Improving Direction-Giving Through Utilization of an RFID-Enabled Kiosk

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ABSTRACT

This paper presents an RFID-enabled module for an electronic kiosk physical user interface which provides personalized information retrieval. The system builds on research in direction-giving by streamlining the process of the direction-giving phase and minimizing the introduction and closure phases, thereby providing the user with a quicker transaction for personalized information. The RFID technology also provides potential for greater security and privacy for the user of the kiosk system as compared to traditional magnetic strip methods. The developed RFID-enabled system is built on top of a current production informational kiosk utilized for a building directory, which was used for initial testing and evaluation.

Keywords: Direction Giving, Interface Design, RFID, Kiosk, Physical User Interface

1. INTRODUCTION

Electronic kiosk systems have been extensively utilized for various applications for many years. These applications include informational, advertising, service, and entertainment kiosk systems (Borchers, Deussen, & Knorzer, 1995). Most are utilized in public areas to provide individual users with needed information.[1] Many kiosks have also had personalized content added to the interface to tailor the interface and dialog to the preferences of each user (Russell & Gossweiler, 2001). This can add greater convenience for the user but also create potential privacy concerns. With the ongoing reduction in cost of touch screen technologies in particular and information technologies generally, site located kiosks are becoming a common feature in public buildings. The focus of our research is on one type of public kiosk, which is designed to provide an individual user with information pertinent to his or her query associated with way-finding tasks.

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Direction-giving and way-finding have been studied extensively by cognitive-psychologists, sociologists, and geographers. This has typically been studied within a social context where one or more individuals give directions to one or more other individuals (Golding, Graesser, & Hauselt, 1996), but the same concepts can be applied to kiosk technology. Many kiosks act as direction givers and the same steps that are utilized by human direction-givers are also used by kiosks; the only difference being that the kiosk is the direction giver while the user is the recipient of the directions.

Contemporary kiosks vary in function and design, with some offering very complex informational services and others offering very simple directional services. For most developers, there is a direct tradeoff between usability and information complexity; when kiosks provide too much information, their interface becomes unwieldy. Given that most kiosks are accessed by one-time users, anything that requires a learning curve thwarts the usability of the system; hence, most tend to have very simple and intuitive interfaces.

Unfortunately, because kiosks require such simplicity, they are not generally used to transfer more complex information. Almost by definition, complex informational output to the user requires complex informational input, which complicates the interface and, in turn, complicates the user experience. To meet the paradoxical requirements of a system that is simple to operate, yet which yields rich and complex information, some mechanism must be employed that can provide complex information to the kiosk display without requiring a complex user interface.

RFID technology offers a means for user authentication based on proximity cards, which wirelessly communicate with the kiosk query engine (Finkenzeller, 2003) through communication with a card reader. Compared to traditional technologies like magnetic-strip cards, RFID proximity cards can offer greater flexibility and ease-of-use to the user as well as, potentially, greater security and privacy protections. Most importantly, by identifying the kiosk user (at least in systems with a known potential user population) the kiosk query engine can retrieve data about the user along with information relevant to the user. Knowing about the user then allows the kiosk to present an informational set relevant to the user with little direct action on the user's part, which means that the user's task is one of simple selection of information presented by the kiosk.

To address the issue of direction-giving with regards to electronic kiosk systems, this research proposes an RFID-enabled kiosk. Therefore the purpose of this paper is to describe the development and testing of an RFID-enabled kiosk system to alleviate this informational deficiencies in the direction-giving problem. This kiosk utilizes RFID proximity card technology to tailor a kiosk in an academic setting to its current user by retrieving the user's class schedule. The system streamlines the direction-giving process by focusing primarily on the direction-giving task and bypassing 2 of the 3 phases (i.e., the introduction and closure phases). Also, RFID technology offers the potential of greater security and privacy for the user.

The rest of this paper is organized as follows. Section 2 provides a brief background in kiosk technology, direction-giving, and RFID. In Section 3 the development of the RFID enabled kiosk is described. A discussion regarding both advantages and limitations of the implemented system is given in Section 4. Finally, Section 5 provides a brief conclusion and some future avenues of research.

2. LITERATURE REVIEW

2.1 Kiosk Technology

Kiosk systems have become commonplace in today's technological society (Barab, Bowdish, Young, & Owen, 2004). Many different areas ranging from entertainment (Stapleton & Hughes, 2005) to healthcare (Nicholas, Huntington, & Williams, 2001) utilize kiosk technology. The systems can consist of simple terminals designed to provide information and services to the general public (Maguire, 1999) to more complex systems employing a variety of interaction methods. One common criterion is that kiosks are public-access terminals utilizing some form of physical user interface (Borchers, et al., 1995). Kiosks also share some structural and operational features; many are touch screen, with either an on-screen keyboard or an actual keyboard for text entry (when needed), they are almost always ruggedized to cope with rough use and sometime exposure to the elements, and they usually provide as much handicapped access as is practicable.

Various kiosk systems have also been developed which allow more methods for interaction with the system than just the traditional touch screen. Christian and Avery developed an intelligent kiosk system which incorporates camera vision that can sense when a user is nearby. The system also incorporates speech feedback for relaying information to the user (Christian & Avery, 1998, 2000). Gauvain et al also developed a kiosk that utilized speech recognition for client input. This allows the user to utilize either traditional touch screen input or speech input to operate the kiosk (Gauvain, Gangolf, & Lamel, 1996).

The term *personal kiosk technology* describes kiosk systems that offer some sort of personalization for the current user of the system by coupling a personal identification device with a kiosk (Russell & Gossweiler, 2001). The problem with such systems is the privacy concerns they present. Various methods have been utilized to protect the privacy of the user such as personal headsets for viewing personal content in tandem with the kiosk (Eaddy, Blasko, Babcock, & Feiner, 2004) and mobile devices for viewing this information in relation to the kiosk (Garriss, et al., 2006). Other tactics are also discussed with regards to kiosk placement to minimize the risk of eavesdroppers (Maguire, 1999). The challenge for a personalized kiosk system is to implement safeguards in such a way as to enhance personal privacy, but the public nature of kiosk systems make this an even more daunting task.

2.2 Direction Giving

A great deal of research has looked at the process of direction-giving between people. This involves the spatial context of one person giving another person directions to a specific geographic area from another (Golding, et al., 1996). The process of direction-giving involves three separate stages: an introduction, the directions themselves, and a closure (Hill, 1987; Klein, 1982; G. Psathas & Kozlo, 1976; Wunderlich & Reinelt, 1982). The introduction, or entry, to direction giving is typically a request initiated by the direction seeker. This normally consists of a question pertaining to how to get to a particular place (George Psathas, 1990). An alternative mode of direction-giving introduction is a question of "where are you," initiated by the giver of the directions (George Psathas, 1986). This is typically thought of in the context of a remote direction-giver (for example, someone on the phone), who needs to have a starting reference before starting the direction-giving process.

The primary direction giving process involves the construction of a route between two primary locations, a starting point and an ending point. The process consists of a set of interchanges between the direction giver and the direction receiver with various deviations in form and structure. While the direction giver is the principal communicator in the conversation, the direction receiver may use insertions to suspend the conversation to clarify points of conflict given by the direction giver (George Psathas, 1990). The entire session is very freeform and can take a number of different tangents depending on the particular context of the direction giving exchange.

The closing of the direction-giving process consists of two parts. The first consists of the ending of the operations or construction of the route, which is marked by an "arrival" at the destination, or indicator of where the destination is at (George Psathas, 1990). Both parties are able to sense, typically through auditory confirmation, that the process has been concluded. The second part of the closing consists of the acceptance of the arrival point by the recipient. This indicates to both parties that not only has the end point been delineated, but also that the recipient has acknowledged that this is indeed the information he or she wanted. From here the conversation can move onto a new topic or close altogether if the direction giving was the primary objective of the conversation (George Psathas, 1990).

An electronic kiosk for direction-giving performs the 3 tasks associated with direction giving, but these interaction occurs between the user and the system. A person must become familiar with the system (introduction), then they can query the system which in turn displays for them where to go (directions), and finally they can complete their interaction with the system (closure). Many researchers (Golding, et al., 1996; George Psathas, 1986, 1990) have focused on providing analysis of the direction giving process, but this research generally takes for granted the fact that the introduction and closure phases are necessary steps in the process. With the advent of tools like electronic kiosks one could argue that human interaction may not be the most efficient mechanism for any of the 3 stages of direction-giving. This is because, in essence, the first and the last stage of interaction with a kiosk used for direction giving correspond to the input and logout stages of information systems use. Most research on and practice associated with information systems shows that input tasks are prone to error and closure tasks often are overlooked by end users (e.g., see Ballou and Pazer, 1985). People are slow at transferring information; they must learn the particular user interface, and users often make mistakes. Any system that can automatically access a user's personal information from a reliable information source will likely reduce the potential for error or user dissatisfaction.

2.3 Radio Frequency Identification

Radio Frequency Identification (RFID) is a technology which can be utilized to facilitate the identification of one or more entities. RFID is a type of near field communication (NFC) technology, which represent a class of technologies developed using short-range wireless technology that are designed to allow interaction of electronic devices which utilize disparate close-range wireless technologies (Strömmer, Kaartinen, Pärkkä, Ylisaukko-oja, & Korhonen, 2006). NFC wireless technology includes a variety of world-wide standards for contactless card technology (Ortiz, 2006), which includes RFID contactless cards. The testing environment for this research utilized RFID contactless cards as one sub-class of NFC technology because of the widespread use of RFID technology, RFID features pertaining to cost and ease of use, and the increasingly common use of RFID in other identification applications (e.g., users increasingly carry RFID cards for tasks such as building access).

Modern RFID systems are derivative of early radio identification technologies (e.g., the IFF transponder), which were originally used during World War II by the British Air Force to identify aircraft (Asif & Mandviwalla, 2005). Mario Cardullo filed for a patent in 1973, marking the beginning of the "modern" RFID systems that use passive radio transponder with memory (Cardullo & William L. Parks, 1973).

RFID technology consists of a transponder, or tag located on the object to be identified, and an interrogator, which is used to read the tag information. RFID technology has grown in popularity in production and supply chain as an alternative to the antiquated, proximity-based optical barcode technology (Atkinson, 2004; Brown, 2006; Caputo, Pelagagge, & Scacchia, 2003; Chappell et al., 2002; Davis & Luehlfing, 2004; Michael & McCathie, 2005; Reiner & Sullivan, 2005; Sutherland & Heuvel, 2006; Weinstein, 2005). Contactless access cards are also being utilized by organizations to restrict access to certain items or areas (Finkenzeller, 2003).. The technology operates wirelessly with the interrogator querying information about tags in its working area While RFID cards can carry some information beyond a simple identifier number, they generally will not hold enough information to add much value to the kiosk experience; here, their value lies in their ability to cue the kiosk's access to a database that can supply detailed information personalized to the user is possession of the specific RFID access card.

3. KIOSK DEVELOPMENT

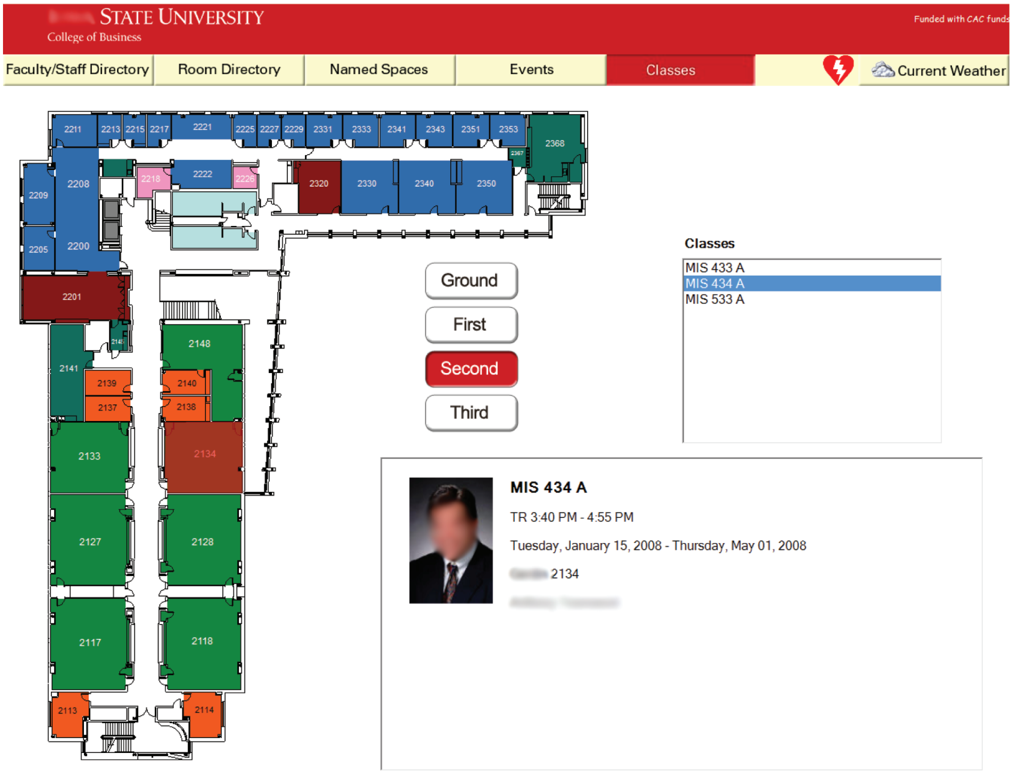
The kiosk utilized for this research was developed for a building on the campus of a large Midwestern university. The system was developed for a single building utilized by the college of business and was deployed in October of 2005 by the main entrance on the first floor. A second kiosk machine running the same software was deployed on the third floor of the same building six months later in April of 2006, so users would see the same information on both kiosks. Both systems also utilize the same kiosk hardware[2], so all physical attributes are identical, except for location. The design and development of the system spanned a six-month period were the standard waterfall systems development life cycle (SDLC) was followed (Royce, 1970). For example, requirements for the system were gathered from the dean's staff. These requirements where then developed into a product by one of the authors that was run through prototype development involving faculty and staff within the college. After modifications were made, the kiosk was tested by faculty and staff for one month prior to initial deployment and continual improvements and enhancements have been performed regularly since that time. The system was developed to run on a small Windows-based computer which was located inside the kiosk encasement. Development of the system was all performed in-house utilizing the .NET programming environment. The system utilizes a local access database for information and synchronizes this information with a departmental SQL Server database twice daily.

The system allows users to access information about room locations pertaining to faculty or staff, classes, as well as by room number or name. The kiosk consists of buttons, listboxes, an information panel, and 2D renderings of each floor in the building (with the ability to view one floor at a time). The user can access information by either selecting the room/location from a listbox along the side of the kiosk or they can select a room from the 2D floor renderings and receive the pertinent information pertaining to that room/space. Besides room information, class information can be viewed for the current semester as well as event information from the business college calendar. See Figure 1 for an example screen capture of the kiosk.

A later prototype of the above kiosk integrated an RFID tag reader with one kiosk. The Phidgets RFID tag reader[3] was utilized as the tag reader due to its easy integration with the system through its USB interface and included API. The reader will read passive tags within a 4 inch range operating at the 125 kHz frequency. The reader does not accommodate collision detection and therefore will only read one tag at a time, which enhances privacy and security. The reader allows the use of proximity cards, which are more typical for users and are currently utilized by faculty, staff, graduate students, and many undergraduates for dormitory access at the university. The reader was affixed to the top side of the machine to allow for easy access by users. The reader was then attached by USB to the computer located inside the kiosk encasement. The student's university ID number is encoded on the card and is utilized by the kiosk system to query the campus active directory system to retrieve the student's class information.

The electronic kiosk system first allows an *introduction* of the user with the system by holding their card up to the reader for authentication. This stage involves the use of the user's RFID mechanism, the system antenna, and the querying mechanism. Once the user's ID is read from the RFID card, the kiosk computer then authenticates the user with the centralized campus directory system and their current class schedule is retrieved. The *direction-giving* involves the schedule being passed back to the kiosk computer which presents this class information to the user with each class listed separately in a listbox on the screen. This stage primarily involves the user with the touchscreen

Figure 1. Example output for a student with the displayed classes and one of these classes selected

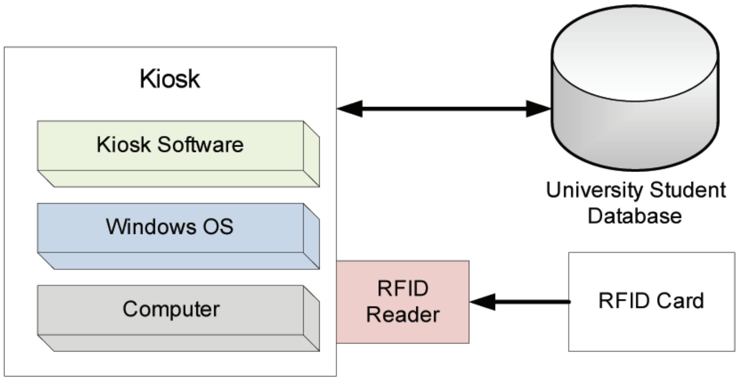


interface and informational responses to the user's touch input. The user can select one of their classes to display greater information about the class including meeting times, meeting location, and professor. If the class is located in the business building, the location is also indicated on a 2D map of the floor with the respective room flashing in red. An example of a user class schedule on the kiosk screen is given in Figure 1, with one of the student's classes selected by the user and the appropriate information and location of the class displayed. Finally, *closure* is achieved when the user removes their RFID card from the proximity of the card reader which removes their personal class information from the kiosk screen and system. This again involves the user's card, the system antenna, and the querying mechanism. A system architecture diagram of the system can be found in Figure 2. Also, a detailed system operation flowchart of the system operating procedures can be viewed in Figure 3.

4. DISCUSSION AND LESSONS LEARNED

The above system provides many advantages over other personalized kiosk systems. As expected, it effectively removes 2 of the 3 steps in direction-giving, introduction and closure, while also simplifying the second phase of the direction-giving process, namely detailing the delivery of directions. While traditional kiosks also simplify human interaction, these systems still require the user to become familiar with the system so they are able to query the system (the introduction phase). Next, the user must

Figure 2. Kiosk system architecture diagram



interact with the system in a way that allows them to successfully achieve their goal; that is, receiving the directions needed to their intended destination (the direction-giving phase). Finally, the user must be sure to have closure with the system to prevent personal information from being visible to the next user of the kiosk (closure). By utilizing RFID technology, the introduction has been reduced to the user holding their personal RFID access card in close proximity to the reader on the kiosk. After this, the user is able to utilize the kiosk with information which has been personalized to their experience. Finally, the system eliminates the need for closure by removing the user's private information from the screen with removal of the user's access card from the vicinity of the reader. A flowchart outlining the tasks necessary for direction-giving in each of three scenarios (traditional human interaction, traditional kiosk, and RFID-enabled kiosk) is shown in Figure 2.

Aside from demonstrating proof of concept, an important contribution of this physical system and the design logic behind it (see the flowchart shown in Figure 2), is that it highlights the importance of automation when considering the design and development of interactive systems such as kiosks. Clearly, with fewer steps in the process that need to be overtly activated by the user there will also be fewer opportunities for input errors, the user will have fewer activities to engage in which will make the task of using the system less complex, the user will likely need to spend less time using the system, and the user will presumably be more likely to rate the use of the system more positively. This has implications not only for an RFID system such as this but also for any similar kiosk or similar system that automates part or all of the interaction process. Therefore, concepts from this study should be relevant to research examining other non-RFID based kiosk and systems requiring user interaction. For example, magnetic card systems would similarly eliminate the need for substantive data input or authentication, which would produce similar efficiencies to those presented here.

As the figure shows, a traditional direction-giving process is inherently time-consuming due to the necessity to interact with another individual (shaded rectangles). The traditional kiosk improves on the direction-giving process by eliminating the human from the process, but still requires introductory learning to become familiar with the system and introductory actions to enter personalized information into the kiosk. Closure is also elongated as the user must be sure to remove personal information from the kiosk screen (large white diamonds). An RFID-enabled kiosk improves on human-centered direction-giving in a similar way as a traditional kiosk by automating part of the process, but also improves on the entry of personal data compared to that of a traditional kiosk. An RFID-enabled kiosk effectively removes the introduction and closure phases of direction-giving by only requiring the user to present or remove a personalized kiosk tag, thereby making these tasks almost completely computer automated (small gray diamonds in Figure 4).

Because of the simplicity of traditional kiosk design, the information that the user can then access from the physical user interface is not generally personalized…barring the use of much more complex data entry activities on the part of the user. This system allows for access to personalized information without requiring extra hardware (i.e. headsets or mobile devices) like other personal kiosk systems discussed above. Also, valuable screen space is not utilized by a keyboard or other traditional input mechanism, since the personalized access mechanism is placed to the side of the outer enclosure of the kiosk. The use of RFID access also alleviates the complex versus minimal information debate discussed in the literature review. The system uses complex information, provided by a simple RFID card mechanism, to provide a simple, yet informationally valuable, interface.

Personalized kiosk systems raise privacy concerns, due primarily to the public nature of the system. Other systems have utilized specialized hardware (as mentioned above), but this hardware can easily be broken, lost, or they may be complicated because they require the user to supply the supplemental hardware themselves. Also, residual information left on the screen by careless users is freely available to the next user of the kiosk. The system we describe provides enhanced security through the use of RFID proximity cards. By utilizing

Figure 3. System operation flowchart

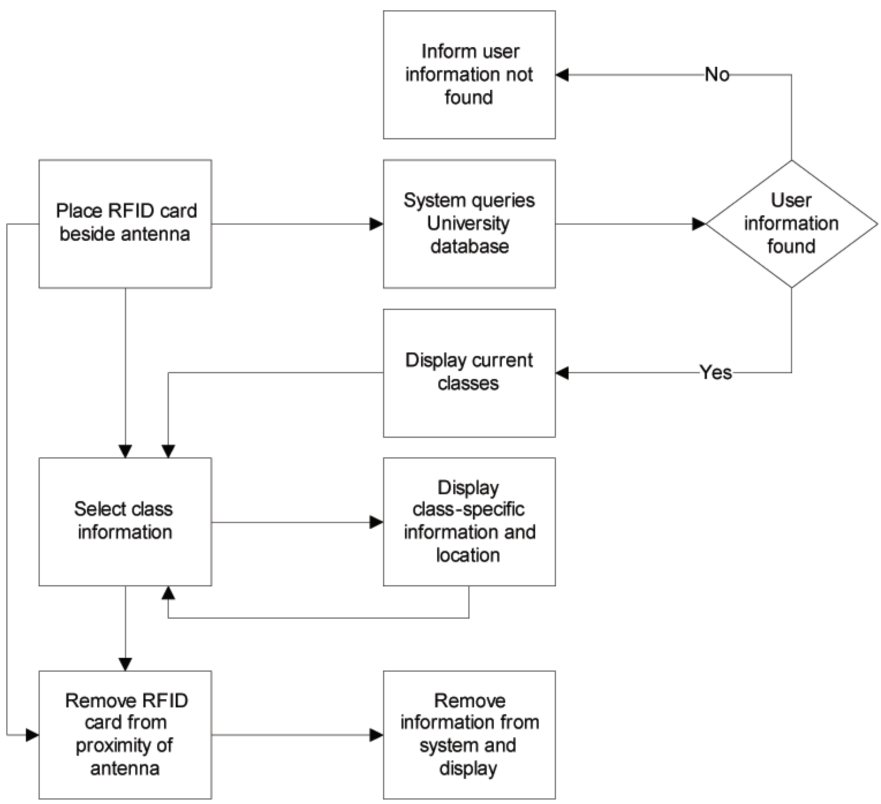
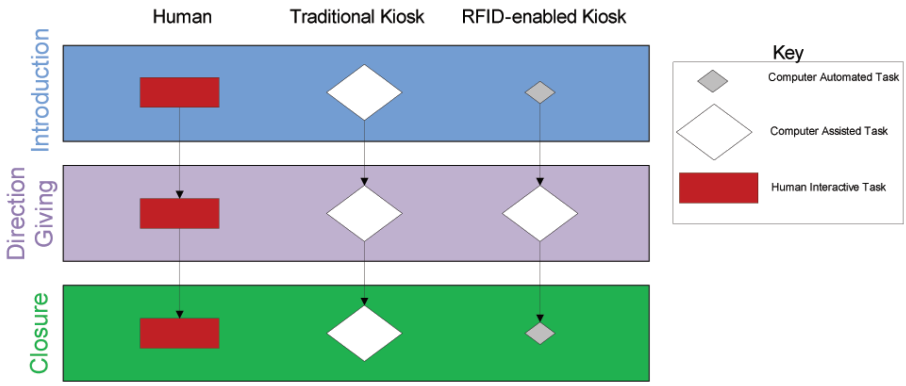


Figure 4. Flowchart outlining the direction-giving process for each of three methods of interaction: human, traditional kiosk, and RFID-enabled kiosk



this technology, the short read range of a few inches[4] ensures that all personal information will disappear from the screen when the user quits holding his or her card next to the reader. Also, the limitation of the system to only read one card at a time ensures that the system will not try to read another user's card if it is brought in close proximity to the system by another user. Compared to magnetic swipe cards, the information will leave when the user removes their RFID card as opposed to timing out with magnetic cards, which could leave the information visible for others.

While the system does offer a viable option to kiosk design to enhance direction giving and personalization, there are limitations. First, there are many security considerations to consider when implementing such a system. For example, the RFID technology should incorporate a secure transfer mechanism from the card to the machine. Our system, being only a test deployment, utilizes a non-secure RFID system and would need to be enhanced for production use. Second, university policies restrict who has access to student records, including class schedules. We had to obtain permission from the individuals who utilized the system to access their class records. This privacy concern would need to be addressed before final deployment. Third, any time a system displays personal information, even class schedules, the ramifications should be thoroughly thought through and the system designed appropriately. While the deployed system only allows one user to access their records at a time, we found that other users could potentially look over the person's shoulder to see what classes he or she is taking. This is not a problem for the type of application developed for our prototype because it dealt only with class schedules, but other kiosk applications used for applications that deal with financial, personal records, or other sensitive data would need to be managed with care.

Another limitation is that many college campuses do not yet offer proximity cards to students based on RFID technology. The campus at which this study took place issued RFID contactless cards to only about half the undergraduates. For this reason, graduate students were utilized to test the system. The campus primarily employs a card utilizing magnetic tape technology for students. While the kiosk system could easily be modified to support this technology, this increases the chances for privacy breaches. As described above, the system presented here has no need for "closure" as this is accomplished as soon as the user's RFID card is removed from the interrogator read area. If magnetic strip technology is utilized, the closure step becomes much more problematic. One option would be to add a button for the user to click once they are finished, but this could be problematic because users may forget to log off. A second option may be to place a timeout value on the display time of the information, but our research found that this time is hard to gauge; too long and someone else could potentially see the information and too short and the screen could change before the user is finished. A third option would be to use some form of camera or motion detection system to assess the user's continuing proximity, but this solution, like the others, does not make a magnetic card as attractive as RFID for this type of application.

5. CONCLUSION AND FUTURE WORK

This research describes the development of an RFID enabled personal kiosk system which allows users to view class and directional information specifically tailored to their needs. The system removes the need for both introduction and closure with regard to direction-giving and information presentation, thereby streamlining the direction-giving process and adding kiosk functionality. The system also utilizes RFID technology for user authentication for increased ease-of-use and potential security benefits.

There exist many avenues for future work pertaining to this research. First, a secure form of RFID authentication should be implemented. The objective would be to enhance the privacy and security features of the system to reduce the likelihood that unauthorized access to private data is likely. While this system offers many potential benefits for users in terms of ease of use and efficiency, there is a need to examine issues that RFID raises both for real and perceived security and privacy risks (e.g., see Lockton & Rosenberg, 2006). For example, do users understand the way that the RFID system will work and where and how identifying information can (and cannot) be gleaned from the system? Recent problems with RFID-enabled passports has raised concern among some members of the public, which may influence how users react to a system like ours.[5] Second, a full-blown field study deployment of the technology should be conducted to test for ease of use as well as adoption by users. In fact, user reactions to such kiosks and issues related to user perceptions of the security, privacy, and utility of these devices represent important areas for research. As a result, future studies should include case studies and surveys of user perceptions about their interactions with these devices. Also, greater research should look at utilizing ambient information to provide specific location-based directions to users. This study only provides a first look at direction-giving and greater granularity of directions should be explored.

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ENDNOTES

1 While most kiosks are designed for individual interaction and, therefore, use, it should be recognized that many times kiosks are used by groups of people. For example, when a group of students approaches one of the kiosks described in our study to query it for information relevant to the group (e.g., to identify the location of a class that all of the students are individually enrolled in), the beneficiaries of the output might be all the members of the group. Nevertheless, the assumption is that one individual in the group would be the primary user of the kiosk as he or she queries the system for the desired information. How the user disseminates the information collected from the kiosk once the session is terminated is beyond the scope of our analysis.

With this said, a variety of research projects involving shared use of various technologies is underway. An appropriate extension to our research would be to look at how kiosks can be used by groups to garner information and make decisions.

2 The kiosk hardware was manufactured by Redy Ref Products and solutions and can be viewed at the following location: http://www.redyref.com/kiosks_tk_4030.php.

3 Details pertaining to the Phidgets RFID tag reader can be found under "RFID" here: http://www.phidgetsusa.com/.

4 Testing of the system found that as long as the card was within 4 inches of the antenna, the user information remained on the system. Also, the information was removed from the screen within ½ second of removing the card from this 4-inch area.

5 Visit http://www.pcworld.com/article/141199/privacy_concerns_over_leaky_us_passport_card.html for information about "leaky" passports.

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