CMPT 880 Proposal
Supporting the needs of Mobile Home Care workers

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ABSTRACT
The problem addressed in this study is how to improve the access of home care workers to information and coordination with other workers in the Saskatoon District Health using mobile devices. We propose an architecture, which supports several typical tasks: retrieving information from the system, notification for plan - or schedule- related changes, entering new data in the system and communicating with other home care workers. The approach focuses on optimizing relevant information presentation and the selection of output channels based on the availability of the resources and knowledge about the context of the worker, e.g. the physical location, and the "activeness" of the device.

Keywords
Adaptation, mobile devices

1. INTRODUCTION
The development of mobile and wireless technology and the impressive commercial success of small screen appliances, especially cellular phones and Personal Digital Assistants (PDAs), have advanced the development of ubiquitous computing [28]. It allows increasingly mobile users to remain "connected" without any dependence on wires. Mobile computing brings interesting new applications and services for information retrieval, communication and collaboration across a diverse range of environments and time barriers [21]. The users of small screen devices increasingly demand more access to information services while they are mobile, for example, the ability to browse multimedia information, and accessing this information anywhere and anytime.

Currently, most applications are optimized exclusively for desktop and broadband clients. They deliver content poorly suited for mobile devices. Small screen computing devices have different features and abilities than desktop computers and have more limitations – screen size, processor power, memory, battery life, bandwidth. The applications for these devices should take these features and limitations into account.

The problem that will be addressed in this study is how to improve the access of mobile nurses in the Saskatoon District Health to information and to the other team members.

This paper has six main sections as follows. In the next section, I will introduce the domain for the study. Section three proposes a solution to the problems discussed in the previous section. A review of the different approaches for adapting and redesigning the existing applications to make them accessible by a diverse group of mobile devices, is explained in section four. In section five, I will propose my approach to improve the problem explained in section two. A description of the proposed approach's characteristics is also presented in section five. Section six addresses the functionality of the system. Finally, section seven summarizes and draws directions for future work.

2. PROBLEM STATEMENT
The domain for this case study is home care at Saskatoon District Health system. For each patient a group of home care workers consisting of nurses, physiotherapists, home health aid, social workers, and dieticians is responsible for looking after the patient. They meet and discuss the necessary treatment for the patient. Then, the duties are divided among the home care workers. The relation between a patient and homecare workers is 1 to N, which means each patient has N home care workers who are taking care of him/her. The relation between a homecare worker and patients is also 1 to N since each home care worker takes care of N patients. Each of the home care team members has different tasks and responsibilities in the area that they are trained for, which allows them to work independently of each other. However, they all have one task in common and that is the treatment of the patient. The home care workers are visiting patients in their home most of the day and even when they are in their offices, their respective departments are usually in different buildings. Therefore, it is very unlikely that they exchange their information, schedule and their medical records.

Based on the above explanation regarding the environmental work and the job description for home care workers, herein, I explain a system that supports home care workers. This kind of systems should be highly mobile and distributed because the home care workers are nomadic and provide their health care services in the different district areas. In such widespread areas, the wireless network's bandwidth is low and varies from one area to another. Moreover, the network connection is unreliable. The data sources are distributed in the number of offices. The home care workers don't have access to the data sources while they are mobile implying that there is no remote access available to the data files, such as health records and schedule. There is also no collaboration in the system when the workers are mobile, which means there is no possible chance to coordinate tasks and to communicate. In summary, a system supporting home care workers is distributed, highly mobile, and dynamic and it doesn't support communication and remote access to data sources.

Scenario: Suppose nurse A is driving towards a patient A place. When she arrives in the patient's home she looks at the patient's medical record and reviews what she needs to do. When she enters the patient A's home, she may suddenly realize that the patient has just had a physiotherapy section. As a result, she cannot measure the patient's blood pressure and heartbeats due to the physical activity. Therefore, she has to re-schedule the patient in another time.

There is a preliminary study conducted by Pinelle and Gutwin [22] on the usability of the electronic health records system on home care at the Saskatoon District Health. Pinelle and Gutwin [22] described the way groups of home care workers care for a patient and listed their existing problems. Their study showed that there were several obstacles for communication between the members of a group that led to difficulties in making changes in treatment, coordination and scheduling for visiting patients. These difficulties were also observed in accessing information while the groups of home care workers were mobile. Pinelle and Gutwin [22] focused on how to improve support for collaboration in the existing electronic health records. They suggested two design approaches as follows. The first approach helped home care workers to maintain awareness of the action of other group members. The second approach provided communication facilities that were related with medical records. Furthermore, they focused on interface issues for human interaction with the core of the health care system. In the approach that I am proposing in this study, my focus is not on the core information of health care, the emphasis will be on the availability of non-critical information, such as scheduling, to optimize work while the home care workers are mobile. The reason for such emphasis is due to the fact that access to the patient medical record data is regulated with health and privacy acts in the province and it would be very hard to get permission to study the actual data files for my research. I also assume that new medical devices that measure the patient's blood pressure and heartbeat while the patient is alone will become available soon; therefore, new kinds of data from the patients' medical devices will be available to healthcare workers I will also focus on supporting adaptively the communication between different members of home care groups while they are on the way.

Among all the members of health care team workers, this study focuses on nurses and their tasks. In general, nurses visit different patients in their place, therefore most of the time they are mobile. Nurses can work in the following contexts: in the office, on the road, and at a patient's home. Nurses face different situations. For example, situation 1, when a nurse makes her schedule she must have knowledge of the other team members' schedules in order to avoid conflict in visiting the same patient. This situation happens because of the lack of centralized scheduling system. As mentioned in the beginning of this section home care workers work in different departments that are located in different buildings and by having a dynamic environment they cannot maintain a centralized schedule. Situation 2: If the nurse visits a patient and notices that the patient's condition has worsened, she needs to notify the other team members of her group. She may want to send a message to the physiotherapist or the social worker of the group not to come for visiting the patient because she is very sick. Situation 3: If the nurse has problem making a decision or doing a procedure she has to be able to consult her colleagues. If the nurse needs some more information about the patient whom she is visiting, she must be able to access to the information she needs even though while she is far from her office. Based on the above explanations, one may divide the problems into two major categories. The first category of problems can be assumed due to the lack of efficient communication whereas the second category of problems can be imputed to the less developed system of accessing to the information.

This study aims to propose a solution to improve the access of mobile nurses to the system of information and to the other team members in the Saskatoon District Health.

3. TECHNOLOGY TO SUPPORT MOBILE HOME CARE WORKERS

To solve these two categories of problems, one possible solution is to provide the nurses with a mobile device such as a PDA or WAP-enabled phone, which offers the functionality of electronic health records and brings more sufficient support for collaborative activities. Several important tasks, which could be supported using mobile devices, are retrieving information from the system, notification for plan -or schedule- related changes or entering new data in the health records, adding new data to the system and communicating with other members of the home care division.

The devices introduced in this study are Pocket PCs (iPaq from Compaq), WAP phones and WebPads. The WAP phones limited computational resources, very small screen size (maximum 1.6") display and naturally, sound/voice as the output channels (see Figure 1). The WAP phones accept voice or written request for accessing information services on WAP servers. They have, on average, 14 hours battery life. Such devices are not convenient for entering a command or request, since entering commands in the WAP phones is a very time-consuming task, due to the small telephone keypad. For instance, if the user wants to enter the letter " *c",* he must press the button "1" three times.

Pocket PCs, have computational resources similar to desktop computers. A pocket PC usually has 64MB or more RAM and 2GB disk capacity. It has, on average, 10 hours battery life. It can accept voice and written command or request as input and use voice and small screen size (maximum 4") as the output channels. Pocket PCs have a touch screen type, which makes them suitable for entering and retrieving information with stylus (see Figure 2).

The WebPads accept one type of input, which is text commands or requests that are entered from a touch screen display (maximum 8") using the stylus or soft keyboard. The WebPads have battery life up to five hours, 64MB RAM memory (see Figure 3).

The Pocket PCs and WebPads have advantages over desktops in the sense that they are portable. They have new features such as providing information with respect to the location of the device. Pocket PCs accept different types of inputs and provide different types of outputs. Both Pocket PCs and WAP phones have some major shortcomings when compared to desktops, for example, small screen size, a lack of keyboard, low memory size, short-time battery life and weak power of the processor.

One of the disadvantages of described devices is their lower ability in connection to the networks as compared to a desktop. In other words, they suffer from low bandwidth and unreliable connection. This pitfall comes from the fact that mobile devices are sometimes affected by the mobile environment, which causes a disconnection in accessing the networks, whereas in a desktop such event does not happen. WAP phones, WebPads and Pocket PCs can be connected to the Wireless Internet using Cellular Digital Packet Data (CDPD) [7] with bandwidth of 19.2 kbps. The wired network bandwidth has a range from 28.8 kbps to 100 Mbps by using a regular modem and Fiber Distributed Data Interface (FDDI) technology, respectively.

Figure 1. WAP phone

Figure 2. Pocket PC - iPaq

Figure 3. WebPad

The infrastructure needed to support mobile devices requires servers providing information-service for the nurses. Figure 4 shows a model of the real world, i.e., Saskatoon District Health, with home care workers provided with mobile devices. It illustrates various positions of the home care workers. For instance, they may be either at their offices, at the patient's home, or on the road. They are highly mobile and distributed in the environment. Figure 4 shows multiple data sources/offices and servers. The servers and CDPD connection provides mobile home care workers with permanent access to the data and to each other. The gray zones in Figure 4 show the areas where the bandwidth is low. In addition, some examples of transactions, such as sending notification note, checking the schedule and retrieving information that might be performed by the mobile nurses is shown in Figure 4. For example, the bandwidth for transferring data from a remote server to a user varies form few bits per second (in a noisy wireless network) to hundreds of megabits per second (in a wired network).

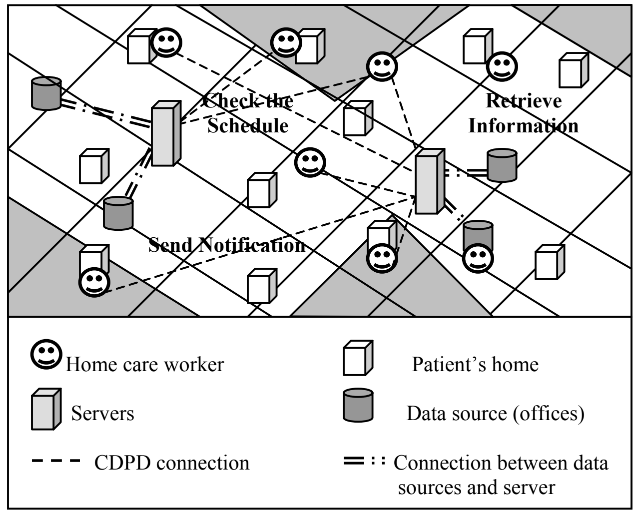


Figure 4. The model of real world (Saskatoon District Health)

The requirements for this nomadic environment can be divided into three groups: technical, devices and information resources. Table 1 shows the key parameter of each requirement. The values for all technical parameters change when the users move from one location to another. The device parameters are varied as well. The desirable characteristics for this nomadic environment include independence of location, of motion, of platform and a wide access to remote files and services [16]. In this study, my focus is on the availability of the communication and accessibility of the information at the current moment.

Table 1. The key parameters of nomadic environment [16]

Requirements	Technical	Devices	Information resources
Parameters	Bandwidth, reliability, delay, storage, processing power	Battery life, size, memory	Independent of location, motion and platform

Having considered such characteristics to support access information and communication for mobile nurses, who use different devices, I propose an architecture that is device-independent. This system is a context aware and a task dependent system. It is able to present the information required for a nurse corresponding to her task in general, as well as the information that is being requested by the nurse, particularly on her current context. Therefore an adaptive information retrieval and presentation approach is needed.

4. ADAPTIVE SYSTEMS FOR MOBILE DEVICES

By designing computer systems, which can adapt their own functionality, designers are allowed to cope with the heterogeneity that is available between and within the users. It also accommodates users throughout their interactions with the system. Figure 5 shows an abstract view for the adaptation. For any adaptation, there is a need to know the variables to which the systems are adapted. For example, Figure 5 shows an adaptive system to variables such as device type and location. Such adaptive system's functionality adapts to environmental variety. An adaptive system needs to know what features of functionality can be adapted i.e. the "degrees of freedom" (shown in the right box, in Figure 5). The adaptation process uses different models for adaptation, such as user models and task models [6].

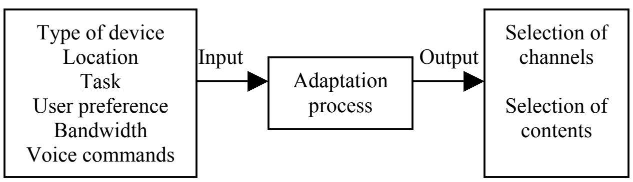


Figure 5. The abstract view of adaptation

User models represent inherent user features and characteristics, for example the user preferences, goals and tasks. User modeling approaches can be classified into two categories, explicit and implicit. Explicit approaches involve the user directly to enter information in the model, while implicit approaches build the model through observing the user's activity. Implicit approaches are preferable in many applications, since they do not require the user's attention. However, they are more difficult to implement and they are not so reliable. Various techniques have been developed for implicit user modeling, including machine learning. Generally they are domain dependent and require a lot of examples. Therefore, often it is preferable to use explicit user modeling approaches, especially if users are expected to cooperate, like for example in an organizational setting.

Task models describe the possible tasks that users can perform during the interaction with application. Building a task model requires significant efforts from the knowledge engineer. The knowledge engineer not only has to become familiarized with the problem domain but it has to interpret, abstract and model data elicited from the domain experts [27].

There are issues in adaptation in a mobile environment such as adapting the content to the user preferences and device capabilities and availability of the information. These issues are explained in the remainder of this section.

4.1 Content Adaptation

Most of the existing Web content is not usable for small devices because it is designed for desktop computers [11]. To date, two different approaches have been proposed to making the existing Web content and services available for various devices. Specifically, these approaches support the content-adaptation for migrating/adapting current applications or information-presentations designed for desktop computers to small devices. In this part of study, I briefly explain each of these approaches and refer the interested readers to find details in the cited references.

The first approach for making the existing Web content and services available for various devices, focuses on keeping the same structure and shrinking the content to match the capabilities of small devices [10]. This approach contemplates at mobile devices as smaller size desktop computers and *adapts* the existing application or information presentation to the small mobile device. In this approach, similar to the traditional applications for desktop, the information is presented through displaying on the screen. In this method, the input (see Figure 5) is the characteristics of a device, such as screen size, and the output is ascribed as a formatted content/information to fit the device's screen capabilities. To make this transformation, there are different techniques classified by Freire et al. [11] into three categories:

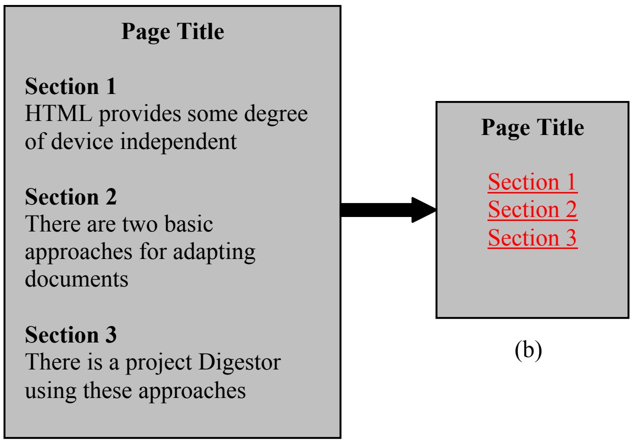
- *Re-engineering* the existing application and services, which means that they create different versions of the web sites for each type of devices. One of the techniques proposed in this category is the device-specific authoring [4]. An example for the device-specific authoring is the Amazon.com [3] that provides different version of its web sites for WAP phone and PDA.
- Creating specialized *wrappers*, which export different views of a web page or a service. An example of such tools is the oraclemobile.com that creates wrappers. The wrappers export pieces of web pages and services, such as stock quotes, traffic and weather information.
- Using *proxies*, which filter and reformat web content. Proxies are created that are able to transform content according to the users display size and capabilities, such as multi color screen or black and white. One technique for doing this is the automatic re-authoring. In an automatic re-authoring, the content goes through a series of transformations, so it can fit the characteristics of a device [4]. An example of the automatic re-authoring is the ProxiWeb [23], which transforms embedded figures and HTML pages to display on a Pocket PC.

There are several possible techniques for automatic re-authoring divided in two categories: syntactic/ semantic and transformation/ elision. A syntactic technique changes the structure of the page, whereas a semantic technique relies on some understanding of the content. An elision removes some information and leaves everything else the same, whereas the transformation techniques involve modifying some aspect of the page presentation or content. Table 2 shows few examples of syntactic/ semantic and transformation/elision techniques. Interested readers can find more details about the different techniques of automatic re-authoring method in Bickmore and Schilit [4].

Table 2. Different automatic re-authoring techniques (Adapted from [4], p. 3)

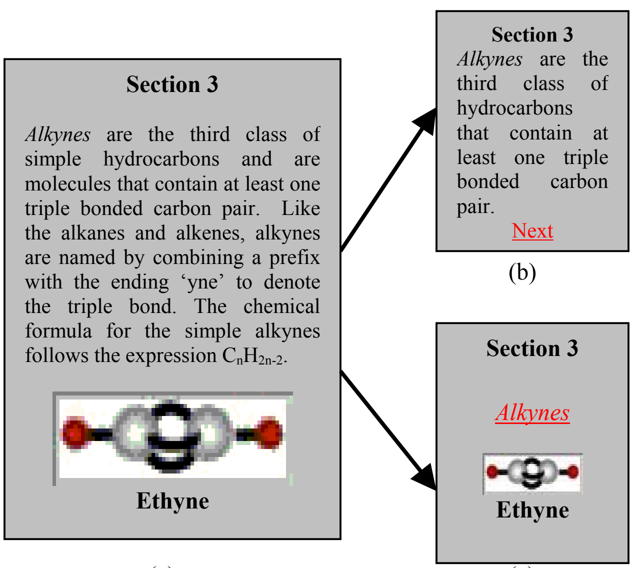
	Elision	**Transformation**
Syntactic	Section outlining	Image reduction
Semantic	Removing Irrelevant Content	Text summarization

Figure 6 shows the content adaptation using the section outlining and Figure 7 show the content adaptation using Image reduction and text summarization in iPaq and WAP phone. Figure 6-(a) and Figure 7-(a) is the results of adaptation formatted for iPaq. Figure 6-(b) and Figure 7-(b) is adapted to the WAP phones, which don't have the capabilities to view images. Figure7-(c) is the result of adapting an image to capabilities of the small WAP phone screens, which can view small images.



(a)

Figure 6. Approach 1,Re-authoring techniques (Adapted from [4], p. 5)



(a) (c)

Figure 7. Approach 1,Re-authoring techniques (Adapted from [4], p. 6)

Although all of the above categories support content-adaptation, there are some drawbacks that can be found in those techniques. Creating and maintaining different versions of a web site is a very expensive and labor consuming activity. The advantage of this type of service is that it delivers the best pages formatted for the specific device. Creating wrappers is costly since the wrappers need to be updated every time a change occurs in the corresponding web sites. Proxy transcoders perform on-the-fly content translation. They present a good solution in allowing users to browse any web sites. The first two solutions are restrictive, since they do not support all kinds of devices and websites [11].

Alatalo and Peräaho [1] presented an example of designing a new navigational structure for the existing web services while considering mobile users. Their study showed that to make such service usable on a mobile device, mobile devices should not be considered as a small version of desktop. Alatalo and Peräaho [1] suggested that the designers use different media as output terminals rather than focusing on the text/graphic display adaptation.

The second approach for making the existing Web content and services available for various devices, views mobile devices, wireless information and communication technologies as a different media rather desktop computers [2]. Instead of keeping the existing structure of application, the application or information presentation is *redesigned* for the small device. This approach focuses on optimizing information presentation and the selection of output devices based on the availability of the resources. Therefore, the second approach uses some of the advantages of mobile technology such as prior knowledge about the physical location of the user, and the "activeness" of the device (the fact that mobile devices can ring, beep, vibrate to attract user's attention) [2]. As a result, depending on the location and device, the system will present information differently and interacts with the user differently.

In the second approach, the required inputs are the characteristics of the device. These characteristics are the capabilities of the device to produce multimedia outputs, the screen size and context of the user of the device. The output would be the suitable multimedia/text presentation of the content/information and it depends on the current context. Having multiple output terminals, such as display windows, voice or sound in a device, a system needs to be able to present information to each of these outputs. Thus, several techniques such as media conversion, e.g., text to speech [13], smart content extraction, or delivery (filtering) are become important for transferring the input to the desirable out put [24]. There are special tools such as *tellme.com* and *heyanita.com* that create wrappers. These tools are able to export voice-enabled services [11]. Therefore, a user can access the various services presented by different mechanisms such as requesting by talking (voice input), enter the request by text (using keyboard or handwriting) or clicking on the icon if the screen type is touch screen.

Applications for mobile users have to be context aware. Context awareness means that the application must have the ability to extract, interpret and use situational information, and adapt the functionality to the current context of user. Korekea-acho [17] classified some examples of context information as follows: identity, spatial information (location, orientation, speed, acceleration), temporal information (time of the day, date), social situation (people that are nearby), nearby resources (accessible device and host), activity (talking, reading, walking), and schedules and agendas.

There are several individual systems, which provide services adapted to the context of the user. For example, Nomadic Radio [26] is a wearable system that delivers news, voice mail and email through an audio system; it is adapted to the user interest and location. The NewsDude [5] is an adaptive radio in a car that selects news to fit the interests of the user. The Audio Aura [20] is an audio-based wearable system, which utilizes sound to indicate automatically email and group activity. The Audio Aura delivers information based on the user location. The Just-In-Time Information Retrieval (JITIR) system proactively retrieves and presents information based on person's local context [25]. A Context/Communication Information Agent (CIA), introduced by Hong and Landay [14], is a proactive application that helps the user to find and deliver the right information at the right time by considering the user context.

4.2 Access Information

Another issue in mobile computing is how to access information while the wireless networks are unreliable. The fact is that the resources are not fixed as they are in the traditional (wired) networks. There is a series of limitations in mobile computing, such as wireless bandwidth and battery life, which vary from one type of device to the other. In this type of environment, mobility of user means that they connect from different access points through wireless links and want to stay connected while on the move, despite possible intermittent disconnection [15].

Existing research on mobile client-server computing can be categorized into three paradigms: *mobile data access*, *mobile-aware adaptation* and *extended client-server model*. With a *mobile data access* the following questions must be answered: How can data be delivered to a client from a server site? How the can the consistency of a client's cache be ensured effectively? The *mobile-aware adaptation* addresses the question of how systems and applications should respond to the environmental changes and resource requirements. The *extended client-server model* suggests a method to support the adaptation of mobile systems and applications by partitioning the functionality and responsibilities of the client and server [15].

From the above paradigms, I will look at the mobile data access. Efficient and consistent data access in a mobile environment is a challenge for researchers because of the weak connectivity and resource constraints. One of the approaches that Jing et al. [15] mentioned is the client cache management that can be used when the client side has enough memory for caching. Caching of frequently accessed data item is an important technique that reduces connection and improves the response time on wireless links. The cached data can support disconnected or intermitted connected operations. The weak connections of mobile clients and, to some extent, the disconnection can affect the cashing strategy. Caching during a weak connection is expensive. Pre-fetching or hoarding data into a client cache is a difficult task prior to the disconnection to the network. Therefore, Jing et al. [15] suggested using an Automated Hoarding to support the disconnected operations, which cache non-local files on the client prior to disconnection. There is one problem with using the suggested method though, and that is the choice of the files that should be stored. Two solutions to this problem are to choose the most recent referenced files or to ask the user to select the files that must be pre-fetched [15]. In a SEER system, an automated hoarding is implemented to predict which files user may access [18]. This automated predictive hoarding is based on observing the user's behavior and studies of the relations between the files and the user's actions. After caching the needed files there might be some changes made to the files on the client or server sides, which force users to validate the cache. One solution for such alteration is to use volume stamps. A server maintains version stamps for each of its volumes that enable the client to track the server's state at multiple levels of granularity similar to the task users do in Coda system [19]. When the connection is restored after a network failure, the client presents its volume stamp to the server for validation. If it is not valid, then the cached object needs to be validated individually. This approach improves the speed of cache validating.

Another important issue is how to request the resource information from the client. Two approaches have been proposed, called *Pull* (information access) and *Push* (information delivery). With *Pull*, the server requests the necessary information from the client. With *Push*, the information goes with each request from the client to server [8]. The implementation of the *Push* approach is more complex but it has the advantage that the server does not have to ask the client for resource information.

4.3 Summary

By now I explained two approaches for content adaptation and discussed various issues concerning the information access with mobile devices. Table 3 shows the summary of these approaches.

Table 3. The summary of content adaptation approaches

Content adaptation approaches		**Techniques**	**Ref.**
First approach (Text)	Re-engineering	Device-specific authoring, Multi version services (Amazon.com)	[4] [11] [3] [1]
	Creating wrappers	Export pieces of services, web pages in text (oraclemobile.com)	[11]
	Using proxies	Filter and reformat, automatic re-authoring, on-the-fly translation (ProxiWeb)	[4] [11] [23] [24]
Second approach (Multimedia)	Re-engineering	Voice version (Amazon.com)	[4] [11] [3]
	Creating wrappers	Export pieces of services, web pages (tellme.com)	[11]
	Using proxies	On-the-fly translation to voice (WebViews)	[4] [11]

The disadvantage of the text approach is that it only adapts to the screen capabilities of device and displays the result in text/graphics. The cost of the first approach depends on what type of technique is used for transforming the input to desirable output. The disadvantage of the second approach, i.e., multimedia, is the added time for converting different media, such as text to speech. In the system domain of this study, i.e., Saskatoon District Health, because of using three different devices with various limitations and capabilities, the best way for adaptation is to use the second approach that supports multimedia presentation. In my opinion, the best solution for this system is the combination of the two approaches because of the importance of real time tasks and the cost involved. By using the proxy, we can create on-the-fly text content for displaying and utilizing interpreter to convert voice to text and vice versa. The problem involved in using proxy is that it will become a slow process if all the contents are created on-the-fly Creating a template for each type of device on-the-fly and storing the template for future presentation can solve this problem. This combination can be more efficient and faster for our purposes.

5. PROPOSED ARCHITECTURE

To support the information and collaboration needs of nurses on a mobile device, I intend to use an architecture that allows information retrieval, notification and collaboration depending on the context and the typical tasks. For representing the information to the nurses on their mobile devices, I will use the second (multi-media) approach of content adaptation that was described in the previous section. Specifically, I will use the different features, the variety of input and output channels offered by mobile devices (PDAs, WebPad and WAP enabled cell phones) to design the presentation of information according to the context and the needs of the user.

The architecture is based on a client-server model and will support: (*i*) Adaptation of information presentation based on the characteristics of a client's device, her context and preferences. (*ii*) Retrieving information from various data sources appropriate for current tasks performed by the user, and (*iii*) Communication between different clients. Figure 8 shows the structure of the proposed architecture, which comprises three groups of components.

The first group of components is on the client side and provides adaptation depending on the mobile device of the user interface for the application. Clients can interact with the system via voice or text. The second group of components is on the server side and includes the servlet, interpreter, proxy, adaptation process, and accessing data sources. In this component, the input is accepted by servlet. When the input is in a voice format, the servlet will send a message to the interpreter whose function is to convert the message to a text. After the text is being converted, it is sent to the proxy. The proxy, then, will pass the converted message to an adaptation process. The adaptation process, in turn, is divided into three parts. The first part contains the factors that form the adaptation's contents. The second part of the adaptation process has a knowledge base that encompasses the information regarding the workflow, schedule and task-related information. The last part of the adaptation process on the server is designed to answer to the questions such as: What should the queries retrieve? How does the system adapt functionality to the needs of the task? Therefore, this part of the adaptation process will take care of the functionality of the system. The last component of the architecture is various data sources and system rules. In this component, the system database contains information about the home care workers, their schedule and patient records.

Generally, in content adaptation, the system needs to realize what kind of device the user has and what the user's current context is. To recognize the current context of the user, first all the potential contexts for the user should be stored in the system database. Second, the mobile devices can provide the location of the user that allows the system to recognize the context. The system provides information for the user based on the client current task. However, presenting the information in an appropriate way depends on the context and device variables. In the following sections, more details regarding of different parts of the process are presented.

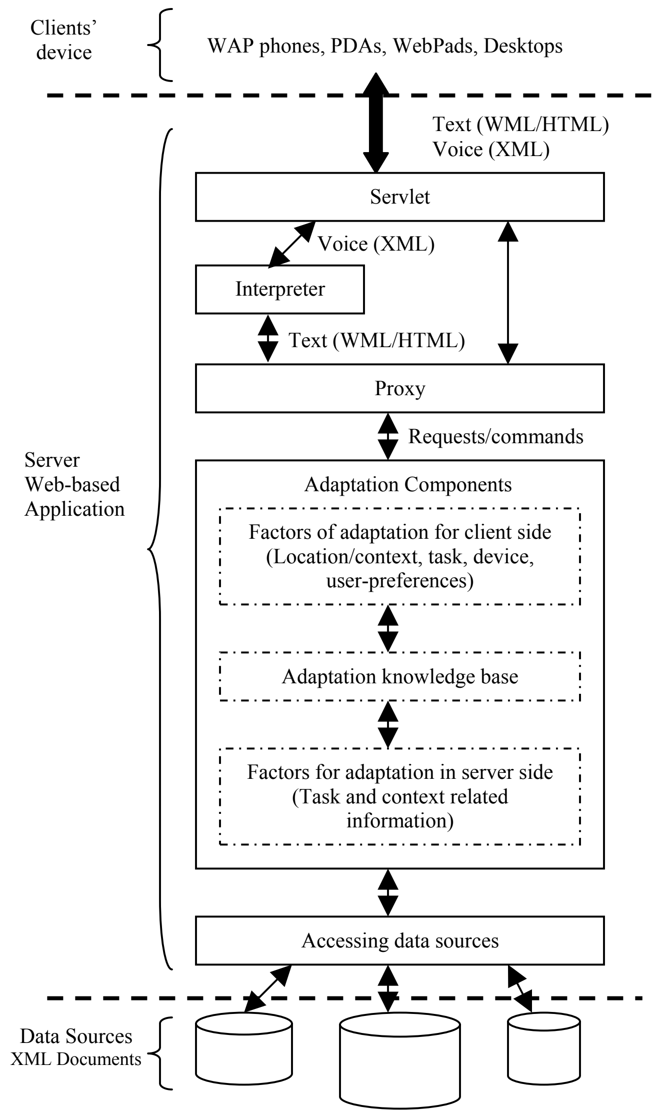


Figure 8. The structure of the proposed architecture

5.1 Defining a taxonomy of possible contexts

Nurses usually have multiple tasks. They involve a variety of actions, e.g. sending a notification message, entering data or retrieving information. The presentation of the information depends on the context (location, ability to type, draw, or use voice for input). It is necessary to define the possible contexts (or situations) of the nurses.

The possible contexts for the nurses are as follows: driving on the road between two patients' home, visiting the patients, and attending in their offices. For each of these contexts, there are some tasks that have higher probability to be performed by the users. For example, when a nurse is driving, it is more likely that she wants to check her schedule and the address of the patient that she will be visiting. During patient visitation, she needs to check the patient's medical record, which shows the patient status in the previous visit by other members of home care. She may also enter a report resulting from the current examination of the patient or send a notification message to other nurses. When the nurse returns to her office, she may need to check her schedule and/or complete her patient's record.

5.2 Recognizing the current context

To present the desirable form of information to the user, system needs to recognize the current context of the user. Such recognition requires determining the user location. To meet such requirements, the user is equipped with a position sensor embedded in her mobile device. In order to send the data about the user position to the system, the user's device should be connected wireless to the Internet. There are different location-identification technologies such as Angle of Arrival (AOA), Time Difference of Arrival (TDOA), Location Pattern Matching (LPM), and Global Positioning Systems (GPS) [9]. All these technologies have a different degree of accuracy in identifying the location. In a wide area network (WAN), the data service of a mobile telephone system, such as the Global System for Mobile communication (GSM), can be used as a wireless communication technology while in a local area network the bluetooth can be used [12]. Therefore, by recognizing the location of the user, the system can know the context of the user, whether she is on the road, in the office or at a patient's home.

5.3 Designing appropriate interfaces for each contexts

When a client accesses the system, the servlet can identify the type of device that is being used. The information for such identification is in the HTTP request from the client. When the system finds out the context of user and the type of device, a decision regarding the appropriate interface for the current context has to be made. For instance, while a nurse is driving, her hands and sight are busy, but she can still receive information provided that the information is read to her by voice. When the nurse is examining her patient, she is not able to use her hands for other tasks, such as typing, putting text or drawing. If the nurse's hands are free, then she can enter text or graphic information and read information on the screen; however, she cannot talk on a cell phone or PDA since the patient will overhear her conversation. In the office, the nurse can use all kinds of communication channels and would probably prefer to choose the appropriate one. As a conclusion, depending on the occurrence of each of the described situations (contexts), the system should be able to provide the appropriate form of information to her mobile device. Since these adaptations happen regularly, it will be a good idea to keep a configuration set for each possible contexts and devices in the adaptation process. This will save time and make the system more efficient.

5.4 Designing appropriate information presentation for the context and task

Knowing the context of the user, and the selected appropriate communication channel and interface to present information corresponding to the context, we can focus on the user's tasks and the type of the information she would like to know.

In this study, I aim to introduce a system that presents different interfaces for information representation. Using a system, such as JITIR provides a search engine with no need for having a query and alarm for notification. The JITIR can automatically find the information that a user needs without asking her [25]. For example, when a nurse drives towards a patient's home, the system will be able to recognize which patient is going to be visited by using the information from the nurse's schedule and her current location. In this case, the JITIR will retrieve the patient's record and makes it available for the nurse by adapting it to the nurse's device. The JITIR will also inform the user about any changes that have occurred in the system. For example, if the nurse is driving to a patient's home and a change happened in the schedule of the day, she can be notified by the system using text-to-speech technology about the change as she is driving. If the nurse is at the patient place, the system can notify her with a beeping sound until she can check the text message.

6. FUNCTIONALITY OF THE SYSTEM

Having considered the scenario discussed in section two regarding of how the current health care workers' system work in the next section, I will explain how the proposed architecture can improve the nurses' work.

The nurse A is driving towards patient A place and needs to check the patient status in the previous visit by another member of the home care group. She may also want to know what would she need to do for the patient. In this situation, when the nurse is provided by a mobile device, she can talk to her PDA or WAP phone asking for the information, which can be read to her automatically by the speech generation program on the server. Meanwhile patient A is visited by a physiotherapist, and the patient A is tired after the exercise. With such architecture in hands, the physiotherapist can immediately write a short note and sends a notification message to the nurse A. The arrival of message is notified by a beep sound first and then the message is read to her. Thus, the nurse realizes that visiting the patient A right after the physiotherapist visitation is probably not a good time to measure the patient's heart beat and blood pressure. Therefore, she can change her schedule and visit patient A later.

In this scenario, the nurse wants to check the patient record so she talks to her PDA/WAP phone and requests the needed information. The servlet receives the request and sends it to the interpreter to convert it to a text. The request, which is in text format will be passed to the proxy and to the adaptation process.

In the adaptation process, the factors for adapting are the context of user, i.e., she is driving, the capabilities/characteristics of her device and performing the desired task. The output would be adapted to these parameters. First, the system looks in the adaptation knowledge base that contains the task-related data and schedule and then sends the request to the next component to retrieve a menu containing links to the types of information needed for the current task. Then, the adaptation process decides what is the best presentation of information according to its knowledge base and the resource information from the user. In this situation, the best interface for the user is that the information is read to her.

Another transaction in this scenario would be the time when the physiotherapists send a notification message. The system gets the request and activates the adaptation process, by using its knowledge base. It knows the schedule of the home care workers. The system recognizes that nurse A is going to visit patient A, so it will beep for her to notify and read the message to her in this way the system can be proactive and take the initiative when appropriate.

For implementing this web-based application, I intended to use the Tomcat servlet. The language that will be used for storing data and communication inside the system is eXtensive Markup Language (XML) and eXtensible Stylesheet Language Transformation (XSLT). XML and XSLT technology allows creating and managing flexible user interfaces. It can handle both static and dynamic data and separates the user interface from the program code by encapsulating the user interface in java servlet. The XML provides the basic infrastructure for building interoperable systems, since XML can be converted to HTML for PDAs and desktops and to WML or DHTML for WAP phones. For transforming the XML documents to other markup languages, there is a need for XSLT. The XSLT document can be used for transformations from one language to another. The proxy in the system can apply XSLT to an XML document in order to produce different content for each different client type. Another advantage of using XML is that there are various markup languages that can be derived from XML. An example of the derived languages is a VoiceXML, which provides an interactive voice communication between human and computers, or the Geography Markup Language (GML), which describes geographic information [9].

For evaluating and testing this system, I would run an experiment in an environment whose characteristics, i.e. nomadic users and unreliable connection, are similar to the ones in the Saskatoon District Health. Users of this environment will have several tasks that should be performed in timely fashion. The users will be provided with mobile devices. The system will be evaluated with respect to availability, reliability, and robustness.

The future works for this research is the implementation and evaluation of the architecture.

7. CONCLUSIONS

In this study, efforts have been made to address some of the problems faced by healthcare workers of the Saskatoon District Health by providing them with mobile devices. The paper discusses issues related to improving the access of mobile nurses to information and to their team members. Various approaches for adapting the existing web applications so that they become accessible via mobile devices are reviewed in this study. To improve the services that are provided by the mobile nurses, this study proposes a new web-based client-server architecture that deploys the advantages of mobile devices providing context aware, device independent, and task dependent information.

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