access to information and in particular has focused on the idea of traceability. This systematization has meant we have been able to start with a clean slate as regards the semantic and pragmatic relationships in the resulting human and machine associative memories. Human beings still depend just as much on external support to access the information they need and eventually solve their problems. I shall introduce the notion of cognitive support in order to back up the use of hypertext in a known and reassuring world.

Modern technological media for external memories must take account of the notion of context. In particular, when the indexing of the knowledge stored is contextualized, it offers users not only more relevant and faster search processes, but also increased assistance with comprehension. Knowledge contextualization is an iterative process that modern technologies make it possible to take into account. I shall give an example of this. In contextualizing we augment the knowledge already available with indications, connections, comments that increase its relevance. And so knowledge is continually being reconstructed. By annotating it, adding opinions, knowledge becomes both more particular and more general. Gradually categories emerge, or they disappear because they are no longer of interest and become obsolete. Artificial intelligence has introduced representations that mean that knowledge can be stored and categorized in a particular way. Use of this formalized knowledge has uncovered the notion of cognitive function extended to machines. Today study of the congruence between human cognitive functions and those of machines is a central question. These cognitive functions are gradually being co-constructed by people, organizations and the technological world. The causal relationships between these functions can only be built up through action and interaction.

Use of the new information and communication technologies has given rise to a dispute between the supporters of direct manipulation and those who favour software agents. In order to understand this dispute correctly we must distinguish between interaction and task. The first point of view favours human-machine interfaces that facilitate interaction, leaving control of the task to the machine's user. The most user-friendly interfaces comprise highly automated instructions for using the machine. The second viewpoint advocates modular programs that help the user perform the task; an information search task, for example. The corresponding interfaces are called deep and consist of highly automated operational procedures supporting the performance of the task. When the machine is intended to connect a user to an external memory, both solutions can be considered in parallel. These technologies offer a new method of achieving connectivity. The connectivity particular to traditional communities was well established and

responded to well integrated uses. Stress was laid as much on user-friendliness as on assistance with carrying out the task. Today's communities and their practices are building new communication codes in both space and time, and between both human and machine agents.

Hypertext: a cognitive model of connectivity. A bit of history

The term hypertext is associated with the expression 'hyperbolic space', which was coined in the eighteenth century and popularised in the nineteenth by the mathematician F. Klein. He used the word *hyperspace* to describe a multi-dimensional geometry. Human mental processes were modelled on these multi-dimensional spaces. In 1945 Vannevar Bush, who was scientific adviser to President Roosevelt, thought up a novel method of organizing and recovering information. This new approach resulted in a machine called *Memex*. The basic idea was to let someone loose in a library to make associative links from any reference in the library. Douglas Engelbart was the first researcher to be influenced by Bush's ideas. His early work at NASA, then at the Stanford Research Institute (SRI), was on the subject of expanding human intellect. In order to navigate quickly around a system with an enhanced intelligence Engelbart invented the mouse as a tool for pointing.

In the early 60s Engelbart and his colleagues designed and developed the *oN-Line System* (NLS), which was presented in public at the ACM[1] conference in 1968. In its initial form it was used as: a filing system for memos, research notes and general documents; a communications network when teleconferencing became possible; a shared work space in which researchers could plan and design projects. In 1963 Engelbart used to say that NLS was 'a good means of intercommunication through consoles'. NLS was a forerunner of IT and email systems. It was renamed *Augment* when Engelbart was with McDonnell-Douglas in the 70s. We should mention that the *computer-assisted cooperative work systems* that are talked about today were introduced by Engelbart. More recently he has launched a cooperative work project at Stanford University with the title *bootstrapping* project. It involves developing an open system of hyperdocuments in order to optimize the capacities of organizations, so that they may become genuinely social organisms in the biological and evolutionary sense. In 1968 Engelbart and English pointed out that users were satisfied with NLS even though it was a commercial failure. It is true that this type of technology was not particularly well suited to the computers of the 60s. Nowadays hypertext is a technology that is used on a daily basis via the Internet. Computers are far more powerful and have graphics processing capabilities that cannot possibly be compared with what existed at that time.

Associative memory

Ross Quillian started out from the principle that the human brain works by association. He thought that semantic memory was nothing but a collection of nodes interconnected by various kinds of associative links. It was the activation of a relevant group of links

that gave meaning to a piece of information stored in a node of the network. The sentence 'the grey bird is in the tree' gives meaning to the node 'bird' by activating the 'colour' and 'place' links. Semantic networks have been used a lot in artificial intelligence to represent declarative factual knowledge. For example, a library catalogue can be represented by a semantic network. It gives a structured external representation of the books. Usually it is possible to access it through of a collection of keywords.

The pieces of information we store in our long-term memory are associated with one another via contextual relationships, which means that they are set up in a given context. We associate the date we met a certain person with the date of a general election, for instance. By thinking of one we get to the other. When certain bits of information are made explicit, they are linked with each other to recreate an external associative memory. Similarly when we can have access to a piece of information, we can also get at those that are linked to it. These are called hypertextual links. A hypertext system can be described as a system comprising a database that is a network of textual or graphic nodes and screen windows that correspond bi-unilaterally to the nodes of a database of links between these nodes. This database of hypertextual links is an oriented graph. We should note that few nodes are on the screen simultaneously. Since the early 90s hypertext has been networked and created the famous World Wide Web. External memory now extends over the whole of our planet.

Traceability

Hypertext is a suitable medium for preserving pathways through a set of documents. These pathways can be recovered when necessary, for example to explain viewpoints, decisions or actions. The development of industrial processes over the last twenty years has been so rapid that the ability to go back easily to a design decision, for instance, has become a major problem. European workers used to stay in the same company from the day they started work till they retired. Nowadays they move around. They change departments more readily, they also move companies and even countries, with developments in Europe. Preserving technical and organizational know-how creates new problems because change is very swift in both time and space.

So it not surprising that the world of research should react to this expansion in the number of technological interfaces and the emergence of new practices. This reaction is associated with a need to preserve know-how just as a biological organism conserves its internal state. Since it is impossible to be sure of retaining employees, as used to be the case, the company or organization adapts by recording its own knowledge and know-how on appropriate media. The media for recording may be of many types, but the increased use of computers encourages people to opt for software records. Computers, and especially computer networks, have opened up new possibilities, leading to reorganization of the content itself, access to it and links within the content. Hypertext allows us to trace knowledge stored on a computer via an indexing system that is sufficiently well-informed about the context to let a user recover a piece of information and above all understand it.

The Concorde was designed in the 1960s. Of course there is a mass of documentation about its design. However it turns out that the information in this documentation is

inadequate. It is frequently necessary to go back to the designers themselves to resolve certain misunderstandings, ambiguities and apparent lack of coherence. Unfortunately not many of the original designers are available today to explain the context of the choices that were made. The history of a design is an extremely rich repository of knowledge that can make one aware of a situation and suggest certain courses of action. It is clearly vital to have it available. But it has to be sufficiently alive (contextualized) to be usable and useful. Its adaptability to current contexts is crucial.

Knowledge must be correctly indexed in order to be properly understood. Indexing is expanding the initial knowledge by teasing out certain intrinsic concepts, which we shall call *semantic descriptors*, and certain extrinsic concepts related to the use of the knowledge, which we shall call *pragmatic descriptors*. In practice semantic descriptors are represented by keywords, and pragmatic descriptors by attributes of the external physical and social context. The former have to arise from the meaning of the knowledge stored. The latter may be built up gradually while discovering various aspects of the usefulness or usability of the knowledge stored. In progressively improving the knowledge stored, both by analysing it (producing semantic descriptors) and by using it (producing pragmatic descriptors), it is possible to get to a true living memory. It is necessary to construct a network of relationships between the descriptors and the knowledge they refer to. We shall call these pieces of information indexed by descriptors *referents*. In hypertext terminology a relationship between a descriptor, or a group of descriptors, and a referent is called a *link*.

Cognitive support and contextualization

The notion of support has been much studied in physics. When an object is placed on a flat surface, this object gets support from the principle of equilibrium between the action of the object (created by the force of gravity) and the reaction of flat surface. The skier who picks out a path over the snow looks for supports in order to stay balanced and negotiate a bend. In this case the supports sought are chosen dynamically, first because the skis slide over the snow and secondly because the character of the snow changes with the terrain.

Just like the skier looking out for physical supports, the user of a system that has a high cognitive component looks for cognitive supports. We shall call keeping a balance in the human-machine interaction cognitive support. On the user's side this balance is expressed in an appropriate awareness of the situation. In particular the machine should send back the information required in order to apprehend and understand the situation correctly. In today's aircraft there are alarm systems that give pilots the warnings they need to make them aware of imminent danger. Alarms that tell them they are close to the ground, for example, are electronic systems that provide pilots with cognitive support.

With the notion of cognitive support we go from a physical three-dimensional world (physical support that is concrete or simulated) to a world with n dimensions that are characterized by semantic and pragmatic descriptors. The user moves around in this hyperspace by following directions that correspond to combinations of descriptors. The cognitive support will be all the more firm the more closely these combinations correspond to the user's requirements. Expert users learn to combine appropriately descriptors

whose use they have become familiar with in context. Frequent and repeated use of certain combinations of descriptors leads to the invention of super-descriptors.

Metaphors and intermediaries in a familiar, reassuring world

An interface between any individual and an external memory is of necessity based on a conceptual model. This model may in some cases be approached through a metaphor suggesting an appropriate interaction. The metaphor is not defined by a process of deduction from axioms, but rather by analysis of the language acts between user and external memory. For instance, the kind of conversation that takes place between an individual and the librarian is often full of metaphors to enable one to explain to the other on one hand what they are looking for and on the other how the library is organized and what it may contain of relevance.

Navigating an intranet, that is, a computerized network of documents spread over several computers within an organization, can become quite complex. Helping beginners to find their way about can be greatly facilitated by the use of a global metaphor for this intranet. It may be the metaphor of the post that delivers mail, or a library with its librarian, called the 'Webmaster' in this case. It may be the metaphor of the videophone with its answering machine, or the electronic book with its semantic depth through links whose material connectivity we are unaware of. It may be the metaphor of a window open on to the world, a sort of interactive television.

Aggregating the combinations of semantic descriptors leads to the use of metaphors by synthesizing meaning. For some designers the use of metaphors has become necessary in order to ensure adequate cognitive support when users move around in a hyperspace of electronic documents, particularly the Internet. They tend to become disoriented. Hypertext users need signposts and some reference to a familiar world. Certain metaphors have their uses. In general I would not advise the use of metaphors that are too vague except in order to learn to use a new system or if the metaphor captures all the attributes of the conceptual model of the relevant interaction.

The Internet is one of the most powerful technologies of the early years of the twenty-first century. It has brought interactive computing within the reach of everyone in the world. However its interactivity is rather poor. The future of informatics is going to be in smaller cheaper computers. Their shapes and sizes will vary according to need. So people will be able to interact with electronic media linked to the task to be carried out in a number of different situations.

Rationalization and cognitive functions

Today the problem of external memories has become sufficiently pressing to require rationalizing. In the 1980s a kind of artificial intelligence was developed that was founded on so-called knowledge-based systems and more specifically expert systems. Alongside this methods and tools were developed for acquiring knowledge and making it explicit based on experts in a field. Bryan Gaines and the Banff school had a big part to play in this scientific and technical field. The aim was to rationalize expert knowledge

in order to make it operational within computerized databases. Usually rationalization is achieved by using representations of information which are standardized in the form of IF-THEN rules, scripts, frames, outlines or more or less complex objects. At that time taking account of the context was not a prime concern. It was sometimes even the case that it was explicitly decided to choose representations that were not associated with any context. The most general information possible was what was looked for. Generalization was one of chief concerns in machine learning. As a member of that community involved in artificial intelligence, I gradually came to realize that the notion of context and specialization of knowledge was in actual fact a vital one as far as expertise was concerned. Indeed specialization and generalization are processes that are closely linked. One specializes and generalizes in equal measure to become more efficient, becoming both expert and researcher. Bit by bit experts build up know-how, skills or capacities relevant to the specialization. Gradually researchers piece together knowledge or information that fits with generalizations. The great question is in the universality of the know-how and the knowledge. Sometimes know-how can be more 'universal' than a body of knowledge. I used this insight to develop the idea of cognitive function as an entity that has a defined role in a certain context and uses a collection of resources. Some resources can themselves be cognitive functions. An agent has a finite group of cognitive functions it has built up as needed. Some cognitive functions may use cognitive functions possessed by other agents. Thus a cognitive function is a network of cognitive functions distributed among several agents. These agents may be humans or machines.

The notion of cognitive function acts as a support for and extends that of external memory. A human being cannot live without cognitive support composed of appropriate cognitive functions, whether internal or external. Building up these internal and external cognitive functions takes place over time. Some of them adapt according to the behaviour and effectiveness of others, and vice versa. This reciprocal adaptation takes place on four dimensions:

- the dimension of internal cognitive functions, which corresponds to the learning, training and practice of a human being;
- the dimension of external cognitive functions, which corresponds to the environment needed to support the human being's activity;
- the dimension of the interaction between certain cognitive functions, which corresponds to the processes required so that the human can use the resources offered by the environment;
- the dimension of the emergence and development of certain cognitive functions, which corresponds to the reciprocal adaptation of human and environment.

It is common to hear it said that external memories are composed of documents. Libraries are external memories. Documents are the intermediaries, or interfaces, between the people who think them up and produce them and those who use them. The ideal would be for the people who have generated the documents to be present in order to be able to use these documents to explain the messages and concepts they have expressed in them. It is normally the document's user who makes the document's contents come (back) to life in order to understand and assimilate it. The main problem is that the cognitive

functions employed by the user are normally not the same as the ones used by the person who generated the document. Understanding what the author put in the document remains a crucial problem.

Contextualization of documents

We have already seen that context is crucial for the traceabilility (search and understanding) of a piece of information, and may be given concrete shape in the form of annotations. Annotations are not generated all at the same time. It is easier, and above all more appropriate and efficient, to generate them whenever the information is recovered. This is the best time to give an opinion, assessment or comment on the information in the context of the concern at that moment. The approach to generating contextual annotations is of necessity linked to events. The next problem is dealing with the resulting episodic memory. In the system called Computer Integrated Documentation (CID) developed at NASA we designed a categorization algorithm based on an original idea of Douglas Fisher's, *concept clustering*. It involves progressively managing clusters of contextual forms, that is, combinations of pragmatic descriptors, as annotations are being generated. This process is exactly the same as classifying index-cards into categories. Four scenarios are usually possible: 1) the current annotation is included in an existing cluster (contextual forms) and so it is appropriate to classify in that cluster; 2) the current annotation does not fit into any existing cluster in the database and so it is appropriate to set up a new cluster; 3) the current annotation makes it clear that two existing clusters can be merged and so it is appropriate to merge those two clusters to form a new cluster; 4) the current annotation makes it clear that an existing cluster can be divided into two or several clusters and so it is appropriate to divide up that cluster in a relevant way. For example, when interest in a document is shared among several people of the same type, it is appropriate to create a cluster for the type of user of this document. If a new user belonging to this type has no interest in this document, it is probably because the cluster that was originally defined needs to be rethought and two clusters created.

Only the experts in a field manage to draw up exhaustive categories of contexts of use for documents in that field. Experience is a guide to contextualization. Electronic management of external memories is extremely useful because the experience of all those who provide contextual annotations can be shared and classified bit by bit. In CID we accumulated both positive and negative annotations. When users of the CID system were satisfied with what they found, they might express a positive opinion. In this case the system would collect and adapt a contextual form associated with the link between/with? the request (the semantic search descriptor each of them had used) to access the information. Next time the system was better informed about the response it should give to the user's request, provided the user gave certain characteristics of the context of the search, such as their personal reference, the current task or relevant temporal data, that is, pragmatic descriptors. When users of the CID system were not satisfied with what they found, they might express a negative view. In this case the system would record an exception on the relevant contextual form. Then the system was able to manage the exceptions: 'I give this information unless . . .' The CID contextualization process is an example of the gradual allocation of cognitive functions to a computer. The further the

contextualization of documents from a field moves on, the more orientation and navigation within the document bank can be guided.

Raw data and interpretation

Analysis of flight recorders from aircraft is an exercise that requires a lot of causal information. The progress over time of certain flight parameters, as well as voices from the cockpit, are available from recorders of different data. These recordings supply several groups of 'points' that analysts use to 'adjust' causal models that were constructed in prior analyses. Although these models may guide investigations, adjusting them using data from recorders is vital. It is the completeness of these data and the causal relationships from the models used for the analysis that ensure the success of the investigation.

The raw data contained in the plane's black boxes make up an external memory that then needs to be interpreted. In every case any information from an external memory has to be unpacked. Interpretation may be left to the user of this external memory or to external agents, which may be human or artificial. Knowledge management, which is so much in vogue today, has become a burning question for our society, where information occupies a large place. In many areas we have developed automata that increase our processing capacity. This delegation of processing, and increasingly dependence, has given rise to new problems such as *situation awareness* of the purposes for which information is being processed.

The mutual influence of human, organizational and technological development

Humans, organizations and technologies have always adapted to each other. This reciprocal adaptation is always guided by dominant models. In the field of information processing, the 1960s and 1970s were dominated by processing of numerical data. Models of mathematical classification were developed. They were based essentially on numerical and statistical approaches. In the 1980s symbolic processing came on the scene. Expert systems based essentially on IF-THEN rules, or knowledge-based systems, were developed to assist decision-making. The 1990s saw the development of interactive technologies and cooperation. The Web gradually proved itself as a tool for preserving knowledge and for e-commerce.

New questions are emerging, such as the credibility of the information we can now access very easily. The problem of the validation of accessible information and knowledge has become a crucial one. Industrial espionage is no longer simply a problem of protecting an organization's knowledge base. It is also a problem of too-ready belief in the bogus information produced by other organizations. How should we deal with this? The skills and knowledge of certain players are vital. Experts have become increasingly scarce gurus who are very highly paid. We are also realizing that their knowledge is time limited. Experts need to recycle themselves quite often to remain up to date.

Information and communication technologies are evolving at a faster and faster rate. Turnover within organizations is accelerating. The external memories of industrial companies are becoming more unstable and ephemeral. Working practices change very fast.

The need to capitalize on knowledge has become essential. The need for knowledge is not so much a matter of forgetting. Retrieval of knowledge is definitely a very useful and beneficial activity, but the main problem of the present era is the speed at which technologies evolve and new practices emerge. We must keep up! The most dismaying thing is that organizations too find it hard to keep up, simply because they are continually reorganizing. The result is permanent instability, where people have to modify their behaviour. Reorganizations tend to show up the existence of different cultures, which have to search continually for a new stability and do it quickly in order to maintain an acceptable level of efficiency.

From the ancestral family to the ad hoc team

In the Quercy family of my childhood three, sometimes four, generations lived together under the same roof. I remember the grandfather spinning yarns about his life for his grandchildren. The family memory's time window was very wide. It is true that the range of the knowledge passed on by word of mouth might be thought narrow nowadays, but it was extremely deep. People used to take time to explain and let a solution mature. In my current work the time window of the organizations I deal with is becoming narrower and narrower due to problems created by rapid development, because of the need for instant profitability. The range of knowledge is wider, but depth of knowledge is shared by only a few individuals. Ad hoc teams are created to solve difficult problems and find solutions as fast as possible.

Knowledge and know-how in the ancestral family were transmitted almost entirely orally and illustrated by action. In comparison members of the ad hoc team were not all trained in the same tradition. They do not have the same culture or language. They may very well not know each other. Sometimes they spend the whole time they are working together trying to understand each other. The team needs physical support such as a logbook, documentary references, or written messages. Is it because the technology is available and in vogue, or because organizations today need this technological support? As we have seen, there is reciprocal adaptation going on.

IT and email help external memories develop

A recent study carried out by EURISCO in a manufacturing company showed up three important aspects of technical documentation. 1) Technical writing skill is not a foregone conclusion. It should be taught and reinforced within design teams. 2) It should be accepted that transparency is a relative concept. There is public information and private information. This dichotomy must be respected. There is still work to be done on this in the legal area. 3) The maturity of a piece of information should be indicated. Before it is made public its level of maturity must be ascertained. Decisions about the maturity of a piece of information often have to go through an evaluation process involving relevant individuals.

Electronic word-processing tools have altered radically the way work in businesses is organized. Secretaries typing reports or technical notes have vanished. Engineers write

technical documents themselves. Documents are no longer generated in the same way. The *cut-and-paste* function has revolutionized document design and production. People who generate documents often use already published documents and work by analogy. They have their own external memories in the form of technical notes, standard letters, progress reports and other documents that are already on file.

Oral communication is the most natural medium for exchanging information and knowledge within an organization. It is also the simplest and frequently the most efficient, especially as things do not have to be formalized to be passed on orally. People manage subjective opinions more effectively and reliably. In addition direct interaction between human beings tends to generate new ideas that were not expected at the outset and may turn out to be extremely effective and creative. All these plus points are obvious in the short term, but they fade away in the long term. Indeed the people involved may no longer be available. If they are, they may forget. If they remember, we need to be sure that their memories are accurate. The big drawback to oral communication is that it is insubstantial. Once a piece of information has been passed on it may be forgotten forever by a community unless it is documented at the time.

Nowadays email transmits in writing much of this oral communication. It is gradually replacing the telephone. It is less intrusive because it works asynchronically; people do not need to reply immediately. It also means a message can be sent to many people at the same time. It provides a semi-formal context for expressing oneself, exchanging ideas, asking for information and answering. Informal email conversations can be preserved. Because of this the ambiguity between 'pseudo-oral' informal conversation and text (which introduces a certain formality) may cause malfunctioning. Some negative side-effects have been recorded, particularly with regard to the maturity of the information transmitted. On the other hand preserving snatches of communication provides an excellent contextualized medium for subsequent traceability.

Conclusion and prospects

The external memories of the Quercy folk of my childhood were quite local. Their space-time windows were limited in scope, but because of that they were deep. Those communities did not know, or did not know much, about the history of France. Michel Serres has already illustrated this idea: 'The villagers and tenant-farmers of my childhood, in Quercy or mid-Garonne, had never had a role in history, so they did not try to understand it because they had no interest in it, or else they only came across it through conscription and military service . . .' The central question is indeed the interest we have in the information and knowledge held by our external memories. They exist only because of our interest in them. An external memory is built up within a community. And in fact it finds it hard to survive in any living sense when that community disappears. Scientists, for example, gather together and acknowledge one another within a community. They invent jargons and a spirit that are difficult to break into for someone coming from outside. In the end it would be better to refer to 'a community's internal memory'.

The late twentieth century saw the emergence of centres of multi-disciplinarity more or less worldwide. For instance the merging of several very different disciplines gave birth to the cognitive sciences. Today scientists in this new field are kept busy trying to

understand each other. Access to the external memories is difficult for the uninitiated. With an initial training as an engineer I started to make my way professionally in a field that was not very open to the soft sciences. The path was and still is very hard. When you are working at the boundary between several scientific communities, it is a bit like being stateless. You cannot take advantage of relevant communities' benefits if you do not have the right passport. As well as being on the fringe of these discrete scientific communities, research on external memories is situated on the border between research and industry, between science and oily rags.

To conclude I shall take the example of systems design. Complex systems, such as aircraft for instance, are designed in a studio. Contrary to expectation, the length of time taken up by the process of designing a commercial aircraft has not changed for decades. What has changed is the pattern of interactions between the people involved in the design process. In the past the organization's stability meant that ideas and concepts used to have time to take shape, because people knew each other. They were in cooperation mode through mutual understanding. Often they stayed in the same company all their working lives. That is why concepts had more chance to come to maturity before the machine hit the metal, as my father used to say. Today economic constraints have cut times right down. The paradox is that the overall time is still the same, because other monitoring and service processes have been created to coordinate people who are working much more in parallel. Colleagues no longer know one another very well because turnover is quite high. People change companies more readily. And so preserving the company's memory becomes a major problem. For this reason it has become vital to have a medium for cooperation. As we have seen, documentation of the design process and the solutions arrived at is today a big issue. Furthermore the quality of the technical documentation is a factor in the quality of the design. Normally we write for potential readers, just as we design for potential users. We know that the documents we write will be read again by several people before they are disseminated to the outside world. Equally we know that artefacts will be tested by several people before they are distributed to the outside world. The reader of a multimedia document has become the user of a software application. From this point of view reading is developing into a human-computer interaction. Writing is also evolving towards the design of interactive software. 'Thinking means writing and writing means thinking.' Writing words, sentences, paragraphs and chapters turns into thinking up objects and software agents. Static paper documents are evolving into (inter)active documents. The active part of a book (or a system) is the reader (or user). Furthermore, the organization of the book (or system), the way the sentences (objects) are written (designed), the style and vocabulary used suggest a certain kind of activity to the reader (user). Sometimes the reader (user) finds it hard to understand what the author (designer) wanted to express (represent). Instead of mobilizing the reader's (user's) cognitive processes around problems of interaction, the largest portion of the reader's (user's) cognitive activity should be focused on understanding and interpreting the (active) document's contents.

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Note

1. Association for Computing Machinery.