# Executives' Mobile Personal Information Systems

**Niall O'Donoghue, Seppo Puuronen and Vesa Savolainen**

Department of Computer Science and Information Systems
University of Jyväskylä
P. O. Box 35
FIN-40351 Jyväskylä
FINLAND
e-mails: niaodon@cc.jyu.fi, sepi@jytko.jyu.fi, vesa@jytko.jyu.fi

**Abstract**: Mobile computing is one of the fastest developing areas in information technology. In this paper, the concept of EMPIS (Executives' Mobile Personal Information System) is defined. The main functional areas of EMPIS are briefly discussed: information, communication, decision making, analysis, and office work support - all overlaying a mobile environment. A deeper analysis of the characteristics of EMPIS as an information tool and communication tool is given. When studying EMPIS as an information tool, we suggest methods for remote data access and information retrieval, and outline a method for searching, querying, and filtering in a mobile environment. EMPIS as a communication tool is analyzed and constructed from the viewpoints of privacy enhanced email and facsimile, mobile group communication, access to company and market news, and challenges of implementing video on EMPIS.

**Keywords:** mobile information system, executive information system, mobile computing, information tool, communication tool

**Mr Niall O'Donoghue** started his studies at University College Cork (U.C.C.), Ireland in 1985. He graduated with an honors B.A. degree in 1988. This was followed by a postgraduate diploma in Education (1988-89) and another postgraduate diploma in Computer Science (1989-90). Immediately on graduating, he began his career as a software tester at Lotus Corporation's European software localization facility in Dublin. He later took a similar position at Microsoft Corporation's European localization facility, also in Dublin, and adopted a variety of roles including project team leadership. In 1994, he decided to further study for an M.Sc. at the Department of Computer Science and Information Systems in Jyväskylä University in Finland. He has since carried out successful research in the area of executive mobile computing (MEMPHIS Project). He will carry out further research in this area for his Ph.D thesis. He has also become involved in Internet website and multimedia production, which will benefit his mobile computing research.

**Dr. Seppo Puuronen** is acting as Professor in Information System Science at the University of Jyväskylä. He received his Ph.D (economics) in computer science in 1988 at the University of Jyväskylä. In 1983-88 he worked at Lappeenranta University of Technology as associate professor and senior lecturer of computer science and 1989-97 as acting associate professor and full professor at the University of Jyväskylä. He has acted as a member of the programme committee of the Finnish Artificial Intelligence Symposium in 1988 and as a tutorial chair of CAISE'95. He has acted as Head of the Department of Computer Science and Information Systems at University of Jyväskylä in 1988-89, 1990-91 and 1997. He has authored several international journal and conference papers. His main research interests are knowledge-based systems, semantic nets, expert systems and knowledge engineering, computers in education, and mobile computing.

**Dr. Vesa Savolainen** is a Professor of Computer Science (Information Systems). He received his M.Sc. in 1971, Ph.Lic. in 1973 and Ph.D in 1977 in Computer Science at the University of Tampere. He became associate professor in 1980 at the Vaasa School of Economics. He worked as a Professor of Applied Mathematics in 1982 and a Professor of Computer Science over 11 years in the period 1981-97 at the University of Jyväskylä. He was Head of the Department of Computer Science and Information Systems at the University of Jyväskylä in 1981, 1993-94 and 1996. He participated in the ESPRIT Project OSSAD, Office Support Systems Analysis and Design, in 1986-89, and ESPRIT Project HECTOR, Harmonized European Concepts and Tools for Organizational Information Systems, in 1989-90. He is a senior member of IEEE and a member of ACM and IFIP WG 8.4 (Office Systems) and WG 8.3 (Decision Support Systems). He has authored quite a number of scientific international, refereed papers on information systems, and also 3 books: "Information Resource Management in Organizations", "Foundations and Algorithms of Graph Theory", and "Perspectives on Information System Development". His main research interests are mobile information systems, multimedia information systems, information systems development methodologies, methods and tools, dynamic modelling of information systems, graph theory and applications, performance evaluation of information systems, measurement information systems and executive information systems.

## 1. Introduction

In this section we shall first discuss the current mobility of managers and then introduce the objective and structure of this paper.

### 1.1 Managers on the Move

The study of the EMPIS (Executives' Mobile Personal Information System) Project [29] among 49 executives revealed that European managers today travel outside their office for an average of 18% of their total business hours. Also telephone and e-mail communication has a similar share, i.e. 18% of managers' total business hours. The trend has lately been and seems still to be towards less meetings and more travelling and electronic communications.

Over the next two to five years, those of us who have an interest in information technology (IT) will witness a surge of innovations particularly in the area of mobile computing and communications. In the modern business world, where many professionals are almost continuously on the move, there is a need to

provide these professionals with the tools of their office, anytime, anywhere [29, 37]. The answer lies in providing executives with a relatively sophisticated, low-power, low-cost, highly-connected mobile office that carries most properties of an EIS, Executive Information System [10, 12, 26, 29, 30]. There have been separate innovations in the areas of computing (notebooks, multimedia, graphical user interfaces), communications (mobile phones, pagers), and information (the World Wide Web) [14, 15, 29]. Thus with the powerful computing infrastructure that has been developed over the last 20 years, and with advances in wireless communications, the concept of a highly integrated *mobile office is* now very much a reality [25]. The idea is essentially to incorporate advances in mobile telephony, computing, communicating, and information retrieving, into one unit. This is indeed an exciting challenge.

In 1995 there was an estimated number of 26 million mobile professionals in Europe and of other 30 million in North America [16]. In November 1996 The Financial Times reported that the density of mobile phones is the highest in Finland with 27.5 phones per 100 inhabitants, while Sweden is second in the world with the corresponding percentage of 27.4. Many of the mobile professionals have to some extent become acquainted with computer and communication technology: they carry a mobile phone, many of them carry a notebook computer or a portable pc, and others also carry a pocket-sized electronic organizer. Research has revealed that mobile professionals are happy to accept new innovations which will boost personal productivity [29]. Corporations are not afraid of adopting new computer technology either. Indeed, desktop video conferencing using PCs and small video cameras has already arrived and is expected to be one of the big growth areas in corporate computing over the next few years. Within a few years we can expect to see mobile video conferencing between the 'executive on the move' and the corporate office. Mobile computing is still in its infancy in terms of bandwidth availability, dependable wireless data transfer, mobile video, and so on. No doubt these features will possibly be the norm on a mobile executive device within the next decade, and even within the next five years.

### 1.2 Objective and Organization of This Study

The primary objective of this paper is to present a set of functional possibilities of mobile information systems for executives and critical analysis of their some central implementation issues. The aim is not to set down any definitive functional architecture because a rough requirement analysis was carried out earlier in [29] and we can build on that. The main functional areas of EIS are shortly discussed - information, communication, decision making, analysis, and office work support, all overlaying a mobile environment - but in this report we shall concentrate on EMPIS characteristics as an information and communication tool.

The themes of this paper are built in the following manner: Section 2 outlines the pertinent characteristics of an EIS and their further adaptation in a mobile environment. Section 3 expands the concept of EMPIS as an information tool. We will suggest methods for remote data access and information retrieval, and outline a method for searching, querying, and filtering in a mobile environment. Section 4 will introduce the notion of EMPIS as a communication tool. The advances in mobile telephone technology and radio technology will be examined since it is in these areas that a suitable wireless communication method for EMPIS may be found. Ways of incorporating secure email and facsimile will be discussed, as will mobile group communications and access to news. Section 5 includes a short summary.

## 2. Key Characteristics Fundamental for A Successful EMPIS

In this Section we first outline the pertinent characteristics of an EIS and then the adaptation in a mobile environment.

EIS has been defined as a computer-based information system designed to provide to a senior manager all the necessary IT services relevant to his or her managerial duties [9, 26, 29]. Not only has access to information been regarded as central to an EIS, but it also incorporates office task support, communications, monitoring, decision making and analysis support, and support to personal productivity. All of these features can have a place in an EMPIS, but the mobility factor provides a greater challenge.

Organizations have adopted EIS due to increased competition, the need for more timely information, better and more efficient reporting, and the need for accurate status updates. Researchers in [4, 10, 12] announced that after two decades of substantial EIS and DSS evolution, the third generation of EIS starts

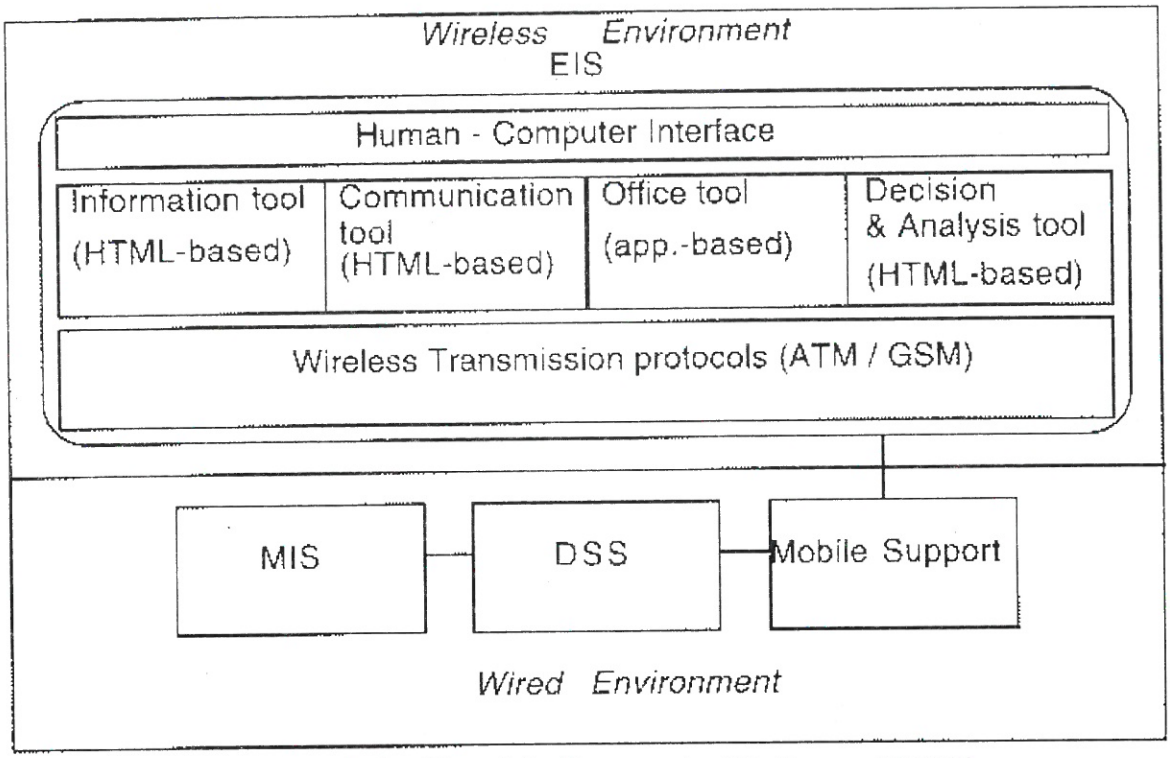


**Figure 1. Our View of the Components of the Proposed EMPIS**

emerge. In view of the growing interest in mobile computing, we could now say that a "fourth generation" of EIS is about to emerge, i.e. a Mobile Executive Support System - hopefully a mess only at the beginning! The newest systems are concentrating on finding ways to enable executives to search and retrieve information from internal and external data sources, from any location. Also the notion of EIS flexibility has emerged. According to [10, 12 and 34], an EIS must be flexible enough to support diverse classes of business data (e.g. external, internal, structured, and unstructured) and distinct classes of users (i.e. executive as well as non-executive users).

Therefore, in the situation when wireless communications can enable the executive to access a wider range of data sources, we predict that it will be necessary for EMPIS to intelligently see through masses of different types of data, contained in various types of databases, in order to quickly extract the desired information. Furthermore, we predict that the EMPIS interface will have to be flexible from the point of view of customization. Not all executives carry out exactly the same tasks or accept similar communication cultures [29]. The executive should be able to determine how the information appears on the interface.

The EIS platform is the networked workstation. Typically the network is wired and thus the workstations are immobile. For this study, we have chosen to adapt the EIS model further to take into account the mobility factor.

Figure 1 illustrates the pertinent characteristics of the Executives' Mobile Personal Information System we propose. In it we suggest a mobile hypertext-based (HTML) human-computer interface for the following reasons:

1. With hypertext code, one can present a wide variety of interfaces, i.e. textual documents, tables, information retrieval search boxes, and imaging. The World Wide Web (WWW) has become synonymous with access to huge amounts of information, and being able to conduct effective searches for information. WWW browsers such as Netscape and Mosaic offer hypertext -based interfaces which present documents, tables, forms, and even questionnaires .

2. Sheldrick [31] has stated that the WWW does for networked computing what GUIs did for desktop computing. There is every reason to expect that a mobile executive can in the near future access remote networked databases wirelessly, from a mobile hypertext-based or Windows-like interface.

3. We envisage being able to start up applications on a WWW server, wirelessly from a remote mobile unit. This will have the advantage of allowing the executive to use an application interface from a remote site, without needing the bulky application code locally on the mobile unit.

Support must be provided for communication. Our research [29] has shown that executives spend a considerable amount of their time on scheduling and arranging meetings, sending emails and facsimiles, and generally communicating. Therefore an EMPIS must provide a method for efficient and dependable remote data transmission. Communication should be uninterrupted when the executive moves from one location to another and data integrity should be unaffected. The EMPIS should be able to alert the executive when important or urgent information arrives to the mobile unit.

In the following Sections, we will examine methods for providing the EMPIS with the executive functions deemed necessary for the mobile executive to carry out his or her tasks. We will discuss the human and functional aspects of implementing these functions. We will also identify essential problems imposed by the mobility of the EMPIS which must be overcome.

# 3. EMPIS As An Information Tool

In this Section we expand the concept of EMPIS as an information tool and sketch its technical solution. Methods for remote data access and information retrieval are then suggested, and finally an outline of a method for key searching, querying, filtering, and disconnected operation is discussed.

Because of the current problems associated with low bandwidth and unreliable connectivity, transmission of data in a mobile environment is slow, expensive, and unreliable [29]. The state-of-the-art today is represented by the ability of sending email and fax via a mobile phone. While this is a significant step in the world of communications, there are still the restrictions on the variety and amount of data which can be sent and received, and the slow transmission speed. This is coupled with the executives' expectations of being able to access data uninterrupted by changes in location or battery power constraints. We can also expect the demand for mobile computing to increase more rapidly than the advances in radio bandwidth or in battery power will allow [22]. Due to these current constraints, it is necessary to look for a method of data access which will not singularly depend too much on the resources of the mobile device, but rather on the interaction of all the components of the mobile environment. A method for providing support for varied data types (for example text, graphical, voice, and full-motion video) is also required.

## 3.1 The Mobile Environment

In this Subsection we first visualize the major components of the suggested mobile environment, which are as follows:

- *The Mobile Unit* (referring to hardware architecture) consists of a portable device smaller than a notebook, incorporating a hypertext-based display which can support graphics, menus, and video. The unit has a built-in speaker and a built-in mini-CD for caching data, and the unit attaches directly to a Global System of Mobile communications (GSM) phone for receiving or sending data. Power comes from a lithium-ion battery and power conservation is achieved by the unit falling 'asleep' or powering down after a period of no use.

  There exist attempts for building these types of units, but with fewer abilities. While waiting for them one can utilize the most advanced laptop computers connected with GSM phones.

- *The EMPIS Base Station* is synonymous with the Base Station subsystem in the GSM network. There is one base station per broadcasting cell (the broadcasting range of the mobile unit), just as there is one mobile phone base station per GSM cell. The task of the support station is to communicate with the mobile unit once it enters its broadcasting range, and handover the communications to another support station when the mobile unit moves out of range. Figure 2 illustrates our conceptual view of the EMPIS environment.

- *The Home Server* is where the permanent mobile unit files reside (see the lower block in Figure 2). The server is also connected via the fixed network to other servers on a local or international level so that data from many sources can be accessed. Therefore the home server can be seen in terms of data accessibility as the gateway between the wireless mobile unit and the

fixed worldwide server network. The home server can handle communication with more than one mobile unit.

synonymous with making vast amounts of information available via the computer screen. This information is already being tapped from the desktop, and now it is ready to be tapped in a mobile environment .

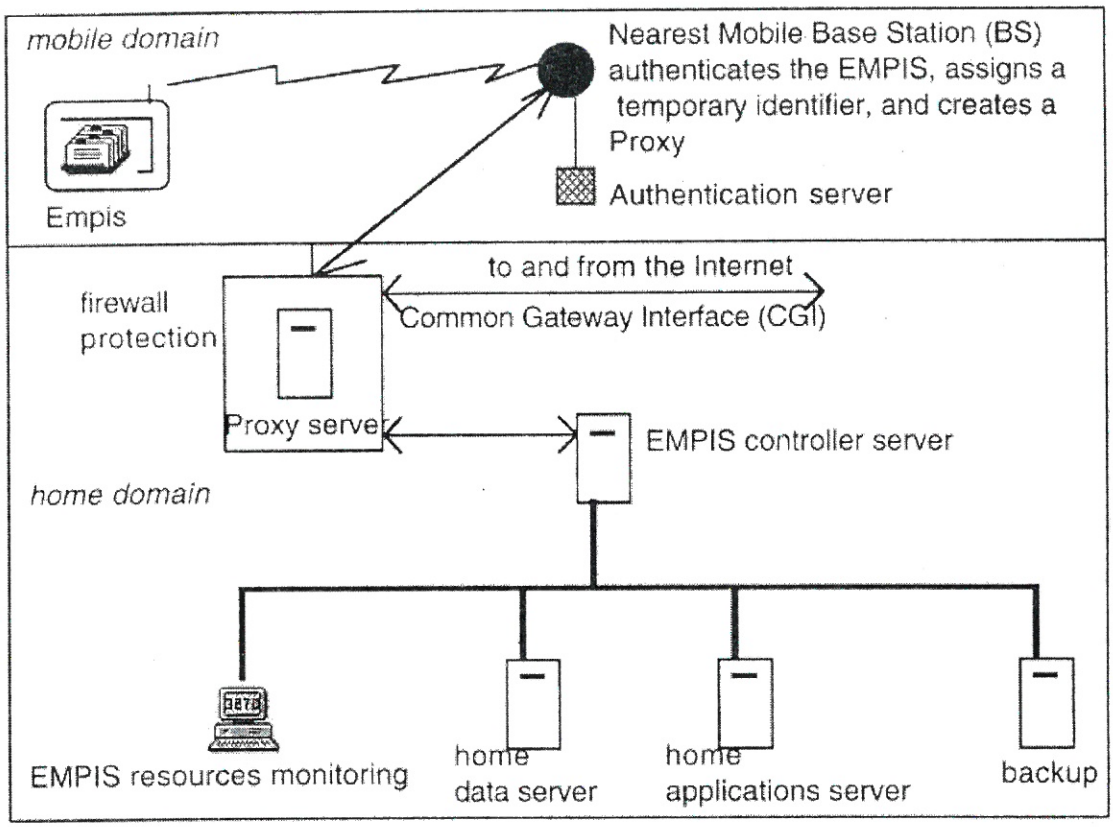


**Figure 2. The Conceptual View of the Proposed EMPIS Mobile Environment**

Executives need to stay abreast of day-to-day activities by viewing first-hand information from representative business activities and transactions. Moreover, they need to get at data directly without having to go through someone else, which would waste time. Executives will seek answers to queries such as "What were the total sales for the first quarter of 1995?" or "Where can I get information on hotels in the city I am commuting to tomorrow?" Such required information can be specific to the executive's work, or more general such as in finding the nearest hotel. We can envisage that the former information requirement will be satisfied mainly by accessing the company databases and filtering out the relevant data. The executive will also be able to perform searches in, for example, the World Wide Web to get general information on other companies. General information such as hotel accommodation is not usually recorded in company databases. Thus we are fortunate that the World Wide Web (WWW) has become so

Now the problem is how can all the various forms of data be queried, retrieved, filtered and merged to make it useful for the executive? To suggest answers to this question, and many such questions throughout this paper, we will lay our emphasis on the benefits of hypertext (HTML) that provides a wide variety of interfaces for the mobile client to required applications and databases.

## 3.2 Data and Their Components

To understand the problem of acquiring data from various sources and presenting them in a meaningful fashion, it is necessary to look at the system and user views (cf. [26]). In this Subsection we shall analyse data and their components by studying such concepts as an event building system, data warehousing and multidimensional data store.

### *An Event Building System*

To proceed to tackling the challenge of merging data, we now introduce the notion of *an Event Building System*. According to Spiwoks [32], an Event Building System is the part of the data acquisition system (DAQ) where the data coming from different streams of the data flow are merged together to make full events that can be sent further down the DAQ to either the next level of filtering or directly to mass storage.

In Spiwoks' analysis [32], data can be subdivided into three parts as follows: *The actual data* are the records or files which the user wants to download to the mobile unit. *The data description* consists of a key identifier which should contain the purpose of remote data access, a unique server address, unique directory address, and the data type (for example, binary or text). When the mobile unit sends a request for the data, the home server receives the data file description and pulls the relevant data from local memory, or continues to search a non-local server. *Synchronization* refers to the timing of the data: the file is read and write accessible, or read-only, or the file may not exist any more. This is a logical aspect rather than a physical aspect of the data. The inputs of the Event Building System are:

- *Sub-Data* consisting of at least a twofold identity (SourceID), defined format, defined memory address, defined timing including signal on availability, read-write status, and protection,
- *Full-Data* consisting of at least a twofold identity (destination ID), defined format, defined memory address, and defined timing,
- *Control,* i.e. the communication channel with the remote user; the user sends a request for data, which signals a change of state of an Event Building, and
- *Configuration,* i.e. a description of the current state of the Event Building.

The outputs of the Event Building System are:

- *Debugging* (short-term output) which consists of a log of the current configuration, the current task, and error messages, and
- *Monitoring* (long-term output) which consists of a log of the system performance; performance may be presented in figures or graphically.

### *The Concept of Data Warehousing*

Data Warehousing concept is useful in our construction. Data Warehousing has been defined as the ability to pull together information from a variety of sources, at regular intervals, to construct an integrated view of business activities [33]. The source data may reside on various servers and the data formats may be of various relational and legacy types.

To be valuable to the mobile executive, the data must be transformed into a consistent view at the Home Server, and transmitted to the remote executive when necessary. To satisfy the need for rapid information response, it is suggested that the data warehouse application should be interactive rather than batch oriented. To this end we suggest that the Home Server memory should act as a data warehouse for the mobile unit, where data can be stored after being retrieved from remote locations and then updated as often as necessary. The data warehouse model suggested in [33] consists of the following types of tables:

- *Primary Data Tables* incorporate both metrics and attributes, and contain the data that the mobile executive is searching for,
- *Descriptor Tables* may contain a data attribute-ID code and a pseudo-English or common-English description of the attribute; there is an one-to-one relationship between the ID and the descriptor, and
- *Characteristics Tables* contain additional information about an attribute and may be used to filter data in an ad hoc manner ; this is particularly useful when the executive wants to carry out some decision processes or analysis scenarios.

To optimize performance, the Primary Data Tables can be pre-summarized and stored in a frequently accessed consolidation hierarchy. It has been anticipated by [33] that the summary tables will cause only a 20% increase in the total required storage space. This modest storage increase results in an anticipated two-to-tenfold increase in query performance. In this way the system works smarter for the mobile executive, not harder. The summary tables can act as data-consolidation containers which hold

high-level data such as for example monthly sales totals or the yearly company budget.

The data warehouse should be capable of integrating data from a wide range of sources and it should be able to detect changes to input data (creations, updates, deletes, etc.) and these changes should be made transparently to reduce maintenance effort.

***The Advantages of A Multidimensional Data Store***

It has been stated that the most intuitive way to look at business information is multidimensionally [6]. It makes it possible for the executive to view many aspects of information such as accounts, time periods and geographical territories. A *multidimensional data store* can allow the executive to transmit new data, such as a company ID for a new cooperating company, to the Home Server database for the benefit of other users. The multidimensional engine should cater for executive tasks such as data aggregations, calculations, and ad hoc analysis. It has been anticipated that the data store should be multiuser read and write, multitasking, and multithreaded. An open architecture would make the data store interoperable with virtually other remote and differently constructed databases. Again, whatever the structure of the database is, we propose that the data contained within should be able to be seamlessly mapped to a format which can be displayed in hypertext format, i.e. on a hypertext interface.

## 3.3 Quering

In this Subsection we shall analyse mobile SQL quering for tabular data and also offer ideas for constructing a more user-friendly HTML interface.

For filtering tabular information the mobile user selects a Hyper link query button on the mobile interface, for example Start SQL Query. This hyper link pulls either a locally cached HTML *Structure Query Language (SQL)* query box (see Figure 3), or executes a query form at the mobile home server itself via the NCSA Common Gateway Interface. A Hyperlink to an SQL Help Tutorial could exist which guides the new user through the commands supported. The structured language form enables the system to authenticate the query via Help before starting. By 'authenticate' we mean that the query is checked for syntax. When the query syntax is asserted to be correct, a status-bar message appears telling the user that the query is ready to start.

Figure 3 illustrates what the hypertext query form on the mobile unit might look like. A Common Gateway Interface (CGI) program should be executed to transmit the query to the database engine, retrieve the results and send them back and display them to the executive. The executive can save the retrieved information to the local cache and submit it to the home server at a later stage (perhaps automatically at the end of the day). When the executive receives the data, the returned data could be in a form

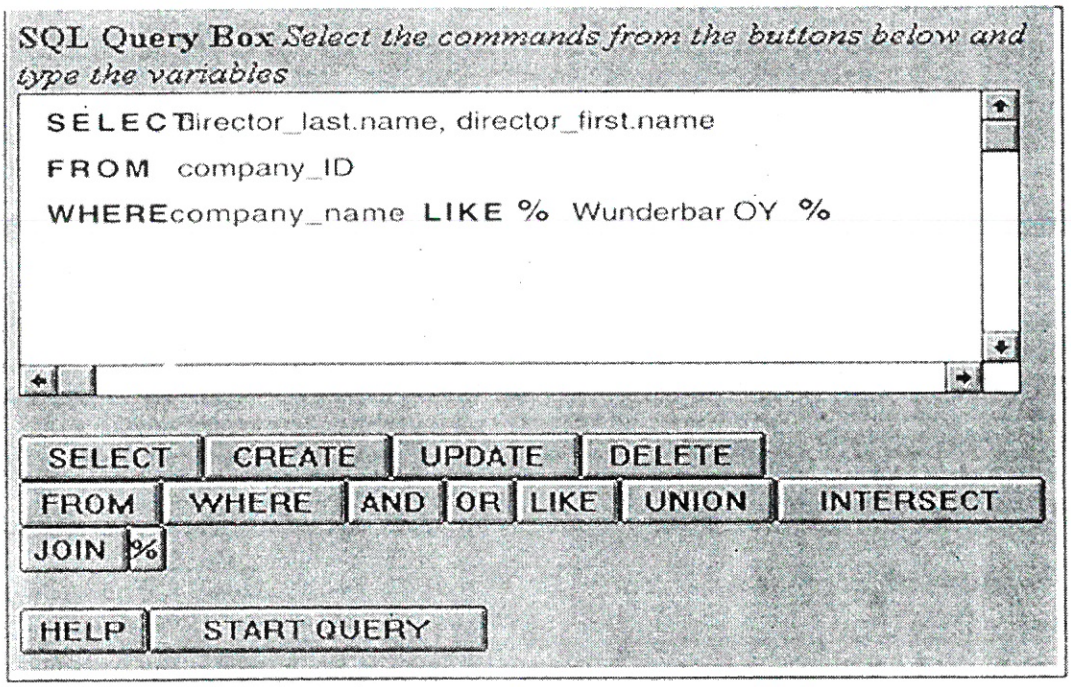


**Figure 3. An Example of A HTML-based Data Query Form for the Mobile System**

that allows the executive to select and sort the information in multiple ways via a Sort button, and further filtering can be achieved using an Extract function.

### *A User-friendly Hypertext Interface*

It must be said that SQL takes time to learn, and time is a precious resource for the mobile executive. In fact it is doubtful if the executive would ever feel comfortable using an SQL interface. A more *user-friendly hypertext interface* should be used for accessing data through the CGI. Achieving efficient information filtering requires both computationally efficient search engines and effective, easily managed user interfaces. According to DeClaris [8], retrieval and filtering are two extremes on a continuum. In information retrieval, queries submitted can vary widely in a single query session, while the data being searched are relatively static. In information filtering, the user's interests may be relatively static, while the queries are submitted to dynamic data libraries. Traditionally, information retrieval has been of a textual nature. This takes us to the next problem of text retrieval in a mobile environment.

## 3.4 Searching, Filtering and Merging

This Subsection offers ideas for searching, filtering and merging in the EMPIS environment.

When the SQL query is transmitted from a hypertext-coded query box, *a Proxy is* created at the nearest Mobile Support Station (see Figure 2). The proxy consists of an encrypted mobile unit home-ID and an encrypted international ID. The proxy is also ready to handle the transfer of the query to the Home Server which has the actual processing power to do *the data searching, filtering and merging.* If the required data are on a local server, the Home Server pulls the WWW-ready data from the source into memory locations reserved on the Mobile Unit WWW server. The Homebase Server should be linked via an optic cable to servers containing WWW-ready data on the LAN. The Home Server can also skip to the Internet to further search if the data have not been located on the local servers. Spiwoks [32] has illustrated how this works. Now the problem of extracting the *information* from the morass of data retrieved begins.

### *Textual Information Retrieval: Latent Semantic Indexing*

*Latent Semantic Indexing (LSI)* is a novel information retrieval method which can improve people's access to electronically available textual materials by 20 - 30% compared with popular word-matching methods [8]. A major problem which must be overcome in textual retrieval is that people use different words or phrases to describe the same idea or concept. The searcher will often use different words to search with, than the words the author of the text uses. This is a fact of human nature. LSI attempts to address this problem posed by varying human word choice by organizing textual information into a semantic structure. It is envisaged that the user can submit a query that does not share words with the text in the document being sought. The LSI technique used is called Singular-Value Decomposition. A matrix of term-to-document association data is decomposed into between 100 to 300 orthogonal factors. The original matrix can then be calculated by linear combination. See [8] for becoming acquainted with the algorithm.

The advantages the LSI concept is supposed to offer are as follows: The LSI method can be used for information retrieval and information filtering applications. It has been used successfully in cross-language retrieval. It is widely applicable to different domains. The following Section introduces another quite different method for textual searching, namely searching structured documents in a hypertext-based environment.

### *Searching Structured Documents*

*Searching Structured Documents* is here proposed to be done by using the WWW-WAIS Gateway SFgate [35]. Before we examine the possible applicability of WAIS to the EMPIS, it is important to define WAIS and SFgate, and describe these components interact to make document querying possible.

*WAIS is* the acronym for Wide Area Information Servers [35, 36]. WAIS servers index each word in every readable file and provide the means to make the index available for query, process queries and deliver results.

WAIS was introduced by Thinking Machines by Pfeifer [27] in 1988 as a method for keyword-searching document databases. WAIS treats documents as uniform bags of terms. Since most documents exhibit some internal structure, this structure is used by WAIS to satisfy user queries. Basically the client sends a couple of keywords to the server. The server

searches the specified database for documents most similar to the query. For the best matching documents it delivers the headlines and document identifiers to the client, which displays them to the user. By selecting a headline, the user can request the corresponding document. WAIS was followed by freeWAIS. FreeWAIS knows a number of built-in document types, which define the separation of files in documents and the contents of the headlines. The difference between WAIS and freeWAIS is that freeWAIS allows Boolean queries which means that one can search for combinations of words in the text. Such a query might be for example "(river or ocean) and (pollution or toxic or waste)". Servers answer search requests using auxiliary data structures called the index [35]. These are created for the original documents by a waisindex program. Requests are answered by the server fetching (parts of) the original files. The set of documents together with their associate index is called a WAIS database.

*SFgate* is a CGI script written in the perl scripting language which interfaces to WAIS servers [27, 35, 36]. It is specially suited for usage with freeWAIS-sf servers. But all free WAIS servers can be connected. You can set up hypertext forms as user interfaces to SFgate. This enables you to use the structured fields features of freeWAIS-sf in a simple manner and makes it easy to the user to specify his queries. SFgate can interface to any number of databases anywhere on the net at the same time. You just have to specify them within the hypertext form. The search result is converted to a query form on the fly. SFgate is self contained (see Figure 4). The script itself connects the servers.

***The Merging Process***

Spiwoks [32] has also conceptually illustrated how the *merging* process takes place. In this process well-known techniques utilized in traditional Executive Information Systems can be simply introduced (see [26]). In the case of EMPIS, there are two sources, which may be physically close or remote. When the remotely located executive transmits a query via the mobile unit to the home server, the server uses its much greater processing power to resend the query through the fixed optic fiber network. The sources receive the query and the data fitting that query (not all the data requested by the query may be at one source, but that is also possible) which is available at that source is written into a shared memory location at the mobile home server. Since the mobile home server also knows the real mobile ID and also knows the location of the mobile unit from the information received by the proxy, the home server can send the merged data down to the proxy, where they are then wirelessly transmitted to the mobile unit.

***The Possibility of WAIS Querying from the EMPIS***

According to [27] most WWW-WAIS interfaces resemble a flat query structure by allowing the user to enter keywords in a small input field, namely forms. Hypertext form interfaces are simple in layout. They hide the sophisticated query and retrieval code. All the executive utilizing EMPIS would have to do is to enter the query into the form and submit it. The EMPIS would then wirelessly transmit the query form to the nearest mobile support station. For further details, we refer to [27] and [13]. It suffices to say at the level of this report that a hypertext

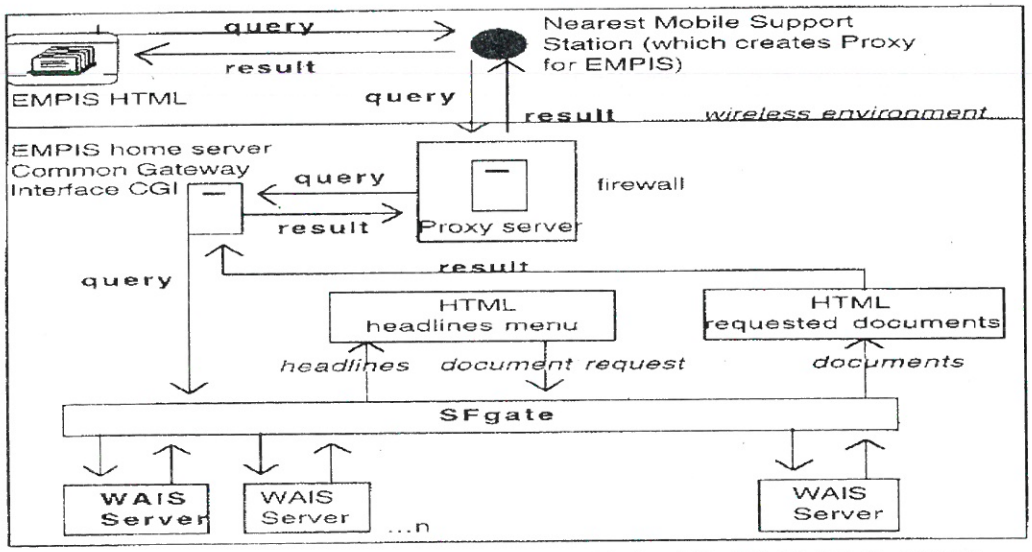


**Figure 4. Adaptation of SFgate Architecture As Defined By [27, 35, 36] To EMPIS**

query form interface can allow the EMPIS executive to query WAIS servers through a wireless digital cellular channel and the WWW-CGI.

### 3.5 Dynamic Documents To Provide Mobile Wireless Access To the WWW

Since we propose that the base interface of the EMPIS could be hypertext-based, and the executive will be able to access varied types of databases and run application programs located on the home server via the CGI standard, the mobile device will also be in a position to access multimedia documents on the WWW [11]. This can present *a performance problem.* Due to the small display screen and the insufficient bandwidth currently available, the EMPIS may find itself overwhelmed by the data included in many multimedia WWW documents. WWW data traffic tends to consist of large bursts of activity during data transfer, with intermittent quiet periods while the executive examines the retrieved data [28]. Kaashoek [20] states that presently wireless communication often cannot deliver the peak performance users expect in an interactive multimedia application.

At the MIT Laboratory for Computer Science, Cambridge MA, a project is under way to design and implement a mobile Mosaic client. To overcome the inflexibilities of rigid information transfer protocols, the project introduced the idea of dynamic documents [20]. Dynamic documents have been defined as programs executed by WWW clients in order to generate the actual information displayed to the user. Thus a dynamic document is not static, but rather it performs actions such as fetching other documents, generating new hypertext documents, accessing data, or even an entire X interface may be generated. Since the document is dynamic, it can be customized to cater for a small display screen, or if large multimedia objects are being retrieved in a situation where bandwidth is limited, the data may be subdivided so that the executive shall get the more accessible data quickly while the slower multimedia data are placed in the background. Dynamic documents are implemented as Tcl scripts which are executed upon reception from a WWW server [20]. The Tcl scripting language is used for reasons of safety, portability and authoring. By using Tcl it is possible to transfer standard hypertext documents into scripts that control the quantity of information initially transmitted to the mobile executive, while the rest of the information is downloading in the background.

To improve interactive performance in a mobile environment, caching at the mobile unit itself is seen as the most effective technique since the executive will roam from one broadcast cell to another. For ease of implementation, caching at the HyperText Transfer Protocol (HTTP) level has been suggested. When a HTTP request is made for a document not already cached, the document is requested from the server, and an exact copy of the server's response, a Uniform Resource Locator (URL), is recorded [20]. When the executive makes a request for the URL at a later stage, the cached document is displayed as if it has come from the network. The cache is randomly emptied when full.

### 3.6 Concluding Remarks on EMPIS As An Information Tool

We anticipate that the information seeking power of EMPIS can be best optimized if the search and retrieval interface is hypertext-based. We offer a number of reasons for this conclusion.

- Firstly, each new release of Netscape or Mosaic offers increased functionality, such as the ability of the user to edit and/or use tables, forms, and download software. This makes the concept of an easily customizable mobile executive information retrieval interface realistic.
- Secondly, the Common Gateway Interface (CGI) can allow remote hypertext interfaced clients access to databases. It requires that the actual search and retrieval engine is located at a home location, and the buttons displayed at the hypertext interface run a user login verification program, before running the database search program.
- Thirdly, the executive does not need to know how the search engine works at the home location. Thus a hypertext interface is user-friendly and uncomplicated, and requires no lengthy tuition which would be unacceptable for a busy executive.

However, from a human viewpoint, we must accept that the SQL and WAIS information retrieval methods may be too complicated for

the mobile executive. Both methods require learning some query commands, and the executives have only little or no free time to learn commands. Of these two methods, WAIS is probably the easiest and least complicated .

## 4. EMPIS As A Communication Tool

In this Section EMPIS is analysed as a communication tool from the viewpoints of technical construction, privacy enhanced email and facsimile, mobile group communication, access to company news and market news, and challenges of implementing video on EMPIS.

It has been asserted by Rockart and De Long [30] that executives work in an unstructured, complex, and changing environment. To deal with this environment, they need up-to-date, externally oriented, mostly "soft" information. Needless to say, this means that if the mobile executive is to be able to access information and be proactive in dealing with the retrieved information, reliable and effective communications are essential [7]. It is also essential to consider what communication services a mobile executive would be most likely to use. A passive and technologically driven approach to supporting executives with a "cafeteria style" selection of applications is not the answer, and it is easy to become blinded by thinking "the more utilities, the better" [30]. The situation may arise where the executive has given little consideration to the kind of support needed to perform the job better, and there is not a lot of free time in which to become familiar with a system stuffed with unnecessary technology. In other words, there is no point cramming the EMPIS with applications which may be rarely used by the executive, just for the sake of technology itself. Therefore, from the point of view of the EMPIS, it is necessary to be selective in choosing what communication media are ultimately really useful.

We envisage that *the EMPIS should incorporate the resources to transmit and receive full email, facsimile, video, and voice, but also resources for one-to-one communication and one-to-group communication should be provided.* Nearly all of the experimental mobile computing projects we have researched are not incorporating the cellular phone in their software or hardware architectures. In the communication architecture we propose, we are incorporating the cellular phone because firstly we believe that the stand-alone cellular phone soon offers reliable voice communication from any location, and secondly the cellular phone could be built into the EMPIS, providing ready wireless data communication.

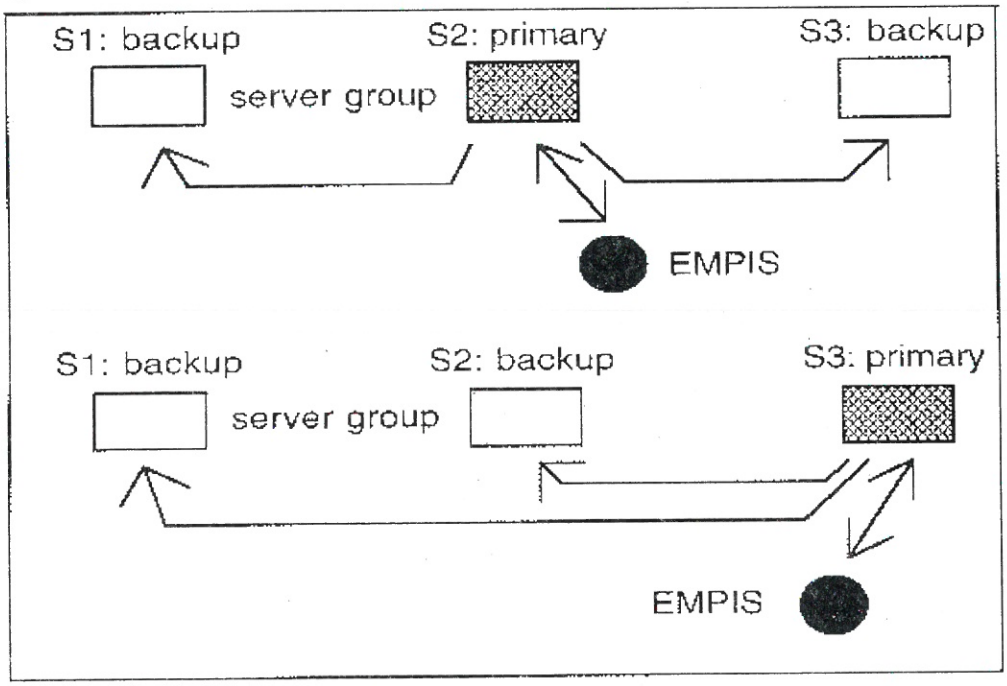


**Figure 5. Intentional Primary Switch (cf. [5])**

## 4.1 Provision for Communication Failure

In this Subsection we analyse the architectural issues of EMPIS from the communication tool viewpoints. The overall system architecture required to implement the server replication scheme sets special requirements to the system hardware. In our scheme, hand-off (the process of maintaining communication connectivity while crossing broadcast-cell boundaries) is realized by switching a control point between replicated servers (see Figure 5). A FIFO (First In, First Out) channel is integrated into the server replication model. The group communication capability is provided only by the servers. The servers carry the communication workload, making the EMPIS independent and lightweight.

In Figure 5, there is an interaction of *the primary-backup approach* between the EMPIS and a server, and *the state machine approach* among the servers. In the primary-backup approach, the EMPIS transmits a request only to the primary server. If the primary fails, one of the backup servers takes over. This failure has been labelled failover [21] . In contrast, the state machine approach has no centralized control where from the EMPIS transmits by multicasting to all servers. The servers change and lock their states simultaneously, and a server failure is invisible to the EMPIS. The primary-backup approach is implemented on top of the state server approach. The EMPIS communicates only with the primary server, but the primary resends inbound messages to the backup servers. This creates the illusion that the EMPIS has multicasting ability. Thus the EMPIS can see one reliable home server, and migrations and primary failures go unnoticed. A primary switch occurs only if there is a primary failure. A server hand-shake protocol should be implemented so that the primary status can be handed over from one server to another to geographically follow the user, as illustrated in Figure 5. This provides an effective method to manage the roamability of the EMPIS and server failures.

## 4.2 Privacy Enhanced Email and Facsimile

In this Subsection EMPIS as a tool for the privacy enhanced email and facsimile is studied. Research has proven that executives spend much of their time planning and arranging meetings, and seeking instantaneous updates on the progress of subordinates [29]. Rockart and De Long have determined that, according to extensive research, electronic mail has made it possible for executives to have real-time, as well as asynchronous, communication with subordinates, other executives and super ordinates [30]. Today, an HTML email/news group interface can easily be implemented on a mobile device.

In a wireless computing environment, the need for secure and confidential transmission of email is of even greater importance than over a fixed network. There should be provision for protection from an illicit party eavesdropping or capturing the email while it is being wirelessly transmitted. The source and destination(s) of the email should be hidden from outside parties [1,16,19,24]. Thus the need for privacy is of great relevance. In the following paragraph we define a procedure for providing email/fax encryption and authentication.

A four-phase transformation procedure is employed in order to represent encrypted message text in a universally transmissible form and to enable messages to be encrypted on one type of host computer to be decrypted on another type of computer [21]. This can especially apply to a wireless environment, where a mobile executive has no knowledge of what type of hardware the email will arrive to. Nor should the executive have any need to worry about the type of hardware at the email destinations. The executive clicks an email button on the hypertext-based mobile interface. An email URL is retrieved either from the EMPIS, or is downloaded from the home server. The executive types the plain text message. When the executive clicks the "send" button, the message is converted to a canonical message text representation. In addition, the send button activates an encryption algorithm which is stored locally on the EMPIS. The encrypted message is encoded into a printable form using a universally accepted character set. Header control fields are added and the message is passed out to the electronic mail system via the cellular phone. The email is received first at the nearest mobile support station, where it is determined if the authorized recipient is in the local vicinity. If so, the message is retransmitted locally. If the recipient is not local, the mobile support station forwards the message back to the mobile home server where there are sufficient processing resources to retransmit the email to the correct location. When the privacy enhanced email reaches its destination(s) the cryptographic control fields within its encapsulated header provide the information required for each authorized recipient system to

perform validation and decryption of the message text.

### *The Benefits Email Can Offer to EMPIS*

In the business world where "global" companies and global communications are expanding, the fastest way to communicate other than by telephone is via email. Email has the advantage over phone in that the sender and recipient do not have to worry about time zones. Rockart and De Long state that email is especially useful in tasks that involve coordination across time zones [30]. Email can be used to a certain extent as a coordination tool. An executive can use email to track project progress by asking for status updates and prearranging meetings [29]. Email has the advantage over phone in that the executive can review email messages to refresh his/her memory, and the executive can prioritize messages in order of importance. Email, especially in a mobile situation, can allow more spontaneous communication of ideas. Notations can be made on the fly. Messages can be sent to more than one person, such as to group aliases.

## 4.3 Mobile Group Management

In this Subsection we examine the notion of group communication in a mobile environment. In the executive setting, we foresee that, in the near future, mobile group communication would most likely be regulated only to those of executive status or higher, or at most down to special expert and project manager level. We also foresee that there must be a method for handling dynamic group membership, and a method for fault-tolerance.

By dynamic group membership, we mean that an executive can log into a particular *group alias* for which he/she has been given the login privilege. Cho and Birman [5] claim that then the executive can login to that alias at any time, from anywhere, and can then leave the group, move to another place, rejoin the same group and continue working with the other members. Group communication therefore allows for location independence and can adapt to a dynamically reconfiguring network topology. There should be provision for *ordered multicasting*, where members of the group alias receive the same set of messages in a predefined order, which allows for better synchronization of multiple processes, or coordinating cooperative actions for handling the mobility of the mobile executive [7]. There should also be provision for fault-tolerance so that the group can somehow continue to communicate even if a failure occurs somewhere in the system.

According to Cho and Birman [5], an important benefit of group communication resides in its ability to support *consistent replicas*, a feature that can also be useful for handling mobility of users.

As stated earlier, the mobile executive can log into a particular group alias for which he/she has been given the login-privilege. Ideally, the EMPIS group alias would have been created at an earlier stage by the system administrator and member privileges would have been set by the mobile system administrator upon request of the cooperating company CEOs or presidents. Then this group alias would have been activated for email and perhaps interactive video-conferencing. To manage the group alias, we could envisage that each server (primary and backups) should maintain a consistent up-to-date log file of each of the group alias member's channel. Each member's group interaction frequency would be tracked and logged by monitoring the channel. The executives may be exchanging ideas or proposals via email, and if one of those executives must leave the group temporarily, the channel is suspended but the log updating for that member is continued when the server continues to act on behalf of the disconnected client. In a mobile videoconferencing scenario [23, 37], it is much more difficult to implement group communication since the video-data density is much greater, and the real-time imaging of each executive onto one recipient's display from different locations is probably quite difficult to manage as well. However we will address the concept of mobile video in a later subsection.

## 4.4 Access To Company News and Market News

It must be said that the greatest computer oriented facility today for accessing economic and stock market news is the Internet. If an executive has the task of monitoring the company stock price fluctuations in order to predict future trends, then the Internet is the best on-line source for Reuters, the Dow Jones Industrial Index, Nikkei Index, and many more. This, of course, deals with external news, which is generally seen as more valuable than internal news [26, 30].

Mobile sales executives might require early news of takeover and merger activities involving major customers or competitors; being mobile, the executive can access market news on the

EMPIS from anywhere; from a hotel room, a customer's office or a cafeteria. In the world of business, time is money, and the 'no-waiting' advantage of the EMPIS pays off. The monitoring of stock prices frequently turns out to be one of the most popular uses of an executive support system. Not only do executives check their firms performance, and that of competitors, but many monitor and analyze their own investment portfolios [29]. The major benefit of computerized news is to provide a faster way of scanning the external environment for information relevant to the business. Rockart and De Long [30] have also concluded that news can also provide a diversion for the hurried executive, looking for a few moments of 'down-time' to relax between stretches of intense work.

Report [38] offers an example of what the EMPIS 'market news' interface might look like: it may include indicators, a variety of different chart displays, editable time axis, filters and alarm functions. Since the proposed EMPIS interface is hypertext-based, internal company news can be downloaded from a daily updated bulletin board on the home server. The bulletin board would contain generally circulated information about what is happening inside the company, as well as summaries of external events relevant to the business. Access to general internal news has been stated as being marginally useful for top management. According to [30] where it is available, executives may find it of interest, but not critical to their function. Perhaps then a simple regularly updated HTML bulletin board would suffice to provide such a service on the EMPIS.

## 4.5 The Challenges of Implementing Video on EMPIS

Video conferencing is becoming increasingly popular in the corporate world. According to a study by Puuronen and Savolainen among 49 West and North European executives, 47% of executives have had some experience of video conferencing [29]. The ability to set up an audio-visual two-way meeting between two distant locations, without having to leave the conference room or office, has enabled companies to save time and expense in communicating with remote contacts, instead of waiting for planes, driving between work sites, using overnight couriers, or faxing back and forth. In general, it can be said that the two most recent trends in IT are the emergence of small, mobile computers using wireless networks and the increasing popularity of multimedia applications.

However, conferencing is still very much conference-room or desktop oriented since the state-of-the-art today is represented by a video camcorder linked via a workstation to the Integrated Services Digital Network (ISDN). ISDN is a technology designed for the public switched telephone network that allows low-cost communication in data, voice, graphics, and video (cf. [2]). It is designed to run over the existing copper local loop that connects the telephone company's central office to the company office or home. With ISDN, bandwidth capacity is increased to 144,000 Kbits per second, compared with the regular fixed telephone cable capacity of only 14,400 Kbits per second. On the mobile front, however, research is being carried out in various communications research institutes worldwide into the possibility of implementing a handheld digital video receiver. Blostein has constructed a mobile cellular/satellite digital video image receiver with ultra low bit-rate, error resilient video coding [3].

But just today we have to raise two relevant issues: Firstly from a functional requirement point of view, does the mobile executive really take part in videoconferencing often enough to warrant a mobile video service? Secondly from an implementation point of view, is it physically possible to bundle the video hardware and software onto a pocket-sized device which already provides a multitude of other more basic functions, without increasing the size of the device beyond being "pocket-sized"? We pose these questions simply because in the course of our research we have noticed that the experimental mobile video devices tended to offer only a mobile video service. A clear solution today to these issues is to utilize a laptop with the mobile phone, although only 12% of executives have had any experiences with this in the winter 1995-96, according to case studies of Puuronen and Savolainen [29].

However, video phones are being designed and prototyped today. The technology is being constantly improved to eventually make small video phones a consumer product. The Berkeley University Infopad project is making progress in the area of mobile video [18]. The project researchers have proposed an interesting methodology for implementing an audio and video function on a mobile entity. They state that a simple event-based operating system is being developed to support the real-time and control tasks for mobile video. Functions include controlling data transmission sequences, selecting which type of packet should be sent. The mobile processor would handle the management of buffers for tasks such as

synchronizing video and audio data streams. A video timing controller and bus interface chip would process the incoming video and voice data, forward the coded data to the buffer where an image decoder would decompress the video on the fly. The project has also suggested a method for reducing the heavy power consumption of the LCD screen [18]. An LCD panel with a memory could be used which would eliminate the constant refresh power consumption. Figure 6 illustrates the Infopad architecture of an IPvideo base station and mobile entity.

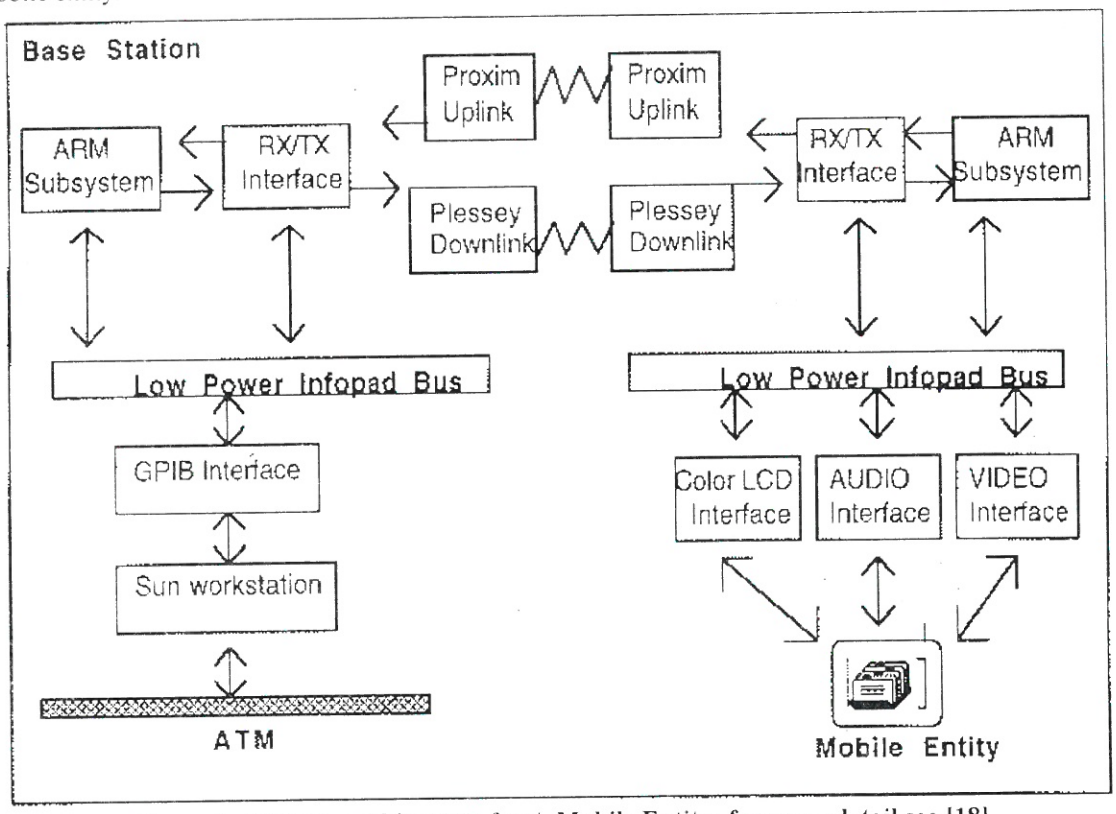


**Figure 6. IPvideo Architecture for A Mobile Entity; for more detail see [18]**

## 4.6 Concluding Remarks on EMPIS As A Communication Tool

We believe that the EMPIS can certainly support the communication functions of email, fax, voice, company news, and market news. These functions have been implemented on desktop EIS systems for quite some time now [26] and they will ultimately be designed for the EMPIS [29]. Mobile video communication provides the real communication challenge facing the EMPIS. The Infopad project is currently looking for ways to implement real-time video on a mobile entity equipped with a color LCD memory panel [18]. Certainly this methodology could provide a path for EMPIS video. That remains to be seen soon.

# 5. Summary

In this paper, Mobile Information Systems were analyzed as one of the strongest development areas in information technology. We defined the concept of EMPIS, Executives' Mobile Personal Information System, as a tool to offer mobile IT services to travelling executives. The main functional areas of EMPIS are: information, communication, decision making, analysis, and office work support.

A deeper analysis of the characteristics of EMPIS as an information tool and communication tool was presented, suggesting methods for remote data access and information retrieval, and outlining a method for searching, querying, and filtering in a mobile environment. EMPIS as a communication tool was analyzed and constructed from the viewpoints of privacy enhanced email and facsimile, mobile group communication, access to company news and market news, and the challenges of implementing video on EMPIS.

As an implementation environment for EMPIS we suggested a mobile hypertext-based (HTML) human-computer interface, and plenty of advantages for this choice were shown throughout our analysis. But as we indicated with many references to ongoing R&D projects, diverse directions are taken today in the field of mobile computing.

## REFERENCES


1. ASOKAN, N., **Anonymity in A Mobile Computing Environment,** http:// snapple.cswashington.edu/mobile/mcsa94.html, 1995.
2. **ATM System Architecture,** http://www.atmforum.com/atmforum/atm_ basics/ notes4.html, 1995.
3. BLOSTEIN, S.D., **Image Processing & Communications Lab.,** Queen's University, Ontario, Canada, http://ipcl.ee.queensu.ca/ 1995.
4. CHI, R. T. and TURBAN, E., **Distributed Intelligent Executive Information Systems,** DECISION SUPPORT SYSTEMS, June 1995.
5. CHO, K. and BIRMAN, K. P., **A Group Communication Approach for Mobile Computing,** http://cs-tr.cs.cornell.edu/TR/ CORNELLCS:TR941424, 1994.
6. Comshare Commander OLAP, **Data Integration,** http:// www.comshare.com /eis.htm, 1995.
7. CSAKI, P., RAPCSAK, T.,TURKHANYI, P. and VERMES, M., **R and D for Group Decision Aid in Hungary by WINGDSS,** a Microsoft based Group Decision Support System, DECISION SUPPORT SYSTEMS, July 1995.
8. DECLARIS, N., **Information Filtering and Retrieval: Overview, Issues , and Directions,** .http://www.enee.umd.edu/ medlab /filter/filter_ project.html, 1995.
9. ELAM, J. J. and LEIDNER, D. G., **EIS Adoption, Use, and Impact: the Executive Perspective,** DECISION SUPPORT SYSTEMS, June 1995.
10. **Executive Information Systems,** A special issue of DECISION SUPPORT SYSTEMS, June 1995.
11. FLYNN, P., **The World WideWeb Handbook,** INTERNATIONAL THOMSON PUBLISHING COMPANY, London, 1995.
12. Full Contact Management Ltd, **What Is Automated Processes, Working Anywhere: Essential Tools for Business,** http://www.magi.com/~jmaduk/aproces.html, 1995.
13. GADD, T.N., **'Fisching for Werds'. Phonetic Retrieval of Written Text in Information Retrieval Systems,** PROGRAM, Vol. 22, No. 3, 1988, pp. 222-237.
14. GILDER, G., **The Bandwidth Tidal Wave.** http://homepage.seas.upenn.edu/ ~~gajl/bandgg.html, 1995
15. GILDER, G., **The New Rule of the Wireless.** http://homepage.seas.upenn.edu /~~gajl/wireless.html, 1995.
16. HERZBERG, A., KRAWCZYK, H. and TSUDIK, G., **On Traveling Incognito,** http://snapple.cs.washington.edu/mobile/mcsa94.htm, 1995.
17. HOW TO SPEND IT magazine, September, 1995.
18. **INFOPAD Mobile Computing Project,** Berkeley University, http://infopad.eecs. berkeley.edu/research/infonet, 1995.
19. JOHNSON, D. B., **Routing in Ad Hoc Networks of Mobile Hosts,** http://ftsu 10.ee.tu-berlin.de/bibl/ps/index.html#CMU, 1995.
20. KAASHOEK, M., **Dynamic Documents: Mobile Wireless Access To the WWW.** http://snapple.cs.washington.edu/mobile/mcsa94.html, 1995.
21. LINN, J., **Privacy Enhancement for Internet Electronic Mail,** ftp:// ds.internic. net/rfc/rfcl421.txt, February 1995.
22. MIRGHAFORI, N. and FONTAINE, A., **A Design for File Access in A Mobile Environment,** http://snapple.cs.washington. edu/mobile, 1995.
23. MITCHELL, H., **Teleworking, CSCW and the Mobile Worker,** in A. Dix (Ed.) Proc. IEE Colloquium on CSCW Issues for Mobile and Remote Workers, London, 1993.
24. MOLVA, R., **Authentication of Mobile Users,** IEEE NETWORK, Vol. 8, No. 2, 1994.
25. O'DONOGHUE, N., **Project MEMPHIS,** Final Report, University of Jyväskylä, Department of Computer Science and Information Systems, Jyväskylä, Finland, 1996.
26. PARTANEN, K. and SAVOLAINEN, V., **Perspectives on Executive Information Systems,** SYSTEMS PRACTICE, Vol. 8, No. 5, 1995, pp. 537561.
27. PFEIFER, U., **Searching Structured Documents With the Enhanced Retrieval Functionality of FreeWAIS-sf and**

**SFgate.** http://www.igd.fhg.de/www/www95/papers/47 /fwsf/fwsf.html, 1995.

28. POSTEL, J. B., **Internet Protocol,** Internet Request for Comments RFC 791, 1981.

29. PUURONEN, S. and SAVOLAINEN, V., **Evaluation of Mobile IT Services: State-of-the-Art and Future Expectations**, EMPIS Project, University of Jyväskylä, Department of Computer Science and Information Systems, 1996.

30. ROCKART, J. F. and DE LONG, D. W., **Executive Support Systems: The Emergence of Top Management Computer Use,** Dow Jones-Irwin, Homewood, IL, 1988.

31. SHELDRICK, D., **Start Becoming A Webmeister**, DATAMATION, March 1995.

32. SPIWOKS, R., **Requirements of An Event Building System,** http://rdl 3doc.cern.ch/public/doc/Note111/Note111.html, 1995.

33. **Sybase, Interactive Query Accelerator,** Sybase Inc., http://www.sybase.com/Products/Whitepapers/iqa_wpaper.html, 1995.

34. **Using EIS To Respond To Dynamic Business Conditions,** DECISION SUPPORT SYSTEMS, June 1995.

35. **WAIS Through the Web - Discovering Environmental Information,** http://www.ncSa.uiuc.edu/SDG/IT94/Proceedings/Searching/crossley/wais. html, 1995.

36. **WAIS Protocol**, University of Dortmund, Germany, http://ls6-www.informatik.uni-dortmund.de/freeWAIS-sf/fwsf_1.html#SEC2, 1995.

37. WILLIAMS, V.A., **Wireless Computing Primer,** MIS PRESS, Inc, New York, 1996.

38. **WinBIS Interface for Windows.** http://www.ping.ch/quoteline/winbisd. htm, 1995.