Demonstrating Coherent Interactions between Personal Mobile Devices and Situated Installations

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ABSTRACT
Mobile devices and situated installations have differing inherent advantages and limitations; coupling – the physical and computational combination – of personal mobile devices with situated installations allows designers to overcome these disadvantages and create interactional synergy. This paper presents a demonstration of a small macro-environment: three conceptually-linked installations to which visitors can couple their personal mobile phone and interact. We discuss two significant design issues – approaches to support the exploration of the macro-environment and the use of portable content - raised during the development of the demonstration. Finally we conclude the paper by outlining our first and future steps in developing a comprehensive guiding framework in this emerging domain.

Categories and Subject Descriptors
H.5.1 [**Information Interfaces and Presentation**]: Multimedia Information Systems—*Artificial, augmented, and virtual realities*; H.5.2 [**Information Interfaces and Presentation**]: User Interfaces—*Input devices and strategies*

General Terms
Design, Human Factors, Theory.

Keywords
Coupling, exploration, context-awareness, targeted advertising, personalisation, mobile devices, situated installations.

1. INTRODUCTION
Personal mobile computing devices – mobile phones, PMPs (personal media players) and PDAs – are *connectable* (both physically and computationally by hardware and software interfaces) and *identifiable* (among other devices by MAC, IP addresses and so on, and as digital representations of their owner). As such, users could navigate an environment (the 'macro-environment', such as a museum) populated by situated installations carrying their mobile device, travelling to and coupling their mobile to installations in order to personalise the services offered by the installation. In addition these mobile devices provide increasingly sophisticated computing capabilities, i.e. *dynamic data storage*, *input* and *output*. The personal mobile device also represents a familiar technology interface; many users will be intimately familiar with their mobile phone.

We can now envisage a scenario such as that illustrated in figure 1, based on the activities of a museum visitor. In this example, a visitor enters the museum (the "macro-environment") and arrives at a terminal (A) where they use the terminal's keyboard to enter their name, age, etc. and also physically couple their mobile to the terminal screen to act as a webcam in order to add a photograph to their registered profile. The visitor finishes their registration by decoupling their mobile from the terminal, and then walks over to a large map of the world, blank except for the outlines of continents and a number of glyphs pinned at various positions (B). The visitor photographs glyphs using their mobile which in turn reveal clues about the marked locations – in some cases this is an interesting fact, while a select few glyphs hide a flag which can be grabbed and held on the visitor's mobile. Once the visitor has explored a number of glyphs and grabbed one or more flags, they are notified that they can explore some of their findings in more detail at the next installation. They leave the map and walk to the final installation (C) where they find that they can create slideshows on a large projector screen based upon the locations from which they grabbed flags, and control the shows using their mobile as a remote control. While watching a slideshow the visitor can save particularly interesting slides to their mobile. The slideshow content is filtered based upon the registered profile of the visitor.

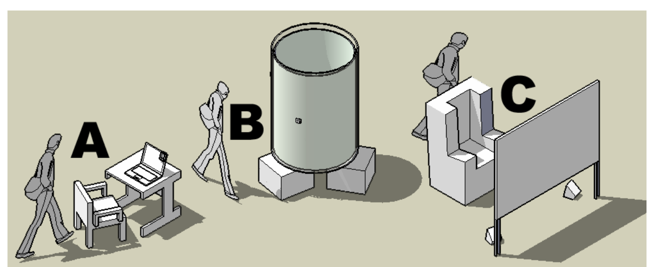

Figure 1. A coherent sequence of coupled interactions

Several key questions arise from a brief consideration of this example, including (but not limited to), "*how can users become aware of - and locate - situated installations? What interactions are afforded by coupling mobile device with installation and how does the user perceive these affordances?"* We began to explore theoretical approaches to map the design space (efforts which are discussed in the conclusion) while at the same time developed a small demonstration of situation similar to that in figure 1 in order to provoke and explore practical design issues.

2. INITIAL DEMONSTRATION
The prototype macro-environment and mobile client (installed on several mobile phones) have been designed in our lab to support two main activity states (inspired by Ullmer, Ishii and Jacob's [11] TUI interaction types, exploration and performance):

- *Macro-exploration* – the mobile device is a tool used to explore the environment to discover an installation; and
- *Coupled action* – the mobile and discovered installation combine to afford the visitor rich situated interactions.

With reference to figure 1, the two states can be identified essentially as the intermediate steps (macro-exploration) and the labeled (A, B, C) steps (coupled action) respectively.

2.1 Macro-exploration

2.1.1 Entry and visitor profiling

Upon entry to the macro-environment and initialisation of a mobile client by a visitor, a profiling dialogue takes place between the visitor's mobile client and a server application (the 'visitor monitor'). During this process, a profile for the visitor (consisting of three parts) is created and stored centrally:

- one *technical* part (what software/hardware components does their mobile include?), built automatically upon entry to the environment;
- one *personal* part (what are the visitor's demographics, interests, etc.?), empty until filled by the visitor at the first installation; and
- one part logging their *macro-exploration* (which installations have been visited and what content has been picked during those visits?), altered as the visitor's experience progressed.

2.1.2 Navigation

We hypothesised that in a rich environment visitors would require clues to fully understand where useful installations are and how they can be used, especially on entry to the environment. Traditional signs do not consider the context of individual visitors, e.g. different galleries in a museum have the same exhibit signs for each visitor, regardless of how interesting the different visitors might find those galleries. We suggest that the personal mobile device can take on the role of an *advertising proxy* for the different exhibits. By directing visitors through their mobiles, we can discriminate between different visitors and target adverts based on context. In practical terms, a visitor would receive a number of adverts for contextually suitable installations, choose one from among those adverts, then be guided to the corresponding installation. By being able to design rules defining who receives adverts under different conditions, the designer can not only ensure that the visitors are directed to valuable installations but also gain control over the flow of visitors in the environment. The portability of the mobile device enables 'the most suitable information to be delivered at any time and place'.

As such two questions needed to be addressed during the design of our demonstration: *when* should a visitor receive adverts and *what* adverts should they receive (i.e. what installation do they advertise)?

***When* should adverts be delivered?**

In response to this question we implemented two approaches. Adverts may be 'pushed' to the visitor by the environment unrequested (i.e. the visitor monitor triggers delivery of the advert(s)), and the visitor may 'pull' or demand suitable adverts at will. These actions are comparable respectively to the passive ('information sniffing') and active ('selection' and 'search') forms of spatial exploration for content proposed by Fröhlich et al. [3]. However, we apply Fröhlich et al.'s terms (in addition to the term 'dictation') to the act of spatial exploration for installations rather than content. The approaches to advert delivery are summarised in table 1, where they are shown in relation to an axis representing the balance of control between user and system.

Table 1. Advert delivery and balance of control

Push	Dictation	System control
	Sniffing	↑
Pull	Search	↓
	Selection	Visitor control

We investigated the supposition that a combination of the two approaches is necessary in order to provide the visitor with the most satisfactory experience. Adverts were *dictated* to visitors when they entered the environment and every time they decoupled from installations. If such a push (or a pull, as described later) results in the visitor monitor returning just one advert to the visitor, photo-follow directions to the relevant installation are triggered immediately and one coupling 'slot' at the installation is reserved for the visitor (so that there is still capacity for the visitor when they finally reach the installation). If more than one advert is returned, the adverts are presented to the visitor as choices; directions are triggered once the visitor confirms a choice. If any suitable installations are determined by the visitor monitor to be fully occupied, they are advertised (rather than hiding the installation from the visitor), but these adverts cannot activate directions.

Whenever choices of adverts are presented in this way, the visitor has time to rest; visitors can also choose to interrupt any directions that they are currently following (and release their reservation at that installation) and return to this resting state. Once at rest, the visitor can then pull an advert by *selecting* any installation that they discover by themselves (by scanning a barcode attached to the installation) or by *searching* for installations (instructing their mobile to pull a fresh set of adverts, updating their choices). Trials by Izadi et al. [7] suggest that the discovery of hidden information (installations in this case) by user-controlled exploration causes the user to engage more deeply with their discoveries, implying that the element of initiative inherent to these approaches, in contrast to dictation, is rewarding. The visitor can also focus their attention elsewhere and leave their mobile to *sniff* for fresh adverts pushed to it by the visitor monitor at regular intervals.

From preliminary trials we are beginning to find that allowing the visitor to rest is essential. Visits to a learning environment are much less beneficial if the visitors are not given time to reflect upon their experiences and discuss them with other visitors: it must always be remembered that visitors to museums, galleries, and so on often visit as part of a group and thus the experience is a social, typically organic one where restrictions on behaviour detract from the enjoyment of the visit. In addition, we do not suppose that macro-environments will contain only installations; they will often contain non-interactive exhibits that visitors may wish to experience without any interference from their mobiles. While we have found that pure dictation does not necessarily provoke a negative response from visitors (visitor guides are often totally linear, yet valuable and enjoyable), providing only a limited amount of initiative causes resentment towards the system – one visitor to an early prototype of the demonstration macro-environment, before the option to interrupt directions was included, commented that, “I am intelligent – why do I have to let the mobile keep telling me when to move?”

***What* adverts should be delivered?**

There are a number of factors – common to all macro-environments – that we suggest can influence which adverts should be chosen by the visitor monitor to be delivered to a visitor following a push or pull.

Resource management is an important consideration for designers of macro-environments. Many of the installations the designers may create – in particular those that form tangible couples - will be inherently limited in their coupling capacity. The installation illustrated at point A in figure 1 for example has a physical holster in which the visitor places their mobile to begin the local experience, while the installation at point C allows a visitor to create and control slideshows displayed on a large projector screen. Both installations are thus limited to couple with only one mobile at a time hence we did not wish to frustrate visitors by advertising those installations when they were already occupied. It is also possible to frustrate visitors by advertising installations that are irrelevant. Again we may refer to the slideshow installation: if the installation creates and visualises slideshows based upon content collected at a previous installation (in this case at the map installation) there is little point advertising the installations to visitors that have not visited the map, or have visited it but collected no useful content. Particular installations may also be irrelevant to visitors if they use coupling interfaces that do not match those coupling interfaces found on their mobile devices. For example, the map installation in our macro-environment utilises a camera on the visitors’ mobiles to allow visitors to photograph the glyphs representing locations that they wish to reveal information about; if a visitor’s mobile device does not include a camera then a direction to this installation would be frustrating.

As such when we create an installation we define three attributes for it:

- *technical requirements* (which technical components does a visitor require to couple with this installation?); and
- *storyline requirements* (visits to which other installations/which collected content are prerequisites for this installation?), both defined when the installations are initialised; and finally
- *coupling profile* (who is currently coupled to the installation and what total capacity does the installation have?), updated as visitors couple with and decouple from the installation.

In practice, each decision made by the visitor monitor (following a choice to push, or receipt of a pull request from a visitor) required a series of cross-references, using the visitor’s profiles and the attributes of every installation to determine the visit suitability of each installation. The installations are classified as either suitable or unsuitable, and then the suitable installations are prioritised depending upon whether they have been visited before and whether they are a prerequisite to another installation. Having classified each installation, the visitor monitor passes adverts for any classified as suitable back to the visitor’s mobile, and they are handled by the visitor as described previously.

Our prototype contains only three installations, and preliminary trials have involved up to a maximum of three visitors at any one time, hence we have yet to test our proposals for macro-exploration with respect to scalability. Key issues to be tackled by further development of our prototype include the impact of higher (more realistic?) numbers of visitors upon flow around a macro-environment, and how the practical implementations of our four approaches will need to be modified to be most effective in dealing with this impact. Also we must investigate the impact of the social structure of the visitors, e.g. do socially connected visitors such as families and friends explore a macro-environment differently? Do they use their personal mobile devices collaboratively? Do adverts need to be chosen for visitors based not just upon personal context but also upon social context?

2.2 Coupled action

Due to the brief nature of this paper we shall discuss only one issue amongst those raised concerning the coupled actions at the installations in the demonstration: the use of *portable content*.

One of the most valuable roles identified for the personal mobile device in the macro-environment is as a *vessel* for content, blurring the boundaries between container, token and tool object types described by Holmquist et al. [6]. While installations (and their content) are situated within specific micro-environments, a mobile device is the perfect container to carry and spread content that might otherwise remain tethered to one point-of-interest. We refer to content that can be moved as *portable content* and our prototype macro-environment illustrates two basic uses for such content.

The flags which may be grabbed from the map installation can be considered *portable selections*, as they hold little interest for the visitor by themselves, but can be used as triggers or *seeds* to create personalised experiences when carried to other installations. In the case of the demonstration, as previously described, the visitor may carry the selections to the slideshow installation, where after coupling they can be used to initiate slideshows based upon content concerning the selected locations.

Our slideshow installation allowed the visitor not just to view slides seeded from their portable selections but also to rate and/or grab individual slides. Slides grabbed by the visitor formed part of their *personal collection* (which we conceptualised as a wallet) that the visitor could browse once they decoupled from the slideshow installation and even when they left the macro-environment through a separate wallet application. As the slides were too rich in information to be shown on a mobile display, each ‘card’ added to the wallet simply showed a thumbnail when browsed by the visitor. Our intention is that the user is enabled to temporarily re-create a slideshow installation outside of the macro-environment on-demand, using their PC, TV, or other large display to re-view their wallet.

We saw unexpected social behaviour provoked even by our small trials, e.g. when a group of visitors were close friends visitors often became the ‘audience’ at the slideshow installation, leaving their mobile device at rest while their friend (the ‘conductor’) coupled to the installation. We are beginning to use this prototype to explore how the experience that the coupled visitor has effects the audience, especially when the coupled experience is seeded – in this case the slideshows viewed by audience members will be different to those available when they couple as they will have gathered different portable selections. In fact we deliberately encouraged this effect by also altering the slideshows created from the same seed with respect to the visitors' personal profiles, e.g. different slideshows would be created for 10 year-old and 25 year-old visitors even if they both used the same portable selection 'Japan'. We may hypothesise that such design can encourage the audience to return to previous installations to find seeds they have missed, and that among some visitors a sense of competition may be aroused. One alternative to discovering original content in situ is for visitors to grab already-discovered portable content from each other. In fact using the previous example of the seed 'Japan', it will be impossible for the 25 year-old to discover some of the slides seeded by the 10 year-old, hence this method would be necessary for him to collect the same slides to his wallet. We intend to explore the value of collaborative management of portable content at multi-couple installations, such as trading tables like Dynamo [8]: does trading of content reduce its role to currency and thus discourage reflection on the content itself?

3. CONCLUSION

We have briefly presented a demonstration of a small macro-environment fully implementing a range of approaches to spatial exploration for installations, and coupled interaction. The demonstration provoked a number of design problems, an explanation of all, especially the technical aspects, being well beyond the scope of this paper. Instead, two interesting challenges brought to our attention during development of the demonstration were discussed: section 2.1 illustrated four approaches to supporting visitor exploration of the environment, while showing how the visitors' and system's needs for control over this process must be reconciled; section 2.2 introduced some simple uses of portable content in the macro-environment, and touched upon the social behaviour that might be initiated through its use.

In parallel to the demonstration we have been developing a theoretical framework for the design of coherent sequences of coupled experiences. The two main pillars of this framework are a dual model of human-computer interaction and system interaction (from entry into the macro-environment to exit from the macro-environment), as well as a systematic mapping of different configurations (physical and computational) of mobile-installation couples.

For the former we draw strongly upon our experience with the demonstration presented here. For the latter, authors such as Norman [9], Gibson [4] and Dourish [2] have made important contributions to our understanding of the perceptual effects of physical configuration and appearance, while useful systemisations of devices in terms of physical and computational properties have also been proposed [5]. Of particular interest from the field of tangible computing is work on the use and implications of mechanical constraints, such as that by Shaer et al. [10] and Ullmer et al. [11], as there is scope here for the application of this research to describe the mechanical effects of the coupling to the installation upon the mobility of the mobile device.

In isolation these two theoretical components of the framework will provide for environment designers a useful descriptive vocabulary and boundaries to the design space. While these tools may allow designers to effectively implement their visions of the macro-environment, we further intend to raise a number of salient design questions based upon the theoretical components, in a similar manner to Bellotti et al.'s [1] design questions for the more general domain of 'sensing-UIs', which can not just guide, but provoke the design of environments which utilize the full potential of this emerging design space.

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