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Creating e-Chains to enable E-Governance Through Embedded Technologies

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Abstract

It is evident in some of the developed countries that IT enabled services can be used very effectively to help bridge the Digital Divide and provide good governance to the citizens of any geographical region. In developing countries, like India, it is imperative that the governance should be transparent and cost of governance should be minimum so that the scarce resource can be deployed for development and enhancement of quality of life of citizens. The authors of this paper have taken a standard framework for E-governance that uses Knowledge Aggregation, Process Constructs, Content Constructs and Delivery Methods with appropriate connectivity, to extend personalized services to the citizens through multi-mode access mechanisms by creating integrated information chain called "e-Chain" which is depicted in Fig 1. A specific example in Fig 2 depicts the instantiation of a Public Food Distribution System, on this framework, which can be deployed in a country like India.

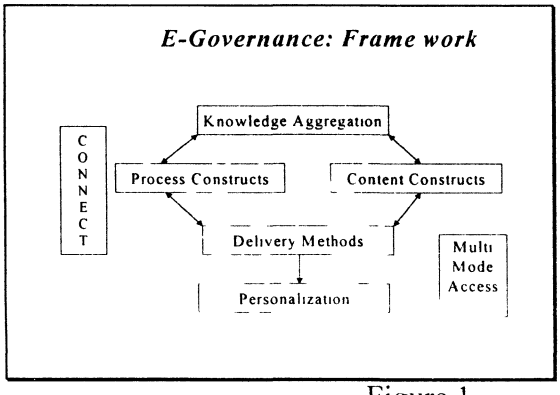

Figure 1

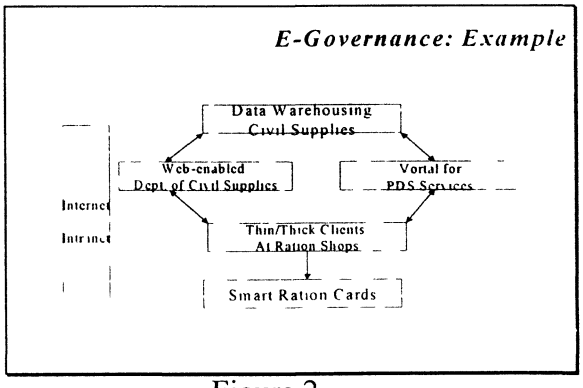

Figure 2

In this paper we describe the key technology drivers and enablers at the Delivery and Personalization levels because it is at the last two levels that a conventional delivery system faces many lacunae. In technology parlance it follows the classic "last mile" and "last foot" problem. The citizens of any country have a right to expect good governance but there is a huge cost to any governance services that must ultimately reach the citizens. The citizen-to-government interactions and transactions are customized at a geographical, community, group, or individual level. The "cost of two-way transaction" depends on time taken to complete the transaction, accuracy and reliability of transacted data or information. It needs to be reduced in order to create a cost-effective, highly personalized delivery mechanism, which should be scalable to incorporate additional services or to handle growing transaction density.

We propose that low cost, mobile computing devices (like "Simputer") will play an increasingly important role in the Delivery and Personalization levels of the E-governance framework. One of the authors of this paper has been involved in the development of such a platform, called the Simputer (http://www.simputer.org) which is now being deployed in certain proof-of-concept applications such as micro financing, land record management, GPS and GSM based tracking to enable E-governance.

The Simputer, a mobile, hand-held device is simple to use and shareable by multiple users through personalized smart cards that allow access to the desired applications. It has multiple connectivity options such as USB Port, built-in IrDA and Modem. It has local language interfaces, Text-to-Speech capability and the touch screen features that enable even an illiterate (computer or otherwise) citizen to interface with E-Governance services. Further, its ability to handle downloadable applications makes it a fairly comprehensive tool for application delivery.

This paper describes the hardware and software interfaces that are being developed and tested to lower the entry barriers for a common man into the world of E-Governance.

1. Introduction

The Information Technology Revolution that the world is currently witnessing seems to be an urban-centric phenomenon. This tends to create a deep "digital divide" between the haves who have access to IT and IT-enabled services, and the have-nots who do not have access to such services. The pace of growth in IT is so rapid that the digital divide is likely to increase exponentially and create deep fissures in society at large unless these problems are addressed at the level of governments and non-governmental organizations.

Traditionally, the government-citizen interface, especially in developing countries, has been based on the classic client-server model whereby government departments provide a few sets of services to their citizen clients through a form-filling mechanism. A client requiring a specific service visits the concerned government office and fills out a request for that service. The government office provides that service in a non-realtime way by asking the client to come back when the office is ready with its answer.

Government agencies are supposed to provide a very wide range of services to their citizens. Unfortunately, because of the geographical vastness and cultural diversity of our country and the low level of literacy of the general populace, citizens do not have access to all the services to which they have a right. Transaction costs for the delivery of information are too high and there is a tremendous lack of transparency in Governance. With the advent of cost-effective Information technologies, it is now feasible to enhance the quality of that delivery process and ensure a greater degree of transparency in governance.

The Solution:

There is an inherent lack of transparency and inefficiency built into this classic client-server model of governance because the client is essentially at the mercy of the government bureaucracy. The *Transaction Cost*, which is the cost incurred by the government to provide that service and the cost incurred by the client to get that service, is tremendously high. There is no incentive to provide quick service at a reduced transaction cost. In fact, the government-citizen interface provides the maximum scope for withholding information selectively to the citizen and thereby creates a potential source of corruption and inefficiency.

An IT-enabled services network alleviates some of the problems associated with the classic model. In this service model, most services are available to the citizens in the form of on-line access to information. However, clients always have needs which require interaction with the service provider and cannot be met through mere on-line access to information. Information Technology plays a critical part in providing interactivity through technologies such as Interactive Voice Response [IVR] Systems. An IVR system is simple to set up and operate because the infrastructure uses the POTS telephone to navigate through a set of speech-based menus. This helps reduce the transaction cost because the client no longer has to visit the government office to acquire the service. A generalized model of this approach is followed by customer call centers where trained operators respond to customer queries and satisfy the client's needs.

The broad parameters under which call centers operate are as follows:

- Provide domain-specific services to clients
    - Improve operational efficiencies through automation of information
    - Automation of repetitive tasks
- Reduce Transaction Cost to Service Provider
    - Geographical location in low-cost service areas
- Provision of 24-hour, 7-day access to services

Mainly, such services concentrate on the content of their services, rather than on understanding the contextual requirement of the client. Essentially, what this means is that content is defined by the service provider and imposes a certain usage model on the client. On the other hand, a client has very specific needs that may not fit into an automated model of services. Interactivity helps to alleviate this problem somewhat by offering a choice of services selectable through navigational menus.

However, the IT-enabled services model does not go far enough in being able to reduce transaction cost and increasing operational efficiency. Various reasons can be attributed to this failure of the traditional IT-enabled services model:

- Lack of service provisioning in local languages
- Lack of appropriate applications that service community needs
    - Example, farmers need information on cropping patterns, irrigation techniques, soil conditions, weather reports, markets, etc
- Distributed access to services
- High transaction costs

Embedded technology can play an effective role in creating e-Chains in the proposed e-Governance Framework to reduce transaction cost and improve operational efficiencies. In order for the benefits of e-Governance to percolate to the target audience, it is essential to analyze the Delivery (transportation) Methods in this Framework and also analyze the specific aspect of Personalization. These aspects are discussed with specific reference to Public Distribution System in India.

2. The problem Statement

2.1 Introduction

The public distribution system (PDS) in India is the oldest and one of the most comprehensive anti-poverty programmes in terms of budgetary expenditures of the central and state governments. From the mid-1960s, the PDS has evolved into a price support-cum-quantity-rationing-cum-subsidy programme. Although the food scenario of the country has undergone drastic changes from one of recurring scarcity to a food surplus situation today, the PDS is continuing more or less unchanged.

The PDS is fraught with problems and has been a subject of much research There is evident disconnect among the needs of the various stakeholders, ranging from customers (poor people) to supplier's (poor farmers) to the government, all amidst a complex web of

information dependencies like the monsoon, the annual budget and World Bank recommendations. The deficiency of a quick and dynamic feedback system that can even out the imbalances in the system inspite of a uniform policy is the main reason for failure in uniform and successful implementation of PDS. As a vicious cycle, a lack of timely and relevant information from the field has led to the formulation of inefficient food security policies.

The creation of the Food Corporation of India (FCI) and the Agricultural Prices Commission in 1965 consolidated the position of the PDS. The Government was now committed to announce a minimum support price for wheat and paddy and procure quantities that could not fetch even such minimum prices in the market. Foodgrains thus procured were to be used to maintain distribution through the PDS with a portion used to create and maintain buffer stocks. PDS was sustained as a deliberate social policy of the Government with the objectives of:

- Providing foodgrains and other essential items to vulnerable sections of society at reasonable (subsidised) prices;
- Having a moderating influence on the open market prices of cereals, the distribution of which constitutes a fairly big share of the total marketable surplus; and
- Ensuring equity in the matter of distribution of essential commodities;

In short, PDS, from mere rationing, had evolved into the National Food Security System. In 20 years, the FCI's subsidy bill has gone up by nearly 20 times. The reasons are

- inefficient procurement, storage, and delivery mechanism resulting in the FCI godowns overflowing with 45.5 million tonnes of foodgrains (wheat and rice), of which at least one million tonnes are believed to be rotten and two lakh tones classified as damaged. The cost of holding such a huge inventory of excess grain is a massive Rs 15,0000 crore.
- Though the FCI's procurement and handling cost is twice as high compared to private traders, the quality of foodgrains procured and supplied is generally sub-standard and low quality.
- Foodgrains worth Rs 500 crore is lost in transit every year and the two lakh 'workers' in the FCI costs the exchequer Rs 875 crore by way of salaries and perks.
- In contrast, the productivity and performance level of FCI workers is among the lowest in the country with an average handling of 10 bags per worker per day.

2. 2. Activities involved in PDS

In typical public distribution system the activities involved are, procurement of food grains, storage management, scientific preservation, capital structure and subsidy, transport management, distribution management, stocks management

Procurement of Foodgrains

Price support purchases are organized in more than 8,000 centers for wheat and 4,000 centers for paddy every year in the immediate post-harvest season. In the last two decades, foodgrain procurement by Government agencies has witnessed a quantum jump from 4 million tonnes to over 25 million tonnes per annum. Each year, the Food

Corporation purchases roughly 15-20% of India's wheat production and 12-15% of its rice production. This helps to meet the commitments of the Public Distribution System and for building pipeline and buffer stock.

Storage Management

The FCI has a network of storage depots strategically located all over India. These depots include silos, godowns and an indigenous method developed by FCI, called Cover and Plinth (CAP). CAP storage is a term given to storage of foodgrains in the open with adequate precautions such as rat and damp proof plinths; use of dunnage and covering of stacks with specially fabricated polythene covers etc. FCI has over 23 million tonnes (owned & hired) of storage capacity in over 1700 godowns all over India.

Transport Management

FCI moves about 22 million tonnes of foodgrains over an average distance of 1500 Kms. An average of 4,00,000 bags of food grains are transported every day from the producing States to the consuming areas, by rail, road, inland waterways etc. Thus by effective planning and management of the transport system FCI regularly moves grain from the producers to the consumers.

Distribution Management

A steady availability of food grains is ensured through thousands of fair price shops spread throughout the country. With nearly 4,50,000 fair price shops spread all over the country, the coverage is almost universal. A steady availability of food grains at fixed prices is assured which is lower than the actual costs due to Govt. policy of providing subsidy that absorbs a part of the overhead costs.

2.3. Computerization of Food and Civil Supplies

Price Monitoring System (PMS) has been developed and implemented at the district level and the data is sent daily/weekly to a server to data processing and report generation. Public Distribution system (PDS) involves issue of essential commodities to a large number of people through a network of Fair Price Shops (FPS) on a recurring basis. Necessary software is implemented to monitor allocation, lifting of the commodities. Storage Information System is developed to monitor the storage capacities available and their utilization. The system provides data of various agencies involved in PDS.

3. Solution Logistics

The solution required at this stage of the process is two folds. One is the logistics management from centre to state warehouse and another is from state warehouse to fair price shops. The solution should provide following services:

1. Shipment Tracking
2. Notification service
3. Billing and Payments from state to central government
4. Warehouse integration and Management for both central government and state government.
5. Logistics Management: Responsibility of entire logistics requirement of the process.

Logistics hub can be developed in order to track the shipment from the moment it leaves central the warehouse and reaches the state warehouse and secondly to track its movement to fair price shops from state warehouse. Electronic fund transfer should be enabled between state and central government and either party can generate reports on the system in order to track a particular shipment. Although there are many solutions as far as truck tracking is involved, by the nature of the level of activity and the funds allocated for this project, GSM based solution that relies on GPRS technology will be ideal to track the vehicle. This will bring transparency to the entire process and will help to pinpoint the defaulter. The Logistics Hub that can be maintained for centre to state warehouse has been shown in Figure 3.

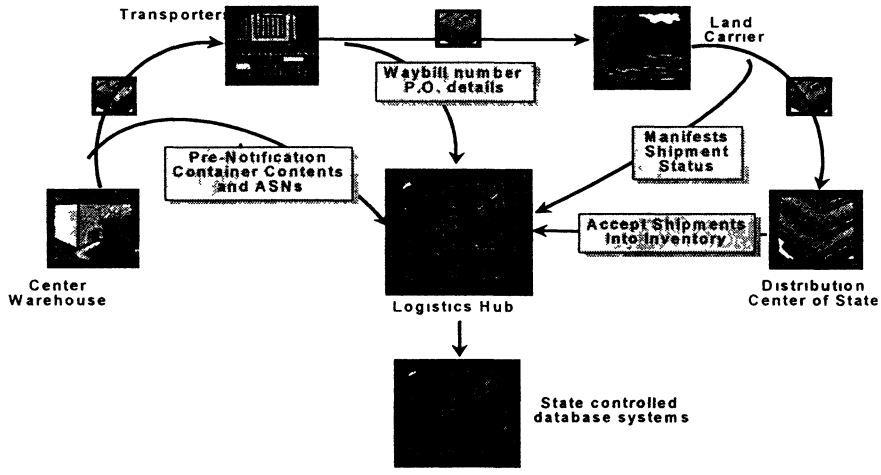

Figure 3

4. Service Delivery Mechanisms – Simputer Application:

There are several forms of delivery mechanism but we shall concentrate on low cost, mobile access devices such as the Simputer that has been recently developed by the Bangalore-based Simputer Trust, of which one of the authors is a founding member and a key system architect.

The Simputer has focused on 3 major goals and for bridging the Digital Divide, each of them being achieved through incorporation of specific technologies that address those objectives:

- To provide a low cost, generic, mobile platform for enabling application delivery
  - An embedded, non-PC architecture that allows product innovation at lower cost
  - Usage of open-source software such as GNU/Linux
  - Simputer General Public Licencing model based on the Free Software Foundation's GPL
  - An open hardware architecture based on the open-source software paradigm, with specific emphasis on low power consumption, cost and size of device
  - Sharing and Personalization, through the use of smart-cards, to reduce cost of ownership

    - Battery technology that enables commonly available cells to be used when required
- To provide multiple connectivity options for the mobile device to enable access to the Internet and dialup servers
    - Built-in analog modem for landline connectivity
    - IrDA Port for data transfer with a PC at short range
    - Universal Serial Bus for fast transfers and access to various peripherals
    - Wireless networking through a filed-upgrade option
- To reduce the barrier to usage of IT-enabled services by relatively IT-illiterate users
    - Simple, iconic interfaces for all applications
    - Text-to-Speech capability for the applications
    - Local language capability in multiple Indian languages
    - Smart-card based personalization information to reduce form-filling input by semi-literate users
    - Access device independence

The SmartCard Reader in the Simputer is one of its most outstanding features that has the potential to open up a vast range of applications that will directly affect the way a citizen gets services from the government. Some examples of its application are in general-purpose Citizen's Card, Driving License, Express Passport, Land Records etc. These are covered in greater detail elsewhere in this paper.

A few of the typical applications that are envisaged for the Simputer are given below. This is by no means an exhaustive list and merely indicated the kinds of applications for which the Simputer is an ideal device. It is important to understand that the Simputer functions best only as an access device, which when connected to a back-end server can be used for a variety of applications. Therefore, it does not have a large amount of non-volatile storage, which is typically expected to be available at the server end.

Other Application Areas

MicroBanking

The Simputer is the ideal mobile platform for a complete, secure micro-banking solution. Several small cooperative banks in the states of Maharashtra and Karnataka, in India, are already providing services to their rural clients at their doorsteps. The current business model of micro-banking has several shortcomings. The Simputer, or a similar mobile device, provides a much more secure environment, with the help of a Smart-Card and simple to use encryption software. It is felt that such mobile devices can increase the level of penetration of micro-banking and access to micro-credit in rural India .

Data Collection

Organizations that collect large volumes of data, such as the National Sample Survey Organization, the Census Bureau, etc. are ideal candidates for a secure data collection

device based on the Simputer. Since the Simputer can also support the Java environment, it is relatively straightforward to develop customized forms-based data collection applications that can enable the Simputer to collect various forms of data in the field and then pass it on to a central repository for further processing. Once again, the Smart Card offers a unique enabling technology for data security.

Internet Access

The Simputer has a simple to use Browser for accessing the Internet through a built-in dialup modem. The user could dial into an Internet Service Provider and access information on the internet. This technology also enables the mobile device to connect a PC based server and transfer information.

Agricultural Information

An important application that can be implemented using the Simputer is the dissemination of information to farmers relating to agriculture, such as crops, fertiliser, irrigation, agricultural finance, farm equipment, weather-reporting etc. Since the Simputer also has a built-in MP3 Player, it could also function as a device for dissemination of education and entertainment programming.

The School Laboratory

A whole range of educational applications can be developed and deployed for the benefit of the rural student population, on the Simputer. It is possible to create self-learning programs, laboratory experiments, information search engines and other tools that can supplement the school curriculum. It is expected that NGOs and educationists would come forward to create suitable program material in this area.

The Kiosk Simputer

The Kiosk Simputer is likely to be the primary access technology for rural communities and for providing them access to IT-enabled services. This product is likely to have the same long-term benefits as the STD/ISD PCO Booth did a decade ago in India. The Kiosk Simputer is a specialized device derived from the basic Simputer which has built-in connectivity to the Internet, a larger screen for convenient viewing, a Smart-Card Reader for access to security and personalization services, and extremely low cost. This device has the potential to serve the entire local community through its ability to access information from the back-end services.

The Simputer is an ideal access device that can be used for the front-end of these application services, whereas the services themselves will be deployed on backend servers. It is possible to create a hierarchical architecture for e-Governance services in which the mobile device is an important deployment technology.

Basically, it is assumed that e-Governance applications and services will be hosted on servers located in Government offices or Community Centres which may be geographically dispersed and interconnected together over a fibre-optic backbone. Users will access these services through broadband connections, using ADSL, or using dial-up analog modems.

The basic Simputer has a built-in Analog modem that can be used to dial into an Internet Service Provider, get a TCP/IP connection and then access the services. This would be typically used from the home or a community centre.

Security is of the greatest concern when so much critical data is accessible through the Internet. The Smart Card would be used as a local authentication device for implementation at various levels, such as IPSec for secure communication, and public key encryption for data encryption, and digital signatures. Of course, there would have to be a Public Key Infrastructure (PKI) and a PKI-compliant Certification Authority to manage the entire security scenario.

The architectural overview of a Simputer-enabled government services is given in Appendix A. The logistics solution in terms of transport trucks tracking solution details are provided in Appendix B.

5. Conclusion

Integrating government departments, along with cost-effective logistics solutions using mobile computing devices and embedded systems can create a quick response systems that help not only in procurement and distribution of food but also in identifying the needy to help the government departments focus better on alleviating the glaring divide between the haves and the have-nots.

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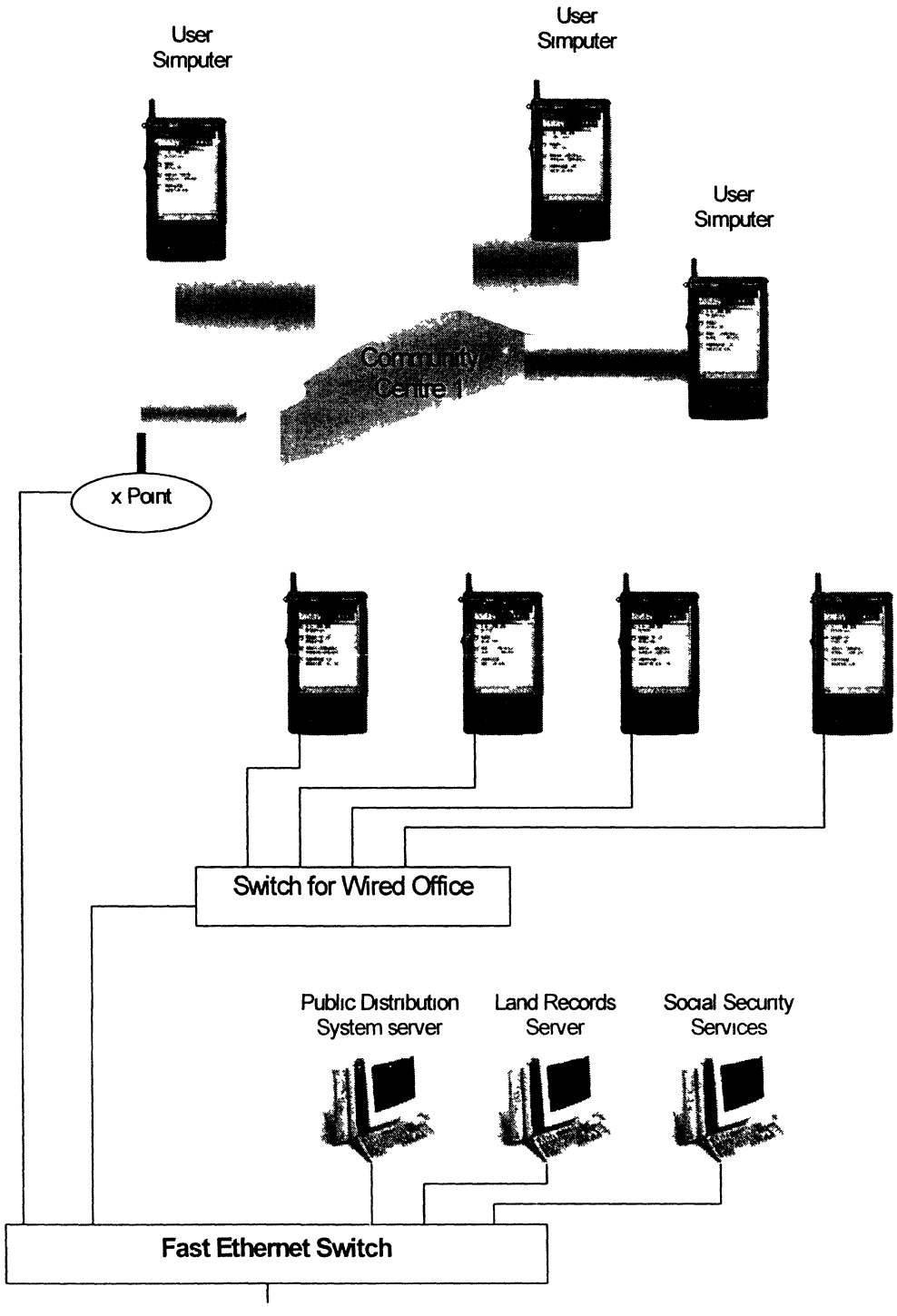


Appendix A – Simputer Enabled Government Services (e.g., PDS)

Appendix B
Specification of GPS & GSM/GPRS based Tracking Platform

1.0 Introduction

This is the description of a GPS/GSM based vehicle tracking and reporting platform, called the Tracker Device, for deployment in the transportation industry. The Tracker Device will be mounted on the chassis of a vehicle and will continuously track its location through a built-in GPS Receiver and will have the ability to periodically report its position to a Call Centre. The communication between the vehicle and the Call Centre will be through a GSM communication link, which could subsequently be upgraded to GPRS when such facilities become available.

The architecture of the Tracker Device is modular so that additional features can be added at incremental cost and effort. There will be an ARM CPU, a GPS Receiver Module, and a GSM/GPRS Communication Module, along with system memory and Flash memory based non-volatile storage for operating firmware, configuration data and tracking information.

The modularity of the hardware architecture is carried into the software also, through the use of a small real-time kernel, eCOS, which has been developed by RedHat and can be obtained from the Open Source Software domain. The advantage of using an RTOS is that it isolates the application firmware from the hardware, thereby making it relatively straightforward to enhance the functionality of the application firmware quite independently of the hardware.

2 variants of tracking product:

- A low-cost Tracker Device with basic functionality
  - 32-bit ARM RISC CPU
  - Conexant or SiRF GPS Module
  - Conexant or Wavecom GSM/GPRS Module
  - Embedded-Linux or eCOS programming environment
  - Tracking Firmware

- An Advanced Tracker Device with extended functionality
  - 32-bit ARM RISC CPU
  - USB interface to PC
  - SiRF's GPS chipset
  - Conexant or Wavecom GSM/GPRS Module
  - Embedded-Linux or eCOS programming environment
  - Analog/Digital I/O for external sensors
  - Larger non-volatile memory storage
  - GPRS capability
  - Battery backup option

- Tracking Firmware
- Embedded Web Server for remote web-based management

In the Advance Tracker, we deploy an embedded web server for remote management of the device through customizable html forms. This device will have a GPRS interface over which a HTTP connection can be established. It should even be possible to download GIS maps from a server into the device and use it as a complete in-automobile navigation system.

The Advanced Tracker will use a chip-set based GPS receiver, rather than a GPS Module, in order to reduce the overall cost of the device. However, it is not proposed to use a GSM chip-set as a replacement for the GSM Module because of stringent certification requirements and time-to-market pressures.

2.0 The Specification of the *Tracker* Device

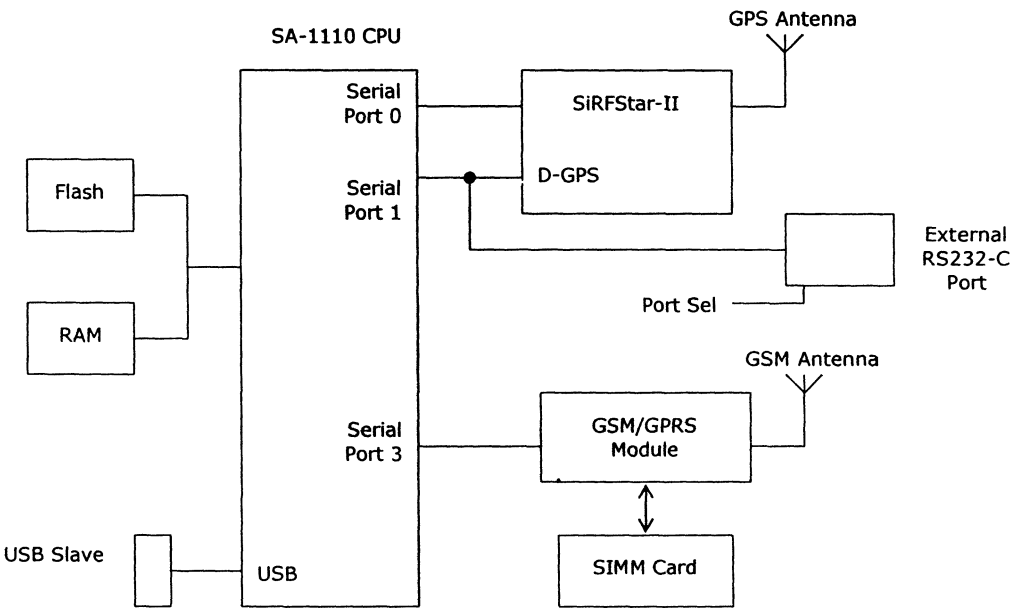
The *Tracker* Device Hardware		
3.2.1 Features	**Tracker Device**	**Advanced Tracker Device**
Processing Subsystem	32-bit ARM compliant CPU • Intel StrongARM SA1110 @133 MHz	32-bit ARM compliant CPU • Intel StrongARM SA1110 @206 MHz
Memory Subsystem	8 MB DRAM 4 MB Flash for Firmware and Data storage	8 MB DRAM 8 MB Flash for Firmware and Data storage
RS-232C Serial Ports	1 Port for GSM Module 2 Ports for D-GPS Module 1 Port for PC Connection	1 Port for GSM Module 2 Ports for D-GPS Module 1 Port for PC Connection
IrDA Port	Yes	Yes
Extension	Nil	USB Slave Port
Digital I/O	Nil	16 programmable I/O
Analog I/O	Nil	4 Analog I/O Ports
GPS Receiver with Active Antenna	Based on SiRF GPS chipset	Based on SiRF GPS chipset Or Conexant GPS/GPRS chipset
GSM Phone with Antenna	Based on Conexant or	Based on Conexant or

for connectivity to GSM network	Wavecom GSM/GPRS Module	Wavecom GSM/GPRS Module
Power Source	Vehicle Battery	Vehicle Battery
Optional Battery Backup	Internal 6xAA NiMH Cells with Battery Charger	Internal 6xAA NiMH Cells with Battery Charger
Expected Dimensions	To be determined	To be determined
Target Bill-of-Materials Cost	~ $170 in volumes of 10,000	~ $210 in volumes of 10,000

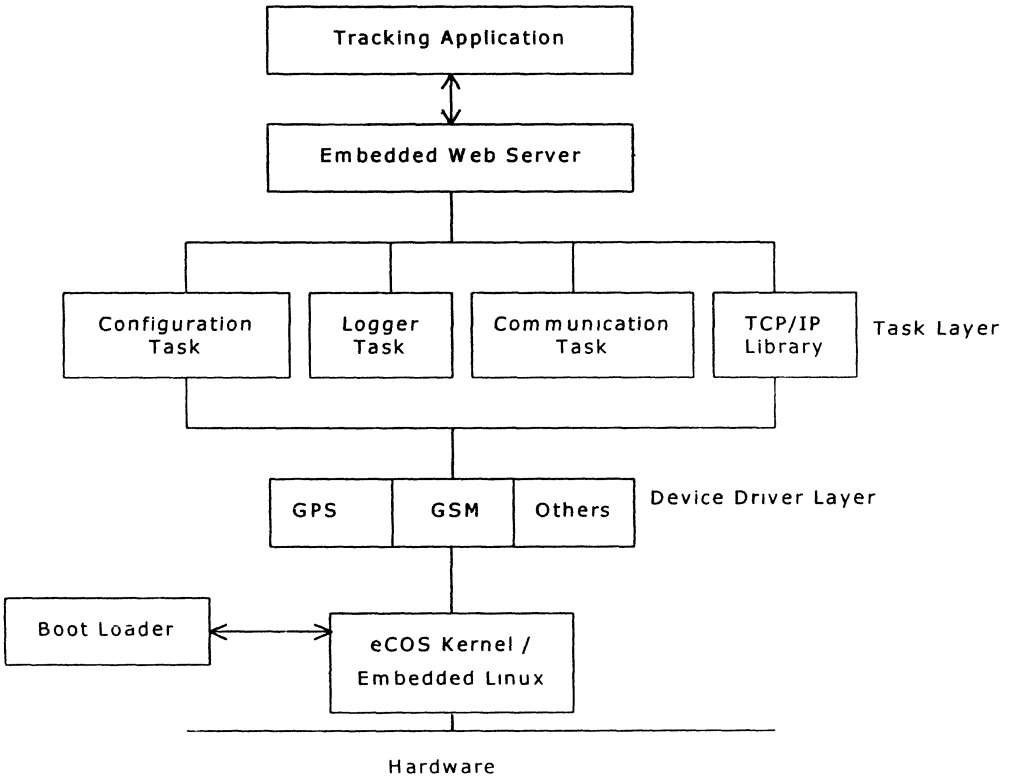
3.2 The Tracker Device Software	
Operating environment	Embedded Linux or RedHat's eCOS real-time kernel with RedBoot
Device Drivers	Dual-Serial Ports for GPS Serial Port for GSM/GPRS Modem thru AT Commands

System Firmware	Integrated Software for
	• System Scheduler on RTOS
	• GPS Module
	  o Logging of Coordinate Data
	  o Format Conversion
	• GSM / GPRS Communication Module
	  o SMS, Voice and Data
	  o SIMM Card
	• Host Interface Module
	  o Configuration Management
	  o Data Transfer
	  o Data Compression
	• Power Management

3.0 Architectural Block Diagram



3.2 Architecture of the Software



3.3 An Overview of the System

The hardware consists of a StrongArm SA1110 CPU, a GPS Subsystem and the GSM Subsystem. Both GPS and GSM subsystems connect to the CPU through dedicated Serial ports. The GPS Subsystem requires an additional Serial Port for providing Differential GPS input to the GPS Engine. Since this feature is likely to be used relatively infrequently, we have decided to share the same Serial Port as an external Port. This function can be selected through a GPIO Pin.

The hardware will also incorporate a USB Slave Controller to enable the Tracker to connect to a PC for faster transfer of data between the Tracker and a PC. Basically, there are 4 major tasks that need to be performed:

- User Interface Functions
- System Initialization and Configuration
    - Embedded Web Services
- Data Logging from GPS Receiver
- Communication through GSM/GPRS
    - TCP/IP Library
    - SMS Messaging

Currently there are tow major options for the operating environment.

As the first option, a real-time operating system based on eCOS software, which is available in the public domain, can be used as the base environment for the Tracking application.

An alternative to eCOS is to use the Embedded Linux operating system which will occupy a larger memory foot-print than eCOS. But there are several advantages to this approach.

Firstly, we have already ported Embedded Linux to the SA1110 platform and is therefore familiar with all porting issues. Device drivers for USB and Modem have also been developed. This will help considerably in reducing the development effort. Secondly, the TCP/IP networking library is well integrated into Linux whereas this will require some porting to integrate within eCOS. Finally, several other support modules such as an embedded web server and security software are more easily available for Linux than for eCOS.

An embedded web server will be used for initialization and configuration of the device from a remote location, over the GSM/GPRS communication channel. While SMS messages will be routed through an SMS Server, data communication over the GSM/GPRS network will use TCP/IP communication. This will require the system to run a PPP protocol over the dial-up connection.

4.0 The Embedded Web Server

An embedded web server is the best way to maintain and configure the Tracker Device remotely. The user needs to use a web browser to log into the Tracker, and after an appropriate authentication can access all the parameterized features of the system. We have decided to us the BOA Web Server, which is extremely fast, stable and easy to set up through simple scripts. Boa is also an open-sources product. Further details about Boa can be obtained from www.boa.org.