An Adaptation Control Model to Support Mobile Web Access

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Abstract. A mobile environment is characterized by low communication bandwidth and poor connectivity. Efficient Web access over a wireless network is challenging because of the varying characteristics of different devices constituting the wireless environment and the adverse interactions among HTTP, TCP and the wireless network. These lead to problems that significantly degrade the user-experienced performance of the web accessed through the wireless network. We have developed techniques to visualize web access in a mobile environment – the proxy-agent mobile document clustering architecture (PMDC). The PMDC architecture allows the mobile users to visualize and navigate through the Web structure without having to download all related links in a Web site. The Proxy-Agent model provides facilities for adaptation in a mobile environment.

Keywords: Mobile Environments, Adaptation, Efficient Web Access.

1 Introduction

The underlying technologies driving the World Wide Web are largely based on the assumption of wired communications and powerful desktop hardware. This is not true when a user is access the Web pages and documents using a PDA and moving from wireless network in a mall to a neighboring office environment. Taking into consideration of the information needs of the user, we have developed visualization techniques for document cluster graph model for the mobile users. A document cluster graph represents the high level structure for providing the navigation models for the mobile user. Based on the access requirements, current activity, and contextual information, the user can specify the adaptation model in a configuration file. The parameters for the document cluster graph model can be adjusted to suit the information needs of the user. We have developed techniques to implement the PDMC architectures using an agent-proxy model [4]. A configuration file is stored at the mobile device. It can be edited by the user at any time to suit the current information needs. The local copy is synchronized with the server configuration file dynamically. This is performed by using a pair of agents called the proxy-master agent and the client agent. The system is able to detect and adapt to rapid changes in contextual information according to the adaptation model stored in the configuration file.

2 Related Work

The objective of this project is to develop technologies to help a mobile user to visualize [6,10], search [1, 2, 7], organize and find information useful to their daily work effectively by providing a high level navigation map without having to traverse all the links. We mainly follow the approach proposed by Leong [8, 9]. The web pages are organized into document clusters, which again can be grouped together into larger clusters. The clusters normally reside on a local side, but they can also be spanned across different sites. The document clusters are extracted and captured in a meta-data structure, in the form of XML documents [3], to be associated with the cluster members as a kind of navigation map. This would be the first entity to be transmitted to the mobile client for the user to get a feeling of the document and its related documents before hand. This XML structure also provides access frequency information of the relevant pages. The whole structure can be visualized by using a three dimensional document cluster graph [11].

3 The Proxy-Agent Model

We have previously described the Proxy-Agent platform – WebPADS – a Web **P**roxy for **A**ctive **D**eployable **S**ervice [4, 5]. The WebPADS platform is an object-oriented system that is based on an active-service deployment architecture, which comprises some components of the system and service objects called *mobilets*. Core components of the system provide essential services for the deployment of an agent-proxy that forms a unit of service, which executes under the WebPADS execution environment. Among the system's components, the event register allows objects to locate and register for event sources. When an event occurs, the objects that have registered for that event source are notified. Event sources include various changes in the status of a network, machine resources and connectivity. Furthermore, the composition of the services of the WebPADS server can be dynamically reconfigured to adapt to the vigorous changes in the characteristics of a wireless environment

4 Document Cluster Graph (DCG) Model

With the advent of mobile computing, it is common for users to access the Web through various mobile devices such as mobile phone, hand-held PC and PDA etc. Each mobile device has different characteristics. A user using a PDA has only 240 x 320 resolution and Web access through the mobile device is normally performed through a few proxy servers, either through a home wireless network or a wireless gateway installed in a mobile user's office. To provide adaptation to suit the requirements of mobile users, we have developed a proxy-agent mobile document clustering architecture (PMDC) to improve the browsing efficiency of a mobile web client. As shown in figure 1, a PMDC architecture supports a number of mobile clients communicating with a base station via wireless channels. The base station maintains a web proxy server as a concentrator of web traffic for the clients, enabling the sharing of common hot web pages needed by individual clients. The notion of document clusters and personalized document clusters are modeled in the form of a directed graph, called document cluster graph.

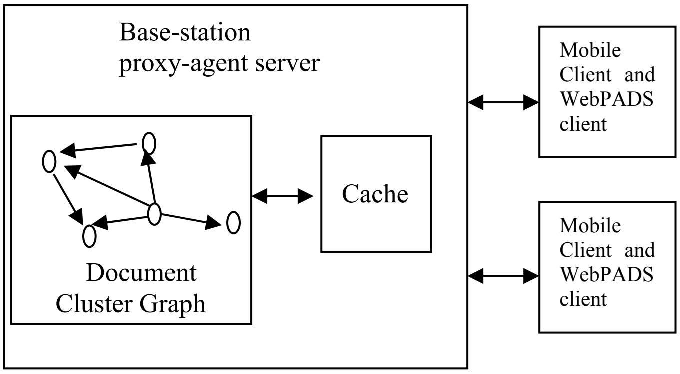

Fig. 1. Proxy-mobile Document Clustering Architecture

When a mobile client requests for an uncached document P from a remote server, the proxy server generates a document cluster using the document P as seed. A document cluster is a collection of web pages that are highly common in some shared properties (such as the distance from the root). It is generated and stored in the cache by optimizing the following gain function proposed by Leong [8]:

ρ (V, E) = Σ $W_{i,j}$ /h^{γ} |V| for all links $l_{i,j} \in$ E where :

V - a set of web pages to be evaluated

E - a set of hyperlinks to be evaluated, most of the links are related to the set of web pages in V.

$W_{i,j}$ - weight of a link from web page (i) to web page (j), which is calculated from the probability of accessing a particular link using the log file from the web server

H - the maximum of the shortest distance between any two pages in the cluster (the depth of the graph G).

γ - An adjustable parameter which is a non-negative value that is greater than zero (γ >=0)

$l_{i,j}$ - Hyperlink from web page (i) to web page (j)

If there does not exist any document cluster information available at the remote web server for the document, the proxy server starts from the seed document, follow the hyperlinks that lead to new documents and tries to include documents whose presence will improve the value for the gain function incrementally. The cycle is repeated until the gain function is maximized for the given parameters, and the cluster yields an optimal value for the gain function.

When a cluster with an optimal value for the gain function is found, the system generates an XML document that encapsulates the document cluster graph so that a web surfer can easily identify where he/she is when navigating through the web. In our XML representation, we indicate either the weight of a link or the conditional access probability of a link in the document cluster graph through the intensity of the link. A naive surfer may follow the link with a high weight, which is more likely to have a close relationship with the current browsing page. To improve the user interface for the user, we have developed facilities for viewing the document cluster in the three-dimensional space, allowing users to browse the structure in different angles. An example of a document cluster graph implemented using a PDA is shown in figure 2.

Fig. 2. An Example of a Document Cluster Graph

5 Weight Adjustment For Document Links

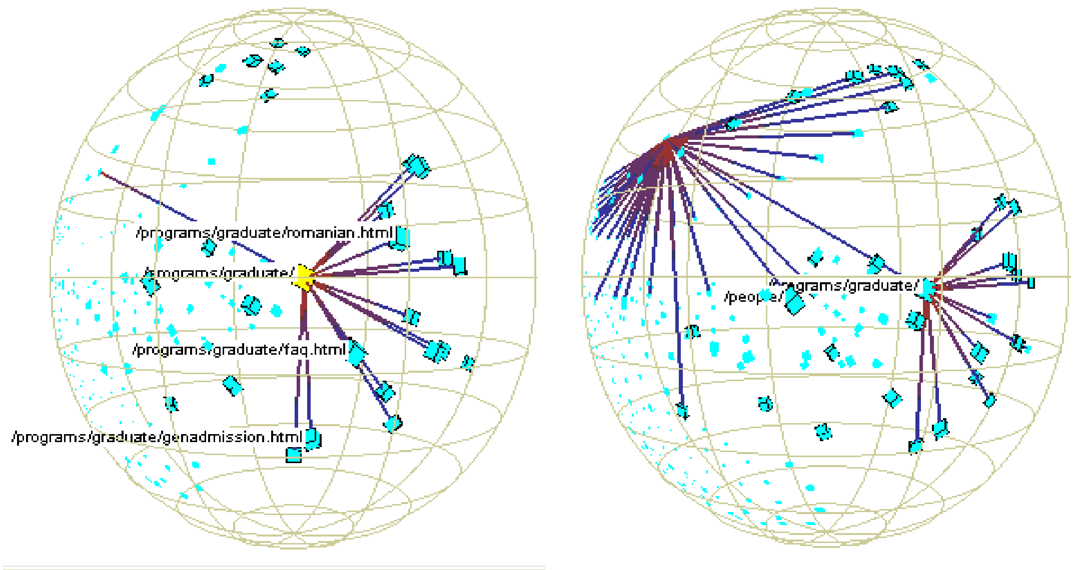

Fig. 3. A Document Cluster Graph with depth level = 2 and depth level = 3

In the proxy-agent mobile document clustering architecture, we have enhanced Leong's model [8] by providing a three-dimensional implementation for viewing the document cluster. All the links from the root to the nodes are enclosed in a three-dimensional sphere. The amount of links visible in the sphere can be adjusted by tuning the parameters. The number of levels displayed in the links can also be adjusted. Figure 3 shows the documents cluster graphs corresponding to depth levels 2 and 3. In our implementation of the adaptation model, the depth parameters can also be adapted according to the display characteristics of the screen.

6 Adaptation in a Mobile Environment

Table 1 lists the contextual information that will be identified for each device. The information collected is used to adjust the settings of the display for the document graph. In particular, the user can alter the settings by choosing various options in order to best suit their actual information needs.

Table 1. Contextual information reported by the WebPADS client

Unit Type	**Contextual Information**
Processor	CPU type, clock rate, utilization
Storage	RAM size, free space, Secondary Storage size, free space
Network	Network type, capacity, data rate, delay, error rate
Power	Battery maximum lifetime, remaining lifetime
Display	Color type, depth, Screen resolution
Audio	Type of sound supported
Operating System	OS name, version
Browser	Browser name, version

Table 2 lists the major options and their possible values. As shown in the table, the adaptation options are used for reformatting of presentation results.

Table 2. The options available for accessing document graphs

Option	**Possible Values**
Device adaptation option	
Text Compression	None, Low, Medium, High
Image Compression	None, Low, Medium, High
Color Scheme	B&W, Color, High Color
Result Details	Document graph depth : 1, 2, 3, 4, 5, 6, 7, 8, 9, 10
Advanced options	
Brightness level	Low, High, Medium
Proxy cache size	Low, Medium, Large
Screen layout	Horizontal, Vertical

To regulate the service configuration policies, the WebPADS system maintains a configuration description file utilizing XML. To dynamically adapt to the changes in the environment, WebPADS employs the environment monitor and event system to monitor and communicate the changes. An environment element consists of one or more conditions, where each condition specifies an event and a relational value that will fulfill that condition.

When a WebPADS client starts, a default service composition is created that is based on the description of the XML configuration file. At the same time, a number of alternative reconfiguration service chain maps are also created. Each map is attached to an environment monitor, which regulates the time and conditions for the service reconfiguration to take place. When all the conditions monitored by a specific environment monitor are fulfilled, the current service composition will be reconfigured to the service chain map attached to that environment monitor.

The configuration file is used for constructing the user adaptation model. Table 3 shows examples of adaptations that can be modeled according to the information in the configuration file and the information from the environment monitor.

Table 3. Examples of the Adaptation Model

Condition (event)	Adaptation Action
Bandwidth = low	Graphic_image_resolution = low
Secondary_storage_space = low	compression = yes
Battery = low	Brightness_level = low
Screen resolution = high	Document_cluster_graph_size = high
Location = office	Proxy_cache_size = large

7 Conclusion

The underlying technologies driving the WWW are largely based on the assumption of wired communications and powerful desktop hardware. This is not true when a user is access the Web pages and documents using a PDA and moving from wireless network in a mall to a neighboring office environment. We have developed WebPADS using an agent-proxy model for wireless access. WebPADS provides contextual information such as mobile device characteristics as well as dynamic event status. Taking into consideration of the information needs of the user, we have developed visualization techniques for document cluster graph model for the mobile users. A document cluster graph represents the high level structure providing the navigation model for the user. Based on the access requirements, current activity, and contextual information, the user can specify the adaptation model in a configuration file. The parameters (specifying the detail level) for the document cluster graph model can be adjusted to suit the information needs of the user. The system is implemented using an agent-proxy model. There are a number of advantages in using the proxy-agent model. Firstly the configuration file can be store at the mobile device and edited by the user at any time to suit the current information needs. The local copy of the configuration file is synchronized with the server configuration file dynamically. This is performed by using a pair of agents called the proxy-master agent and client proxy agent in WebPADS. Secondly, WebPADS is able to detect and adapt to rapid changes in contextual information according to the adaptation model stored in the configuration file. Thirdly, WebPADS is able to maintain on-going service provision as the mobile node movies across different domains (e.g. from a home network to an office network in a wireless environment).

A major concern about our implementation is that the adaptation for Web access is computationally intensive. The adaptation model for access document using a cluster graph also requires a lot of processing. In our experiments, it was noticed that the execution of the WebPADS client did not increase the CPU loading of the mobile device significantly [4, 5]. This is because a lot of computations like compression mobilet and DCG computation are performed at the proxy server. Our experiment has shown that in addition to context adaptation, user adaptation can also be implemented effectively. Future directions of research include using AI techniques to improve flexibility in adaptation. Experiments can be carried out to evaluate the effectiveness using different mobile platforms.

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