“The Disappearing Computer 2”

A new proactive research initiative
from IST – Future and Emerging Technologies

PRESENTATION OF THE INITIATIVE
draft working document

1. Introduction

The purpose of this document is to provide some guidelines to potential proposers interested in submitting proposals for projects in the IST-FET proactive research initiative “The Disappearing Computer 2”, open in the IST-FP6 1st Call for Proposals (17 December 2002 to 24 April 2003) (http://fp6.cordis.lu/fp6/call_details.cfm?CALL_ID=1).

For more information on the FET proactive initiatives, see http://www.cordis.lu/ist/fetint-p.htm .

2. Background and Scope

The mission statement of the disappearing computer FET initiative (initially launched in 1999, see http://www.cordis.lu/ist/fetdc.htm) is to see how information technology can be diffused into everyday objects and settings, and to see how this can lead to new ways of supporting and enhancing people’s lives that go above and beyond what is possible with the computer today.

Under this initiative, a number of research projects have investigated how to make ‘information artefacts’ based on new software and hardware architectures integrated into everyday objects. They have researched how collections of artefacts can act together, so as to produce new functionality. They have also considered approaches for designing for collections of artefacts in everyday settings, and how to support people’s experience in these new environments.

Having the same overall mission as the original initiative, Disappearing Computer 2, aims to give a particular thrust to the work done to date – it aims to define and develop the core architectures and frameworks for future *Ambient Systems*.

By Ambient Systems, we mean IT systems intimately integrated with everyday environments and supporting people in their activities. These are likely to be quite different to those of current computer systems, and will have to be based on radically new architectures comprising an unbounded set of “building blocks” – where these blocks may be embedded in everyday objects, be it stand-alone objects or software entities.

In order to meaningfully bridge the conceptual distance between “people interacting with Ambient Systems” and the “design of the building blocks of Ambient Systems”, the research effort should span the entire spectrum ranging from scenarios of use through to architectural design. Scenario work should provide realistic contexts of use and interaction, inspired by observations of people and their activities. Ideally, these need to be diverse enough to ensure that the architectures could become “universally” applicable. It is expected that work on the development of architectures should be done in conjunction with building research prototypes where the architecture is evaluated against the scenarios applied in a diversity of real-world settings.

The aim of this initiative is thus to investigate, define and develop the core architectures and underlying frameworks for such ambient systems.

It is envisaged that in the longer term, work on the disappearing computer 2 should lay the foundations for the development of a new range of guidelines and standards that would underpin the future development of Ambient Systems.

3. Ambient Systems will require new supporting frameworks and architectures

Applications of a future ambient computing and networking world will be based on dynamic compositions of numbers of heterogeneous devices and spontaneously allocated resources. Such applications may either be designed a priori for a particular purpose, or may interactively emerge from opportunities in the current setting. For example, unexpected combinations of devices may give rise to new functionalities and interactive behaviours that are neither pre-programmed nor foreseeable.

In the future, Ambient Systems may scale to integrate dozens of devices per house or thousands of devices per building or in a town square. Applications will be supported by many more software entities per device, and very large numbers of devices and software entities will compete for a range of resources such as computing cycles, communication bandwidth, storage, and in particular human attention and energy.

An Ambient System operating in such complex and competitive settings will have to orchestrate devices and entities to support and enhance everyday human activities. To achieve this, systems have to be so designed as to support a range of human activities, and be intimately inter-twined with physical settings, consisting of spaces, places and everyday objects as books, pens, chairs and materials.

Although there has been a range of instances of prototype systems that have been built (such as in disappearing computer 1, http://www.cordis.lu/ist/fetdc.htm), there is little commonality across them and there are still very few support tools to help in the development of particular systems. Moreover, there is no consensus on a set of underlying frameworks and architectures that in the future would enable a range of applications to be built in a range of different settings.

Clearly, the development of architectures and supporting frameworks is at the core of this initiative. This work however, should be grounded in reality, and should be done in conjunction with the practical aspects of designing and building Ambient Systems: studying people's behavioural patterns; building software and hardware prototypes; evaluating these with people in real-world settings, etc. Thus it is expected that the development of architectures and frameworks be done in parallel to practical implementations and experiments.

Architectures should strive to encapsulate underlying "universal" principles and concepts, so that Ambient System designs can be applied to a very broad range of settings rather than a few isolated cases. These settings will be extremely diverse (e.g. in their nature or physical extent) and architectures should accommodate and foster this "plurality".

4. Beyond current architectures

Ambient Systems fundamentally challenge accepted approaches to developing computing, networking and interaction environments. Consider, for example, the following observations:

1. Ambient Systems are designed to become one with physical settings in which they operate – thus challenging the tenet of location transparency.
2. Ambient Systems cannot make assumptions about the supporting infrastructure in its dynamically changing physical settings – thus challenging the end-to-end principle.

3. Ambient Systems must deal with devices that may be purposefully designed to operate with limited resources (power, memory, etc.) – thus challenging the expectation that everything will be always online and consistently responsive.
4. Ambient Systems will integrate devices and entities in unexpected configurations which may lead to interference at the logical as well as the physical level – thus placing the requirement that they anticipate and resolve these conflicts.

To be able to meet these and other challenges, Ambient Systems require a radical rethink of the underlying assumptions of systems architectures. In particular, composition, interoperability, scalability and stability are critical aspects of these architectures, making it essential that they be studied in the context of their target environments.

5. The challenges to be addressed

One of the most important differences with ambient systems to both traditional and even advanced mobile architectures is that they will be intimately connected with their setting, beyond merely being sensitive to particular contexts. Devices that together form environments that support the concept of "**the real world being the interface**" will by definition have to take notions of space, situation and physical affordance into account. Concepts relevant to building design and representation of knowledge in physical spaces are likely to play an important role. In this sense, overall architectural design will include a variety of design domains, from system design and interaction design through to the knowledge of the design of buildings and places.

Ambient Systems will be based on an unbounded set of devices and software entities, embedded in everyday objects or "stand-alone". Not only will these systems have to scale to a large number of entities but also to a heterogeneous collection of them. The sheer number of entities that make up ambient systems implies that access to resources will be extremely competitive, and the resources in question most importantly include human attention and energy. Hence, Ambient Systems will have to embody adaptability on an entirely new scale. For example, communication will need to become adaptive to sustain high densities of devices, and computations may need to split and migrate to adapt to available energy and communication. Moreover, Ambient Systems will have to deal with all this autonomously, invisible to human users.

Related to these challenges are the problems of stability, scalability and complexity. Ambient Systems are characterised by constant and often unpredictable change. These architectures will have to support stable operation as well as evolution and expansion in the environment, giving applications fair access to public resources and providing frameworks in which privately owned resources can be securely shared. A major challenge will be to manage what applications and on whose behalf get access to resources, and for how long. For example, devices and applications will have to negotiate for stable provision of collective functionality.

Abstractions are needed for composition of ambient sitemaps. These will be concerned with definition of the "building blocks" of Ambient Systems, their syntax, and semantics, and how such building blocks can aggregate. Tools, languages, control mechanisms and ontologies will be essential to provide the supporting frameworks. However, as it will be impossible to define all the possible objects, parameters and meanings up-front, the important thing will be the ability to define and relate things at the right level of abstraction, and in an open and extensible way.

The abstractions need to cover many levels, to support autonomy, programming, and user involvement. Ambient systems are so complex that they must function proactively and largely autonomously, requiring abstractions for discovery and management of entities and resources. But, at the same time they have to provide abstractions and programming models to allow designers to construct new applications and interactive environments. Equally important, is the ability to allow people to shape their environments in everyday use.

Finally, the design of Ambient Systems will have to embrace notions that will respect human freedom and identity. Systems should be designed to empower and support people in their activities, but in ways that would not enable the control or manipulation of others. These considerations include a range of aspects from personal privacy thorough to “system trust”. From a research perspective, this places challenge of trying to embody such principles into the design of Ambient Systems at different levels.

6. Approach/Implementation (financing instruments and indicative budgets)

As described previously, it is expected that the core of the work would be on architectures and supporting frameworks. At the same time, surrounding this core activity there need to be a number of tasks on the development of scenarios, on observation of peoples everyday settings, on prototyping and on evaluation. To link all these aspects, it is expected that an iterative approach to work would be used, with work on the “core” and the “surrounding” tasks to be done simultaneously, each informing the other. Overall, the aim of the core would be to evolve towards a “universal” architectural specification i.e. one that offers the plurality of being able to be used as the backbone of constructing future applications in a diverse range of settings.

The initiative will only use the two new financing instruments, i.e. Integrated Projects (IPs) and Networks of Excellence (NoE) (see http://www.cordis.lu/ist/fetint-p.htm). It is expected that 2-3 Integrated Projects could be launched in total and possibly one Network of Excellence.

Integrated Projects would aim to develop all aspects of the work described: from architecture work through to scenario work. These IPs would be considered as competing alternatives or may end up being partially complementary. During the course of the work, each IP, with the assistance of the NoE, should develop cross-reference common benchmarks. They should thus include in their workplan provisions for joint collaborative work with the other IPs and NoE of this initiative. The aim is to develop commonly agreed sets of performance testing and evaluation benchmarks to be used at the end of the initiative, for making each an assessment of their relative merits.

The suggested organisation for an IP is that of a central core responsible for overall architectural design and implementation. Around that a number of surrounding tasks would carry out work in specific activities and diverse settings, such as scenario development and ethnography, in parallel with system specification and design, hardware and software development, benchmark definition for performance assessment, and, prototyping and performance evaluation. There would be a number of such specific tasks ensuring that the core architectural work can adapt to a range of situations and settings. Research dealing with architecture would be present in the core task and in the specific tasks. The main outcome of each IP should be seen as the core; the main demonstration of results is carried out by the specific tasks. The core will exist for the duration of the IP and the satellite tasks may come and go over the lifetime of the IP. Performance evaluation methods should include a measure of the degree of usability and universality.

What should be avoided is the approach of trying to design a “perfect universal architecture” that is developed for a number of years in the abstract and then implemented and “shown” to be applicable in a number of situations. Ideally a large number of alternatives should be developed first and these should be iterated on and selectively pruned or enlarged as work in the IP evolves.

Depending on the quality and nature of proposals and the available total budget for the initiative, an indicative EC financial support per project can be estimated to be in the order of **five to ten million Euro per IP** and in the order of **one to one million and a half Euro per year per NoE**.
