2002

Mobile home security with GPRS

Duy Nguyen
Edith Cowan University

"Mobile Home Security with GPRS"

A dissertation to be submitted in partial fulfilment of the requirements for the degree of

Bachelor of Science Honours
(Computer Science)

By: Duy Nguyen
(0990145)

Supervisor: Maurice Danaher

June 2002

Department of Computer Science,
School of Information Technology and Mathematics,
Edith Cowan University,
Perth, Western Australia.

USE OF THESIS

Table of Contents

Figures

Tables

Abstract

This thesis presents the results of an honours project on the development of a security system for use on mobile devices. *Mobile Home Security* (*MHS*) is a prototype system that aimed to fully investigate a potential use of the wireless high-speed technology *General Packet Radio Service* (GPRS) in transmitting video from a static location.

This thesis *Mobile Home Security with GPRS* describes in detail the design and developmental stages for the system. The research focused on the sending of video from a security capture device over a high speed radio network.

The first stage of the research involved the design and development of a prototype system. In the next stage three critical aspects of the system were studied, capturing of video, transfer of security video over a packet network and the playback of the video.

Test cases were performed in succession and measurements were obtained to study for deficiencies in the *MHS* system. Transfers of video over the different proposed GPRS network speeds and quality video playback on a mobile computing device were examined to determine the optimum settings for the system. The results from the test cases proved that the *MHS* system can be effectively used as a wireless security system.

The successful implementation of the *MHS* system provided a positive indication that the *MHS* system and other video applications like it can utilise the high speed GPRS network to provide wireless video based solutions.

Declaration

I declare that this thesis does not incorporate without acknowledgment any material previously submitted for a degree in any institution of higher education, and that, to the best of my knowledge and belief, it does not contain any material previously published or written by any other person except where due acknowledgment is made.

Acknowledgments

This project would never have been achievable if I had not received tremendous support from Edith Cowan University Staff, fellow students and friends.

I would like to thank my supervisor Maurice Danaher for allowing me to work with him through most of the two semesters. His continual help to provide needed resources and endless advice will not be forgotten.

1 Introduction

This thesis describes the *General Packet Radio Service* (*GPRS*) network and the development of a wireless video home security system that exploited the capabilities of the *GPRS* network.

The primary purpose of this research was the implementation of an application to utilise the full features of a broadband wireless network. A research topic was selected that could take the latest in wireless technology and make a working prototype application that would be ideal for that particular network.

Communications manufacturers such as Nokia™ and Motorola™ have been investing research and development resources into creating new mobile devices which can successfully utilise the *GPRS* network; one example is the Motorola MPEG-4 video demonstration mentioned in chapter three below. As technology continues to rapidly develop we have seen major new application within the wireless data communications market such as live high quality video playback on demand, mobile offices which can operate virtually anywhere and mobile gaming.

Currently in Australia communication giants Telstra and Optus have marketed the new *GPRS* network extensively. Most new phones sold in Australia are now capable of connecting to the *GPRS* network. Australian streets will soon contain millions of people using mobile phones with *GPRS* enabled. At many street corners people will be accessing email, WWW and corporate networks independent of their location. A communication media future where the user is not tied down physically will soon become reality.

The six chapters of this report set out the knowledge gained through this research project.

1.1 Chapter Synopses

1.

A brief introduction to the research results, the background of the technology being investigated, and chapter synopses of the remainder of this paper.

2.

The research problem statement, background information regarding this particular research topic and the significant reasons behind the research. A foundation for future video enabled mobile security developments using wireless high speed networks will be established.

Explanations of security and performance issues are considered and investigated. The relatively new wireless network technology, the *GPRS*, is explained in detail. The *MHS* system for the *GPRS* network will provide a background for future mobile (wireless) security applications.

3.

A review of literature related to this research, which examines the *GPRS* as a whole and the separate components that make up that network, followed by an examination of the history and the deployment of the network in relation to speed and who operates it. System performance and security tests, as designed by the researcher, were conducted for the effects of video transmission and playback over a packet-switched network, for both wired and wireless networks.

4.

An evaluation of the research and system test designs in comparison to the findings and recommendations of previous research. This provided a suitable basis for the methods used to conduct the performance and security tests. Issues associated with the hardware and software acquired for the *MHS* system, in order for it to be functional at the practical testing stage of the research project, are also examined. This chapter answers the 'what' and 'how' questions that needed to be asked in order to conduct quality performance tests on the system.

5.

Discusses the findings and results for the test cases performed on the system, selection criteria with respect to optimal video resolution and performance on the GPRS wireless network, and recommendations on desirable results from the tests that would clearly answer the research questions and an outline of unexpected results.

6.

Concludes the thesis and presents a summary of the recommendations on video performance of the overall system. This was obtained from the results provided by the test cases during system testing.

2 The Problem

2.1 Background of study

2.1.1 Internet Security Applications

The commercial and personal security market in general has bloomed over recent years, especially since September 11th 2001. Greater demand for newer security devices has led to a diverse security market globally. Laurin (2002, p1) stated that Americans spend about $4 billion dollars in the security market each year, and similar large expenditures can be found in many Asian, European and Latin American countries.

The growth rate for technological advancements in the security market is rapidly increasing with more focus on developing mobile security solutions with remote access. The growth in mobile communication technologies has led to the possibility of sending and receiving of video data streams across a radio network.

Mobile Home Security (*MHS*) is one such solution which is aimed at the video communications market. The *MHS* system has been developed to provide a foundation for further possible developments in the application of a 'truly mobile' security system.

A 'truly mobile system' is one that allows the user to access captured video images from a security device anywhere without being physically connected to a ground based component of the world's telecommunication infrastructure. Provided that a radio network exists within the operational area, the connection and access availability is virtually unlimited.

In order for the system to be an effective security system it must be able to be successfully implemented and reliable for practical use. A high degree of reliance is placed on the radio network which provides the primary backbone of the system; for a wireless security system to be effective it must send data across a radio network quickly with minimal packet loss and errors.

2.1.2 General Packet Radio Service

The *General Packet Radio Services (GPRS)* radio network was to be the fundamental element of our system. The high bandwidth and packet switch nature of the *GPRS* network made it the optimal choice of a wireless network for our investigation. These two requirements allowed for an acceptable video stream over the *Internet Protocol (IP)* network. The *GPRS* network has enabled the mobile user to expand their horizons (Sharples 2000). Users in North America can now expect even more increased bandwidth speed when the third generation of *GPRS* is introduced in early 2003 (Dawson 2001).

Ever since the first appearance of the *GRPS* radio network in Europe, it has dramatically expanded as an international standard for higher speed radio networks. The main reason for the success of the *GPRS* network globally is due to the fact that it operates as a packet switch network rather than the traditional circuit switched network.

All major mobile telecommunication carriers within Australia offer some kind of access to the *GPRS* network. The only significant difference between the various commercial network carriers is the set of access speeds they offer. The theoretical optimised traffic speed possible for the *GPRS* network would be 160 kilobits per second (Kbps) according to Pysavy (2000, p. 1). Usha (2000, p. 5) however stated in his report speeds of 115 Kbps would be a more accurate maximum speed that network carriers would be able to offer consumers.

Initial speeds we would expect to be available within Australia would range from 28 to 40 Kbps Usha (2000, p. 1). This initial speed will however affect the video transmission quality of our system. Video over packet switch network must be able to handle significant speeds for its upload and download transmission. Ganley's *Video over IP (VoIP)* (2001, p. 1) research describes coding schemes of video streams and the bandwidth required by a network to provide suitable performance.

2.2 *Significance of the Study*

Home security systems that use the *Internet Packet* (IP) Surveillance technology have, until now, been ground wire based solutions. This means that the user needs to be connected physically to wires (telephones) to gain access to the remote system. The need for mobile remote access is becoming more apparent and will become the next advance in the development of remote security systems. The currently available wireless internet solution is the *Wireless Application Protocol* (WAP). The *WAP* technology and how the network connection is made have generally restricted applications to a dreadfully low bandwidth speed and expensive access cost. This cost factor can be considered important because the *WAP* enabled user must pay for the call to connect and the whole time used, even the idle and handshaking time.

These limitations in the *WAP* network for wireless Internet have limited the possibilities of truly mobile video applications. Our research investigated the *GPRS* network and its potential to deliver video data over a radio network.

The simple *Mobile Home Security (MHS)* system, the purpose of which is to improve surveillance of personal belongings, is one step in furthering the development of mobile applications. Mobile technology like the *GPRS*, which offers exceptional bandwidth speed and solid performance on a packet network, will definitely help extend the versatility of mobile applications.

The *MHS* system will provide insight into future bandwidth hungry video data applications. Results of this research will provide potential users and developers with –

- A method to implement successfully their own mobile security system.
- An awareness of problems of such a system and how to deal with those problems.
- Insights into potential further developments and variations of the system, not only for wireless security applications but also other related fields in mobile communication technologies.

2.3 Statement of the problem

The research investigated the possible uses of video applications, their performance and related security issues over a possible wireless *GPRS* internet connection that these applications use.

2.4 Research objectives and questions

2.4.1 Objectives

The objectives of this study were to:-

1. Develop a home security system that would be completely mobile in every sense of the word mobile.
2. Allow connectivity to be endless and implemented so that an object may be monitored from anywhere provided that a *Global System for Mobile Communications network (GSM)* with *GPRS* network exists.
3. Provide an effective installation of the *MHS* system as a complete working system that would allow us to determine if this type of security system can be successfully implemented.
4. Allow for reliability tests to be performed with respect to video over the packet switch network.

2.4.2 Questions

The research questions for this study were:-

1. Can we design and implement successfully a mobile personal security application for the home with the use of the high speed *GPRS* Network?
2. Is the system reliable and effective on a *GPRS* network?
3. Are there any performance issues of video over a packet network in terms of quality of video, performance and *Quality of Service* (QoS)?
4. Which of the *MHS* system settings would be the optimal setting for a *GPRS* network?

2.5 Summary

Mobile security systems operating over a wireless environment have many security and performance issues that must be considered and investigated. This is especially important when the wireless network *GPRS* is still considered a relatively new technology. The *MHS* system developed for the *GPRS* network will hopefully provide the fundamental background needed for future mobile security solutions and video applications of a similar nature.

3 Review of the Literature

3.1 General Literature Review

3.1.1 GPRS

Mobile computing devices are now as technologically advanced as their desktop counterparts. Over recent years we have seen more powerful handheld devices with high speed internet connections like that of the *GPRS* network. This type of internet connection utilizes the existing *Global System for Mobile Communications* (GSM) radio network (Usha 2000, p. 6). The *GPRS* network was designed to improve services offered by telecommunication providers.

Its nature, the delivery of data as packets over an existing *GSM* network is what makes it ideal for a security system like the *MHS*. Usha (2000, p. 2) describes the sending of packets of data across two stations as the most efficient way to deliver data wirelessly over a *GSM* network.

The understanding of the overall functionally of a *GPRS* network is best facilitated by breaking it up into its components. After examining the core components that co-exist within the *GPRS* network, we can then clearly explain the process of 'how it works' with the use of a simple example.

3.1.2 GPRS Packet Nature

The *GPRS* network operates like any packet-switched network and is similar to wired *Local Area Networks* (LAN), Ekeroth (2000). A packet switched network operates by splitting up a whole piece of data into smaller sized packets before sending them across the network. Figure 3.1 is an illustration of how data is sent in a packet switched network. This also shows how data is broken into multiple elements called packets. Each packet contains the destination and source information. A *GPRS* packet network will send these packets across a radio network, which may use more than one route for each packet to travel to its destination. The packets are sent orderly one after another over the network. The route they take to reach the destination may differ and

therefore some packets may be received earlier than others. Because of this the order which packets are received at the destination may not be the same as the order at the source. The application layer will be responsible for reorganizing the received packets into the original data order.

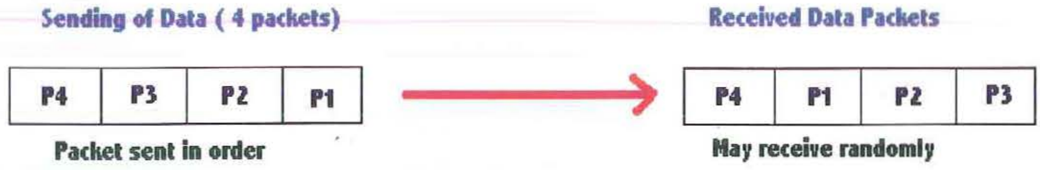

Figure 3-1 Packets of Data

More traditional Circuit-switched networks have relatively poor network performance because, before data is sent, there must be established a circuit link between two points. Because data has to be sent to and from this dedicated link only, it produces a costly overhead to both the communication services provider and its users. In a situation where a circuit-switched network is experiencing a near full utilization of dedicated lines, a request by an additional end-user for a dedicated line to be initiated, would need to wait until a used line is closed and made free to use. Packet-switched networks have solved most problems commonly found in circuit-switched networks.

GSM is an internationally accepted radio network for mobile digital devices. Currently most major destinations around the world can offer connections to both *GSM* and *GPRS* (Rysavy 2000, Vriendt 2002). The *MHS* system is designed to be implemented with a *GSM* network that has the *General Packet Radio Services* (*GPRS*) enabled.

GPRS in Australia is a relatively new technological advance in the mobile communication market. *GPRS* enables higher speed data rates and the always-online technology means that the user is only charged for data transfer. Rysavy (2000, p. 2) states that 'in theory' speeds of 160 Kbps are possible however users should expect an initial operational speed of 26-52 Kbps.

3.1.3 How GPRS Works.

To fully understand how circuit-switched *GSM* networks migrate to a packet-switched network like *GPRS*, we must first explain the additional components that operators must implement. The components needed to overlay the existing networks are (Rysavy 1998, p. 6).

- *GPRS* Support Nodes
- A Charging Gateway
- *GPRS* Tunnelling Protocol (GTP)

Figure 3.2 is a simple illustration of key components that interact within the *GPRS* network and its access to the internet.

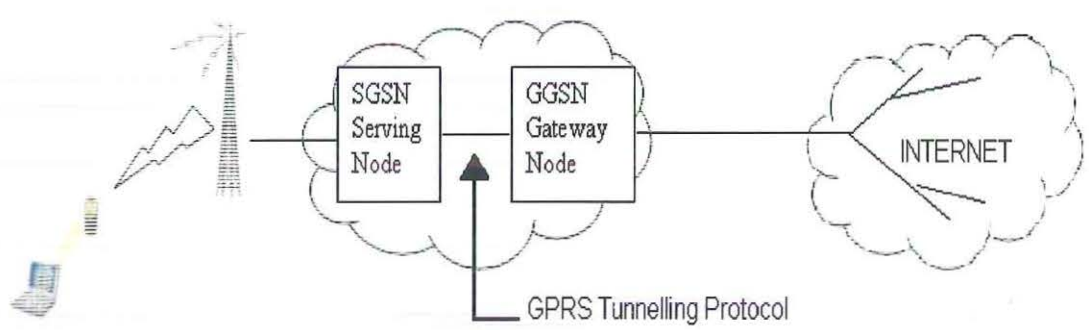

Figure 3-2 *GPRS* Components

3.1.4 GPRS Support Node (GSN) Architecture

The *Serving GPRS Support Node (SGSN)* and *Gateway GPRS Support Node (GGSN)* are based on the *wireless packet platform* (WPP). This platform is considered as a core node in *GPRS* networks. Originally developed by the Ericsson Mobile Data Design team, its main objective was to provide a new general-purpose and high-performance packet-switching platform (Ekeroth, 2000, p.156).

As a result of this, *WPPs* have the characteristics of compactness and high functionality usually found in data communications. *WPP*s contain the features of robustness and scalability that commonly exist in telecommunications.

GPRS networks currently in place and running effectively have *GPRS* support nodes. These support nodes play two supporting functions for the *GPRS* network, one acts as a serving node and the other a gateway node. To describe these two support nodes better we will refer to the proposed Ericsson *GPRS* Support nodes, commonly referred to as *GSNs*.

Ekeroth and Hedstrom (2000, p. 1) put it best when they stated "the *GPRS* support nodes constitute the parts of the Ericsson cellular system core network that switch packet data". Their report demonstrated the architecture and functionality of these *GPRS* support nodes.

A typical *GPRS* network has two support nodes:-

1. A serving *GPRS* support node (*SGSN*)
2. A gateway *GPRS* support node (*GGSN*)

3.1.5 Serving *GPRS* Support Node (*SGSN*)

SGSN is one of the primary components of cellular *GPRS* networks. The main task of an *SGSN* within a *GPRS* radio network is to provide routing methods for incoming and outgoing IP packets. An *SGSN* acts as an addressing messenger between two *GPRS* subscribers within the operational area served by the *SGSN*.

Other roles and services that the *SGSN* provides are:-

- Ciphering, this includes both encryption and decryption.
- Authentication (with the use of ciphering).
- Session management and communication set-up to the mobile user.
- Mobility management, which must handle roaming and handover of a mobile user between mobile networks.
- Logical Link management.
- Connection to other nodes.

With the uses of the management services offered above, the *SGSN* is capable of collecting charging data for each *GPRS* subscriber. Charging data may include the timed records of network access and any additional *GPRS* resources used.

3.1.6 Gateway *GPRS* support node (*GGSN*)

Another core support node is the Gateway *GPRS* support node (*GGSN*). The main function of a *GGSN* in a *GSM* network is to act as an interface to external IP packet networks (Ekeroth, 2000, p.158). The external networks like that of an Internet Service Provider (ISP) commonly consist of other routing hardware and servers.

A *GGSN* with relation to external IP network access is responsible for the routing of the *GPRS* subscribers IP based address to that of the external networks (Granbohm 1999). The *GGSN* is also responsible for initial communications linkage, between the two networks, and session management of the *GPRS* connections. These management capabilities of the *GGSN* allow for volume charging of subscribers. This allows for an accurate billing mechanism for *GPRS* subscribers, which is cheaper than its WAP counterpart.

The *MHS* system as implemented utilises the above features of the *GPRS* support nodes. If we consider the above features of the *GPRS* network and its *GSN* we can closely relate how this particular wireless network offers features that are found in more traditional wired IP networks.

3.1.7 Charging Gateway

The Charging Gateway is a component which is more concerned with billing and logging of subscriber's activities. The charging gateway is responsible for keeping accurate data logs of the network activity.

Examples of entries logged are:-

- Charging Data, peak or off-peak volume charging
- Data being requested and sent
- Collect data records from GPRS nodes
- Storage of Data Records
- Buffering and sending of data to Billing systems

For this project the charging and billing functionality of the *GPRS* network was not investigated nor was it implemented.

3.1.8 *GPRS* Tunnelling Protocol (GTP)

This protocol functions over the top of the standard *TCP/IP* protocols to encapsulate *IP* or X.25 Packets. This ensures packets of data are correctly forwarded between the *SGSN* and *GGSN* nodes. This will be explained in more detail below through the use of an example.

3.1.9 Simple *GPRS* Example

Using the above Figure 3.2 we will describe the steps involved when a *GPRS* subscriber attempts an internet or external network connection. In this example, a laptop owner connects to the internet or World Wide Web via their *GPRS* capable mobile phone. Like most digital mobile phones, the *GSM* base stations communicate with the handsets by sending and receiving of packets. However the data calls in Australia are unchanged and still connected through circuit-switched voice networks.

Once a packet is sent from the subscriber and received by the *GSM* base station, a packet is then forwarded to the serving node (*SGSN*). During this time the *SGSN* is constantly communicating with the *GGSN*. Packets within a *GPRS* network are encapsulated (processed) differently to that of external *TCP/IP* networks (X.25). Because of this packets that are forwarded between the *SGSN* and *GGSN* nodes need to be passed through a specialised protocol. This protocol is the *GPRS Tunnelling Protocol* (*GTP*).

The *GTP* allows subscribers to experience straightforward IP or X.25 connections to external networks. The connection to these networks seems constant and continuous to the subscriber, but the actual connection after each transaction is dropped. Sometimes a connection to a particular network will involve multiple connections and disconnections from the *GPRS* handset and the *GPRS* network.

3.1.10 Radio Data Networks

For a security system to be effective and efficient the total throughput speed must be, relatively, as high as possible. The higher the bandwidth available for video streams over a network, the higher the quality of images is possible (Bartlett, 2000, p. 2). Table 1 lists all current radio networks and the speed at which they operate.

Looking at Table 3.1, we can see how GPRS would be considered as one of the big steps that mobile data communications need to take to be able to provide for further advancements. The new upcoming EDGE technology will allow for smooth transition from standard GPRS to higher speed Enhanced GPRS, Rysavy (2000).

Radio Services	Operational Speeds	Additional Information
Circuit Switched Data (CSD)	9.6 Kbps per Timeslot	• Commonly known as the GSM network. • Data is sent over a voice channel. • Defined to operate at 14.4Kbps, however was never offered.
Short Message Service (SMS)	0.001Kbps to maximum of 0.1Kbps	• Data is sent via controlled channels • 160 Bytes of data per message is sent each SMS.
Cellular Digital Packet Data (CDPD)	13.2 Kbps uploads 12.1 Kbps Downloads	• Found in D-AMPS systems • Data is sent via idled(unused) voice channels
High Speed Circuit Switched Data (HSCSD)	76.8 Kbps Maximum	• Similar to CSD but with a total of 8 timeslots allocated.
General Packet Radio Service (GPRS)	9.05 Kbps to 21.4 Kbps per Timeslot 171.2 Kbps Maximum for 8 TS	• Mobile devices must be 8-slot compatible to receive maximum speed. • Packet Switched network. • Similar to IP networks (Internet) • Random Packet access, packets are sent orderly, but may be received randomly.
Enhanced GPRS	8.8 Kbps to 59.2 Kbps per Timeslot 473.6 Kbps Maximum for 8 TS	• Also known as EDGE • Operates on concepts of GMSK and 8-PSK • New transition of GPRS
Universal Mobile Telecommunication System (UMTS)	2 Mbps allocated per user	• CDMA with TDD/FDD modes
Broadband Radio Access Network (BRAN)	25 Mbps allocated per user	• Ongoing projects ETSI

Table 3-1 Current Radio Networks

3.2 Literature on previous findings

Ganley's research (2001) into 'security and performance issues associated with voice and video over internet protocol' led to many findings from which he recommended various precautions and actions to initiate when developing an application for *Video over Internet Protocol* (VoIP). Ganley (2001, p. 2) found video over an Internet Packet (IP) network had many security problems that led to poor system performance latency times and error detection.

Video encoding schemes which favour 'good' to 'excellent' rating by Ganley were found to be those where video feeds were above 16Kbps. This type of bandwidth can be found in applications such as video conferencing (Ydrenius 2000, p. 16).

Ydrenius (2000, p .85, 86) determined that scalable coding of video over a packet network has no real gain within a network which has no packet loss. Networks with no packet loss are characterised by having few linked nodes and a low level of interruption transmission that is clean from noise. Ydrenius's (2000) test setup consisted of two nodes, one for sending and encoding of video data stream and one for retrieval of these streams. The network setup was that of a standard *LAN* configuration running at 100Mbps.

With networks where communication errors can occur, packets are lost randomly and usually these lost packets are re-requested by the destination node. *GPRS* networks due to their wireless nature will sometimes have communication drop out or interference with respect to scalable coding of video feed as mentioned in the findings of Ydrenius (2000, p. 85). Packet networks with packet loss rates of around 10 percent should look into coding their video as scalable.

The findings show that the quality of the video degradation was substantial for non-scalability schemes, especially for video streams where the series of images are complex and changes between frames are difficult to display.

Ydrenius (2000, p. 85) concluded in his paper that the 'break-even' point between scalable and non-scalable coding of video over a packet network was at approximately 2 percent packet loss. This means that where there are packet losses within a typical packet network one should only consider using a scalable coding.

Scalable coding of video is commonly found in video conferencing encoding schemes. The simulation of video over a packet network was used by Ydrenius (2000) to find a more recommendable total bit rate for video conferencing. The test results concluded that a typical uncompressed video conference image sequence will need between about 384 and 512 Kbps. Such video streams, after compression, will require a network total bandwidth speed of between 64 and 128 Kbps.

3.3 Similar Studies Literature Review

In Barcelona, Spain Motorola demonstrated the potential of high speed *GPRS* (Sharples 2000, p. 1). A presentation from Motorola to the public, demonstrated how it was possible to show an *MPEG-4* video playback over a *GPRS* network. In this presentation a handheld PC was connected to a *GPRS* capable mobile phone, which received constant *MPEG-4* video feeds from the internet. *MPEG-4* is a scalable video compression algorithm which is capable of delivering near DVD quality image. Compared to the first and second generations of *MPEG* encoding, the *MPEG-4* encoding schema does require higher processing power and larger working space for the decoding process.

Sharples (2000, p. 2) describes the demonstration as a method of 'Expanding Horizons' in the mobile data market. Sharples (2000) continues to explain that the opportunities for other applications with video are endless, by providing many fascinating examples like:-

1. Provide mobile users access to full-motion video.
2. News updates.
3. Financial stories.
4. Sports highlights.
5. Short entertainment clips.

6. Music video.
7. Weather reports.
8. Traffic reports.
9. Home or work security cameras.
10. Corporate communications networks.

The *MHS* security system is an example of an application that aims at utilising the full features of the high speed *GPRS* network.

Narikka (2001, p. 1) reported *GPRS* performance issues that wireless application designers need to take into consideration when developing applications for the *GPRS* network. Narikka (2000, p. 1) describes the "hype from reality" of *GPRS* and explains what is commonly misunderstood by most developers.

GPRS timeslots are used for uplink and downlink transfers between nodes. *GPRS* can have multiple timeslots ranging from at least 1 timeslot to the full 8 timeslots. Narikka (2001, p. 2) shows how each timeslot can carry different amounts of data depending on the coding schema used.

There is a range of GPRS packet coding schemes, from coding schema 1 (CS-1), designed to carry 9.05Kbps, up to coding schema 4 (CS-4) that can handle 21.4Kbps per timeslot. So in theory the maximum throughput that could be possible would be 171.2Kbps. This is achievable when all eight timeslots are utilised with the CS-4 as the coding schema.

Realistically CS-2 is a fair indication of what the end-users should expect to be made available by GPRS service carriers. CS-2 is described by Narikka (2001, p. 1) as being the must suited coding schema for general practical use in the real world. This is mainly due to the network's ability to maintain a steady speed of 13.2 Kbps even in relativity poor radio conditions.

There is great emphasis on the possible speeds that applications designers should use. The *MHS* system is developed with the CS-2 as the default coding schema. There will be 1, 4 and 8 timeslots made available at any given time. Chapter four will contain more details of the simulated connection speeds used during testing of the *MHS* system.

3.4 Summary

The key factor for any video system over a packet based network is bandwidth. Bandwidth has been declared by most network administrators and application developers, to be a major factor that influences the full potential of the network or the application that uses the network.

The bandwidth speed possible for the *GPRS* network and how these connection speeds are achievable with the use of the various coding schema was examined. This chapter has provided a detailed description of the *GPRS* network and how *GPRS* functions as a wireless network.

Research papers and references to existing materials on the *GPRS* network as a potential video security system were hard to obtain at the time of the research. However the work completed by both Ganley (2001) and Narikka (2001) provided good foundations for the design of the *MHS* system.

4 Research design

4.1 Model MHS System Design

The proposed *MHS* system design consisted of four hardware devices connected to two networked computers, both having access to the Internet, with four software applications installed to manage intra-network and inter-network communications. Figure 4.1 illustrates the major components and their interactions within the *MHS* system. This model design was later used to produce a *GPRS* speed simulator prototype; which would be used for the testing of video performance over different predetermined network speeds.

There are seven components that make up an *MHS* system:-

1. *MHS* System Design.
    a. Hardware.
    b. Software.
2. *MHS* System Environment.
3. WebCam Server.
4. Web Camera.
5. Motion Sensor Software.
6. The Alarm.
7. Personal Digital Assistant (PDA).

4.1.1 MHS System Design

The following list contains a brief description of each of the hardware and software components that make up the system; see Appendix B 'System Hardware and Software Specifications' for technically detailed descriptions.

Resources that are needed to be acquired for an *MHS* system:-

Hardware

- A Personal Computer used as the WebCam Server.
- A Personal Computer used as a *GPRS* Docking Station.
- Compaq IPAQ H3800 Pocket PC 2002 (PDA).
- Logitech USB WebCam Express.

Software

- Pocket PC 2002 simulator.
- Band Speed Balancer (BSB) network proxy server.
- File Transfer Protocol (FTP) Server.
- Active WebCam by PY Software™.

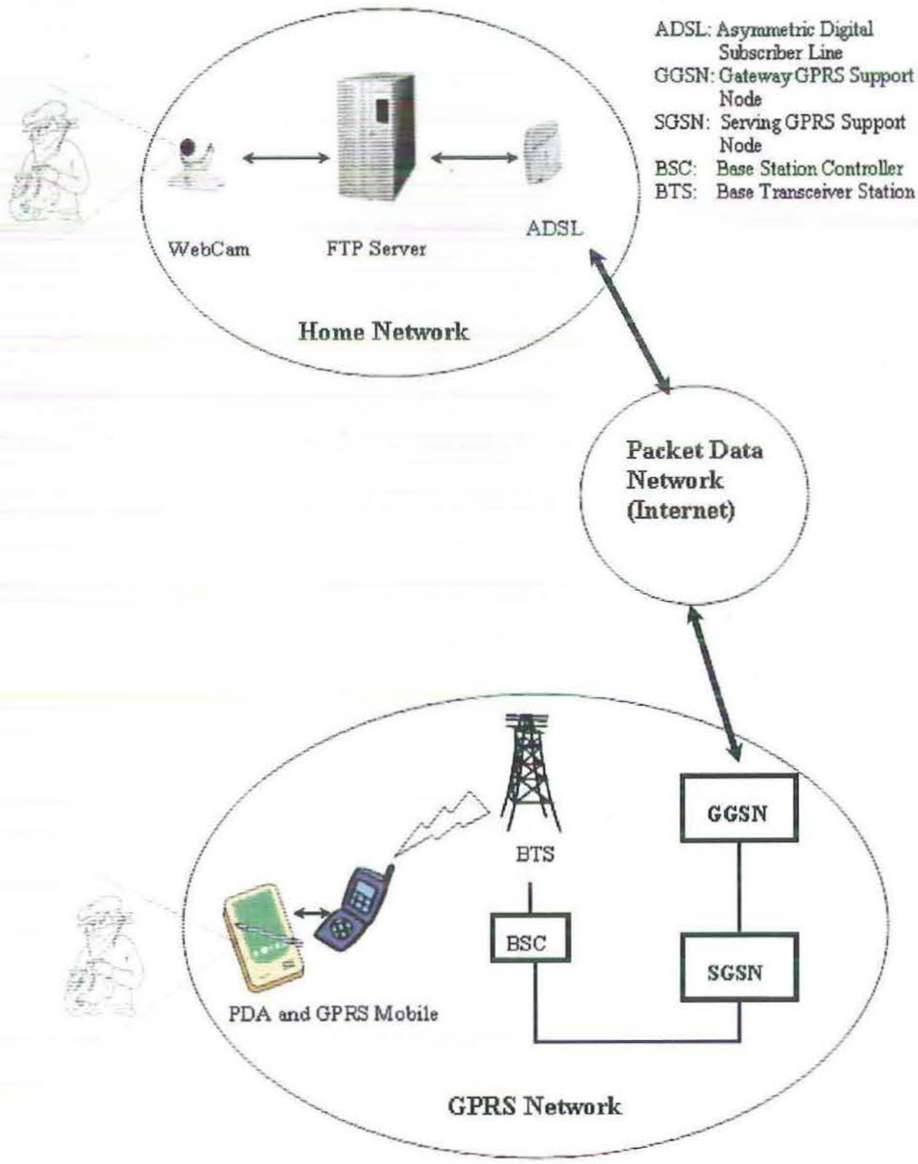

Figure 4-1 *MHS* System Design

4.1.2 MHS System Environment

An *MHS* system can be implemented in any location that needs to be securely monitored for motion events. An *MHS* system can be implemented in a diverse range of environments, such as:-

- Monitoring of personal belongings at home.
- Parental monitoring of children.
- Replacement of analog based security systems.
- Applications where motion detection is required.

4.1.3 WebCam Server

An *MHS* system will consist of a standard generic web camera connected to the WebCam server, as illustrated in the above Figure 4.1. The main purpose of this server is to act as a dedicated webcam monitoring station. The server must have a permanent internet connection with static *IP* addressing. Static *IP* addressing ensures that a reliable storage server exists. Without static *IP* addressing the mobile user would have to constantly update the server *IP* address, which would not be easily accessible for connecting devices (*PDAs*) that are located remotely.

Most Australian *ISPs* operating in the capital cities currently offer access to *Asymmetric Digital Subscriber Line* (*ADSL*) services and other forms of broadband internet connection. *ADSL* can offer the following:-

- Permanent connections
- Fast uplink and downlink speeds (64Kbps to 6Mbps)
- Static IP Addressing
- Relative inexpensive compared to other broadband connection.

The bandwidth speed and the above characteristics of *ADSL* will allow for the possibility of a home user, with standard phone lines, to implement the *MHS* system in their home or personal office.

All video and images captured are to be stored in a local folder. Access to this folder on the WebCam server should only be made possible via remote-access; this would be done through a File Transfer Protocol (*FTP*) client. An *FTP* server application will only grant access to users with login accounts. No anonymous login will be made available. This will ensure that accesses to security files on the server can only be made by the rightful owner. The installed *FTP* server will keep a full trace log of all connections and transactions.

An *FTP* session log will contain the following:-

- Duration.
- Connection problems.
- Successful login attempts.
- Unsuccessful login attempts.
- Data transfers, uplink and downlink.

The data collected from the *FTP* server's log files will allow for the testing and measuring of security issues that may reside within the proposed *MHS* system.

4.1.4 WebCam

The security camera chosen for an *MHS* system is a generic web camera with limited functionality. Functions like built-in motion sensors that are available on advanced models are not required on web cameras that might be used with this system. Many parameters were taken into account when choosing the type of web camera required for use with an *MHS* system, because of the nature of the security application being developed. A generic web camera was chosen as it is widely used and low cost. This means that owners of a generic web camera, whether it has motion sensors or not, can implement and use an *MHS* system.

4.1.5 Motion Sensor

As generic web cameras do not have a built-in motion sensor, a person developing an *MHS* system will need to install the *Active WebCam for Windows™ (AWCW)* software on the server, thus introducing motion sensing capabilities to the system. Those motion sensing capabilities are used to detect changes in images captured. PY Software™, a global streaming media company based in the USA who produces various software platforms, is the manufacturer of this software. As at October 2002, Version 3.1 of *AWCW* was available for a free trial at the download section of their website http://www.pysoft.com. This webcam software or a later version is needed to enable motion sensing on a camera without built-in motion sensors.

AWCW can be configured for different levels of motion sensing and light settings. Figure 4.2 illustrates the application settings for motion detection. The software works by running the web camera constantly while it compares frame after frame for differences, this also includes comparing of light intensity. Slight (1-10%), moderate (11-60%) and severe (61-100%) motion settings are available for the user.

Figure 4-2 Motion Detection Settings

Depending on the environment being monitored, a user might choose to employ the slight setting that will compare for the smallest detectable amount of change between frames. Sensitivity settings of 4 to 10 percent will achieve this. To enable larger objects, such as a human body to be detected, rather than small objects of no importance like a spider crawling up the classroom wall, an *MHS* system must have motion settings above 70 percent.

4.1.6 Arming of the Alarm

Once the required motion is detected by the camera and software, an alarm is raised. The WebCam server will then notify the system owner with an email. The email will contain attachments of still video shots of the motion that the camera has captured. The email will be detailed with the time at which the image was captured and the date this alarm was triggered.

After the system owner has received this email alert, and has viewed the images captured; they may choose to investigate the situation further by connecting to the *FTP* server and downloading the actual captured video of the whole incident. The owner after watching the video replay will decide what actions are appropriate to take e.g. calling local law enforcement authorities or in situations where a false alarm may have occurred, the owner can ignore the email and alarm completely. Figure 4.3 shows the semantics of the email alert an *MHS* system would use.

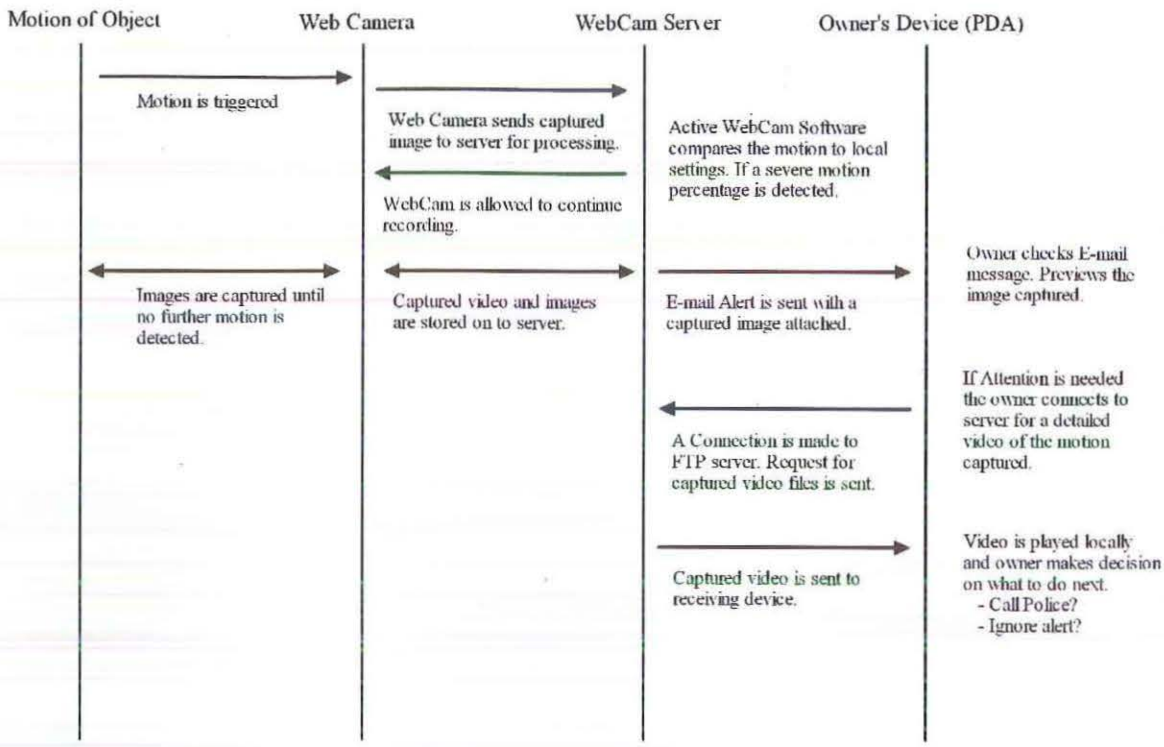

Figure 4-3 Email Alert Notification

4.1.7 Personal Digital Assistant (PDA)

A *Personal Digital Assistant*, also known as a *PDA*, was chosen as the receiving device for the video output from the WebCam server of an *MHS* system. The colour screen and processor capability are important features of the 'specification of hardware requirements' of the mobile device. The 'specification of software requirements' includes the operating system WinCE with Pocket TV version 0.9.6, the latter being made available to handle the video feed from the server. The overall package that a *PDA* offers satisfies both of the requirements specifications for an *MHS* system.

4.2 *GPRS Simulation Design*

4.2.1 GPRS Network Speeds Simulation

A simulation of the *GPRS* network speeds was designed so that the test case scenarios could be evaluated. The tests examined for deficiencies in the network structure and the overall performance of that network to deliver video at a particular speed. The video performance test cases under different simulated network speeds are detailed later in this chapter.

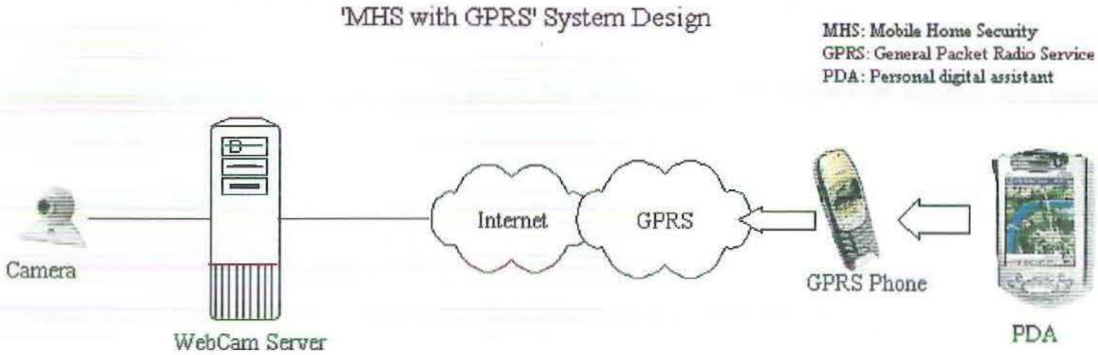

Figure 4-4 The *MHS* System Simplified.

Figure 4.4 illustrates a simplified version of the *MHS* system design. For the simulation of the various *GPRS* network speeds, the original *MHS* system design was modified to accommodate a wired LAN environment. Figure 4.5 demonstrates the new LAN environment that the performance tests operated under.

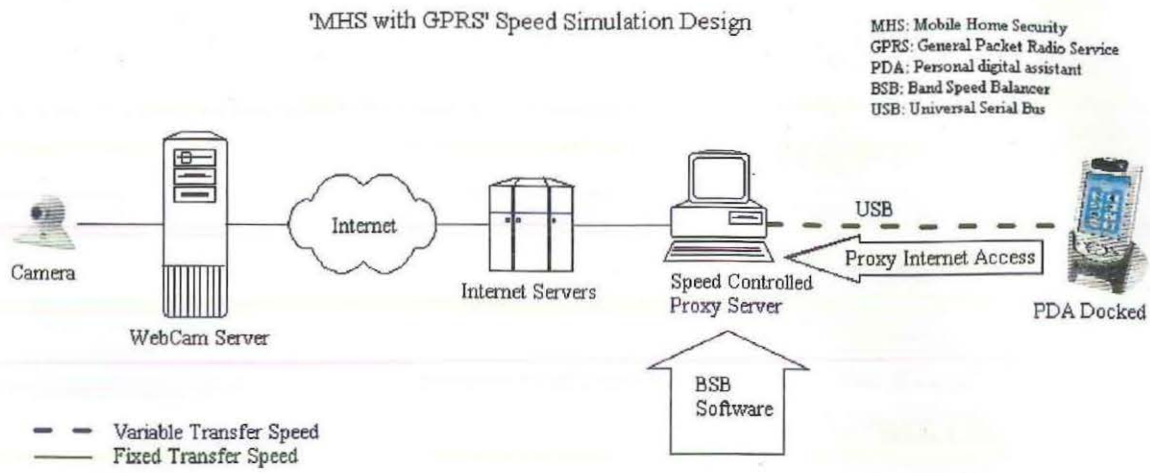

Figure 4-5 GPRS Speed Simulation Design

GPRS speed simulation was achievable by restricting the speed at which the *PDA* accessed the network. Unlike the original design (Figure 4.1) the *PDA* was connected to a docking station which accessed the internet and network resources through a USB proxy connection. The *USB* cable from the docking station only acted as a media to transport the data packet to and from the Internet; the speed at which the packets were transferred was dependent on the proxy server.

A proxy server has been defined by Thing (2003) as "a server that acts as an intermediary between a workstation user and the Internet so that the enterprise can ensure security, administrative control, and caching service".

The *Band Speed Balancer* (BSB) as developed by Aleksandr Mantrov is a freeware proxy server that can limit the speed at which a user can link to the internet. Version 1.6 of the BSB software can be downloaded from the Internet at http://www.bsb.net.ru/en/index.shtml.

The features of a *BSB* are that it:-

1. Automatically limits speed of the data downloading to IP-address up to the specified value.
2. Limits size per week of data which are downloaded to IP-address.
3. Limits the number of simultaneous connections from the browsers and other HTTP-using programs that users use for surfing in the Internet.
4. Logs all the HTTP-requests in the file in the Apache-like format.
5. Can help, with the use of a special client-side program "BSB Client Informer", the users receive the information about their size of data downloaded for current week and current restriction of speed. (Thing, 2003)

The ability of the proxy server, with respect to the user, to be invisible, allows for a system simulation to be transparent. From the PDA point of view, when requesting, for example, a web page, all internet requests and returned responses appear to be directly from the Internet servers. For effective simulation of the *GPRS* network speed, the proxy must simulate the transparency of the actual *GPRS*, therefore leaving the speed at which the coding schema operates as being the only independently managed variable.

The proxy server for the *MHS* system has the following tasks:-

1. Control how the *PDA* connects to the Internet.
2. Restrict the network speed to match the *GPRS* coding schema.
3. Operate transparently to the *PDA*.
4. Receive requests for an Internet resource from the *PDA*.
    a. The request can be for services like WWW, *FTP* and E-mail.
5. Forward the request onto the Internet.
    a. The proxy server is acting on behalf of the *PDA*.
    b. The link speed is fixed.

6. Pass request from the internet and onto the *PDA*.
    a. The link speed can be limited and controlled.
    b. The complete session details are stored on log files.

4.3 Security and Performance Tests

4.3.1 Security and Performance

The following explains the various test cases developed and how each test supported the objectives and questions of the research. To ensure that the research questions were answered, any single test case was performed more than once to ensure that the measurements and results were accurate.

Before developing the test cases, there needed to be an understanding of what variables of the *MHS* system needed to be examined. These test cases, once developed, were aimed at examining video performance of a security system over the *GPRS* packet switched network.

4.3.2 What to Measure

Ganley (2001, p.1) of Cylink® Securing E-business recommends that for successful *Video over Internet Protocol* (VoIP) we must discuss issues of:–

- Security of VoIP over the network.
- Performance of VoIP and its network.

For *MHS* to provide a reliable and effective security system we must keep in mind the above two recommendations by Ganley (2001, p.1). In terms of security issues to be investigated with the *MHS* system we needed to examine the following:–

- Security issues at the application level.
- Security issues at the IP network or transport level.

The security issues stated above only apply to situations where the test and measurements of an uncontrolled security system is required. For example, in an uncontrolled environment such as where the *MHS* system would be implemented; these security issues would definitely need to be investigated. Levine (2002, p.2) implies that, at the application level, responses to security threats may be in the form of:-

- Protecting data channel transfers with encryption
- Access control (physically)
- Strong authentication mechanisms
- Validating user supplied inputs

The test cases were all controlled environments, and these security issues were not investigated. The research question shown in chapter 2 was aimed at investigating the video performance over a packet based network and not concerned with the security issues at the application level.

To determine the efficacy of the MHS system to deliver video security over a wireless network, it is important to understand which controlled variables to measure during the design phase of the test cases. Ganley (2001, p.3) mentions that performance of video over a packet network should be measured by the following three variables:–

- Video Quality.
- Transfer time.
- Quality of Service.

4.3.3 Video Quality

Video quality is directly related to the video compression or encoding scheme applied (Ganley 2001, p2). The compression or encoding scheme was dictated by the bandwidth and the number of simultaneous connections (Ganley 2001, p2); therefore different targeted video compression rates were trialled to determine the best video quality possible for a radio network.

As shown in Appendix B, the hardware specification explains that the Logitech WebCam Express camera has three major resolution settings for recording video. They are as follows:-

1. High Quality, 320 x 240 30 Frames/s.
2. Medium Quality, 320 x 240 15 Frames/s.
3. Low Quality, 176 x 144 15 Frames/s.

These settings are standard resolutions, which are commonly used on the Internet and by people publishing video for the web. Performance tests for video over the different *GPRS* speeds used the following resolutions for the video file:-

1. Full screen playback on the *PDA*, because the resolution of the *PDA* screen is rated at 320 x 240 pixels. We used the resolution of 320 x 240 running at the following frames per second, 5, 10, 15, 24, and 30.
2. Windowed playback with the resolution of 176x144 at the frame rates of, 5, 10, 15, 24, and 30 per second.

Each of the above different tests for video had the following compression scalable *MPEG* (Motion Pictures Experts Group) bit rates applied (see Table 4.1), with one case where no compression was used:-

Video Compression	**Target Bandwidth**	**Bit Rate (Kbps)**
MPEG	28K Modem	4
" "	33.6K Modem	8
" "	56K Modem	16
" "	ISDN-1	32
" "	ISDN-2	64
" "	T1	128

Table 4-1Video compressions

4.3.4 Transfer Time

In a network the transfer time is essentially the time it takes to complete transmission of a data file between two points. For the *MHS* system we investigated the total transfer time, with any latency, for a video data file to get from one network point to another. It was important that the system was optimised to have a low acceptable transfer time. This requirement is due to the fact that effective security systems, in general, must have a fast turnaround time.

Processing times of different video settings and the transfer times were measured. Once all measurements were completed and comparison had been made, the transfer times were benchmarked and analysed to find the optimal transfer rate.

4.3.5 Quality of Service

Ganley (2001, p.4) describes the *Quality of Service* (*QoS*) of a network as the idea that transmission rates, error rates, and other characteristics can be measured, improved, and, to some extent, guaranteed in advance. *QoS* focuses mainly on constant streams of multimedia data across the *IP* network.

Using the *Internet's Resource Reservation Protocol* (*RSVP*) the *MHS* system *QoS* can be investigated and managed. *RSVP* allows for the tracking of packets passing through a server; these packets can be analysed based on policy and reservation criteria arranged in advance.

With the results from the log sheets from the server, *QoS* allowed for the measurement of the average delay at a server. This provided a guaranteed delay in terms of the variation in delay in a group of packets, packet losses, and the transmission error rate.

4.4 The Three Test Cases

Three test cases were designed and run under different simulated network speeds. Each test case was developed to examine for video performance issues of the *GPRS* network and the hardware on which the video was viewed. Each test case was performed one after another in the order of:-

1. Capture Test; tested the video capturing of video from the web camera and the ability to successfully compress the raw video.
2. Transfer Test; measured the time taken for the compressed image to be sent to the *PDA* via various transmission speeds.
3. Playback Test; examined the ability of the PDA to display the capture video with relation to image quality.

4.4.1 Test Case 1 "Capture Test"

The *MHS* system's ability to produce and publish captured video files was evaluated. This examined the real time processing capabilities of the WebCam server to encode raw captured video with various compression rates. Image quality of compressed video was compared to the uncompressed video clip. Test Case 1 measured and found the:-

1. Compression rates that were achievable with respect to:
    a. Video resolution.
    b. Frame rate.
2. Effective compression ratio with respect to:
    a. File sizes between different video encodings.
    b. Image quality of compressed and uncompressed video.

4.4.2 Test Case 2 "Transfer Test"

Set out to examine the scalable measurements of the time taken for an *FTP* transfer session to complete. Monitored and measured time to:-

1. Download a particular video clip at different proxy speeds.
    a. The Proxy logs and *FTP* server logs recorded session times for the file transfer.
    b. The video file properties were fixed and only the network speeds changed to match the CS-2 timeslots. See section 3.3.
2. Download video clips with different compression.
    a. The Proxy logs and *FTP* server logs recorded session times for the file transferred.
    b. The network speeds were fixed and only the *MPEG* compression bit rate was changed as per Table 4.1 in section 4.3.3.

4.4.3 Test Case 3 "Playback Test"

The playback of the downloaded video file on the Compaq IPAQ™ *PDA* was examined for any deficiency. All video playback tests were examined for the following conditions:-

1. Did it play back successfully?
2. Did it achieve an acceptable video quality evaluation for
    i. Effective frame rate?
    ii. Image quality?
    iii. Text image clarity?
3. Was there any unexpected issue of concern?

4.5 Pocket PC 2002 Emulation

Another approach to provide the same results was to have the PDA emulated within a desktop computer. The emulated PDA performed identically to a real physical PDA, with the added features of being more manageable when network tests are performed. Figure 4.6 show this emulated version of the latest Pocket PC 2002™ operating system for the *PDA*.

The *PDA* emulator running on a desktop computer can be used to test and measure the speed of video download through the *GPRS* speed simulator. Using the actual hardware over its emulator counterpart will provide for accurate test results that demonstrate the video processing capabilities of a physical *PDA*.

Figure 4-6 Pocket PC 2002 Emulation

4.6 Design Limitations

GPRS in Western Australia is a relatively new introduction to the market place. The service providers that offer *GPRS* are limited to Telstra™, Vodafone™ and Optus™. Like most new services it is relatively costly to subscribe to the *GPRS* network. In order to gain access to the *GPRS* network the mobile phones must be able to handle the *GPRS* data network. Currently most mobile phones on the market place are equipped with *GPRS* capability; however use of that facility is very expensive and was not feasible for Honours level research.

The *GRPS* network speeds needed for all video test and measurements was simulated. This methodical approach for a simulated *GPRS* network was an alternative method that provided similar results to a 'real network'.

The controlled environment for the system testing did not allow simulation of real operating conditions of the radio network. Elements that could not be simulated are communication dropout areas that *GSM* mobiles are prone to; therefore packet loss and the methodology behind packet recovery could not be examined.

5 Findings

5.1 The Implementation of the MHS System

After acquiring all resources mentioned in chapter four, the *MHS* system was then implemented into the chosen environment. This chapter explains the installation steps that lead to the fully functional *MHS* system and the results gathered from each of the test cases, as outlined in section 4.4.

5.2 The Steps of the MHS Installation

This section provides a breakdown of the implemented components and installation processes that was achieved with the proposed *MHS* system simulation. The components that were installed are the:-

1. WebCam Server.
2. FTP Server.
3. Active WebCam™ Software.
4. Band Speed Balancer (BSB) Proxy.
5. Personal Digital Assistant (*PDA*).

5.2.1 WebCam Server

A designated desktop computer located in the workshop was chosen to be developed into the WebCam server. This developmental stage involved the installation of both hardware and software as listed in section 4.1. The specifications of the hardware that makes up the computer are stated in detail in Appendix B.

The Logitech™ web camera worked flawlessly first time and required no additional software installations. The WebCam server running under Windows XP™ did not even need software drivers for the hardware device. Once connected and initialised the video that was being captured by the web camera was shown on the screen. Initial inspection of the web camera's properties showed that the camera could handle all the resolutions and frame rates required for the test cases.

5.2.2 FTP Server

The application to be used for the *FTP* server was not determined until the developmental stage of the research, primarily because there are many *FTP* server applications available freely on the internet and most *FTP* servers have similar features and functionality. This meant that no real importance was placed on this software selection.

The chosen *FTP* server was *'BulletProof FTP Server v2.15'* developed and maintained by *BulletProof Softwares Ltd*, chosen from 406 alternative similar products offered on http://www.download.com, an online library of software developers and their products. Both commercial software and private freeware are available for download at this website. The *BulletProof FTP Server* was chosen based on the fact that the software could be used for evaluation purposes, thus allowing for a 30 day trial of the full software.

The selected *FTP* server application was then installed. This required a download from the Internet and a quick hassle-free installation. After about three minutes the *FTP* was up and running in the background of the operating system. Once the *FTP* server was operational, the user accounts were added to the master user list, this is shown in Figure 5.1. This list of user accounts later controlled who could access the captured video files from the WebCam server.

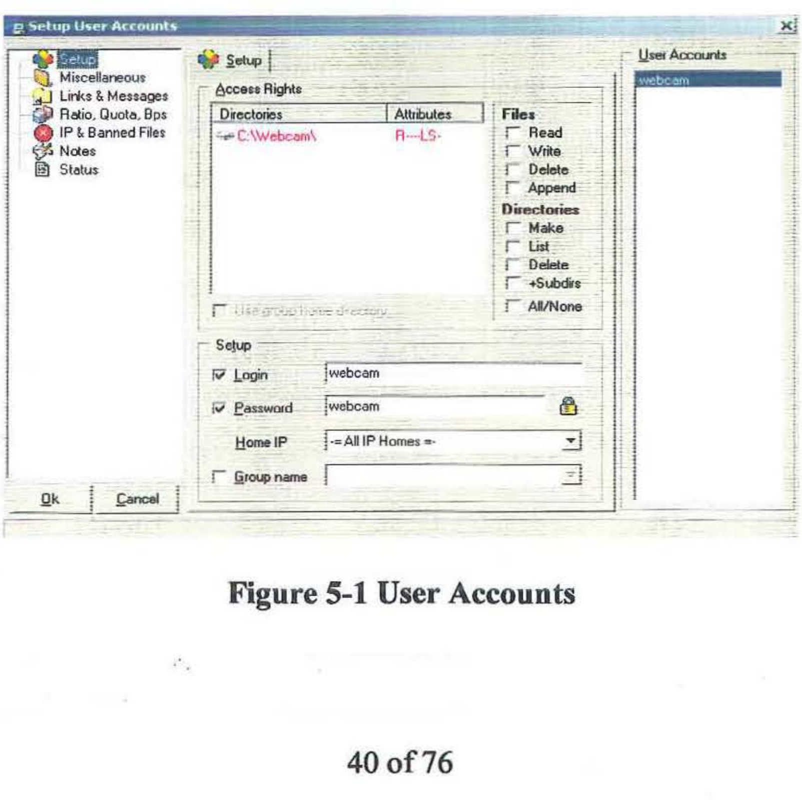

Figure 5-1 User Accounts

5.2.3 Active WebCam™ Software

The next step was to install the Active WebCam™ software onto the server. This installation consisted of three major steps:-

1. *Active WebCam*™ Installation and Configurations.
2. Web Camera and Motion Detector Configurations.
3. Emailed Alarm Alert Configurations.

Active WebCam™ Installation and Configuration

Step one involved installing the Active WebCam software and adjusting the initial configuration screens to achieve the desired settings. Software settings that could be adjusted to user requirements were:-

- Camera Settings.
- Internet Settings:-
    i. Image settings.
    ii. Publishing methods.
    iii. Captions.
    iv. Connections.
    v. Scheduler.
- Video Record Settings.
    i. Capture Frame Rate
    ii. Output File Format
    iii. Video Compression Settings
- Motion Detection Settings.
    - Motion sensitivity setting.
    - Motion time checking.
    - Email Alert.
    - Record a video.

Out of the above configurable options, the *MHS* system modified the following default settings:-

1. Camera Settings.
    a. The capture method of the web camera was changed from *Video for Windows* (VFW) to DirectShow. DirectShow allowed for a 32-bit data access to the capturing device. For the *MHS* system the 32-bit access via the *USB* port.
2. Internet Settings (shown in Figure 5.2).:-
    a. Publishing methods.
    b. *HTTP* Broadcasting is enabled.
    c. WebCam home page was created locally and published electronically on the in built web server.
    d. Published frame rate was changed to 8 frames per second.
3. Caption Header.
    a. Changed to "Captured on dd/mm/yyyy at hh:mm:ss".
4. Scheduler.
    a. Time and day for the homepage to start publishing was entered.
5. Video Record Settings.
    a. Capture Frame Rate was modified to the desired settings mentioned in chapter four.
    b. Output File Format was set to scalable *MPEG*.
    c. Video Compression Settings were modified to the desired bit rates of 8, 16, 32, 64, and 128 Kbps.
6. Motion Detection Settings (shown in section 4.1.5 Figure 4.2).
    a. Motion setting; 70 percent.
    b. Motion time checking; 0.5 times per second
    c. Email Alert option was enabled via the local outgoing mail server.
    d. Record a video option; 18 second record time.

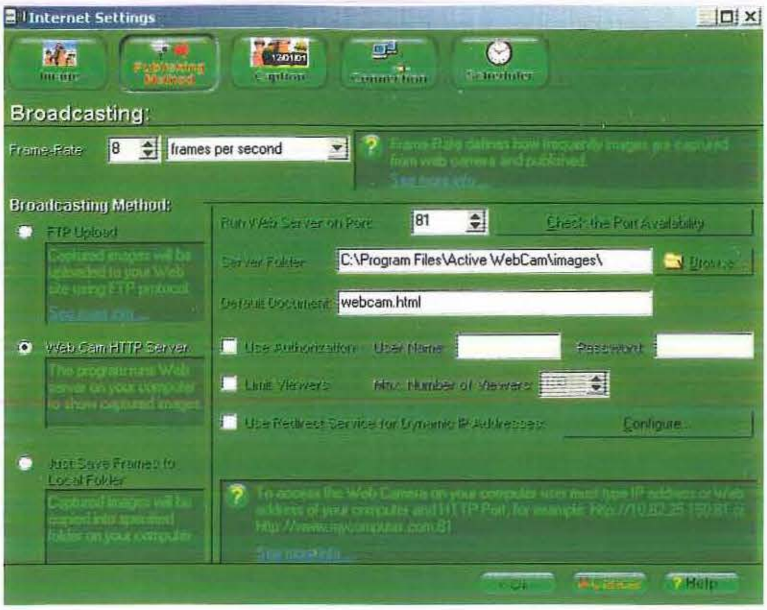

Figure 5-2 Internet Settings

Web Camera and Motion Detector Configurations

Step two involved the establishing of the connection between the WebCam server and the web camera. With the above option of DirectShow enabled the Logitech WebCam was detected by the controlling software and a live window appeared showing the current video images from the camera.

The *MHS* hardware and software requirements described in Chapter 4 were all integrated onto the WebCam server successfully. All interactions from the capturing device to the motion software were running flawlessly. The next step was to implement the proposed settings for motion detection and the email alert mechanism.

Emailed Alarm Alert Configurations

The final step that took place before the system was brought up and broadcasting was the inspection of the motion detection and email settings. The initial inspection of the WebCam server in relation to the motion capture showed that the setting of 70% did detect larger movements, like that of a human walking by, chairs falling down and a hand wave in front of the computer.

A smaller object in the form of a tennis ball was rolled across the workshop floor to determine, at 70%, if the camera had detected movements. When the live preview showed the ball rolling across the ground, the motion percent bar jumped from 0-1 percent to the high 30s. Even with the motion being detected by the system, the software did not respond to this security threat because the detected motion percentage was much lower than the required percentage.

The email was sent from the WebCam server to the recipient successfully on all occasions where motion detection was triggered. The email received provided a detailed image of the first frame the camera had captured and an informational time stamp. With this email we were able to gather the following information:-

1. What had happened that triggered this email alert.
2. When it happened, the time (to the second) and date.
3. The time the email was sent compared to the actual incident time.

5.2.4 Band Speed Balancer (BSB) Proxy

The *BSB* proxy software was installed after completing the installation of the above WebCam server. The software configuration options were not able to be modified using the now typical *Graphical User Interface* (GUI) for a windows application. Instead of menus and options, *BSB* used the older approach of a text file which consisted of a set of text options that needed to be edited using a general text editor. Figure 5.3 illustrates the settings for a *GPRS* speed of 13.2 Kbps, which is equivalent to coding schema 2 with a time slot of 1, which was one of the three different settings used during the testing phase of this project.

BSB.CFG - Notepad

File Edit Format View Help

```
[Config]
; see site bsb.net.ru for description of setup of bsb.cfg GPRS Speed at 13.2kbps
ListenPort=89
AdminPort=3131
ParentProxy=10.82.25.153
ParentPort=88
TotalSpeed=13200
DefaultSpeedLimit=13200
DefaultSizeLimit=1000
LimitTime=1
ConnectionsCount=1
MaxConnections=0
ConnTimeoutTime=240
SpeedLimitHours=0:00-24:00
SizeLimitFile=errors\bsb.html
ParentNoConnFile=errors\pnc.html
ConnTimeoutFile=errors\cto.html,,504 Gateway Timeout
NoConnFile=errors\nmc.html
IPSizeLog=ipsize.csv
AllIPMode=0
IPSpeedLimitType=1

[IP]
; List of IP-addresses allowed to access internet with individual restrictions
; see site bsb.net.ru for description of setup of bsb.cfg
10.82.25.153
```

Figure 5-3 The *BSB* configuration file.

Once configured to the right speed setting, the *BSB* application was launched as a Windows™ service. The *BSB* service operated as part of the background processes of the operating system. Any changes made to the configuration file could not be made successfully unless the *BSB* service was stopped and restarted.

A sample file was downloaded through the *BSB* proxy to see the effects of the 13.2 Kbps restriction. The log files from the proxy server indicated that the speed of operation was not higher than the allowed speed.

5.2.5 Personal Digital Assistant (*PDA*)

After the server side was completed and running effectively, the next step was to implement the *PDA* to receive email alerts and video downloads from the WebCam server. The internet connection was the main aim of this part of the implementation.

Pocket Outlook™ for Pocket PC 2002 allowed for a step by step guide on the email and internet configuration. The process was completed and test emails were sent from the *PDA* and incoming emails were received.

FTP video transfers were achievable over the Pocket Internet Explorer ™ through a direct *Uniform Resource Locator* (*URL*) address. A direct call consisted of the following *URL* format "ftp://<*IP* address of *FTP* server>:<port number>/". An example would be "ftp://123.203.24.45:21" which states that the server *IP* address is 123.203.24.45 and the listening port on the server is 21. The listening port for an *FTP* session is a port number at which the server listens for incoming and outgoing packets. By default most *FTP* servers use port 21 as a standard for *FTP* sessions.

The first limitation found with the planned system design was authentication over the Pocket Internet Explorer™. The original system design stated that there would be no anonymous logins allowed and only password protected users accounts would be allowed access. With the above *URL* formatting Internet Explorer would only connect to the *FTP* server anonymously. Whereas on the desktop version of Internet Explorer, after an attempt of an anonymous login, a security login window will appear that then allows you to enter a username and password for access, this function was absent from the Pocket PC version of Internet Explorer.

To overcome this limitation we had to have the login and password as part of the *URL FTP* format. The new *URL* now therefore read:-

- ftp://<username>:<password>@<ip address>:<port number>/
- Actual screenshot is shown in Figure 5.4 with the listing of files on the right.

Figure 5-4 URL Directory Listing

Video playback for *MPEG* encoded files on the *PDA* was another limitation that was not considered during the design stage. The *PDA* had Microsoft™ Windows Media Player for Pocket PC installed. Once again, unlike the desktop version the mobile version only supported Windows media files with the extension of *WMV*, which stands for Windows Media Video. Playback of the *MPEG* encoded security video could not be performed without additional software support.

The installation of an *MPEG* decoder on the *PDA* was required. PocketTV™ for the *PDA* is an application that could decode and playback *MPEG-1* and *MPEG-2* video files. The software developed by MpegTV™ is a free software that needs to be registered via the internet before any playback can commence.

The video files were downloaded onto the available space on the *PDA* internal memory and the PocketTV™ software opened all video files effortlessly. The playback of video was near instantaneous.
The implementation environment that was chosen fitted nicely into place. The university computer workshops furnished an easy environment for the *MHS* system to monitor. During the day there were substantial activities that the *MHS* system captured and stored and at night there was little to no activity that the system could detect. There were some nights when the camera did detect movements of the cleaners cleaning and security guards turning off the workshop lights.

5.3 Test Case Results

The test cases were run in succession after the *MHS* was online and running. Appendices C, D, E, F, G, and H are tables of the results gathered from the three test cases that were run under the above configuration. Each particular test case had a unique test case identification assigned to it. Test cases C and D had been grouped up into their frame rates to speed up the testing process.

All test results gathered were recorded into printed sheets, which were later transferred into spreadsheets. These spreadsheets were later edited to form the appendices mentioned above.

5.3.1 Video Test Files

A short video was recorded at different:-

1. Video resolutions, 320x240 and 176x144.
2. Frame rates, 5, 10, 15, 24, and 30 fps.
3. Video compressions at bit rates of 4, 8, 16, 32, 64 and 128 Kbps.

These short videos were captured video of the movement of a person's hand picking up an object. Each video size was different with relation to their video settings. Encoded videos with the lower 176x144 resolution tended to have data sizes of 100Kbytes.

5.3.2 Video Measurements

All the test cases measurements were in the units of:-

1. Time; measured in seconds.
2. Data files; Kilobytes (Kbytes).
3. Transfer Speed; Kilobytes per Second (Kbps).
4. Frame Rate; Frames per Second (fps)
5. Compression Ratio; compares Raw video file to the Mpeg encoded video file.
6. Compression Bit Rate in (Kbps)
7. Video Resolution; X Pixels by Y Pixels.

5.3.3 Test Case One Findings

The aim of the first test case was to examine the capabilities of the developed WebCam server to perform sufficiently with respect to the requirements set out by the *MHS* system design. The system demonstrated that it had the capabilities to:-

1. Capture recorded motion onto raw uncompressed digital files.
2. Convert these raw files into encoded *MPEG* files with reasonable data sizes that can be later used for transmission over a *GPRS* network.
3. Deliver fast turnaround time for video compression and network transfer.

One particular unexpected finding during the testing process for test case one was the *MHS* system inability to encode video files with frame rates of 5 frames per second. Test cases numbered from 'C0002' to 'C0007' for 320x240 and 'D0002' to 'D007' for 176x144 resolutions were not achievable because of this limitation. These test results are shown in Appendices C and D as 'n/a', which means 'Not Available'.

Apparently the *MPEG* encoder used was unable to support uncompressed videos with a recorded frame rate lower than 10 fps. All the test cases that would have required the use of these unavailable files were abandoned. The original uncompressed video file was still available for testing.

The following tables summarises the test case one results gathered from the testing phase. Figure 5.5 shows a comparison table for the 320x240 test results. Compression dynamically reduced large raw files into more reasonable size video for transfer over a *GPRS* network. On test case 'C0029', an eight second video, uncompressed, created a 29,931 Kbytes file. With *MPEG* encoding at 64 kbps the original file compressed into a small 287 Kbytes.

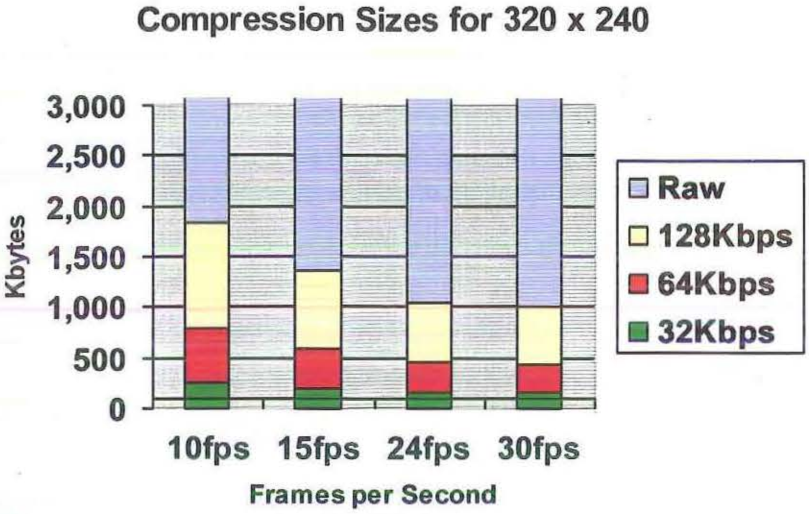

Figure 5-5 Compressed File Sizes.

Compression time, on any particular file, had no noticeable effects when different *MPEG* bit rates are used. Figure 5.6 illustrates that the lines on the graph nearly form a straight line, which indicates that no major overheads were involved when compression is performed with different bit rates. Video with frame rates 24 and 30 fps show similar times for bit rates of 8, 16, 32, and 64 Kbps.

Further investigation, not part of the *MHS* system test design, was performed to see why the compression times did not display a dependent variable relationship to the bit rate settings. An investigation of *MPEG* compression on a computer with a slower processor speed showed that bit rates did have an effect on the compression time. The *MHS* system was developed on a computer with a processor speed of 1.5Ghz, with the latest processing technology that could handle *MPEG* compression effortlessly, thus resulting a similar compression time for each different bit-rate.

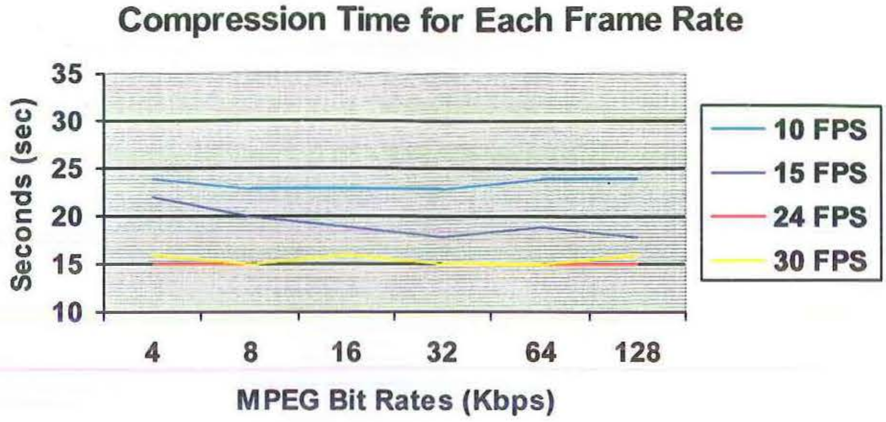

Figure 5-6 Compression Times

Results for the compression ratios achieved with *MPEG* encoding show a competitive result for videos with 30 fps and 24 fps. This is especially noticeable when the encoded bit rate is set to 128 Kbps. The two files only differed in size by an insignificant 28 Kbytes. Figure 5.7 shows a graph of the three highest bit rates for video, with the ratio between the uncompressed and compressed versions being the measurement. A ratio of nearly 1:200 was obtainable with 32 Kbps encoded *MPEG*. The highest quality video tested was the 30 fps video with a 128 Kbps bit rate: this test yielded a result of 1:52, which is a very acceptable ratio for optimised video over a *GPRS* network.

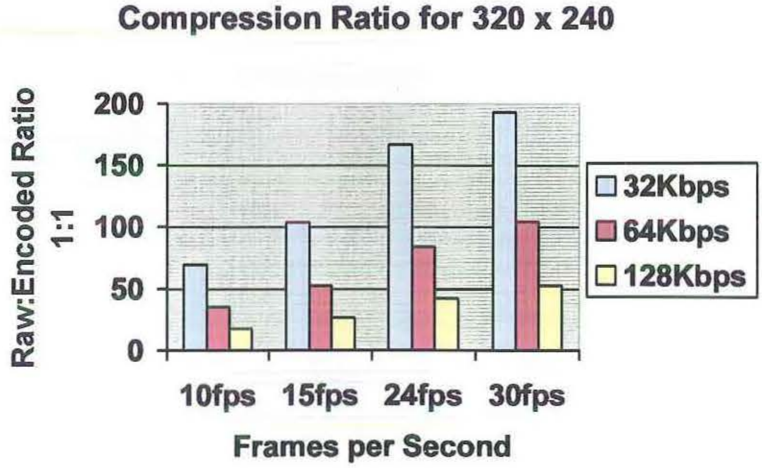

Figure 5-7 Compression ratios for high bit rates.

The compression ratio was much superior when a higher frame rates video was encoded. A closer analysis, inspecting the video properties, confirmed that the *MPEG* encoder added additional frames into video files that had low insufficient frame rates. These additional frames increased the overall size of the video file, thus yielding a lower compression ratio.

Results for test case one with video resolution of 176x144 can be found in Appendix D. There were no unusual findings for test case one.

5.3.4 Test Case Two Findings

Test case two was used to measure for the total turnaround time of the *MHS* system over a *GPRS* network. The total turnaround time is the time it takes for the *MHS* to:-

1. Record motion into raw digital video files.
2. Compress these video files.
3. Transfer these files over various *GPRS* speeds.

The measurements gathered from these test cases are shown in Appendices E and F. The following figures and graphs are originated from the test cases with the resolution of 320 x 240.

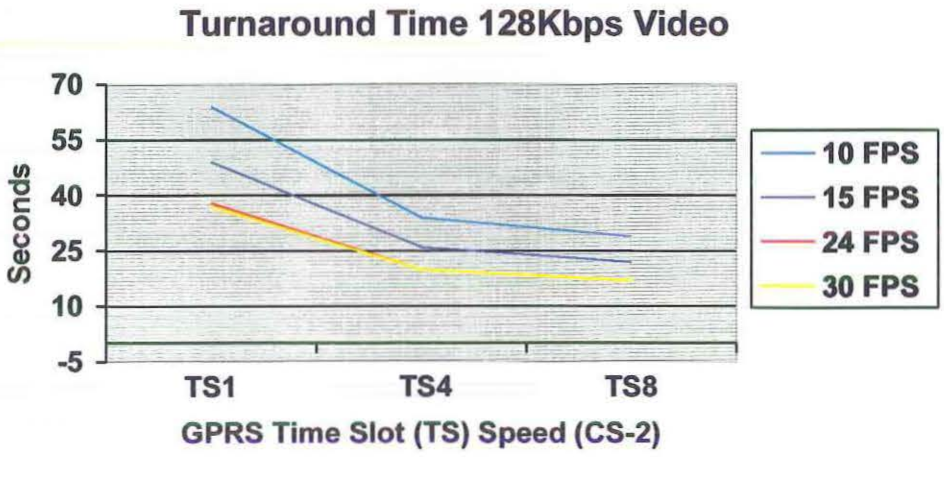

Figure 5-8 Turnaround Times for 128Kbps Video

Figure 5.8 is a line graph of the turnaround times for the *MHS* system when 128Kbps video files are used. The x axis of the graph shows the timeslot/s that the *GPRS* CS-2 uses. Timeslot (TS) 1, 4, and 8 have speeds of 13.2, 52.8 and 105.6 Kbps, respectively.

An important finding, with relation to the frame rate at which the *MHS* system should record its video capture, was that for the frame rates of 24 or 30 fps, at 128 Kbps, there was no significant difference in turnaround time. The video with 30 fps was larger than the 24 fps when recorded, however this 30 fps video did provide similar results to that of the 24 fps video. This can be seen in Figure 5.8 where the two lines overlap each other.

With the test results like the above, an easy selection could be made as to which of the two high frame rates the *MHS* system should incorporate as its preferred video setting. The *MHS* would provide a highly efficient video transfer if the frame rate was set to 30 fps.

There were no results that indicated any deficiency within the network to transfer files at the various *GPRS* speeds. Results in Appendices E and F where 'n/a' has been entered means that the device displayed an inability to store the incoming data; this feature is not related to the *MHS* system design.

The *PDA* used had, at testing, about 30 Mbytes unallocated resources. This was after the installation of additional software. Test case 'E0043' successfully transferred roughly 20.5 Mbytes of data. However, when the files got larger than about 20 Mbytes, the *PDA* did not download the files completely.

The above limitation was due to the unavailability of memory resources on the PDA and is not considered a limitation on the *MHS* system. This is because the *MHS* system design was aimed at finding and developing the best possible video setting for a *GPRS* network. The sending of large raw uncompressed data would never have been considered as a possible video setting.

5.3.5 Test Case Three Findings

The 'Playback' test cases were focused on the abilities of the *PDA* to electronically playback the encoded and uncompressed video files. The files were transferred over the various *GPRS* speeds and played one at a time.

The playback tests evaluated for:-

1. Successful play back of video.
2. Video quality of video.
   i. Effective frame rate
      a. Jumpy, moderate, or good.
   ii. Image quality
      a. Blocky, smooth, or very smooth.
   iii. Text image clarity.
      a. Blurred, clear, or very clear.
3. Any unexpected issues of concern.

Appendices G and H contain the observations made for each test case. All video files, except those marked 'n/a', played back successfully. There were two test cases that did not playback due to hardware related problems that resided within the *PDA*; these were test cases 'G0022' and 'G0028'. The description of this particular problem was stated in section 5.3.4.

The overall performance of video playback was satisfactory, and 'jumpy' playback was only noticed in test cases where the original frame rate was at 5 and 10 fps. Anything above 15 fps provided moderate to good video playback in general.

Image quality, in terms of clarity and smoothness, increased with the *MPEG* bit rate that was used in the encoding. Video that showed clear smooth images with acceptable frame rates for the *MHS* system would be the video that was encoded with 64 or 128 Kbps.

Text clarity on the video playback was examined to ensure that the time-stamp was readable on the bottom corner of the video. The time-stamp is a caption that is imprinted on the video during playback, it also provided the date and time of when the video was created. Figure 5.9 illustrates the clarity of a low bit rate (8Kbps) text image and a high bit rate (128Kbps) text image. The image on the right shows a very clear time-stamp text.

Figure 5-9 Text Clarity

Results confirmed that there were no unexpected issues of video performance with the video playback test. All video did playback successfully, however, higher bit rate *MPEG* encoded videos did provide significantly clearer and smoother playback.

5.4 Evidence that supported the Research Questions

1. "Can we design and implement successfully a mobile personal security application for the home with the use of the high speed GPRS Network?"

Yes. In this research a prototype functional system was developed that met all desired requirements, thus satisfying this question.

2. "Is the system reliable and effective on a GPRS network?"

Yes. The results from the test cases have provided a strong indication that the system performed reliably and effectively for its domain.

3. "Are there any performance issues of video over a packet network in term of quality of video, performance and Quality of Service (QoS)?"

Generally speaking no, the only main issue of concern was that large video files did not play back due to technical issues. Other than this particular video performance issue, the *MHS* system had no performance issues relating to video.

4. "Which of the MHS system settings would be the optimal setting for a GPRS network?"

Based on results gathered from the three test cases applied to the *MHS* system, the 'optimal' configuration for a *GPRS* network running at a minimum speed of 13.2 Kbps would consist of the following settings:-

- A high speed processor for the encoding process.
- A video device that is capable of capturing at least:-
  - 320 x 240 resolution screen size.
  - 24 frame per second capture rate, more preferably 30 fps.
- Video encoding bit rate of 128kbps or higher.
- A playback device with a screen size of 320x240.

5.5 Unanticipated Findings.

There were no unanticipated findings from the research other than the hardware related limitations as reported in the chapter on test case results.

5.6 Summary

The installation of the *MHS* system from ground up was explained in this chapter. During the installation and developmental stages the researcher continued to watch out for any limitations that had not been considered previously in the system design process.

This chapter provides a description of the step by step implementation of the *MHS* system design and it's evaluation for any errors. The unexpected findings were minimal and further investigations were always carried out, beyond the system scope, to find the reasons behind the limitations.

Once fully developed and functional, the *MHS* system was broken down into three testing criteria for video performance. The three criteria were developed into three test cases that examined and evaluated the abilities of the *MHS* system to:-

1. Capture video at different settings.
2. Transfer video across various *GPRS* network speeds.
3. Playback the captured video.

Each test case evaluated any deficiencies within the *MHS* system and provided an insight to the possible causes of the limitations found on the system.

Finally it was demonstrated, through the implementation of the detailed and extensive testing procedures for video performance, that the *MHS* system based upon the *GPRS* network did provide results, which supported answers for all the research questions stated in chapter two.

6 Conclusion

The video security applications market is increasingly providing newer and technologically more advanced security products. These products aim at helping to assist the home consumer to better prepare and protect themselves from crimes of theft and vandalism. The *Mobile Home Security system* with *GPRS* is one such product. The research idea behind the design and development of a mobile security system arose as a result of the researcher awareness of the need to have a wireless and mobile video application that operates on high speed radio networks. Newly introduced network services, like *GPRS*, offer much greater network speeds than the previous low speed circuit-switched networks, thus providing a good foundation upon which the system design could be based.

GPRS being the backbone of the *MHS* system and the main focus of this research, the high speed bandwidth provided by *GPRS* allowed for high quality video playback on mobile devices. This research provided test results that measured the way the *MHS* system would:-

- Capture video effectively for a security type system.
- Efficiently transfer video over the proposed *GPRS* network speeds.
- Provide optimal video playback on a mobile computing device.

The three areas of investigation of the designed and developed system were broken into three test cases. Each test case was performed in succession and measurements were recorded. Results gathered from the testing found minimal unexpected limitations with the system design. Further investigations into the cause of these limitations were examined. The limitations were related to playback of the uncompressed video and did not affect the operation of the *MHS* system.

The *MHS* system prototype was designed to investigate the *GPRS* network and the speeds at which the *GPRS* service operates. By developing a video based application, like a home monitoring security system, the research was able to suggest the *GPRS* network as a preferred wireless data network for video systems.

Literature obtained of previous findings on video performance provided an indication of what attributes should be used when investigating video over a packet based network. The wireless *GPRS* network is a packet based network which was examined for the capability of that network to provide a home security application with fast video transfers.

The *MHS* system based on the original design allowed for a smooth implementation of a fully functional *MHS* system. This working prototype was examined and tested for any deficiencies within the system design and the *GPRS* network, which the *MHS* system was intended for. The running *MHS* prototype provided test results that gave answers to all the research questions thus making the *MHS* system a prime candidate for any wireless high speed network.

In closing, the objective of this Honours research project was to design, develop and produce a working system that could utilize the full potential of the features offered by the GPRS network. High speed, effective transfer time and efficient video compression and playback were achievable from the *MHS* system. This project researched a relatively new technology, *GPRS*, and applied a possible video application to it. The results from this research have demonstrated that the project has been successful and all research objectives have been achieved.

Appendix A: Glossary of terms used

ADSL – Asymmetric Digital Subscriber Line, A service allows for higher bandwidth use on standard copper telephone networks. ADSL is provided by internet service providers and telecommunication providers.

AWCW- Active WebCam for Windows, the software that was used to operate the camera and record for motion detections.

BSB – Band Speed Balancer, the proxy service that allow for restricted access speeds to a packet based network.

BSC – Base Station Controller, within a *GPRS* network this base station keeps track of where in the mobile user is located.

BTC – Base Transceiver Station, within a GRPS network, is used to receive and transmit communication data to a mobile user.

CS – Coding Schema, the mechanism that is used to prepare data for transport over a GPRS wireless network.

CS-1 – Coding Schema 1 provides up to 9.05 Kbps transmission speed.

CS-2 – Coding Schema 2 provides up to 13.2 Kbps transmission speed.

CS-4 – Coding Schema 4 provides up to 21.4 Kbps transmission speed.

DVD – Digital Versatile Disc is an optical disc technology that can hold 4.7 GB of data.

Email – Electronic Mail

FTP – File Transfer Protocol is a standard Internet protocol, is the simplest way to exchange files between computers on the Internet or packet network.

GGSN – Gateway *GPRS* Support Node

GPRS – General Packet Radio Services, "is a packet-based wireless communication service that promises data rates from 56 up to 114 Kbps and continuous connection to the Internet for mobile phone and computer users" (Thing 2003)

GSM –Global System for Mobile communication is a digital mobile telecommunication system that is available for used in Australia and other parts of the world.

GSN – **GPRS** Support Node, they play two supporting functions for the *GPRS* network, one act as a serving node and the other a gateway node.

GTP – GPRS Tunneling Protocol. This protocol functions over the top of the standard *TCP/IP* protocols to encapsulate *IP* or X.25 Packets

GUI – Graphical User Interface

IPAQ – IPAQ is the marketing name given to a PDA that is sold by Compaq™

IP –The Internet Protocol is the scheme or protocol by which packets of data is transfer from one computer to another on the Internet or network.

ISP – Internet Service Providers

Kbits –stands for Kilobits a second, sometime refer to Kbps (interchangeable).

Kbps –stands for Kilobits per second, commonly used in the U.S as a standard for the bandwidth that data transfer operates.

Kbytes –stands for **Kilobytes**. A unit of measurement that represent 1000 bytes.

LAN – Local Area Network

Mbytes –stands for **Megabytes**. A unit of measurement that represent 1000 Kilobytes.

MPEG – (pronounced EHM-pehg), stands for **Moving** Picture **Experts** Group, is a developed standard for digital video and digital audio compression.

N/A –Not Available, these 'n/a can be found on some test case results.

PDA – Personal **D**igital Assistant. Also know as a handheld computer and palmtop.

QoS – Quality of Service "is the idea that transmission rates, error rates, and other characteristics can be measured, improved, and, to some extent, guaranteed in advance. QoS is of particular concern for the continuous transmission of high-bandwidth video and multimedia information. Transmitting this kind of content dependably is difficult in public networks using ordinary "best effort" protocols" Thing (2003)

RSVP – Resource Reservation Protocol "is a set of communication rules that allows channels or paths on the Internet to be reserved for the multicast (one source to many receivers) transmission of video and other high-bandwidth messages" (Thing 2003)

SGSN – Serving *GPRS* Support Node

TCP/IP – Transmission Control Protocol/Internet Protocol "is the basic communication language or protocol of the Internet". (Thing 2003)

TS – Time Slot/s

USB –Universal Serial **Bus** is a plug-and-play interface between a computer and add-on devices.

VoIP –Video over **IP**, not to mistaken for the Voice over IP.

WAP –Wireless Application Protocol "is a specification for a set of communication protocols to standardize the way that wireless devices, such as cellular telephones and radio transceivers, can be used for Internet access, including e-mail, the World Wide Web, newsgroups, and Internet Relay Chat (IRC)." (Thing 2003)

WMV –Windows Media Video is developed and maintained by Microsoft™. WMV is a generically given name for Microsoft's video encoding product.

WPP – Wireless Packet Platform, developed by the Ericsson Mobile Data Design Team. SGSN and GGSN are based on this platform.

WWW – World Wide Web commonly referred as the Internet.

X.25 –The **X.25** is a protocol, "adopted as a standard by the Consultative Committee for International Telegraph and Telephone (CCITT), is a commonly-used network protocol. The X.25 protocol allows computers on different public networks (such as CompuServe, Tymnet, or a TCP/IP network) to communicate through an intermediary computer at the network layer level" (Thing 2003)

Appendix B: System Hardware and Software Specifications

WebCam Server Computer

CPU	1.5 GHz AMD Athlon 4
Memory	512 MB DDR
OS Version	Windows XP
Service Pack	Service Pack 1
Hard disk	40.1 G 7200rpm IBM Desk star
Graphics	LeadTek Geforce 2 MX 400, 64MB

Web Camera

Web Cam	Logitech USB web Express.
Interface	Universal Serial Bus
Video Res.	High Quality, 320 x 240 30 Frames/s. Medium Quality, 320 x 240 15 Frames/s. Low Quality, 176 x 144 15 Frames/s.
Still Res.	320 x 240, 640 x 400

Network

Network Interface	Intel 10/100 NIC
Subnet Mask	255.255.255.0
IE Version	6.0.2800.1145

Software

FTP Server	FTP Server by Pablo Software Solutions Version 1.58
Video	Active WebCam by PY Software

PDA Compaq IPAQ H3800

CPU	ARM SA-1110, Rev B4
Memory	64 MB RAM 32 MB Flash-able ROM Total capacity of 96 MB useable memory storage
OS Version	Windows CE 3.0 (Pocket PC 2002, build 11178)
Service Pack	N/A
Software	Pocket Internet Explorer, Pocket TV
Hard disk	Uses system memory and external expansion slot.
Graphics	Colour LCD panel with backlit. Resolution Horizontal Pixels: 240 pixels. Vertical Pixels: 320 pixels.
Network Capabilities.	The following network adaptors are supported -AsyncMac1 NDISWAN Adapter -NE2000 Compatible Ethernet Drivers -PPTP1 NDISWAN Adapter

Appendix C: Test Case One Results for 320x240

Test Case Number (Cxxxx)	Video Resolution (Pixels)	Rate (fps)	Video Compression (Method, Bit-Rate)	Video Duration (Seconds)	Raw Data Size (Kbytes)	Encoded Data Size (Kbytes)	Compression Ratio (Raw:Encoded)	Compression Time (Seconds)
C0001	320x240	5	none	8	9,679	none	none	none
C0002	320x240	5	Mpeg. 4Kbps	n/a	n/a	n/a	n/a	n/a
C0003	320x240	5	Mpeg. 8Kbps	n/a	n/a	n/a	n/a	n/a
C0004	320x240	5	Mpeg,16Kbps	n/a	n/a	n/a	n/a	n/a
C0005	320x240	5	Mpeg,32Kbps	n/a	n/a	n/a	n/a	n/a
C0006	320x240	5	Mpeg,64Kbps	n/a	n/a	n/a	n/a	n/a
C0007	320x240	5	Mpeg,128Kbps	n/a	n/a	n/a	n/a	n/a
C0008	320x240	10	none	8	18,229	none	none	none
C0009	320x240	10	Mpeg. 4Kbps	8	18,229	183	99.61	24
C0010	320x240	10	Mpeg. 8Kbps	8	18,229	183	99.61	23
C0011	320x240	10	Mpeg. 16Kbps	8	18,229	184	99.07	23
C0012	320x240	10	Mpeg. 32Kbps	8	18,229	262	69.58	23
C0013	320x240	10	Mpeg. 64Kbps	8	18,229	523	34.85	24
C0014	320x240	10	Mpeg. 128Kbps	8	18,229	1046	17.43	24
C0015	320x240	15	none	8	20,480	none	none	none
C0016	320x240	15	Mpeg. 4Kbps	8	20,480	165	124.12	22
C0017	320x240	15	Mpeg. 8Kbps	8	20,480	165	124.12	20
C0018	320x240	15	Mpeg. 16Kbps	8	20,480	166	123.37	19
C0019	320x240	15	Mpeg. 32Kbps	8	20,480	197	103.96	18
C0020	320x240	15	Mpeg. 64Kbps	8	20,480	391	52.38	19
C0021	320x240	15	Mpeg. 128Kbps	8	20,480	782	26.19	18
C0022	320x240	24	none	4	25,205	none	none	none
C0023	320x240	24	Mpeg. 4Kbps	4	25,205	146	172.64	15
C0024	320x240	24	Mpeg. 8Kbps	4	25,205	146	172.64	15
C0025	320x240	24	Mpeg. 16Kbps	4	25,205	147	171.46	16
C0026	320x240	24	Mpeg. 32Kbps	4	25,205	151	166.92	15
C0027	320x240	24	Mpeg. 64Kbps	4	25,205	300	84.02	15
C0028	320x240	24	Mpeg. 128Kbps	4	25,205	599	42.08	15
C0029	320x240	30	none	5	29,931	none	none	none
C0030	320x240	30	Mpeg. 4Kbps	5	29,931	151	198.22	16
C0031	320x240	30	Mpeg. 8Kbps	5	29,931	151	198.22	15
C0032	320x240	30	Mpeg. 16Kbps	5	29,931	152	196.91	16
C0033	320x240	30	Mpeg. 32Kbps	5	29,931	155	193.10	15
C0034	320x240	30	Mpeg. 64Kbps	5	29,931	287	104.29	15
C0035	320x240	30	Mpeg. 128Kbps	5	29,931	571	52.42	16

Appendix D: Test Case One Results for 176x144

Test Case Number (Dxxxx)	Video Resolution (Pixels)	Frame Rate (fps)	Video Compression (Method, Bit-Rate)	Video Duration (Seconds)	Raw Data Size (Kbytes)	Encoded Data Size (Kbytes)	Compression Ratio (Raw:Encoded)	Compression Time (Seconds)
D0001	176x144	5	none	8	2,899	none	none	none
D0002	176x144	5	Mpeg, 4Kbps	8	2,899	n/a	n/a	n/a
D0003	176x144	5	Mpeg, 8Kbps	8	2,899	n/a	n/a	n/a
D0004	176x144	5	Mpeg, 16Kbps	8	2,899	n/a	n/a	n/a
D0005	176x144	5	Mpeg, 32Kbps	8	2,899	n/a	n/a	n/a
D0006	176x144	5	Mpeg, 64Kbps	8	2,899	n/a	n/a	n/a
D0007	176x144	5	Mpeg, 128Kbps	8	2,899	n/a	n/a	n/a
D0008	176x144	10	none	8	4,088	none	none	none
D0009	176x144	10	Mpeg, 4Kbps	8	4,088	53	77.13	6
D0010	176x144	10	Mpeg, 8Kbps	8	4,088	54	75.70	5
D0011	176x144	10	Mpeg, 16Kbps	8	4,088	90	45.42	5
D0012	176x144	10	Mpeg, 32Kbps	8	4,088	172	23.77	5
D0013	176x144	10	Mpeg, 64Kbps	8	4,088	357	11.45	5
D0014	176x144	10	Mpeg, 128Kbps	8	4,088	712	5.74	5
D0015	176x144	15	none	6	6,539	none	none	none
D0016	176x144	15	Mpeg, 4Kbps	6	6,539	62	105.47	7
D0017	176x144	15	Mpeg, 8Kbps	6	6,539	62	105.47	6
D0018	176x144	15	Mpeg, 16Kbps	6	6,539	95	68.83	6
D0019	176x144	15	Mpeg, 32Kbps	6	6,539	190	34.42	6
D0020	176x144	15	Mpeg, 64Kbps	6	6,539	379	17.25	6
D0021	176x144	15	Mpeg, 128Kbps	6	6,539	757	8.64	6
D0022	176x144	24	none	4	7,504	none	none	none
D0023	176x144	24	Mpeg, 4Kbps	4	7,504	62	121.03	7
D0024	176x144	24	Mpeg, 8Kbps	4	7,504	62	121.03	7
D0025	176x144	24	Mpeg, 16Kbps	4	7,504	67	112.00	7
D0026	176x144	24	Mpeg, 32Kbps	4	7,504	137	54.77	7
D0027	176x144	24	Mpeg, 64Kbps	4	7,504	271	27.69	7
D0028	176x144	24	Mpeg, 128Kbps	4	7,504	540	13.90	8
D0029	176x144	30	none	5	10,401	none	none	none
D0030	176x144	30	Mpeg, 4Kbps	5	10,401	75	138.68	10
D0031	176x144	30	Mpeg, 8Kbps	5	10,401	75	138.68	9
D0032	176x144	30	Mpeg, 16Kbps	5	10,401	78	133.35	9
D0033	176x144	30	Mpeg, 32Kbps	5	10,401	150	69.34	9
D0034	176x144	30	Mpeg, 64Kbps	5	10,401	300	34.67	10
D0035	176x144	30	Mpeg, 128Kbps	5	10,401	599	17.36	10

Test Case Two
"Transfer Test"

Test Case Number (Exxxx)	Video Resolution (Pixels)	Frame Rate (fps)	Video Compression (Method, Bit-Rate)	GPRS CS-2 Timeslots (1,4,8)	Transfer Speed (Kbps)	Transfer Data Size (Kbytes)	Transfer Times (mm:ss)	Compression Time (mm:ss)	Turnaround Time (mm:ss)
E0001	320x240	5	none	1	13.2	9,679	12m31s	0s	12m31s
E0002	320x240	5	Mpeg, 4Kbps	1	13.2	n/a	n/a	n/a	n/a
E0003	320x240	5	Mpeg, 8Kbps	1	13.2	n/a	n/a	n/a	n/a
E0004	320x240	5	Mpeg, 16Kbps	1	13.2	n/a	n/a	n/a	n/a
E0005	320x240	5	Mpeg, 32Kbps	1	13.2	n/a	n/a	n/a	n/a
E0006	320x240	5	Mpeg, 64Kbps	1	13.2	n/a	n/a	n/a	n/a
E0007	320x240	5	Mpeg, 128Kbps	1	13.2	n/a	n/a	n/a	n/a
E0008	320x240	5	none	4	52.8	9,679	3m50s	0s	3m50s
E0009	320x240	5	Mpeg, 4Kbps	4	52.8	n/a	n/a	n/a	n/a
E0010	320x240	5	Mpeg, 8Kbps	4	52.8	n/a	n/a	n/a	n/a
E0011	320x240	5	Mpeg, 16Kbps	4	52.8	n/a	n/a	n/a	n/a
E0012	320x240	5	Mpeg, 32Kbps	4	52.8	n/a	n/a	n/a	n/a
E0013	320x240	5	Mpeg, 64Kbps	4	52.8	n/a	n/a	n/a	n/a
E0014	320x240	5	Mpeg, 128Kbps	4	52.8	n/a	n/a	n/a	n/a
E0015	320x240	5	none	8	105.6	9,679	3m34s	0s	3m34s
E0016	320x240	5	Mpeg, 4Kbps	8	105.6	n/a	n/a	n/a	n/a
E0017	320x240	5	Mpeg, 8Kbps	8	105.6	n/a	n/a	n/a	n/a
E0018	320x240	5	Mpeg, 16Kbps	8	105.6	n/a	n/a	n/a	n/a
E0019	320x240	5	Mpeg, 32Kbps	8	105.6	n/a	n/a	n/a	n/a
E0020	320x240	5	Mpeg, 64Kbps	8	105.6	n/a	n/a	n/a	n/a
E0021	320x240	5	Mpeg, 128Kbps	8	105.6	n/a	n/a	n/a	n/a
E0022	320x240	10	none	1	13.2	18,229	23m39s	0s	23m39s
E0023	320x240	10	Mpeg, 4Kbps	1	13.2	183	14s	24s	0m38s
E0024	320x240	10	Mpeg, 8Kbps	1	13.2	183	14s	23s	0m37s
E0025	320x240	10	Mpeg, 16Kbps	1	13.2	184	14s	23s	0m37s
E0026	320x240	10	Mpeg, 32Kbps	1	13.2	262	20s	23s	0m43s
E0027	320x240	10	Mpeg, 64Kbps	1	13.2	523	40s	24s	1m4s
E0028	320x240	10	Mpeg, 128Kbps	1	13.2	1,046	1m21s	24s	1m45s
E0029	320x240	10	none	4	52.8	18,229	6m43s	0s	6m43s
E0030	320x240	10	Mpeg, 4Kbps	4	52.8	183	3s	24s	0m27s
E0031	320x240	10	Mpeg, 8Kbps	4	52.8	183	3s	23s	0m26s
E0032	320x240	10	Mpeg, 16Kbps	4	52.8	184	3s	23s	0m26s
E0033	320x240	10	Mpeg, 32Kbps	4	52.8	262	5s	23s	0m28s
E0034	320x240	10	Mpeg, 64Kbps	4	52.8	523	10s	24s	0m34s
E0035	320x240	10	Mpeg, 128Kbps	4	52.8	1,046	20s	24s	0m44s

Test Case Two
"Transfer Test"

Test Case Number (Exxxx)	Video Resolution (Pixels)	Frame Rate (fps)	Video Compression (Method, Bit-Rate)	GPRS CS-2 Timeslots (1,4,8)	Transfer Speed (Kbps)	Transfer Data Size (Kbytes)	Transfer Times (mm:ss)	Compression Time (mm:ss)	Turnaround Time (mm:ss)
E0036	320x240	10	none	8	105.6	18,229	5m08s	0s	5m8s
E0037	320x240	10	Mpeg, 4Kbps	8	105.6	183	1s	24s	0m25s
E0038	320x240	10	Mpeg, 8Kbps	8	105.6	183	1s	23s	0m24s
E0039	320x240	10	Mpeg, 16Kbps	8	105.6	184	1s	23s	0m24s
E0040	320x240	10	Mpeg, 32Kbps	8	105.6	262	2s	23s	0m25s
E0041	320x240	10	Mpeg, 64Kbps	8	105.6	523	5s	24s	0m29s
E0042	320x240	10	Mpeg, 128Kbps	8	105.6	1,046	14s	24s	0m38s
E0043	320x240	15	none	1	13.2	20,480	27m28s	0s	27m28s
E0044	320x240	15	Mpeg, 4Kbps	1	13.2	165	12s	22s	0m34s
E0045	320x240	15	Mpeg, 8Kbps	1	13.2	165	12s	20s	0m32s
E0046	320x240	15	Mpeg, 16Kbps	1	13.2	166	12s	19s	0m31s
E0047	320x240	15	Mpeg, 32Kbps	1	13.2	197	15s	18s	0m33s
E0048	320x240	15	Mpeg, 64Kbps	1	13.2	391	30s	19s	0m49s
E0049	320x240	15	Mpeg, 128Kbps	1	13.2	782	1m00s	18s	1m18s
E0050	320x240	15	none	4	52.8	20,480	7m32s	0s	7m32s
E0051	320x240	15	Mpeg, 4Kbps	4	52.8	165	3s	22s	0m25s
E0052	320x240	15	Mpeg, 8Kbps	4	52.8	165	3s	20s	0m23s
E0053	320x240	15	Mpeg, 16Kbps	4	52.8	166	3s	19s	0m22s
E0054	320x240	15	Mpeg, 32Kbps	4	52.8	197	3s	18s	0m21s
E0055	320x240	15	Mpeg, 64Kbps	4	52.8	391	7s	19s	0m26s
E0056	320x240	15	Mpeg, 128Kbps	4	52.8	782	15s	18s	0m33s
E0057	320x240	15	none	8	105.6	20,480	5m27s	0s	5m27s
E0058	320x240	15	Mpeg, 4Kbps	8	105.6	165	1s	22s	0m23s
E0059	320x240	15	Mpeg, 8Kbps	8	105.6	165	1s	20s	0m21s
E0060	320x240	15	Mpeg, 16Kbps	8	105.6	166	1s	19s	0m20s
E0061	320x240	15	Mpeg, 32Kbps	8	105.6	197	1s	18s	0m19s
E0062	320x240	15	Mpeg, 64Kbps	8	105.6	391	3s	19s	0m22s
E0063	320x240	15	Mpeg, 128Kbps	8	105.6	782	8s	18s	0m26s
E0064	320x240	24	none	1	13.2	25,205	n/a	n/a	n/a
E0065	320x240	24	Mpeg, 4Kbps	1	13.2	146	12s	15s	0m27s
E0066	320x240	24	Mpeg, 8Kbps	1	13.2	146	12s	15s	0m27s
E0067	320x240	24	Mpeg, 16Kbps	1	13.2	147	11s	16s	0m27s
E0068	320x240	24	Mpeg, 32Kbps	1	13.2	151	11s	15s	0m26s
E0069	320x240	24	Mpeg, 64Kbps	1	13.2	300	23s	15s	0m38s
E0070	320x240	24	Mpeg, 128Kbps	1	13.2	599	46s	15s	1m1s

Test Case Two
"Transfer Test"

Test Case Number (Exxxx)	Video Resolution (Pixels)	Frame Rate (fps)	Video Compression (Method, Bit-Rate)	GPRS CS-2 Timeslots (1,4,8)	Transfer Speed (Kbps)	Transfer Data Size (Kbytes)	Transfer Times (mm:ss)	Compression Time (mm:ss)	Turnaround Time (mm:ss)
E0071	320x240	24	none	4	52.8	25,205	n/a	n/a	n/a
E0072	320x240	24	Mpeg, 4Kbps	4	52.8	146	2s	15s	0m17s
E0073	320x240	24	Mpeg, 8Kbps	4	52.8	146	2s	15s	0m17s
E0074	320x240	24	Mpeg, 16Kbps	4	52.8	147	2s	16s	0m18s
E0075	320x240	24	Mpeg, 32Kbps	4	52.8	151	2s	15s	0m17s
E0076	320x240	24	Mpeg, 64Kbps	4	52.8	300	5s	15s	0m20s
E0077	320x240	24	Mpeg, 128Kbps	4	52.8	599	11s	15s	0m26s
E0078	320x240	24	none	8	105.6	25,205	n/a	n/a	n/a
E0079	320x240	24	Mpeg, 4Kbps	8	105.6	146	1s	15s	0m16s
E0080	320x240	24	Mpeg, 8Kbps	8	105.6	146	1s	15s	0m16s
E0081	320x240	24	Mpeg, 16Kbps	8	105.6	147	1s	16s	0m17s
E0082	320x240	24	Mpeg, 32Kbps	8	105.6	151	2s	15s	0m17s
E0083	320x240	24	Mpeg, 64Kbps	8	105.6	300	2s	15s	0m17s
E0084	320x240	24	Mpeg, 128Kbps	8	105.6	599	5s	15s	0m20s
E0085	320x240	30	none	1	13.2	29,931	n/a	n/a	n/a
E0086	320x240	30	Mpeg, 4Kbps	1	13.2	151	11s	16s	0m27s
E0087	320x240	30	Mpeg, 8Kbps	1	13.2	151	11s	15s	0m26s
E0088	320x240	30	Mpeg, 16Kbps	1	13.2	152	11s	16s	0m27s
E0089	320x240	30	Mpeg, 32Kbps	1	13.2	155	12s	15s	0m27s
E0090	320x240	30	Mpeg, 64Kbps	1	13.2	287	22s	15s	0m37s
E0091	320x240	30	Mpeg, 128Kbps	1	13.2	571	44s	16s	1m0s
E0092	320x240	30	none	4	52.8	29,931	n/a	n/a	n/a
E0093	320x240	30	Mpeg, 4Kbps	4	52.8	151	2s	16s	0m18s
E0094	320x240	30	Mpeg, 8Kbps	4	52.8	151	2s	15s	0m17s
E0095	320x240	30	Mpeg, 16Kbps	4	52.8	152	2s	16s	0m18s
E0096	320x240	30	Mpeg, 32Kbps	4	52.8	155	3s	15s	0m18s
E0097	320x240	30	Mpeg, 64Kbps	4	52.8	287	5s	15s	0m20s
E0098	320x240	30	Mpeg, 128Kbps	4	52.8	571	11s	16s	0m27s
E0099	320x240	30	none	8	105.6	29,931	n/a	n/a	n/a
E0100	320x240	30	Mpeg, 4Kbps	8	105.6	151	1s	16s	0m17s
E0101	320x240	30	Mpeg, 8Kbps	8	105.6	151	1s	15s	0m16s
E0102	320x240	30	Mpeg, 16Kbps	8	105.6	152	1s	16s	0m17s
E0103	320x240	30	Mpeg, 32Kbps	8	105.6	155	1s	15s	0m16s
E0104	320x240	30	Mpeg, 64Kbps	8	105.6	287	2s	15s	0m17s
E0105	320x240	30	Mpeg, 128Kbps	8	105.6	571	5s	16s	0m21s

Test Case Two
"Transfer Test"

Test Case Number (Fxxxx)	Video Resolution (Pixels)	Frame Rate (fps)	Video Compression (Method, Bit-Rate)	GPRS CS-2 Timeslots (1,4,8)	Transfer Speed (Kbps)	Transfer Data Size (Kbytes)	Transfer Times (Seconds)	Compression Time (Seconds)	Turnaround Time (Seconds)
F0106	176x144	5	none	1	13.2	2,899	3m45s	0s	3m45s
F0107	176x144	5	Mpeg, 4Kbps	1	13.2	n/a	n/a	n/a	n/a
F0108	176x144	5	Mpeg, 8Kbps	1	13.2	n/a	n/a	n/a	n/a
F0109	176x144	5	Mpeg, 16Kbps	1	13.2	n/a	n/a	n/a	n/a
F0110	176x144	5	Mpeg, 32Kbps	1	13.2	n/a	n/a	n/a	n/a
F0111	176x144	5	Mpeg, 64Kbps	1	13.2	n/a	n/a	n/a	n/a
F0112	176x144	5	Mpeg, 128Kbps	1	13.2	n/a	n/a	n/a	n/a
F0113	176x144	5	none	4	52.8	2,899	56s	0s	0m56s
F0114	176x144	5	Mpeg, 4Kbps	4	52.8	n/a	n/a	n/a	n/a
F0115	176x144	5	Mpeg, 8Kbps	4	52.8	n/a	n/a	n/a	n/a
F0116	176x144	5	Mpeg, 16Kbps	4	52.8	n/a	n/a	n/a	n/a
F0117	176x144	5	Mpeg, 32Kbps	4	52.8	n/a	n/a	n/a	n/a
F0118	176x144	5	Mpeg, 64Kbps	4	52.8	n/a	n/a	n/a	n/a
F0119	176x144	5	Mpeg, 128Kbps	4	52.8	n/a	n/a	n/a	n/a
F0120	176x144	5	none	8	105.6	2,899	30s	0s	0m30s
F0121	176x144	5	Mpeg, 4Kbps	8	105.6	n/a	n/a	n/a	n/a
F0122	176x144	5	Mpeg, 8Kbps	8	105.6	n/a	n/a	n/a	n/a
F0123	176x144	5	Mpeg, 16Kbps	8	105.6	n/a	n/a	n/a	n/a
F0124	176x144	5	Mpeg, 32Kbps	8	105.6	n/a	n/a	n/a	n/a
F0125	176x144	5	Mpeg, 64Kbps	8	105.6	n/a	n/a	n/a	n/a
F0126	176x144	5	Mpeg, 128Kbps	8	105.6	n/a	n/a	n/a	n/a
F0127	176x144	10	none	1	13.2	4,088	5m17s	0s	5m17s
F0128	176x144	10	Mpeg, 4Kbps	1	13.2	53	4s	6s	0m10s
F0129	176x144	10	Mpeg, 8Kbps	1	13.2	54	4s	5s	0m9s
F0130	176x144	10	Mpeg, 16Kbps	1	13.2	90	6s	5s	0m11s
F0131	176x144	10	Mpeg, 32Kbps	1	13.2	172	13s	5s	0m18s
F0132	176x144	10	Mpeg, 64Kbps	1	13.2	357	27s	5s	0m32s
F0133	176x144	10	Mpeg, 128Kbps	1	13.2	712	55s	5s	1m0s
F0134	176x144	10	none	4	52.8	4,088	1m19s	0s	1m19s
F0135	176x144	10	Mpeg, 4Kbps	4	52.8	53	1s	6s	0m7s
F0136	176x144	10	Mpeg, 8Kbps	4	52.8	54	1s	5s	0m6s
F0137	176x144	10	Mpeg, 16Kbps	4	52.8	90	1s	5s	0m6s
F0138	176x144	10	Mpeg, 32Kbps	4	52.8	172	3s	5s	0m8s
F0139	176x144	10	Mpeg, 64Kbps	4	52.8	357	6s	5s	0m11s
F0140	176x144	10	Mpeg, 128Kbps	4	52.8	712	13s	5s	0m18s

Test Case Two
"Transfer Test"

Test Case Number (Fxxxx)	Video Resolution (Pixels)	Frame Rate (fps)	Video Compression (Method, Bit-Rate)	GPRS CS-2 Timeslots (1,4,8)	Transfer Speed (Kbps)	Transfer Data Size (Kbytes)	Transfer Times (Seconds)	Compression Time (Seconds)	Turnaround Time (Seconds)
F0141	176x144	10	none	8	105.6	4,088	48s	0s	0m48s
F0142	176x144	10	Mpeg, 4Kbps	8	105.6	53	1s	6s	0m7s
F0143	176x144	10	Mpeg, 8Kbps	8	105.6	54	1s	5s	0m6s
F0144	176x144	10	Mpeg, 16Kbps	8	105.6	90	1s	5s	0m6s
F0145	176x144	10	Mpeg, 32Kbps	8	105.6	172	2s	5s	0m7s
F0146	176x144	10	Mpeg, 64Kbps	8	105.6	357	3s	5s	0m8s
F0147	176x144	10	Mpeg, 128Kbps	8	105.6	712	8s	5s	0m13s
F0148	176x144	15	none	1	13.2	6,539	8m28s	0s	8m28s
F0149	176x144	15	Mpeg, 4Kbps	1	13.2	62	4s	7s	0m11s
F0150	176x144	15	Mpeg, 8Kbps	1	13.2	62	4s	6s	0m10s
F0151	176x144	15	Mpeg, 16Kbps	1	13.2	95	7s	6s	0m13s
F0152	176x144	15	Mpeg, 32Kbps	1	13.2	190	14s	6s	0m20s
F0153	176x144	15	Mpeg, 64Kbps	1	13.2	379	30s	6s	0m36s
F0154	176x144	15	Mpeg, 128Kbps	1	13.2	757	58s	6s	1m4s
F0155	176x144	15	none	4	52.8	6,539	4m57s	0s	4m57s
F0156	176x144	15	Mpeg, 4Kbps	4	52.8	62	1s	7s	0m8s
F0157	176x144	15	Mpeg, 8Kbps	4	52.8	62	1s	6s	0m7s
F0158	176x144	15	Mpeg, 16Kbps	4	52.8	95	1s	6s	0m7s
F0159	176x144	15	Mpeg, 32Kbps	4	52.8	190	3s	6s	0m9s
F0160	176x144	15	Mpeg, 64Kbps	4	52.8	379	7s	6s	0m13s
F0161	176x144	15	Mpeg, 128Kbps	4	52.8	757	14s	6s	0m20s
F0162	176x144	15	none	8	105.6	6,539	1m47s	0s	1m47s
F0163	176x144	15	Mpeg, 4Kbps	8	105.6	62	1s	7s	0m8s
F0164	176x144	15	Mpeg, 8Kbps	8	105.6	62	1s	6s	0m7s
F0165	176x144	15	Mpeg, 16Kbps	8	105.6	95	1s	6s	0m7s
F0166	176x144	15	Mpeg, 32Kbps	8	105.6	190	1s	6s	0m7s
F0167	176x144	15	Mpeg, 64Kbps	8	105.6	379	3s	6s	0m9s
F0168	176x144	15	Mpeg, 128Kbps	8	105.6	757	7s	6s	0m13s
F0169	176x144	24	none	1	13.2	7,504	9m36s	0s	9m36s
F0170	176x144	24	Mpeg, 4Kbps	1	13.2	62	4s	7s	0m11s
F0171	176x144	24	Mpeg, 8Kbps	1	13.2	62	4s	7s	0m11s
F0172	176x144	24	Mpeg, 16Kbps	1	13.2	67	5s	7s	0m12s
F0173	176x144	24	Mpeg, 32Kbps	1	13.2	137	10s	7s	0m17s
F0174	176x144	24	Mpeg, 64Kbps	1	13.2	271	20s	7s	0m27s
F0175	176x144	24	Mpeg, 128Kbps	1	13.2	540	41s	8s	0m49s

Test Case Two
"Transfer Test"

Test Case Number (Fxxxx)	Video Resolution (Pixels)	Frame Rate (fps)	Video Compression (Method, Bit-Rate)	GPRS CS-2 Timeslots (1,4,8)	Transfer Speed (Kbps)	Transfer Data Size (Kbytes)	Transfer Times (Seconds)	Compression Time (Seconds)	Turnaround Time (Seconds)
F0176	176x144	24	none	4	52.8	7,504	2m37s	0s	2m37s
F0177	176x144	24	Mpeg, 4Kbps	4	52.8	62	1s	7s	0m8s
F0178	176x144	24	Mpeg, 8Kbps	4	52.8	62	1s	7s	0m8s
F0179	176x144	24	Mpeg, 16Kbps	4	52.8	67	1s	7s	0m8s
F0180	176x144	24	Mpeg, 32Kbps	4	52.8	137	2s	7s	0m9s
F0181	176x144	24	Mpeg, 64Kbps	4	52.8	271	5s	7s	0m12s
F0182	176x144	24	Mpeg, 128Kbps	4	52.8	540	10s	8s	0m18s
F0183	176x144	24	none	8	105.6	7,504	2m18s	0s	2m18s
F0184	176x144	24	Mpeg, 4Kbps	8	105.6	62	1s	7s	0m8s
F0185	176x144	24	Mpeg, 8Kbps	8	105.6	62	1s	7s	0m8s
F0186	176x144	24	Mpeg, 16Kbps	8	105.6	67	1s	7s	0m8s
F0187	176x144	24	Mpeg, 32Kbps	8	105.6	137	1s	7s	0m8s
F0188	176x144	24	Mpeg, 64Kbps	8	105.6	271	2s	7s	0m9s
F0189	176x144	24	Mpeg, 128Kbps	8	105.6	540	5s	8s	0m13s
F0190	176x144	30	none	1	13.2	10,401	13m27s	0s	13m27s
F0191	176x144	30	Mpeg, 4Kbps	1	13.2	75	5s	10s	0m15s
F0192	176x144	30	Mpeg, 8Kbps	1	13.2	75	5s	9s	0m14s
F0193	176x144	30	Mpeg, 16Kbps	1	13.2	78	6s	9s	0m15s
F0194	176x144	30	Mpeg, 32Kbps	1	13.2	150	11s	9s	0m20s
F0195	176x144	30	Mpeg, 64Kbps	1	13.2	300	23s	10s	0m33s
F0196	176x144	30	Mpeg, 128Kbps	1	13.2	599	46s	10s	0m56s
F0197	176x144	30	none	4	52.8	10,401	4m04s	0s	4m4s
F0198	176x144	30	Mpeg, 4Kbps	4	52.8	75	1s	10s	0m11s
F0199	176x144	30	Mpeg, 8Kbps	4	52.8	75	1s	9s	0m10s
F0200	176x144	30	Mpeg, 16Kbps	4	52.8	78	1s	9s	0m10s
F0201	176x144	30	Mpeg, 32Kbps	4	52.8	150	2s	9s	0m11s
F0202	176x144	30	Mpeg, 64Kbps	4	52.8	300	5s	10s	0m15s
F0203	176x144	30	Mpeg, 128Kbps	4	52.8	599	11s	10s	0m21s
F0204	176x144	30	none	8	105.6	10,401	3m43s	0s	3m43s
F0205	176x144	30	Mpeg, 4Kbps	8	105.6	75	1s	10s	0m11s
F0206	176x144	30	Mpeg, 8Kbps	8	105.6	75	1s	9s	0m10s
F0207	176x144	30	Mpeg, 16Kbps	8	105.6	78	1s	9s	0m10s
F0208	176x144	30	Mpeg, 32Kbps	8	105.6	150	1s	9s	0m10s
F0209	176x144	30	Mpeg, 64Kbps	8	105.6	300	2s	10s	0m12s
F0210	176x144	30	Mpeg, 128Kbps	8	105.6	599	6s	10s	0m16s

Test Case Three
"Playback Test"

Test Case Number (Gxxxx)	Video Resolution (Pixels)	Frame Rate (fps)	Video Compression (Method, Bit-Rate)	Video Duration (Seconds)	Actual Playback (Seconds)	Significant Playback (Y/N)	Quality (Low,Med, High)	Video Playback Observations (frames,image and text quality)
G0001	320x240	5	none	8	8	Y	LOW	Jumpy frames, smooth image, clear text
G0002	320x240	5	Mpeg, 4Kbps	n/a	n/a	n/a	n/a	No file was avaliable, refer to C0002
G0003	320x240	5	Mpeg, 8Kbps	n/a	n/a	n/a	n/a	No file was avaliable, refer to C0003
G0004	320x240	5	Mpeg, 16Kbps	n/a	n/a	n/a	n/a	No file was avaliable, refer to C0004
G0005	320x240	5	Mpeg, 32Kbps	n/a	n/a	n/a	n/a	No file was avaliable, refer to C0005
G0006	320x240	5	Mpeg, 64Kbps	n/a	n/a	n/a	n/a	No file was avaliable, refer to C0006
G0007	320x240	5	Mpeg, 128Kbps	n/a	n/a	n/a	n/a	No file was avaliable, refer to C0007
G0008	320x240	10	none	8	8	Y	LOW	Jumpy frames, blocky image, blurred text
G0009	320x240	10	Mpeg, 4Kbps	8	8	Y	LOW	Jumpy frames, blocky image, blurred text
G0010	320x240	10	Mpeg, 8Kbps	8	8	Y	LOW	Moderate frames, blocky image, blurred text
G0011	320x240	10	Mpeg, 16Kbps	8	8	Y	MED	Moderate frames, blocky image, blurred text
G0012	320x240	10	Mpeg, 32Kbps	8	8	Y	MED	Moderate frames, smooth image, clear text
G0013	320x240	10	Mpeg, 64Kbps	8	8	Y	MED	Moderate frames, smooth image, clear text
G0014	320x240	10	Mpeg, 128Kbps	8	8	Y	HIGH	Moderate frames, smooth image,very clear text
G0015	320x240	15	none	6	6	Y	HIGH	Moderate frames, smooth image,very clear text
G0016	320x240	15	Mpeg, 4Kbps	6	6	Y	LOW	Jumpy frames, blocky image, blurred text
G0017	320x240	15	Mpeg, 8Kbps	6	6	Y	LOW	Moderate frames, blocky image, blurred text
G0018	320x240	15	Mpeg, 16Kbps	6	6	Y	MED	Moderate frames, smooth image, clear text
G0019	320x240	15	Mpeg, 32Kbps	6	6	Y	MED	Moderate frames, smooth image, clear text
G0020	320x240	15	Mpeg, 64Kbps	6	6	Y	MED	Moderate frames, smooth image, clear text
G0021	320x240	15	Mpeg, 128Kbps	6	6	Y	MED	Mod. frames,very smooth image,very clear text
G0022	320x240	24	none	n/a	n/a	N	n/a	File was too big to open in PDA
G0023	320x240	24	Mpeg, 4Kbps	4	6	Y	LOW	Moderate frames, blocky image, blurred text
G0024	320x240	24	Mpeg, 8Kbps	4	6	Y	LOW	Moderate frames, blocky image, blurred text
G0025	320x240	24	Mpeg, 16Kbps	4	6	Y	MED	Moderate frames, smooth image, clear text
G0026	320x240	24	Mpeg, 32Kbps	4	6	Y	MED	Moderate frames, smooth image, clear text
G0027	320x240	24	Mpeg, 64Kbps	4	6	Y	MED	Mod. frames,very smooth image,very clear text
G0028	320x240	24	Mpeg, 128Kbps	4	6	Y	HIGH	Good frames,very smooth image,very clear text
G0029	320x240	30	none	n/a	n/a	N	n/a	File was too big to open in PDA
G0030	320x240	30	Mpeg, 4Kbps	5	5	Y	LOW	Moderate frames, blocky image, blurred text
G0031	320x240	30	Mpeg, 8Kbps	5	5	Y	LOW	Moderate frames, blocky image, blurred text
G0032	320x240	30	Mpeg, 16Kbps	5	5	Y	MED	Moderate frames, smooth image, clear text
G0033	320x240	30	Mpeg, 32Kbps	5	5	Y	MED	Moderate frames, smooth image, clear text
G0034	320x240	30	Mpeg, 64Kbps	5	5	Y	HIGH	Good frames,very smooth image,very clear text
G0035	320x240	30	Mpeg, 128Kbps	5	5	Y	HIGH	Good frames,very smooth image,very clear text

Test Case Three
"Playback Test"

Test Case Number (Hxxxx)	Video Resolution (Pixels)	Frame Rate (fps)	Video Compression (Method, Bit-Rate)	Video Duration (Seconds)	Actual Playback (Seconds)	Significant Playback (Y/N)	Video Quality (Low,Med,High)	Video Playback Observations (frames,image and text quality)
H0001	176x144	5	none	8	8	Y	LOW	Jumpy frames, smooth image, clear text
H0002	176x144	5	Mpeg, 4Kbps	n/a	n/a	N	n/a	No file was avaliable, refer to D0002
H0003	176x144	5	Mpeg, 8Kbps	n/a	n/a	N	n/a	No file was avaliable, refer to D0003
H0004	176x144	5	Mpeg, 16Kbps	n/a	n/a	N	n/a	No file was avaliable, refer to D0004
H0005	176x144	5	Mpeg, 32Kbps	n/a	n/a	N	n/a	No file was avaliable, refer to D0005
H0006	176x144	5	Mpeg, 64Kbps	n/a	n/a	N	n/a	No file was avaliable, refer to D0006
H0007	176x144	5	Mpeg, 128Kbps	n/a	n/a	N	n/a	No file was avaliable, refer to D0007
H0008	176x144	10	none	8	8	Y	MED	Jumpy frames, smooth image, clear text
H0009	176x144	10	Mpeg, 4Kbps	8	8	Y	LOW	Jumpy frames, blocky image, blurred text
H0010	176x144	10	Mpeg, 8Kbps	8	8	Y	LOW	Jumpy frames, blocky image, blurred text
H0011	176x144	10	Mpeg, 16Kbps	8	8	Y	LOW	Jumpy frames, blocky image, blurred text
H0012	176x144	10	Mpeg, 32Kbps	8	8	Y	MED	Jumpy frames, blocky image, clear text
H0013	176x144	10	Mpeg, 64Kbps	8	8	Y	MED	Jumpy frames, smooth image, clear text
H0014	176x144	10	Mpeg, 128Kbps	8	8	Y	MED	Jumpy frames, smooth image, clear text
H0015	176x144	15	none	6	6	Y	MED	Moderate frames, smooth image, clear text
H0016	176x144	15	Mpeg, 4Kbps	6	6	Y	LOW	Moderate frames, blocky image, blurred text
H0017	176x144	15	Mpeg, 8Kbps	6	6	Y	LOW	Moderate frames, blocky image, blurred text
H0018	176x144	15	Mpeg, 16Kbps	6	6	Y	MED	Moderate frames, blocky image, blurred text
H0019	176x144	15	Mpeg, 32Kbps	6	6	Y	MED	Moderate frames, smooth image, clear text
H0020	176x144	15	Mpeg, 64Kbps	6	6	Y	MED	Moderate frames, smooth image, clear text
H0021	176x144	15	Mpeg, 128Kbps	6	6	Y	MED	Moderate frames, smooth image, clear text
H0022	176x144	24	none	4	6	Y	MED	Good frames, smooth image, clear text
H0023	176x144	24	Mpeg, 4Kbps	4	6	Y	lOW	Moderate frames, blocky image, blurred text
H0024	176x144	24	Mpeg, 8Kbps	4	6	Y	lOW	Moderate frames, blocky image, blurred text
H0025	176x144	24	Mpeg, 16Kbps	4	6	Y	lOW	Moderate frames, smooth image, clear text
H0026	176x144	24	Mpeg, 32Kbps	4	6	Y	MED	Moderate frames, smooth image, clear text
H0027	176x144	24	Mpeg, 64Kbps	4	6	Y	MED	Moderate frames, smooth image, clear text
H0028	176x144	24	Mpeg, 128Kbps	4	6	Y	MED	Moderate frames, smooth image, clear text
H0029	176x144	30	none	5	5	Y	MED	Good frames, smooth image, clear text
H0030	176x144	30	Mpeg, 4Kbps	5	5	Y	LOW	Moderate frames, blocky image, blurred text
H0031	176x144	30	Mpeg, 8Kbps	5	5	Y	LOW	Moderate frames, blocky image, blurred text
H0032	176x144	30	Mpeg, 16Kbps	5	5	Y	MED	Moderate frames, smooth image, clear text
H0033	176x144	30	Mpeg, 32Kbps	5	5	Y	MED	Moderate frames, smooth image, clear text
H0034	176x144	30	Mpeg, 64Kbps	5	5	Y	MED	Moderate frames, smooth image, clear text
H0035	176x144	30	Mpeg, 128Kbps	5	5	Y	MED	Good frames, smooth image, clear text

References

Andersson, C. (2001). *GPRS - A Key Step For The Mobile Internet, Ericsson*. 2002.

Bartlett, J. (2000). Managing *IP Video Streaming Bandwidth*, PictureTel IP Services. 2002.

Dawson, K. (2001). *AT&T Wireless Starts GPRS in Seattle*, CommWeb.com. 2002

Ekeroth, L. and P.-M. Hedstrom (2000). *GPRS Support Nodes*. Ericsson Review 3: 156-169.

Ganley, M. J. (2001). *Security and Performance Issues Associated with Voice and Video over Internet Protocol*, Cylink. 2002.

Granbohm H. and Wiklund J., *GPRS-general packet radio service*, Ericsson Review, no. 2, 1999, pp. 82-88

Laurin, A. (2002). *2002 Global Security Market Prospects*. USA, Axis Communications.

Levine, M. (2002). *The Importance of Application Security*, @Stake Inc. 2002.

Park, J.-H. (2002). *Wireless Internet Access for Mobile Subscribers Based on the GPRS/UMTS Network*. IEEE Communications: 38-49.

Rysavy, P. (1998). *General Packet Radio Service (GPRS)*. GSM Data Today Online: 7.

Rysavy, P. (2000). *Emerging Technology: Clear Signals for General Packet Radio Service*. Network Magazine. Dec 5.

Sharples, B. (2000). *MOTOROLA: Seeing is believing -- Motorola and PacketVideo demonstrate MPEG4 video over GPRS.* M2 Presswire. May 10.

Thing, L. (2003). *About Whatis?com* [on-line], Available WWW: http://whatis.techtarget.com/waboutUs/0,,sid9,00.htmlTechTarget. [2002, October 10]

Tsai, S. M., P. C. Yang, et al. (1998). *A service of home security system on intelligent network.* IEEE Transaction on Consumer Electronics 44(4)

Usha (2000). *GPRS General Packet Radio Service,* Usha Communications Technology. 2002.

Vriendt, J. D., P. Laine, et al. (2002). *Mobile Network Evolution: A Revolution on the move.* IEEE Communications Magazine April: 104-111

Ydrenius, F. (2000). *Scalable Coding of Video over IP-based Networks.* Electrical Engineering, Linkoping: 103.