Intimate Computing and the Memory Prosthesis: A Challenge for Computer Systems Research?

(Abstract)

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At EuroPARC we are trying to build a human *memory prosthesis* — a portable device to help individuals remember things. It will automatically capture and organise predefined classes of information and provide easy ways to recall it when needed, perhaps without even being asked. We call this device a memory prosthesis because it augments normal human memory. It differs from most other information systems in that it focuses on helping the user recall things *they once knew*. Our objective for the memory prosthesis is to assist users with everyday memory problems. Target tasks for the memory aid include: recalling names of people, places, and procedures, finding files, papers and notes, in whatever medium they are expressed, and remembering to perform tasks.

The memory prosthesis is an example of a new class of interactive system we envisage will be made possible by forthcoming advances in micro-electronics. Using cellular radio and infrared technology computers are able to communicate with each other without wires. This new development heralds the dawn of mobile computing. At present radio transceivers are large and power hungry, so much so that the machines to which the transceivers are attached are fairly large. We are looking a short while into the future when mobile computers will be somewhat smaller, indeed small enough to be worn rather than carried — perhaps resembling a watch or piece of jewellery. We look to a time when people don't have to remember to take their computer with them, they *wear* it and take it everywhere.

Such systems will have several fundamental capabilities not previously available on such a wide scale. They will dynamically connect and communicate, not only with each other, but with office equipment, domestic appliances and much of the other business and consumer electronic equipment that surrounds us.

The wireless communication technology used by these systems will be cellular — perhaps based upon the new digital cellular telephone standards. The low-power requirements of a tiny wearable computer will limit the range to a few meters and so communication cells will be small. The consequence of relying on small cells for communication is simple yet profound, mobile computers will know where they are. To find out their location they simply ask the nearest non-mobile object.

So to summarise: computers will be small enough to wear and take everywhere; they will be embedded in domestic appliances, office and consumer equipment; they will talk to each other using cellular wireless communications; and they will know where they are.

Taken together these facilities provide us with another view of mobile computing. Popular views of mobile computing regard it as a tool providing access to information and computation whilst the owner is away from his or her desk. We view it the other way round. Our computers can now gain continuous access to *us* and our immediate environment, wherever we are. In consequence, our personal computer will be able to find out much more about us, and like any other personal assistant, the more it knows the more useful it can be. To distinguish this style of system from *personal computing*, we have coined a new phrase: *intimate computing.*

Carrying a computer around *everywhere* offers almost limitless opportunities to capture useful information. Wherever we go, whatever we do, our tiny computer can *automatically* liaise with the equipment we use to do our work, with the portable computers belonging to the people we meet, and with the devices embedded in the building where we work, to construct a detailed personal cross-reference to much of the information with which we come into contact. Indeed, one of the most likely down-sides for intimate computing is the ease with which we may drown in the incoming tide of unstructured data — *unless it is filtered and organised automatically too.*

Most personal information systems, paper-based or computer-based, require some help from the user to construct a useful database. Typically the *user* has to recognise that an item of information might be required in the future; he or she must then make the effort to *capture* it; and lastly, and perhaps most importantly, he or she has to *organise* the information in a manner that makes it easy to find it again. But to do this, the user must be able to predict the situation in which the information will be needed and think up some indexing terms which he or she guesses might plausibly spring to mind the next time the information is sought. A common problem is to guess incorrectly! For example, Mary may choose to file a useful journal article by author or title, yet subsequently only manage to recall that it was the one her boss gave to her.

This example highlights a well established feature of the human memory system — people are particularly good at recalling activities from their own lives. Psychologists call this mechanism *episodic* or *autobiographical memory.* Experiments have shown that humans are not particularly good at remembering the *time* of an episode in their life, but they are much better at remembering *where* the episode occurred, *who* they were with, or *what* they were doing. We call this the *context.*

On the other hand, computers are excellent at recording the *exact* time an item of information was created, stored, communicated or processed in some way. For example, if Mary chooses to write a note about the journal article on her portable computer, the computer will almost certainly timestamp the note for her. In fact almost every computer transaction is timestamped in some way already. Electronic files are timestamped, telephone call-times are recorded for billing, faxes have the arrival time printed on them, and even each frame of a video sequence contains a time code. Moreover, computers are very good at searching through large bodies of data for items with a particular

timestamp. So if we can give a computer system an exact timestamp it won't take very long to find all the items that are tagged with the same date and time. Yet as we have stressed already, context is fairly easy for humans to remember while exact timestamps are not. If only the context that gave rise to an item of useful information could be used by the computer to find the same item later on...

Previous work at EuroPARC has shown how this might be achieved with mobile technology. For example, Newman and his colleagues have demonstrated a technique called *episode recognition* [2]. Location data obtained from Active Badges can be used to construct automatically, a diary of an individual's life expressed in terms of their location and encounters with other members of staff and visitors. Experiments have shown that these chronicles are a powerful aid to recall, and can be used both to index, and retrieve other less memorable data collected automatically at about the same time. As a result it has been suggested that a more comprehensive diary containing richer descriptions of the user's activities might provide a useful indexing mechanism for navigating through a huge database of personal information [1]. We now believe it is possible to design a computer system in which imprecise informal yet personal memories we have for past events can be used as keys to recover detailed information about the event itself.

Clearly our primary motivation for building this system is to provide more effective support for human memory. But in doing so, we are encountering all sorts of technical problems for which we have no convenient solution. Nevertheless, our programme of work proceeds in anticipation of acceptable solutions becoming available shortly. By trying to build this demanding application we hope to create another small focus for research in computer science and engineering and highlight some of the technical challenges that lie ahead for all of us.

References

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[2] Newman, W., Eldridge, M., & Lamming, M. (1991). *Pepys: Generating Autobiographies by Automatic Tracking.* In Proceedings of the second European conference on computer supported cooperative work. Amsterdam.