A User Interaction Model for NFC Enabled Applications

Yaw Anokwa[1], Gaetano Borriello[1], Trevor Pering[2], Roy Want[2]

[1]Computer Science and Engineering
University of Washington
Seattle, WA 98105
{yanokwa,gaetano}@cs.washington.edu

[2]Intel Research, Santa Clara
2200 Mission College Blvd.
Santa Clara, CA 95054
{trevor.pering,roy.want}@intel.com

Abstract

Near field communication (NFC) is a short-range wireless protocol that allows users to connect devices and access content and services by simply holding enabled devices near each other. This paper introduces a user interaction model for NFC enabled applications. Our model specifies that enabled devices take on the properties and context of the objects required in the interaction. This transformation leverages the existing knowledge users have about certain objects and thus can support a number of different applications tied together with simple, intuitive and repeatable interactions. In this paper, we present an overview of the model and the system we have implemented to enable evaluation. We also detail some research challenges we are pursuing.

1. Introduction

Mobile devices have become the primary platform of ubiquitous computing. There are now over 2 billion cell phone users worldwide [11] and many of these users carry these devices with or near them [4]. As these devices grow in popularity, technologies that enable more natural interactions between users, devices, and their environments have spurred a rich and vibrant research community. It is likely that rather than carrying augmented everyday objects as suggested by Want et. al [10], users will instead carry a single device that has the same functionality as today's everyday objects. For example, instead of a tagged car key, a cell phone could be authorized to open and start a car.

Near field communication (NFC) is a technology evolved from short range radio frequency identification (RFID). Like RFID, NFC works via magnetic field induction and is designed for simple and safe transfer of data between compatible devices. Effective range is limited to 20 centimeters and data transfer rates peak at 424 kbits/s making it a good technology for scan/touch interactions. NFC goes beyond RFID in that it is a symmetric protocol. Readers can read from tags and other readers directly.

Bi-directional device to device transfer of information is the key feature that differentiates NFC from RFID. For example, users can use their mobile devices to scan a tag embedded in a "smart" movie poster and either get information about the movie, view a trailer or purchase tickets to the movie. This scenario can be accomplished with RFID but with NFC, users can then go home, scan an enabled TV with their mobile device, transfer the trailer to the TV and watch it on the larger screen. The mobile device's ability to act as both a tag and a reader makes this scenario possible. Users can also transfer tickets that were purchased at the poster by scanning their respective mobile devices.

Unfortunately, many of the proposed NFC enabled applications are not framed under a general interaction model. This is a significant problem for NFC because it can both be used for simple interactions like touching a secure door with a cell phone to gain access and for more complex scenarios such as buying a movie ticket. Without a user model in place, NFC enabled applications may end up a mix of poorly thought out interfaces without a unifying interaction model.

We solve this problem by relying on a user's pre-existing cognitive model of the objects with which they are interacting. When a mobile device scans an item, the device takes on the properties and context of the item scanned. We call this process a *transformation*. For example, if a cellphone scanned a smart movie poster, it could take on the properties of a movie ticket. It could contain all the information printed on a standard ticket, it would be used to gain access to a movie, it could be given to a friend, and finally when authorized at a theater would become a ticket stub. So after a transformation, each interaction with the mobile device is intuitive because the mobile device behaves like the scanned item. Of course, a single device may transform itself into any previously scanned item.

The remainder of this paper surveys related work and describes our model in more detail. We also discuss the major components of our system and how they work together to enable and evaluate the model. Lastly, we present some of the research challenges we face and our future plans.

2. Related Work

Want's early work on using RFID tags to link the physical and virtual worlds is the basis for much of the research involving tagging objects. Want's idea was to derive some semantic meaning from the attached tag. By augmenting everyday objects with RFID, actions could be initiated by simply scanning objects. For example, scanning a book could purchase it from an online book seller.

Valkkyen and Tuomisto [9] define physical browsing as object selection when performed by either pointing, scanning or touching. Pohjanheimo et. al [5] demonstrate the feasibility of such a system on a mobile phone. Rukzio and Leichtenstern [8] conduct a user study that demonstrates that for a variety of scenarios, touch is a preferred interaction method due to its intuitive and error resistant nature. Cooltown [1] links real world objects with corresponding services in a URL-centric model of interaction. There is also some work on middleware [6], [7] to enable NFC, but nothing that explicitly mediates interactions across a variety of NFC enabled applications.

Finally, the NFC Forum [2] has built some application functionality into the draft specifications of the NFC standard. These applications range from posters with embedded URLs to better device controllers. While the specifications are still in a draft stage, there has been little work on how users will consistently interact with these different applications.

Our approach is different from previous work because rather than just embedding data in a tag for our mobile device to acquire, we allow the mobile device to impersonate the item being scanned. Instead of tying virtual services with real objects through middleware, we are also exploring the physical interaction between enabled objects in addition to device to device interaction. Our approach has the benefit of developing a model that uniquely fits NFC's capabilities.

3. User Model

In current RFID or NFC applications, the tag being scanned often holds a unique identifier that either launches a service or holds some semantic meaning. So for example, scanning a smart movie poster results in a URL that points to a movie site where one can purchase a ticket. If a ticket is purchased, the device becomes authorized (often via a passcode), and that authorization is checked when the user arrives at the movie theater.

Unfortunately, this method of interaction ignores the user's previous knowledge about a movie ticket. In the real world, purchasing a movie ticket gives you a physical object you can interact with. You can see and verify the ticket is correct, you can keep the ticket stub as a souvenir, you can give the ticket to a friend as a gift. Our model leverages this existing knowledge in framing how NFC enabled applications should be built.

In our model, we define an *item* to be any NFC enabled device (both passive and active). An *object* is then all that the item encapsulates. For example, an item may be a movie poster, but that poster may have objects ranging from the poster itself, movie tickets you can buy or a movie trailer you can view. Objects can also be the context or properties of the item. *Actions* are things that an object can do or can be done to the object. For example, for a movie ticket, an action might be 'give as gift' but for the trailer, an action might be 'watch now'.

When a mobile device scans an item, the item returns the relevant information needed to describe itself. This can be a list of objects and their associated actions. The user specifies which actions to take and/or objects to retrieve. The mobile device then executes the action, possibly including the transfer of object data into its own internal database. This interaction is shown in Figure 1.

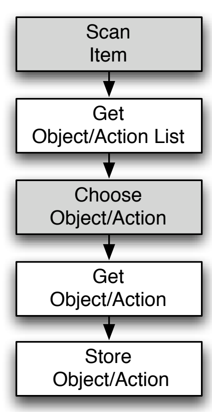

Figure 1. Using a scan to get and store an object or action. Grey boxes are steps that require user action.

For example, scanning the smart movie poster would get a list of actions such as: buy a couple of movie tickets, download a trailer, read reviews, or download directions to the theater. Each of these actions may cause an object (the trailer, reviews, etc) to be downloaded into the device's database. The interface on the device will reflect this interaction perhaps by showing an animation of the action or objects involved. In addition, the action of purchasing the movie tickets, may also automatically trigger a financial transaction between the device and the movie theater.

Once the objects are on the device, another series of actions can be associated with each object. These actions either come from the information read from the item or can be added by the mobile device. The basic actions should reflect what could be done with the physical object, but more complex actions should also be available for advanced users.

Again, the general idea is for the basic functionality of the physical object to be emulated by the device and should be the basis of the interface the user interacts with. This interaction is shown in Figure 2.

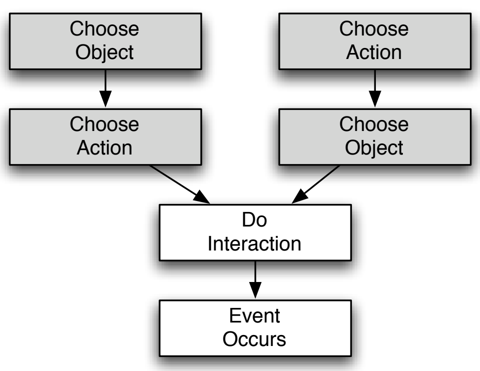

Figure 2. Once in the object database, users can select an object or an action. Interactions can be as simple as another scan or as complex as using an application. Grey boxes are steps that require user action.

If the object being scanned is another mobile device, that device can advertise a list of objects it contains. These objects can be placed in *bags* which are advertised when the device is scanned. Bags define a set of objects that may be shareable. Bags marked private require authorization through sharing of a key (perhaps another object), while bags marked public require no authorization. Bags can also be authorized for certain groups of people by including their public keys. For example, when a mobile device is the target, its public bag may contain a calendar, a business card, or even a photo album.

4. Example Scenario

To tie together the concepts presented so far, we will use the following example scenario involving the purchase and transfer of movie tickets.

John is walking through the mall when he sees a new movie poster has been placed near the food court. The poster boasts a new NFC based technology called MovieTouch. John knows his Motorola E680 phone is NFC enabled so he touches the poster with his phone. Immediately, the E680 beeps and displays a list of objects and actions that the poster has sent to the phone.

He doesn't know much about this new movie, so he selects the 'View Trailer' action on his phone. The trailer is downloaded over a WiFi or Bluetooth connection and starts playing with the phone's media player. While watching the trailer, he learns that the movie stars Drake Stone.

It turns out John's girlfriend Alice is a huge Drake Stone fan and would probably want to see the movie tonight. John returns to his objects and actions menu and this time selects 'Buy Tickets'. The phone's location service selects the nearest theater and using the phone, John buys two tickets. Looking through the 'New Objects' list on his phone, John confirms that he has both tickets and moves one to his public bag and the other to his 'Alice Bag'.

John calls Alice and tells her to meet at the theater because he has a surprise for her. When they meet, John allows Alice to touch her phone to his. Alice sees the movie ticket in John's 'Alice Bag' and is thrilled at the surprise. She downloads the ticket from John's phone to hers. She then places her ticket in her public bag.

When Alice and John enter the theater, they touch their phones to the access point. It authorizes their access to the Drake Stone movie and leaves a virtual movie stub in their public bags that Alice and John can keep as a souvenir.

5. System Components

To implement the model and scenario described above, we have built a system designed around a Motorola E680 phone. The E680 phone has a 300Mhz Intel XScale processor, 50MB flash memory, 2GB SD card, Bluetooth and USB. The E680 boots Linux and runs binaries built with a C cross-complier as well as Java ME midlets.

NFC functionality is split into two boards. The first board is driven by a MSP430 and is equipped with 48k flash, 10k RAM, an accelerometer, and an 802.15.4 radio. The board multiplexes the phone's SD slot to allow SD card support while NFC is enabled. On top of the first board sits a Philips PN531 based board that implements the NFC circuitry. The two-board sandwich is plugged into the SD slot of the phone. Despite all the modifications, the phone functions as originally designed. The hardware components are shown in Figure 3.

The hardware is controlled by a Linux device driver that moves tag data from the board to Linux user space. Once in user space, a socket based binary moves the data to the

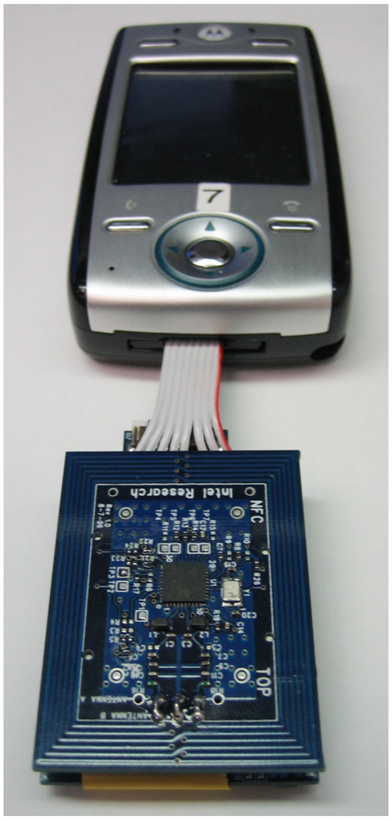

Figure 3. The NFC board sits on top of a microprocessor board. The two-board sandwich is interfaced to the phone using the SD slot. Note that the NFC board can be folded back under the phone.

Java ME layer or pipes it to another binary to trigger other events from Bluetooth transfers to application launches.

We have built a file sharing application to demonstrate the feasibility of our model. Since the NFC interface is not yet integrated with this application, we emulate NFC functionality through a Bluetooth connection between two phones. An emulated scan is started through a button press on the initiator device. The target device sends a list of shareable objects (movies, documents, pictures, music, applications, etc) to the initiator. The initiator sees a graphical representation of the objects and then selects which objects/actions it would like to receive. Another button press initiates the transfer.

We use custom hardware rather than commercial systems because such systems [3] often do not allow for exploration of advanced use cases like file transfer over NFC and sensors paired with NFC. Additionally, our system can exploit all parts of the NFC protocol as well as answer basic questions about what a custom NFC solution can offer. For example, how fast is the NFC transfer protocol in exchanging information? Is it more effective (both power and bandwidth) to use NFC to bootstrap another communication medium (Bluetooth, WiFi or IrDA) for data transfer? Will the complete interaction be faster than IrDA, WiFi or Bluetooth alone? Which is the easiest interaction for users? What are the tradeoffs between power and ease of use?

6. Future Work

In addition to the questions posed about our current system, we plan to explore the effectiveness of the model with user studies. We hope to use the accelerometer already on our NFC board as the basis of other modes of interaction including gestures, tapping and shaking. We also want to explore the idea of putting objects in bags and developing user interfaces for setting permissions and selecting objects in bags.

We hope to investigate issues not addressed by our models. For example, what if a user has no previous knowledge about the item with which they are interacting? How does the problem space change once you introduce multiple devices? How does one manage a long list of actions? Will the idea of bags constrain application designers?

NFC enabled applications and services offer the chance for improved usability and natural interactions for mobile devices. Similar to the way the desktop metaphor mediates interactions in multiple desktop applications, our work provides a similar metaphor for NFC enabled applications. As we build and evaluate our tools, we hope to answer the above questions and further refine our model.

References

[1] T. Kindberg, J. Barton, J. Morgan, G. Becker, D. Caswell, P. Debaty, G. Gopal, M. Frid, V. Krishnan, H. Morris, J. Schettino, B. Serra, and M. Spasojevic. People, places, things: web presence for the real world. *Mobile Networks and Applications*, 7(5):365–376, 2002.

[2] NFC-Forum. NFC-Forum homepage. *http://nfc-forum.org*, 2006.

[3] Nokia. User guide for Nokia NFC shell for Nokia 3220. *http://www.nokia.com/link?cid=EDITORIAL_4795*, 2006.

[4] S. N. Patel, J. A. Kientz, G. R. Hayes, S. Bhat, and G. D. Abowd. Farther than you may think: An empirical investigation of the proximity of users to their mobile phones. In *Proceedings of the Eighth International Conference on Ubiquitous Computing (Ubicomp 2006)*, pages 123–140, 2006.

[5] L. Pohjanheimo, H. Kernen, and H. Ailisto. Implementing touchme paradigm with a mobile phone. In *sOc-EUSAI '05: Proceedings of the 2005 joint conference on Smart objects and ambient intelligence*, pages 87–92, New York, NY, USA, 2005. ACM Press.

[6] J. Riekki, T. Salminen, and I. Alakarppa. Requesting pervasive services by touching RFID tags. *IEEE Pervasive Computing*, 05(1):40–46, 2006.

[7] J. Riekki, T. Salminen, and I. Alakarppa. Requesting pervasive services by touching RFID tags. *IEEE Pervasive Computing*, 05(1):40–46, 2006.

[8] E. Rukzio, K. Leichtenstern, V. Callaghan, P. Holleis, A. Schmidt, and J. S.-Y. Chin. An experimental comparison of physical mobile interaction techniques: Touching, pointing and scanning. In *Proceedings of the Eighth International Conference on Ubiquitous Computing (Ubicomp 2006)*, pages 87–104, 2006.

[9] P. Valkkynen, I. Korhonen, J. Plomp, T. Tuomisto, L. Cluitmans, H. Ailisto, and H. Seppa. A user interaction paradigm for physical browsing and near-object control based on tags. In *Physical Interaction Workshop on Real-world User Interfaces*, 2003.

[10] R. Want, K. P. Fishkin, A. Gujar, and B. L. Harrison. Bridging physical and virtual worlds with electronic tags. In *CHI '99: Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 370–377, New York, NY, USA, 1999. ACM Press.

[11] G. Wearden. Nokia: 2 billion cell phone users by 2006. *http://news.com.com/2102-1039_3-5485543.html*, 2006.