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Interim Report

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Project Title	SPOT-IT

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Introduction

In the world as it is today, there are many people who are either visually impaired or completely blind. These people often have to rely on others to help them perform various daily tasks. This is mostly because blind or low sighted people lack information about their surroundings, which sighted people receive naturally by simply looking around (even unconsciously). The aim of our project is to provide visually impaired people with contextual information about their surroundings, thus enabling them to know (i.e., "to see") what is happening around them. Such newly gained information will in turn enable them to be more independent and self-sufficient, since they will no more have to rely on others to provide them with this information or perform tasks based on this information.

To achieve this goal we devised a system called SPOT-IT, which uses a mobile device to read data from RFID tags placed on various objects near the user. Gathered data is used to retrieve meaningful information associated with the RFID tag, which is presented to the user in spoken form.

Ideally, the ultimate objective of our system would be to make visionless people completely independent. But this will hardly be possible unless one could truly restore their sight and enable them to see the same way as today's sighted people see. Thus, the true objective of the SPOT-IT system is to increase the level of independence of blind and visually impaired people by going a step beyond the current boundaries of seeing aids.

Benefits of the Project

The SPOT-IT project is targeted primarily at blind or severely visually impaired people, whose lives are greatly influenced because of their disability. To adequately understand the benefits, which our system will provide to society and visionless people in particular, we first need to understand how many blind and visually impaired people there are. Alone in the U.S. there are 750,000 blind people while some 8.9 million people suffer from low vision[1]. The situation is similar in other developed countries and even worse in developing countries. Worldwide there are close to 150 million people suffering from significant visual disability, 38 million of whom are blind[2].

Consequently, the SPOT-IT project will bring the following benefits to society:

- increased independence and self-sufficiency of visually impaired people,
- improved quality of life of blind people,
- an organized and partially centralized way of care for blind people,
- hazard warnings,
- an organized way to distribute information based on user location.

Furthermore, the system's functionality can be extended to other applications for sighted people thus providing new possibilities of information acquisition and processing.

Innovation

The key to accomplishing the audacious goals set by the SPOT-IT project, are several vital innovations. Perhaps the most important one is the use of RFID chips to tag entities (be it objects or information) with the purpose of providing people with contextual information. Amongst others, this provides the blind with an alternative way to detect (i.e., "to see") the

[1] Microsoft ® Encarta ® Reference Library 2005. © 1993-2004 Microsoft Corporation. All rights reserved.
[2] WHO Press Release, 21 February 1997. http://www.who.int/archives/inf-pr-1997/en/pr97-15.html

entities. The described concept presents a significant design difference compared to the common use of RFID chips for tracking goods, animals or people.

In order to utilize the full extent of possibilities provided by RFID chips we designed two web-services, which supply our system with the necessary data: the RFID Name Service (RNS) and RFID Tag Service (RTS). Both of these web-services are responsible for the translation of data obtained from an RFID chip into meaningful information for the user, which is stored on a server in the Internet.

The final innovative point is the incorporation of a text-to-speech engine, which is capable of converting the supplied information into a form, which is perceivable by a visually impaired person – the speech. Once the information is in spoken form, it is presented to the user via headphones by conventional means of either a wired or a wireless connection (such as Bluetooth). In order to maintain privacy, we experiment with the concept of a personal area network (PAN) via data transmission through the human body.

In order to compare the SPOT-IT system to existing systems, we have discussed its functionality with blind people from CEZAP (an association of blind people in our country). From this discussion and from our own investigation, we concluded that there are no comparable systems presently available, which would offer a similar degree of functionality.

System Organization

The SPOT-IT system is based on client-server architecture and uses RFID chips to tag various objects. The client side of the system is comprised of a mobile device (a PDA or a Smartphone) equipped with additional add-ons and the corresponding application software (see Figure 1). The input is gathered by an RFID reader, which searches for RFID chips near the user and forwards the acquired data to the mobile device for further processing. The system communicates with the user by means of a synthesized voice, which is transmitted to headphones via a wireless personal area network or a wired connection.

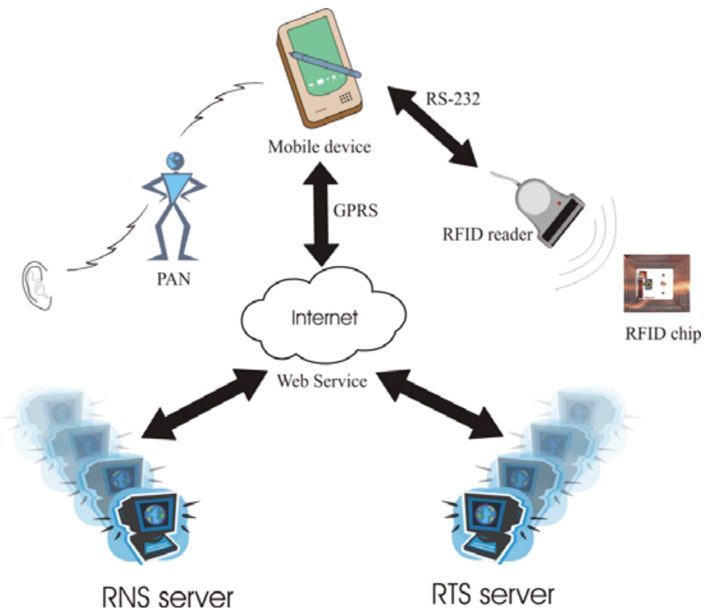

Figure 1. Overview of the SPOT-IT architecture.

The server side is comprised of a distributed group of two types of internet servers – RNS and RTS servers. These are used to interpret data gathered from nearby RFID chips into meaningful information, which is presented to the user. The conversion is a two-stage process, in which first the RTS server, which contains the actual chip data is identified by means of the RNS web-service. Thereafter the data is downloaded onto the mobile device for further processing from the respective RTS server.

Each RFID chip contains data, which uniquely identify a message that is presented to the user when a chip is detected nearby. This includes the following:

- an *ownerID*, which is used to uniquely identify the owner of the chip (be it an individual or an organization) and is used by the RNS service to identify the server where the actual message associated with the chip is stored;

- a *chipID*, which uniquely identifies the message associated with the chip for a given *ownerID* and is used by the RTS service to identify the actual message after the RTS server had been found;
- a *category* the message associated with the chip belongs to, which is used for information filtering;
- a *hash* value computed from the chip's data used for authentication and error checking. This value is used to identify chips which "belong" to the SPOT-IT system and is particularly important since we expect a large number of different RFID chips to be used in the near future.

A significant design effort was spent on the client software architecture. We devised a modular software architecture in order to allow for independent development of the individual modules, easier extensibility and also to meet the constraints imposed by mobile devices. The resulting client software architecture consists of the following modules:

- main application module, which includes the user interface and application logic,
- text-to-speech module used to synthesize voice output,
- web-service module used to communicate with the RNS and RTS services,
- cache module used to store and access downloaded chip data,
- RFID reader module, which provides a communication interface to the RFID reader.

Principles of Operation

The entry point to the SPOT-IT system is the presence of an RFID chip near the user. Therefore, the client software periodically polls the RFID reader for the presence of an RFID chip in the vicinity of the user. If a chip is detected a series of actions is taken (see Figure 2). First, the chip's data is read and a hash value is computed. Then the stored hash value and the computed hash value are compared to authenticate the chip. If these values are different, the chip is ignored, because it does not contain valid data. (The chip does not "belong" to the SPOT-IT system, or its data is corrupted.)

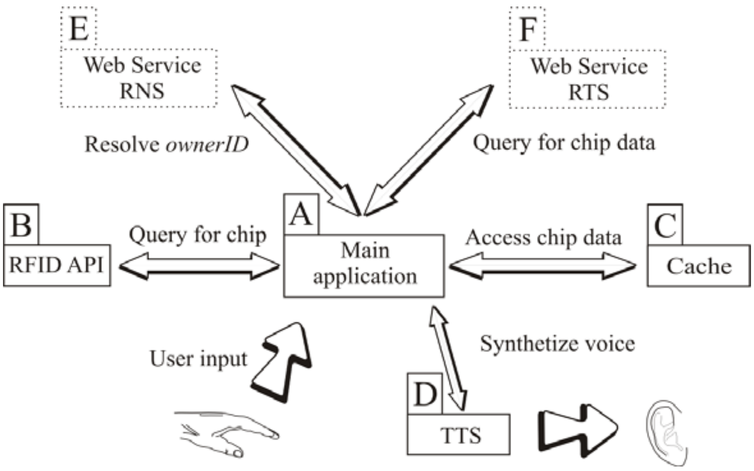

Figure 2. Overview of Spot-it operation.

For a valid chip, the message associated with the chip has to be retrieved. The SPOT-IT system employs a caching mechanism to speed things up as well as to extend battery life. Thus, each chip, for which data is downloaded, is stored in cache. Hence, if an RFID chip is detected, the software first checks if it is already present in cache and if so it uses the data from cache instead of downloading the same data again.

In case the data is not present in cache, it must be retrieved from an RTS server. For this, first the corresponding RTS server is identified by the RNS service, which translates *ownerIDs* into corresponding RTS server addresses. Once the correct RTS server is identified it is queried for the data associated with the given chip. The downloaded data is then stored in the cache should it ever be needed again.

Once all the relevant data is present, it is processed based on a predefined set of filtering rules. These are necessary, because with time there will be many RFID chips present and it would not be desirable to notify the user about each and every one of them. An example of a filtering rule would be “Ignore this chip until its data changes” or “Ignore commercial information.” which would ignore chips belonging to the category “*commercial*”.

Finally, if the filtering stage determines that the information should be presented to the user, it is converted into spoken form by the TTS module and transmitted to the headphones. At this point, the user interface becomes important, as it allows the user to affect the playback of the message. The message can be repeated, the playback of a message can be paused, or the message can be skipped altogether.

Methodology Used and Development Plan

After first stage of problem identification and a quick feasibility study, we opted for an agile development approach based on prototyping. The project’s life cycle could be best described by means of an incremental and iterative model, which together with feature driven development allowed for easy incorporation of changing requirements represented as features, short iterations and early testing.

In the first stage of the project, we completed a number of tasks:

- we gathered initial project ideas and evaluated them;
- we decided on the system’s functionality;
- we made a list of hardware and software requirements and designed the software architecture;
- we successfully tested the basic functionality of key technologies required to complete the project (RFID, TTS, Web-Service, PAN).

The project schedule for the second stage of the project is summarized in Appendix B.

Our team consists of four members: Martin Adam is primary responsible for hardware related parts of the project and the development of an RFID reader interface. Michal Barla is occupied with the software development of the RFID API and web-services. Peter Sivák works on hardware related issues of data transmission through the human body, web-services and on database support. Michal Tvarožek is primarily responsible for speech synthesis, project documentation and application logic and provides advice concerning mobile and desktop application development.

Outcome

The primary goal of the project is the design and evaluation of an original system that is supposed to shift the boundaries of present-day information acquisition possibilities. In order to evaluate the practical feasibility of the design as well as for demonstrational and testing purposes, we expect to have a prototype of the system ready by the end of the project. This would include a mobile device equipped with all necessary add-ons and the respective software and all the server components necessary to run the RNS and RTS web-services.

Consequently, the practical implementation of the SPOT-IT system should prove to be a straightforward process since the costs of the necessary components are relatively low. The used RFID chips cost around $0.60 each and this will decrease even further if used in large numbers. We expect most of the other components to be integrated into handheld devices in the future. Even at present, the RFID reader module only amounts to $70 and the components required for the PAN module cost no more than $20.

Appendix A – Definitions/Acronyms

PAN – Personal Area Network
PDA – Personal Digital Assistant
RFID – Radio Frequency Identification
RNS – RFID Name Service
RTS – RFID Tag Service
TTS – Text-To-Speech

Appendix B – Project Schedule

Period: February 18 – April 24, 2005

Module	Task	Responsibility	Due Date
B	RFID application logic design, implementation and testing	Martin Adam, Michal Barla	17.03.2005
–	Headphone interface design, construction and testing	Martin Adam, Peter Sivák	18.03.2005
Report	Final Report outline	Michal Tvarožek	18.03.2005
A	XML Message processing module design, implementation and testing	Michal Barla	25.03.2005
E	RNS web-service design, implementation and testing	Michal Barla, Peter Sivák	29.03.2005
F	RTS web-service design, implementation and testing	Michal Barla, Peter Sivák	29.03.2005
E+F	Web interface design, implementation and testing for the RNS/RTS services	Martin Adam	29.03.2005
A	Web-service client design, implementation and testing	Martin Adam	29.03.2005
A	Message filtering module design, implementation and testing	Michal Barla	01.04.2005
–	Web-service benchmark of the performance of a relational vs. XML database	Peter Sivák	03.04.2005
C	Caching module design, implementation and testing	Michal Tvarožek	07.04.2005
Report	Final Report draft	everyone	08.04.2005
D	Text-to-speech engine interface design, implementation and testing	Michal Tvarožek	14.04.2005
A	Main application and user interface design, implementation and testing	Michal Tvarožek	16.04.2005
ALL	System testing	everyone	19.04.2005
Report	Final Report completion	everyone	23.04.2005