A Context-based Document System for Wearable Computers

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Abstract

With the continuous availability of wearable computers, users have the opportunity to create and acquire large numbers of files. The ability to store and retrieve documents effectively with these machines is a key issue. Hierarchical storage is not adequate because the user must focus on where a document is stored instead of on what it contains. This paper explores how context can be used to help the capture and access of documents in a wearable computer. It examines several systems that use context with documents. It then presents a new storage system that uses context to aid in the capture and access of documents in a wearable computer.

1. Introduction

Wearable computer users can collect and generate a large number of documents with a variety of formats and content including email, web pages, papers, and notes [5]. It is desirable to have a system that allows for flexible storage of these documents as they are gathered and created without imposing the strict structure of traditional storage systems. The wearable computer is also in the unique position to capture rich context about the user from both the real and virtual worlds.

We have created a storage system for wearable computers that leverages off the user's real and virtual context. Additionally, the user can explicitly provide context for specific documents. By using the context, the system can provided greater flexibility in storing documents. It then allows users to retrieve documents by using the context related directly to the document or context related to the user that is then linked to the document with time.

2. Related Work

The "Forget-me-not" [3] is designed for use with a wearable system. It logs the context of the user over time so that it can later be used to find information. The context saved includes information about the user both in the physical and virtual worlds. This system is not directly tied to document storage, but it does allow context to be used to find previously accessed files that are stored elsewhere.

Two systems designed for desktop computer use are Time-Machine Computing (TMC) and Presto. TMC [4] aids with document storage and retrieval by incorporating time to allow more effective use of the desktop space. Although the desktop metaphor may not transfer well to a wearable, this system demonstrates how the context of time can be used effectively with documents. Presto [1] replaces location based storage system's use of hierarchies and file names with a set of optional properties composed of name-value pairs attached to a document This allows the user the flexibility to associate any context desired with the document. Information is latter retrieved by searching through the properties.

3. Contextual Storage

The above systems provide different ways to capture and retrieve documents using context that might be used with a wearable computer. Among these works three different types of context are being used. There is context linked to specific documents, context about the user and the explicit use of time. None of the above systems, however, directly support all three forms of context. We have created a contextual storage facility that combines these features into one coherent system. We provide attributes linked with documents, to create a storage space along with a facility to log context streams. Finally, time is integrated throughout the system.

In our system the user can provide context linked to specific documents. These attributes are similar to Presto's properties and relax the naming requirements for documents. We also support the storage of context about the user, similar to Forget-me-not, with context streams. Context streams are collections of context over time that are not associated with any one document.

The final piece of context some of these systems provide support for is time. Forget-me-not and TMC both use time but in rather different ways. TMC lets the user move documents in time and is similar to the idea of valid time in a temporal database [2]. The time used in Forget-me-not, however, logs when items were actually created and deleted. Temporal databases provide this capability with transaction times. We utilize both types of time creating a bitemporal system [2]. The times are stored with documents, their attributes, and context streams. This allows the system to record when items are created and changed (transaction time) and allows the user to manipulate time to suit their needs (valid time).

Documents are retrieved with a query that can contain information about time, the document attributes as well as context streams. A query with just attributes is similar to Presto, a query using just time is similar to TMC and a query only using context streams is similar to the Forget-me-not. However, all of the pieces of context can also be used together. For example, if user location is stored in a context stream, queries like 'return all of the documents that I modified yesterday while in room 102' can be constructed.

4. Prototype

Our prototype implements the temporal functionality of the system on top of the normal relational database Postgres, running on the Linux operating system. We provide a file system like interface to manipulate documents with functions to open, close, read, and write. Additionally there are functions to manipulate context streams and the attributes associated with documents. Finally, a query interface supports the ability to retrieve documents from storage using attributes, context streams and time.

The primary performance concern for using this system is the additional time overhead. We did some preliminary tests using the first author's wearable which is based on the MIT Lizzy design [5] with a 100 MHz 486 CPU, 64MB RAM and a laptop IDE hard disk drive. Storing a document and a set of attributes took on average 1 second, while saving an item to a context stream took approximately 0.5s. Queries of varying complexity took between 1s and 5s. Although this performance is adequate, there was no special effort put into this and several performance enhancements could be made.

There are several possible directions for future work with our prototype. Creating an effective query mechanism that can be exposed to the user will be challenging because the system allows many complex bindings between time, context streams, documents and attributes. Likewise a user interface (UI) that effectively allows the wearable computer user to build queries and that displays the results in a meaningful way is critical. Finally, the true value of this system can only be measured once it is deployed for use on wearable computers.

5. Conclusions

We have developed a contextual storage system for use with wearable computers. It leverages off of the context exposed in various existing works but also has several new features. Our system makes an explicit distinction between attributes and context streams and is the first to incorporate the two into one document storage system. Attributes are a set of context tied to a specific document while context streams are related to the user and do not belong to any single document. Our system also makes extensive use of the times found in a bitemporal database. Although some of the existing systems incorporate time none use both valid and transaction times and none use time for documents, attributes and context streams.

We believe this type of storage facility is valuable to a wearable computer user for several reasons. First, the wearable has access to the rich context of the user. The context can serve as retrieval cues for accessing documents by associating the access time of the document with the time of the context. The flexible nature of attributes is also valuable to the wearable user. This frees the user from the ridged requirements for paths and names used in hierarchical storage systems. The ability to use time is also very valuable. It allows the user to manipulate the times of a document, attribute or piece of context to suit their needs and also to log when the events occur. Furthermore, it permits very complex, but useful queries.

The existence of capture and access systems based on context will become more necessary as the use of wearable systems expands. The authors are also users of wearable computing devices. Their experience, added to the work of others, indicates a clear need for an infrastructure to support the flexible context-based document system described in this paper.

6. References

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