A TOUCH IS WORTH A THOUSAND CLICKS

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Abstract: The fusion of interaction and discovery technologies can facilitate easy, intuitive and impromptu access to networked entities by users without the need for significant administrative overhead. Due to mobility, complex connectivity and small user interfaces, traditional service discovery methods fail to meet the demands placed by such environments. This paper presents work-in-progress on how NFC-enhanced mobile devices can enable intuitive service discovery by non-expert users in smart environments through simple gestures such as touch. With this new paradigm, physical space becomes an extension of the traditional GUI. An extensible RFID tag record is presented that can be utilised in a variety of scenarios. The proposed approach is further illustrated through a technical realisation based on the UPnP framework. An example use case is selected and the step-by-step process of service discovery and user interaction is described.

1 INTRODUCTION

The increasing penetration of short-range wireless access mobile devices and the introduction of networked environments are giving rise to new user interaction and service models. These models emerge as homes and workplace environments are gradually being transformed into *smart spaces* populated with a diverse set of devices and applications all waiting to be accessed and used. The trend for such spaces is to provide intelligent, *I-centric* service architectures. *I-centric* communication considers the human behaviour as a starting point to adapt the activities of communication systems to it rather than being unaware of user needs and situations. Discovery and interaction technologies can be combined to create a consistent user experience that significantly reduces the administrative and configuration overhead.

Meeting these requirements poses a number of logistical and technical challenges. Due to mobility, more complex connectivity, small user interfaces (UIs) and limited text input, issues such as mobile service configuration, discovery and activation will have to take a different path to success than the desktop devices. In this setting, object tagging is a powerful concept for grounding immaterial mobile services in the real world. Radio Frequency Identification (RFID) has received tremendous attention lately as a promising technology for smart space object tagging and an important enabler in the mobile terminal business. RFID tags based on the Near Field Communication (NFC) technology have a modifiable state and a short operating range. These tags can be interpreted by middleware and relevant applications running on the mobile device itself. This is different from Electronic Product Code (EPC) technology. EPC tags are typically simple object IDs with a reading range of the order of meters, and EPC readers need to access a backbone infrastructure in order to interpret them semantically.

This paper proposes a method that extends the concept of user-to-device interaction beyond the limitations of the traditional GUI interface and provides easy service discovery and launching. In the new interaction paradigm, user input can be received through *touch* in the same way as it is received through mouse clicks and menu selections. As a result, physical space becomes an extension to the mobile device GUI and physical objects can be mapped to virtual objects. Discovery does not require detailed knowledge of local network configuration or service initiation processes. An object may be selected, clicked upon or dropped on different application icons depending on the user's

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intentions and different actions are invoked. For instance, if a user selects a picture on mobile phone X and then touches mobile phone Y, it is interpreted as the user's intent to share the image. If a user selects a picture on a mobile phone and then touches a printer, it is interpreted as the user's intent to print it.

The successful deployment of such pervasive computing environments will rely on the promptness of the self-configuring procedures and the ease of use of the discovery process for the average user. Many technologies were originally developed for zero-configuration networks in controlled and familiar environments (e.g. home, office). Recent research has focused on the use of these technologies in mobile computing scenarios. Some well-known service discovery protocols are Service Location Protocol (SLP, by IETF), Jini (a Java-based approach by Sun), Universal Plug and Play (UPnP, by Microsoft) and Bluetooth Service Discovery Protocol (SDP). Currently, these technologies lack the ability to ensure independence from the networking layer, interoperability between devices of different manufacturers, and cannot provide a complete solution for the easy, secure and intuitive interaction between non-expert users and services:

- They require manual intervention and are typically deployed in traditional network topologies where trained users work through powerful hosts (Heidermann, 1998), (Misra, 2001).
- Discovering services often implies performing multicast searches over wireless interfaces. Potentially, this can result in long lists of available services and devices.
- Even in cases where the user has identified the type or *friendly* name for a service, a search may still be necessary in order to launch it.
- The user is required to setup suitable network access in order to reach the desired service.

The proposed approach enables a non-expert user to discover and use the desired service through a one-step process by touching dedicated service access points, thus, eliminating the need for multiple manual steps and multicast searches.

The paper is organised as follows. Section 2 gives a brief overview of the NFC technology. Section 3 summarises prior literature. Section 4 introduces an interaction model based on the *touch* paradigm and discusses its role as a powerful enabler in mobile terminal services. Section 5 presents the service discovery approach, the NFC tag record structure and the technical realization through the UPnP framework. Finally, section 6 concludes the paper.

2 WHY NFC TECHNOLOGY?

Though RFID technology has, traditionally, been used in industrial and logistics-related applications, it is well suited for automatic service discovery and configuration. User applications have been limited, focusing on payments at points-of-sale and contactless public transport tickets. Nokia, Philips and Sony recently established the Near Field Communication (NFC) Forum to promote the use of contact-less short-range technologies in a variety of consumer applications (NFC Forum). Bringing two NFC devices together should engage the wireless devices' interfaces so that they can (a) exchange data purely over NFC or (b) exchange configuration parameters in order to link in a peer-to-peer network over another wireless medium. A proximity RFID technology operating at the unregulated band of 13.56 MHz with an operating distance of 0-10cm has been chosen. Reasons for this include compatibility with existing payment and ticketing solutions, maturity and availability of technology and parameters, such as size and power consumption. Due to the very short operating range the usage paradigm of such NFC systems resembles a *touch gesture*. Technology miniaturization makes it feasible to integrate NFC functionality into consumer products and mobile devices and it is well positioned to revolutionise the user experience.

3 RELATED WORK

This section summarises selected publications in the area of RFID-enhanced service discovery. One approach has been to explore the integration of RFID technology with Web services. In (Kerer) the authors present a presence-aware infrastructure in order to implement a committee meeting scenario. RFID tags are attached to the devices of the meeting attendees and they are detected when they enter the meeting room. The information on the tags is used as input to the presence manager, the authentication and personalization services and the persistent repository, all of which create a collaborative environment. In (Romer, 2003) the authors analyse example use cases such as Smart Tool Box, Smart Medicine Cabinet, Smart Agenda, RFID Chef and Smart Playing Cards in order to extract generic design concepts. They present two prototype frameworks based on Jini and Web services. Tags are attached to physical objects which hold pointers to their virtual counterparts. The prototype architecture uses RFID interfaces to periodically scan the surroundings for tagged objects. When a tagged object is detected, it is registered, mapped to its virtual counterpart, its activity is logged and associated executables are run based on the application. Though there are several similarities, both (Kerer) and (Romer, 2003) focus on a very different usage model than the one proposed in this paper, which is driven by explicit user actions.

The proposed approach in this paper is closely aligned with (but independently explored from) Elope as described in (Pering, 2005). Both architectures investigate how RFID-enhanced physical objects can be discovered and their associated services launched through RFID-enhanced mobile devices. One distinct difference is that Elope focuses on a web-based service discovery framework, whereas this paper integrates RFID technology with the UPnP framework. Again, the details of the data representation on the tag are not discussed in (Pering, 2005).

In (Bettstetter, 2000) mobile devices act as the mediator between the user and RFID-augmented physical objects. The tags contain data that trigger context events in the system (referred to as CAPNET-based middleware). The primary focus of (Bettstetter, 2000) is on usability tests, the users' perception of visually marked RFID tags, the social acceptance of a touch-based interaction model, and the users' feedback on security concerns and the user interface. This paper places a stronger emphasis on the design of the middleware architecture, the technical realization through the UPnP technology and the details of the data representation on the tag for network connectivity and service discovery (an aspect not addressed in (Bettstetter, 2000)).

Passive RFID tags and Bluetooth nodes are used in (Siegemund, 2003) to augment everyday products and objects. Bluetooth nodes are attached to RFID scanners and they are used as mobile access points allowing data stored on a passive tag (e.g. product codes) to access the background infrastructure in order to be semantically interpreted. The focus of (Siegemund, 2003) is on logistics-driven use cases such as Smart Product Monitoring, Smart Medicine Cabinet and Remote Interaction with Smart Objects and Locations. In contrast, this paper focuses on consumer-driven services such network access, printing, faxing, teleconferencing and so on.

In (Ravendy) the authors present a middleware platform, referred to as MSDA, that manages the dynamic composition of networks, integrates existing middleware protocols (e.g. Jini, UPnP), and provides a generic service to clients for performing service discovery. MSDA-aware clients can connect with services in different discovery domains through ad-hoc networks, hotspots or Internet/Cellular networks. The intended user interaction model is different from the proposed method in this paper. In (Ravendy) users can discover a new service by reading an RFID tag but additional manual steps are necessary. The user needs to initiate a search for an available service in the network that can interpret and process the description read from the RFID tag. The type of RFID technology used and the tag data representation are not discussed.

An RFID-enhanced framework for intelligent products is presented in (Bajic). The key technologies utilised are RFID and UPnP as in this paper. The focus, though, is on logistics and production processes and the RFID technology is based on EPC standards. Objects are enhanced with UPnP functionality. RFID sensing or direct UPnP message exchange invokes the service discovery process by providing the object ID. The example case study is a warehouse management system.

In (Want, 1999) RFID tags of very small capacity (a few bytes) are affixed to physical objects containing a simple ID. The tag reader scans the object ID, determines the current application context and provides the appropriated feedback. The use cases focus on how RFID-enhanced objects can be used to present information on a wireless handheld device. However, this approach does not enable services to access data stored in mobile devices.

4 THE TOUCH PARADIGM

Users do not want to employ technology but rather to interact with their environment. Even though mobile phones have become a commodity, a major part of mobile applications and services is hardly used by today's consumers. For example, basic functions such as calling or text messaging are easy to use and have been widely adopted. In contrast, browsing or file sharing require complex configurations and setup procedures and are less popular at present. In this work:

- The *touch* paradigm creates an intuitive user interaction model. It allows for *fast*, *convenient* and *intuitive* user interaction with smart objects, devices, services and other users.
- Service discovery provides a unique opportunity to boost the adoption of mobile services, in particular wireless proximity services. Rather than require new models of behaviour, social interaction in proximity can build on familiar human activities such as giving, sharing, greeting, self-expression, acknowledgement and so on.

4.1 Context Awareness

User activities in proximity can exploit the benefits of context information relevant to service discovery. Context information enables the right services to be delivered to the right user at the right time. Objects pertaining to a certain context can be *active* or *passive* at given moments in time depending on the situation of the user. Proximity-based services can be categorised in four context-aware categories:

a) *People in places*: social interaction, communication and collaboration in close physical range. Example applications are face-to-face content sharing, ad-hoc collaboration and group formation.

b) *Me and my stuff*: creation, management and storage of personal and 3rd party content with particular focus on the home environment. For example, personal mobile devices (e.g. phones, PDAs) can access and control services and content on networked home devices (e.g. laptop, audio system, home appliances).

c) *Smart spaces*: accessing local content and services relevant to a particular location. Location-based services can find application both in the workplace and in the consumer market. For the former, an example is personal mobile devices discovering and interacting with other devices in a specific room or building (e.g. printers, projectors). Examples for the latter are service activation at point-of-sale locations and content download (e.g. download a movie preview from a poster).

d) *Safe consumption*: research and purchase of goods, content and services with perceived security and trust. All transactions have security and privacy requirements but special attention is needed when purchases and monetary transactions are involved such as ticketing and electronic wallet applications.

Location is an important element of context information that can be exploited. NFC technology can provide a convenient way to access location-aware, mobile services and content through hot spots, e.g. NFC-equipped devices could easily read tags at point-of-sale locations. This can serve to compliment cellular coverage and provide the illusion of full mobility, thus, making it less necessary to assure real-time full mobility for all applications. Yet, commercial success of this business model is dependent on whether users are willing to wait to connect, pricing and sufficient coverage with clearly marked hot spots.

4.2 UI Interaction

Enabled by NFC technology, service discovery has a direct impact on the design of smart and intuitive user interfaces (UIs) for pervasive computing. Currently, similar point-and-click interfaces are not flexible. Most RFID readers, bar code scanners and IR remote controls are single purpose devices. In some cases, IR can be used for multiple purposes, but the interface can hardly be characterized as intuitive, or point-and-click.

Traditional graphical user interface displays receive input through mouse clicks and menu selections. With the NFC-touch paradigm the physical space (e.g. a room) becomes an extension to the GUI of a mobile device, where physical objects (i.e. NFC-enabled objects and devices) can be *touched upon* in order to activate associated services and applications in the same manner as clicking on an icon on a conventional display. An object may be selected, clicked upon or dropped on different applications, which invokes different actions. Three key modes of interaction are shown in Table 1.

Table 1: Key interaction modes.

MODE	DESCRIPTION	EXAMPLE
Select	selection is H/W independent via the traditional GUI (e.g. mouse click, menu list) or NFC touch. Selected objects can be interrogated or trigger associated applications	user selects a printer that he/she visually discovers in a room to check its properties (e.g. 'network access', 'is it a colour printer?').
Select-and-launch	select an object & launch application. Associate metadata to physical objects by various means (e.g. bar codes, tags, service description).	user touches the tag on a movie DVD and the browser is launched with the movie URL as an input.
Select-drag-and-drop	select object A, drag it to resource B, drop it on B & resource B launches associated application. This event pattern associates an object with an application that it is not normally associated with.	use a mobile phone to transfer a file from a laptop to a local printer. The phone-laptop touch gesture represents the file select-and-drag. The phone-printer touch gesture represents the drop.

5 PROOF-OF-CONCEPT ARCHITECTURE

This paper introduces a method for enabling easy service discovery in smart spaces by NFC-equipped mobile devices. There are two critical players:

a) The smart space devices: these are NFC-enabled devices, either physically accessible by the user (e.g. a projector), or accessible through service access points (e.g. touch here to send a fax). Their service discovery parameters (also referred to as service discovery record) are stored in an NFC tag that a user device can read when it is within the scanning range. A tag format is designed for this service discovery record. The tag design is compatible with the guidelines provided by the NFC Forum. Additional backbone network devices such as network access points (NAPs), configuration servers (DNS, DHCP), AAA servers and so on may provide other necessary functionality. The task of setting up and configuring smart space environments is out of the scope of this paper and it is addressed in (Antoniou, Krishnamurthi & Reynolds, 2006).

b) The user devices: they are NFC-enabled mobile devices with one or more wireless network interfaces (e.g. WLAN, Bluetooth, GPRS/WCDMA).

The rest of this section presents the architectural design for the proof-of-concept prototype currently under development (Antoniou & Varadan, 2006). Its technical realization features the integration of NFC technology with the UPnP framework. The security aspects of this work are addressed separately in Shakhshir & Kalofonos, 2006), (Antoniou & Kalofonos, 2006).

5.1 The User Experience

Anna is at the departure's lounge awaiting her flight. She wants to print a copy of a report she has stored on her mobile phone to read in the plane. She locates a *smart printer*. She selects the report file (e.g. by highlighting it) and touches her phone to the printer hotspot (tag). Instantly, the printer is added to her list of available services and a connection is established between the two devices. By having selected the report file first and then touching the printer, the phone deduces the intention of the user, which is to send the file to this printer. Without any further action by the user, the printer control application is launched on the mobile phone and the report is printed. Through the printer control application UI, Anna can check the printer properties and the status of the printing job.

It should be noted that the proposed method can potentially facilitate remote access to previously discovered devices as well. Assume that Anna has already discovered a fax service at the airport in the same manner as she discovered the printer. She can launch the fax service multiple times by clicking on the fax icon that appears in her mobile phone UI.

5.2 The Tag Record

The NFC tag record design is a flexible and extensible structure (Figure 1) that can be used to store discovery parameters of smart network devices, services and NAPs for a variety of use cases[1]. The information exchanged is the Payload. The Payload contains a Header and a record list with

[1] NFC standardization is ongoing, hence naming conventions and record formats are still evolving.

[2] An industry consortium created by Microsoft.

one or more records. The Header contains the length of the Payload and it is used to determine how much data must be read from a tag. Each record is a sequence of three elements, a triplet of *(Type, Content-Length, Content)*. The record *Type* identifies the structure and semantics of the record by providing the *Type* name. For the case of service discovery, a suitable choice would be the discovery protocol name and version number. The *Content-Length* identifies the length of the record *Content*. The record *Content* contains the actual data. The example tag record of Figure 1 is further explained in the rest of this section.

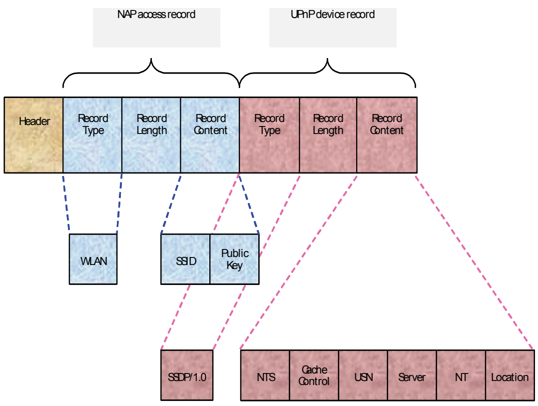

Figure 1: Tag record: UPnP service discovery via a WLAN.

5.3 UPnP Overview

Universal Plug and Play (UPnP) is a set of protocols including the Simple Service Discovery Protocol (SSDP), the Simple Object Access Protocol (SOAP) and the General Event Notification Architecture (GENA) originally developed by Microsoft Corporation and currently under development by the Universal Plug and Play Forum[2]. UPnP standardizes the protocols spoken between clients (called control points) and services. It leverages existing standards such as TCP/IP, HTTP and XML.

Devices, services and control points are the basic abstractions of the UPnP device architecture. The device model is hierarchical. In a compound device, the root device and any embedded devices are discoverable. Clients can address a root or an embedded device independently. Soap servers in the device act as entry points for interacting and controlling it. Each service has a set of methods or actions with a set of optional input/output parameters and return values. The control point is the client and the device is the server. Control points can invoke actions on services. All UPnP devices that conform to UPnP Forum specifications follow the same basic pattern of operation: addressing, description, discovery, control, eventing and presentation. SSDP is used for the service discovery process to (a) announce a device's presence to others and (b) search for devices and services. A device sends a multicast message to either advertise its presence to control points or to search for services in a UPnP network. Devices that hear this message respond with a unicast response message.

UPnP uses XML to describe device features and capabilities. For instance, the aforementioned advertisement message contains a URL that points to an XML file in the network describing the UPnP device's capability. By retrieving this XML file, other devices can learn about the advertised device's features, control it and interact with it.

5.4 SSDP Announcement for the Smart Device

An example SSDP presence announcement for a printer is shown in Table 2. A brief explanation of the various fields is given next. For a detailed description the reader is referred to (UPnP), (Printer). The value of the NTS field identifies this SSDP message as a presence announcement of a new device or service. The Cache-Control field specifies the duration that the presence announcement is valid. The control point (user) device caches the complete service discovery record for the time frame defined by Cache-Control. The USN field provides the device Universally Unique ID (UUID). It may contain other information about the device type (e.g. root device, device type, service type). Server field provides information on the operating system of the device, the product name and version. The NT field has a potential search target description, i.e. how the control point can search for the discovered device or service. Finally, the Location field contains the URL from which the UPnP device description document can be retrieved.

This presence announcement is included in the printer tag record as shown in Figure 1. The printer record is of Type 'SSDP/1.0', i.e. the service discovery protocol used. Its Content field consists of the six sub-records, namely NTS, Cache-Control, USN, Server, NT and Location URL.

Table 2: SSDP presence announcement.

Field	Example Data
NT: Specifies the search target value	"urn:schemas-upnp-org:device:Printer:1"
USN: Concatenation of device ID and NT value	"uuid:0e2fc7b3-4c09-4665-b4aef6f90448ba99::urn:schemas-upnp-org:device:Printer:1"
Server: Concatenation of OS name & version, UPnP/1.0, product name & version	Microsoft-Windows-NT/5.1 UPnP/1.0 UPnP-Device-Host/1.0
Location: URL of root device description document	"http://192.168.64.11:53911/upnp/device/Printer.xml"
Cache-Control: Number of seconds the announcement is valid	1800 seconds
NTS: 'alive' or 'bye-bye'	ssdp:alive

5.5 SSDP Announcement for the NAP

For this example implementation, it is assumed that the printer device is connected to the network through a WLAN NAP. In this case, the WLAN record is of type 'WLAN' and its Content field contains the SSID and (optionally) a Public Key. If more than one NAP with the same SSID value are available, the user device can connect to the access point with the best signal strength. In cases where no connectivity parameters are specified, it can be assumed that the advertised device is accessible through the public internet. The setup and configuration process between the printer and the NAP are addressed in more detail (Antoniou, Krishnamurthi & Reynolds, 2006).

5.6 NFC-based UPnP Service Discovery

Anna's select-and-touch action triggers a series of steps (Figure 2). Anna selects the report she wants to print. This event selection is stored in the Activation module. Next, she touches the printer tag with the NFC interface on her mobile device. The printer tag is read and passed to the Direct Access module in the middleware layer. The tag is parsed and the two records are extracted. These records are then processed in sequence. First, the 'WLAN' NAP record is passed to the Connectivity module to setup the network connection. Secondly, the Service Discovery SSDP/1.0' record is passed to the Service Discovery module which triggers the UPnP discovery process. This process is equivalent to the UPnP engine receiving a presence announcement through a multicast message. When completed a 'Discovery Complete' message is sent to the Activation module.

If the user device were in the default UI application when the printer tag was touched, the printer would be discovered and its icon would be added to the available devices. In this case, a selection event has taken place *prior to* touching the printer tag. As a result, the Activation module launches the printer control point application with the selected object (report) as input for printing.

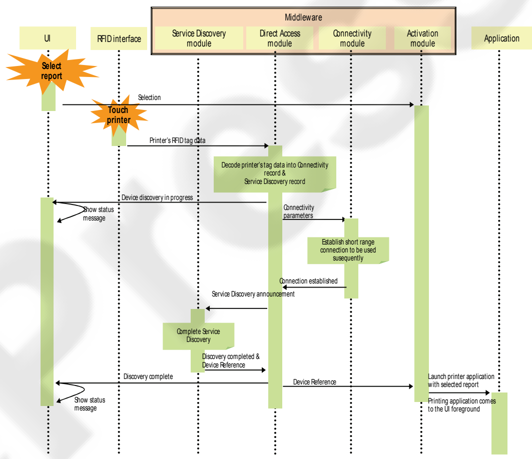

Figure 2: The service discovery process.

6 CONCLUSIONS

Technology miniaturization has made it feasible to integrate NFC functionality into consumer mobile device and has given birth to the *Touch paradigm*. User input is received through straightforward gestures such as touching or pointing and clicking as part of everyday activities. An efficient UI design can potentially replace sequences of multiple button clicks and menu selections by a simple touch or point-and-click action in order to complete a task. By exploiting the benefits of this paradigm, it is possible to enhance existing service discovery protocols in order to create smart space architectures.

This paper presents work-in-progress on how service discovery and interaction can be simplified through the use of NFC technology. An extensible tag record is proposed with application in a variety of service discovery scenarios and protocols. NFC-enhanced middleware is designed to (a) retrieve tag information over the NFC interface (b) perform service discovery and connection establishment and (c) launch associated applications for further interaction with the discovered devices. The proposed architecture integrates NFC technology with the UPnP framework and does not require detailed knowledge of network configuration or service initiation processes.

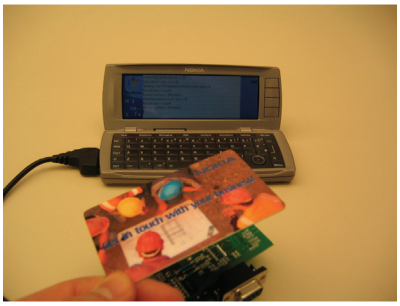

Figure 3: Prototype HW Setup.

The proof-of-concept implementation is currently in progress and will be presented in a follow-up paper. It is developed for a Nokia 9500 Communicator handset in Symbian OS. The NFC interface is provided through an internally developed prototype, which is connected to the phone through a USB cable (*Figure 3*). The NFC interface allows reading from and writing to Mifare Ultralight (48 bytes) and Mifare Standard tags (1Kbytes/ 4Kbytes). Future research directions will explore other service discovery frameworks, as well as, content sharing.

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