A middleware for pervasive interaction in a retail store

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ABSTRACT
This article present a middleware to provide enhanced interaction in a pervasive store as well as two example prototypes. The focus of this work is on the store infrastructure rather than the client's mobile phone to support an enhanced user experience as well as staff business activities.

Author Keywords
Pervasive retail, Middleware, Pervasive interaction

ACM Classification Keywords
H.5.2 User Interfaces: User interface management systems (UIMS); H5.1 Multimedia Information Systems: Artificial, augmented, and virtual realities

General Terms
Design, Experimentation, Pervasive Learning, Workplace Learning.

INTRODUCTION

Much research work and industrial development about the use of ICT in retail environments is centered around the client mobile phone as featured in one of the latest GS1 white papers [1]. In our work, we are more concerned with supporting a pervasive store infrastructure that enable a better user experience and supports the staff in their business activities. This is more in line with Weiser's vision of a pervasive environment supporting users activities seamlessly [2].

Towards this end, we have developed a middleware infrastructure that enable the integration and the orchestration of hardware and software services to provide the basis for an enhanced interaction environment. This middleware offers the possibility to interact with information either through a classical mobile device or through tangible interactions with store furniture.

In the next section we will present the middleware infrastructure we have designed and developed. Next, we will show its use through two different prototypes. The proposed solution will be compared to existing works before conclusion.

MIDDLEWARE FEATURES AND ARCHITECTURE

The heart of the pervasive system is the communication middleware running on a local server in the store. The goal of this middleware is to enable the integration of hardware and software services to allow interaction with digital information from the physical environment. Due to the heterogeneity of the protocols to take into account (Web services, UPnP, TUIO...) we need to bridge the different technological worlds in a transparent manner.

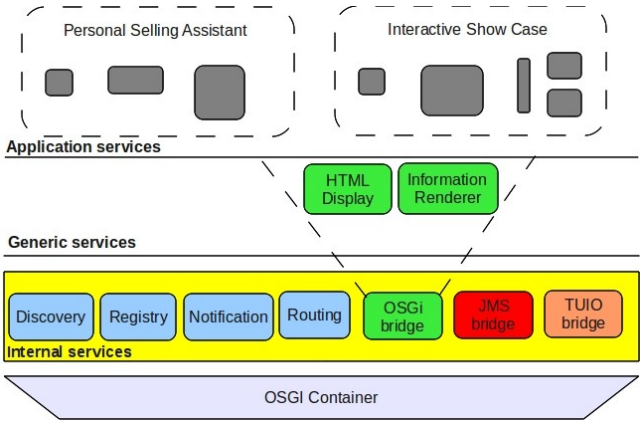

Figure 1: Functional architecture of the middleware.

Figure 1 shows the global architecture of the middleware. It has been developed using the OSGi technology to be able to support dynamic extension of the middleware and its services [3]. We also use OSGi internal messaging service to build our message oriented middleware. Internal services provide the basic functions of the middleware :

- discovery and registration of new services providers that can appear in the pervasive environment. The discovery mechanism can rely on native mechanisms (e.g. UpnP discovery) or be provided in an ad hoc manner (e.g., using an ad hoc protocol or through a static deployment descriptor). Upon discovery, service providers are included in the registry;
- A publish subscribe notification service is provided so that events in the pervasive environment can trigger specific behaviour. Notably, service providers can expose state variables whose value change can be observed by interested services;
- Service invocations and event notifications can cross technological boundaries and are supported by the routing service which can simply pass the

message from one service to another or support more advanced orchestration of services;

- The middleware has to support the range of technologies that can be deployed in a traditional information systems as well as protocols more geared towards specific interaction mechanisms (e.g. TUIO for touch surfaces) or hardware (e.g., UPnP). Each technological world is integrated into the middleware through a specific bridge responsible for the handling of protocols specificities and message conversion.

Some generic services have been developed in the scope of the retail activity support. These services have been developed using OSGi too but thanks to the middleware they are available from any technology. These services are related to the display of useful information (e.g., product information). Any screen available in the environment can provide a *HTML Display* service which allow the display of the content identified by a URL. This content can be split between different screens (e.g., a TV and a PDA) and presented according to a predefined patterns thanks to the *Information Renderer*. This service relies on an information model in XML as well as presentation patterns that define content splitting and formatting according to specific roles or views.

Application specific services can be build on top of that such as the Personal Selling Assistant and the Interactive Showcase which are described in the next sections.

Service providers provide a set of services corresponding to a service type (i.e., a common interface or API) allowing the provision of the same functions through different devices. For instance both a simple screen and a touch screen would provide an *HTML Display* service, but only the latter would also provide a TUIO input service. A provider description is done using an XML language and defines the services as well as public state variables (see figure 2).

```
<provider name="Samsung screen" providerType="HTMLDisplay",
          protocol="UPnP">
  <services>
    <service name="Display">
      <statevar>
        <var name="URL" />
        …
      </statevar>
      <actions>
        <action name="displayHTML">
          <method name="displayHTML" />
          <param name="url" type="string" />
          …
          <return type="void" />
        </action>
        …
      </actions>
    </service>
    …
</services>
```

Figure 2: Provider XML definition.

PROTOTYPES

Two kinds of prototypes have already been developed on top of the middleware. The first one to support seller activities in hypermarkets and the second one to design an interactive showcase.

Personal Selling Assistant

The Personal Selling Assistant has been developed in the scope of a three year project to provide pervasive learning within the sellers' business activities. To enhance acceptance of the prototype, business related services have been provided. The seller digital assistant has been designed through a user-centered approach and tested in a laboratory environment as well as in the field.

The prototype client has been developed using Java/Swing on a Samsung Q1 mobile windows PC. A second experiment used a Villiv computer which was a little smaller and lighter. This mobile assistant offers access to training material as well as product information. Furthermore a product comparison tool like the one available in many e-commerce store is provided. The seller can interact with the information through her/his mobile assistant but can also display information on a screen available in the department store to share with a client for instance. This has been used by the sellers to demonstrate some technologies based on available training material or to build an argumentation based on the product comparison tool in front of a client (see figure 3).

Figure 3: In store prototype use

Our experience with these deployments in different stores is that the mobile device extended by the pervasive environment can provide valuable support for the interaction with information as well as mediating the interaction with the client. However, is has an impact on this interaction since introducing a “third party” in the client-seller interaction involves a change in the way selling is done. We observed that in front of the client the mobile device is not used systematically but rather when the seller can use information to support her/his argumentation.

In a more classical perspective the device has to be chosen so that it does not hinder the business activities : form factor, connectivity, autonomy... More generally, it is the whole pervasive environment that has to be designed to support the activity. For instance the location of displays screens, charging facilities, etc. that can be used by sellers

has to be defined according to the department store architecture and product placement.

Interactive Showcase

The interactive showcase provides a means to associate product information as well as value-added services to the presented products. Interaction with this information is done through tactile interaction that can trigger information display (involving multiple screens if available) as well as behaviour (e.g., a motor enabling the rotation of a product to be able to view every parts).

Figure 4 presents the interactive showcase which is based on a screen onto which products are presented. The upper window is in fact a touch surface allowing the user to interact with the products by pointing on them or on appearing menus and information. All these elements are orchestrated by the middleware that allow to combine display management as well as touch interaction and actuators. This prototype has not be evaluated formerly yet. However it has been demonstrated at an e-commerce fair where thousands of people tried it and it proved stable.

Figure 4: Interactive show case.

RELATED WORK

This project has some similarities with the work presented in [4] about augmenting the retail environment with interactive displays. However, the cited paper is focused on the specific interaction system put in place rather than a more generic distributed infrastructure that we propose. [5] proposes also a platform to support pervasive display use in retail for interactivity and personalised advertising. In the same spirit as we have done, the platform supports multiple displays as well as a set of sensors (e.g., Rfid, Bluetooth) to support interaction. This work does not handle the integration of multiple technologies and interactions means in a transparent manner though.

In a different perspective, [6] provides a study of the use of sensor network to support store operation and defines requirements and use case that can complement our current services.

CONCLUSION

In this paper, we have presented a middleware to support an extended interaction with software and hardware services within a pervasive environment to enhance user's experience in retail environments. Our different prototypes and experimentations have shown that our middleware is robust and the integration of new sensors and actuators is easy. This integration can be straightforward is the service relies on a managed technology. If a new technology is brought into the middleware, a new bridge must be developed according to specified interfaces to support message handling and transformation and the middleware services are readily available.

The next step of this work is to ease the design, development and deployment of this kind of environment by developing a software factory [7] that will enable the automation of the process based on technological and business models than enable code generation and deployment directives according to a business oriented design.

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