

The Relevance of Wireless Technology and Standards to Provide Services in a Tertiary Institution.

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5th WWW Applications Conference 2003, Durban, South Africa.

ABSTRACT

The objective of this research was to investigate the relevance of using wireless technology and standards in a South African Tertiary institution. The most important factor to explore was to ascertain to what extent anywhere, anytime access to services required by students would be relevant for their use and how it would be accomplished. A project was launched to undertake this research.

The procedure followed was to setup and configure a wireless network and to acquire mobile devices. Wireless technology and standards were researched with special emphasis on mobile applications. The Wireless Fidelity (Wi-Fi) (Black Box Corporation. 2002) networking standard, Wireless Application Protocol (WAP), General Packet Radio Service (GPRS) and Bluetooth technology were used for this project.

The outcome of this research indicates that although wireless technology is relevant and available, applications would have to be developed to provide students with mobile services. Wireless technology provides a number of options, each offering advantages depending on the intended use, environment and infrastructure deployed.

The conclusion derived is that wireless systems do provide relevant solutions and that information technology departments and users should be made aware of these new technologies when planning upgrades or implementing future systems. The impact these systems would have on infrastructure and software applications must be considered accordingly. Wireless technology and standards, interface with existing information and technology systems to provide students with anywhere, anytime-mobile services. These findings provide a solution to the research by Oblinger, Resmer and Mingle (1998) defining a trend that students are moving to a 24-hour access learning-mode, originally limited to laptop computers, but now also includes other mobile devices.

Keywords

Wireless technology, mobile technology, wireless communication, tertiary institution.

1. INTRODUCTION

Student's lives and study patterns are changing due to increased availability and use of mobile devices such as Personal Digital Assistants (PDA's), laptop computers and new generation Web-enabled mobile phones. These devices are used for wireless Internet browsing and access to services, including mobile commerce (m-Commerce). Mobile education is defined as a service or facility that supplies learners with electronic information (including content) in the quest to acquire knowledge, regardless of location and time, made possible using mobile standards and technologies by Lehner, Nosekabel and Lehmann (2002).

Wireless technology and standards are playing an important role in the new paradigm of mobile education influencing student-learning patterns. This research also investigates how wireless technology and standards may be implemented at a tertiary institution and to what extent it can interface with existing information and technology systems and architecture.

2. WIRELESS TECHNOLOGIES

Wireless technologies and standards such as Bluetooth, GPRS, WAP and Wi-Fi are establishing themselves in industry. These technologies were used in a pilot project to develop mobile applications aiming to provide students with access to services anywhere and anytime. These technologies and standards were investigated to determine how students could access information and services using wireless connections. Interfacing these technologies to existing information and technology systems, networks and architecture were tested in a simulated environment.

3. Wi-Fi

3.1 General Information

The Institute of Electrical and Electronic Engineers (IEEE) specification of the 802.11 wireless LAN standard was developed by the IEEE committee in order to establish over the air (OTA) interfaces between wireless clients and base stations, commonly known as Access Points, as well as interfaces between wireless clients.

Wi-Fi generically refers to any type of 802.11 network, either 802.11b, 802.11a or 802.11g IEEE protocols. Technologies that contain both 802.11a and 802.11b technologies are commonly referred to as dual band. Certification of compliance is awarded by the Wireless Ethernet Compatibility Alliance (WECA), an industry group dedicated in promoting interoperation between 802.11 products. Wi-Fi Certification safeguards consumer information and improves business confidence using Wireless Local Area Network (WLAN) products bearing the official Wi-Fi logo. This signifies that such products have undergone and passed rigorous interoperability certification requirements.

3.2 Technical Information

The 802.11 standard is divided into 802.11a and 802.11b sub-standards. The 802.11b standard operates in the 2.4 GHz spectrum supporting a bandwidth of 11 Mbps for transmission of raw data at indoor distances of between 30 and 50 meters and outdoor

distances of up to 500 meters Davoli (2002). An additional standard, 802.11a for WLANs operating in the 5 GHz spectrum range with a maximum data rate of 54 Mbps is also available (Black Box Corporation. 2002.).

A recently ratified standard, 802.11g operates in the 2.4 GHz spectrum with a maximum data rate of 54 Mbps (Broadcom Corporation. 2003) provides backward compatibility with the 802.11b standard. This allows for continued support of 802.11b devices, thus protecting the substantial investments in 802.11b (Intel. 2002).

This extension of 802.11b is backward compatible to earlier 802.11 specifications allowing speeds of 1, 2, 5.5 and 11 Mbps respectively, on the same transmitter. Multiple 802.11b access points are able to operate in the same overlapping area but over different channels. The 802.11b, and later 802.11g standard is emerging as the only standard deployed for public short-range networks, typically implemented at airports, hotels, conference centers, coffee shops and restaurants, whereas 802.11a uses the relatively under-utilized 5 GHz spectrum. Although this 5 GHz spectrum is less crowded, the signals have higher absorption rates endangering it to be more easily blocked by walls and objects.

3.3 802.11a, 802.11b and 802.11g

The main draw-card migrating to 802.11a networks, is the availability of increased bandwidth with a near five-fold increase in the data communication rate of 54 Mbps, compared to the 11 Mbps data communication rate of 802.11b, ideally suited for applications such as audio, video streaming and network enabled games.

A drawback adopting 802.11a is the lack of compatibility between systems, using Orthogonal Frequency Division Multiplexing (OFDM) modulation. Businesses and institutions that have invested in 802.11b networks and related systems would be reluctant to migrate to a faster, but incompatible 802.11a network. As an interim solution, vendors developed dual-band wireless access points supporting both 802.11a and 802.11b devices, providing compatibility for devices operating in the same environment but minimizing interference as they operate at different frequencies. The technical implications are that 802.11g supports both, Complimentary Code Keying (CCK) modulation used in 802.11b and OFDM, making it the only standard for the foreseeable future (Broadcom Corporation. 2003), especially with it's distinct advantages of backward compatibility and high data communication rates.

4. BLUETOOTH

4.1 General Information

Bluetooth is an International open specification enabling short-range wireless, voice and data communications. The Bluetooth Special Interest Group (SIG) produced the Bluetooth wireless communication specification to be readily available and with no royalty payable. The open specification was the fundamental objective of the SIG to foster widespread acceptance of the technology Bhatt (2000).

Bluetooth enabled devices communicate by using radio waves to transmit and receive data specifically designed for short-range communication at a maximum operating distance of 10 meters. This could be extended to 100 meters using booster components. A significant design aspect was to ensure very low power consumption, making the technology suited for use in small, portable personal devices powered by batteries. This technology is well suited to a student environment where mobile phones and PDAs could be charged overnight at home.

Bluetooth communicates utilizing the unlicensed 2.4 GHz radio spectrum using a spreaded spectrum, facilitating frequency hopping and full-duplex signals up to 1600 hops per second. These radio wave signals are immune to bright - or darkness, penetrate obstacles and do not require being in line-of-sight with each other, as required by IRDA (Infrared Data Association. May. 2001). The signals hop between 79 frequencies at 1 MHz intervals offering a high degree of external interference immunity. This facilitates up to seven simultaneous connections making it ideal an ideal choice for use on a busy campus Bhatt (2000).

From a portability point of view, Bluetooth utilizes an interface mode that may offer an alternative interface to serial RS232 and USB connections used in modems, digital cameras and Personal Digital Assistants. Other peripherals such as printers, scanners, keyboards, mice and headsets could also utilize Bluetooth.

4.2 The Success of Bluetooth

It is a well-established standard allows industry and enthusiasts to use and expand the specification. Contributing to the success of Bluetooth is also being a cross-industry solution that marries a vision of engineering innovation to satisfy business and consumer expectations. The major advantage of Bluetooth is the easy mobile and re-configurable interfacing facility between devices requiring sporadic communication.

4.3 Limitations of Bluetooth

Bluetooth was not designed to carry heavy traffic loads and is not a replacement for LAN-, WAN- and Backbone infrastructures. It is also not intended to provide server-based applications.

4.4 Bluetooth Topologies

The fundamental building blocks of a Bluetooth topology are the Master and the Slave units, where the Master forms a piconet, providing the clock and hopping sequence to synchronize all other devices in the piconet. The Master also numbers the communication channels Bhatt (2000).

1. Piconet limited to 8 units:
 - Peer to Peer (or one master and one slave)
 - Multi-slave (up to 7 slaves with one master)

2. Scatternet

- Several piconets in constant communication

5. GPRS

5.1 General Information

GPRS is a data-only value added service for information to be sent and received across a mobile phone network. GPRS brings true packet data connectivity to the Global System for Mobile communications (GSM) market. GPRS's technology makes efficient use of radio and network resources and plays an important role to support third generation network (3G) products. GPRS must not be confused with GPS (Global Positioning System).

5.2 Key Network features of GPRS

5.2.1 Packet Switching

GPRS overlays a packet based air interface on the existing circuit switched GSM network (Cisco Systems. 2003). Supplementing circuit switched network architecture with packet switching is a major development. GPRS is delivered to network operators only needing to add infrastructure nodes and software to upgrade the service.

The Internet is an example of a packet data network.

5.2.2 Spectrum Efficiency

Packet switching technology governs GPRS radio resources used only when users are sending or receiving data, in contrast to dedicating a radio channel to a mobile data user for a fixed period of time. The available radio resource can be concurrently shared between several users. This efficient use of radio resources facilitates many GPRS users to potentially share the same bandwidth and be served from a single cell. The actual number of users supported depends on the application being used and the amount of data being transferred. Due to the spectrum efficiency of GPRS, less idle capacity is needed for use during peak usage periods.

GPRS improves the peak time capacity of a GSM network since it simultaneously:

1. Allocates scarce radio resources more efficiently by supporting virtual connectivity.
2. Combines traffic that was previously sent using Circuit Switched Data (CSD) to GPRS instead, thereby reducing short message service (SMS), Center and signaling channel loading by migrating some traffic that previously was sent using SMS to GPRS instead using the GPRS/SMS interconnect that is supported by the GPRS standards.

5.2.3 Mobile Internet Awareness

GPRS enables Mobile Internet functionality allowing interworking between existing Internet and GPRS networks. Services used over the Internet such as web browsing, chat, email and telnet will be available over the mobile network.

Web browsing is an important application and when routed via GPRS, uses the same protocols of the GPRS network, but can be viewed as a sub-network of the Internet with GPRS

capable mobile phones acting as mobile hosts. This could lead to each GPRS terminal having its own IP address.

5.3 Key User Features of GPRS

5.3.1 Speed

A theoretical maximum speed of up to 171.2 Kbps is achievable with GPRS using all of its eight timeslots simultaneously (Cisco Systems. 2003). GPRS proposes data rates from 56 to 114Kbps, three times as fast as the data transmission speeds possible over fixed telecommunications networks and ten times as fast as current CSD services on GSM networks. Allowing information to be transmitted faster, immediately and efficiently across the mobile network, GPRS could become a low cost mobile data service compared to SMS and CSD.

5.3.2 Immediacy

GPRS facilitates instant connections enabling information to be sent or received without delay as the need arises, depending on the radio coverage. No dial-up modem connection is necessary, making GPRS "always-on" (Agilent Technologies. 2000-2003). Immediacy is one of the advantages of GPRS (and SMS) compared to CSD. High immediacy is an important feature for time critical applications such as remote credit card authorisation or m-Commerce application, reducing the amount of time a user has to wait.

5.3.3 Service Access

To use GPRS, the following is required:

- A mobile phone or terminal that supports GPRS.
- Subscription to a mobile network operator that supports GPRS.
- GPRS must be enabled for the user. Some mobile network operators may allow automatic access to GPRS, others will require a specific configuration.
- Knowledge to send and/ or receive GPRS information using their specific model of mobile phone, including software and hardware configuration (this creates a customer service requirement).
- A destination to send or receive information through GPRS. With SMS this is often another mobile phone, in the case of GPRS, it is likely to be an Internet address, since GPRS is designed to make the Internet fully available to mobile users for the first time. GPRS users can access any web page or other Internet applications.

5.3.4 GPRS Applications

GPRS facilitates several new applications not available before over GSM networks due to the CSD speed limitations (9.6 Kbps) and message length of SMS (160 characters). GPRS fully enables Internet applications on desktops, spanning from web browsing to chat over the mobile network. Other applications for GPRS include File Transfer Protocol (FTP) and home automation - the ability to remotely access and control in-house appliances and machines.

GPRS offers a wide range of corporate and consumer applications listed below:

- Chat
- Text and Visual Information
- Still Images
- Moving Images
- Web Browsing
- Document Sharing (different people in different places can work on same document at the same time)
- Audio
- Corporate email
- Internet email
- Remote LAN Access
- File Transfer

5.3.5 GPRS Terminal classes

Terminal classes define mobile phones and mobile stations that support GPRS. GPRS terminal classes can be one of three classes: A, B or C (Agilent Technologies. 2000).

- A Class terminal can be connected to GPRS and GSM services simultaneously, GSM includes voice and SMS services facilitating both, GPRS and GSM calls simultaneously. Therefore Class A terminals support simultaneous circuit-switched and packet-switched traffic.
- B Class terminal can monitor GSM and GPRS channels simultaneously, but can only support one of these channels at a time, not simultaneous traffic. Class B terminals enable making or receiving voice calls or sending/receiving SMS during a GPRS connection. During voice calls or SMS, GPRS services are suspended and then resumed automatically after the call or SMS session has ended.
- C Class terminal can be attached to either a GPRS or GSM service where the user has to select the required service. Therefore Class C terminals can make or receive calls from the service they manually select and the non-selected service is not reachable.

6. WAP

6.1 WAP Information

WAP has become the de facto standard bringing Internet content and advanced technical services to wireless networks and wireless devices. WAP enables a range of new and innovative value-added services. WAP is a communication protocol between mobile devices or to a server installed on the mobile phone network.

WAP was designed to deliver information in a format suitable to be displayed on thin-client devices, such as mobile phones. In addition, WAP-compliant services and applications run over all network types. WAP, being a communications protocol and application environment can be built on most operating systems including PalmOS, EPOC, Windows CE, FLEXOS, OS/9, JavaOS etc. It provides service interoperability even between different device families.

6.2 WAP Operation

WAP follows a client-server approach. A micro browser is incorporated into the mobile phone, requiring limited resources, therefore making WAP suitable for thin clients. The intelligence lies in the WAP Gateways. The services and applications accessed by the micro browser temporarily reside on a server and not permanently on mobile phones. This client-server approach results in minimizing the utilization of resources on the mobile phone also enriching the functionality of the mobile network (Mobile Lifestreams Ltd. 2000).

WAP is a comprehensive and scaleable protocol designed for use with:

- Most mobile phones.
- Any existing or planned service including the following: SMS, CSD and GPRS.

6.2.1 Micro browsers

WAP-compliant mobile phones use built-in micro browsers to (Mobile Lifestreams Ltd. 2000) operate as follows:

- Launch a request in Wireless Markup Language (WML), a language derived from Hyper Text Markup Language (HTML) specifically for wireless networks, from the mobile phone using the built-in micro browser.
- Pass the request to a WAP Gateway, retrieving the information from an Internet server either in standard HTML format or WML. If the returned content is in HTML, a filter residing in the WAP Gateway will attempt to translate it to WML.
- Returning the requested information from the WAP Gateway to the WAP client.

7 Students use of wireless technologies and standards

7.1 WLAN usage by students

WLANs are extending the wired world airwaves, providing wireless access in classrooms, libraries, offices and common areas. Wireless access makes life more convenient and appealing to students as computer laboratories are often over crowded resulting in some students not being able to use a workstation. According to Bull, Bull, Garofalo and Harris (2002) education is facing an era of ubiquitous wireless computing. PDAs are regarded as

essential tools to stay organized and on schedule, fundamental requirements for learners Fryer (2002). WLANs are making student's lives easier by facilitating anywhere anytime access when they need to work.

7.1.1 Methods of access and services offered

Students can access a WLAN by using either a laptop, PDA or workstation. In order for laptops to access the WLAN a wireless network card (PCMCIA) needs to be installed including software drivers. A PDA can either have built in Wi-Fi capabilities or would require a Wi-Fi card or Wi-Fi sleeve in order to access the WLAN. Services that are accessible through the WLAN include logging onto the Intranet, browsing the Internet and printing to a network printer.

Students are therefore not restricted using workstations in computer laboratories to access services, provided wireless access points are available on campus.

7.2 Student use of GPRS, WAP

According to market surveys more mobile phones with GPRS support are being sold, thereby offering students GPRS connectivity wired directly to anytime and anywhere services which will revolutionise the way academic content, services and facilities will be provided.

WAP content delivered over GPRS allows students immediate access to WAP services. The use of GPRS over WAP results in a cost-effective solution and students would therefore only be charged for the amount of packet information transferred and not for the call duration spent online. Therefore, theoretically a student could stay online all day and not incur any additional costs, but only be billed when information is sent or received. WAP transfers information in a compact form, thus reducing the size of the information packets sent or received. Therefore, reducing the cost of accessing WAP services.

7.2.2 Available services accessible using GPRS and WAP services

GPRS facilitates students to access services that are provided on a web server. Although these services would have to be developed, GPRS allows students to connect to a particular service using their mobile phone and to interact with the application directly using a WAP micro browser on their mobile phones.

In order to successfully access these services the following are required:

- A WAP enabled mobile phone.
- A contract with a Mobile Service Provider that offers GPRS.
- GPRS enabled by their Mobile Service Provider. Without GPRS access, the WAP services would still be possible but the students would be charged for the amount of time they are online, irrespective of the size of packet information sent or received.
- Uniform Resource Locator (URL) of the service they wish to access.

7.2.3 Benefits of using GPRS and WAP

The use of GPRS and WAP facilitates anywhere, anytime access to services. This changes the study patterns of students making information access more convenient provided possible obstacles are overcome, e.g. the availability of affordable products and Information Communication Technology (ICT) integration to existing systems.

7.3 Future use of Bluetooth.

Bluetooth is becoming an important technology and cannot be excluded when planning future mobile systems. Bluetooth can be used to provide students with access to wireless services. Students can use their Bluetooth enabled mobile phones, laptops and PDAs to connect to a Bluetooth master, allowing them access to various services that reside on the Bluetooth master. This in turn, acts as a server to other Bluetooth slaves (clients).

There are various advantages that Bluetooth offers, for example, no additional billing to access services. Students can connect to a Bluetooth master from any given location as long as they can communicate with the Bluetooth master, therefore they are not restricted to be in a classroom or computer laboratory to access these services. Connecting to a Bluetooth master is a relatively simple and user-friendly process.

8 Conclusion

Due to the increased availability of affordable mobile devices such as laptop computers, PDAs and mobile phones, students would be able to acquire mobile devices and expect to use them on campus. This action calls for new perspectives on education as far as facility management, content delivery and provision of services are concerned.

Although the former two mobile devices are becoming affordable, advanced mobile phones are now issued at entry-level offering Java, GPRS and Bluetooth enabled capabilities.

During this research project it was not possible to identify a particular leading technology or to rank the various technologies in some order of preference, but all will most probably coexist, each technology offering a particular solution or advantage for a specific application.

From the literature surveyed, Wireless 802.11b and 802.11g networking standards will be the industry leading WLAN standards, WAP and GPRS will be used to connect to wireless services and the Internet from mobile devices, and Bluetooth will be the wireless interfacing standard between peripherals. Future expansion of ICT systems and networks will have to incorporate mobile architecture and offer mobile applications.

For the foreseeable future, the bridge between existing (traditional) ICT and the new mobile paradigm will be the adoption of wireless technologies and standards. This research considered the wireless technologies available and concludes that institutions will have to provide and maintain mobile services to their students.

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