The Significance of Wireless Local Area Networks for the University Sector

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Abstract

The wireless networks create new opportunities for university teaching. Conventional classrooms can be converted within minutes into computer laboratories providing access to local and remote databases, multimedia presentations, telephony (voice over IP) and other resources. Students bring laptop computers with wireless network cards to the classroom and gain access to the university network through the wireless access points. Other benefits include access to the university library, online study groups or online enrolments from any place within the range of the wireless network.

The paper outlines the fast progress of wireless technology in relation to the university teaching and problems related to the multiplicity of standards. Also explained are the differences between major wireless Local Area Network standards. In addition, the paper summarizes the required equipment and provides details of two wireless networks from the university sector.

Introduction

Installation of the conventional wired Local Area Networks (LAN's) requires an expensive cabling system. Finding a fault in such system is not a trivial task and requires a lot of experience and the application of advanced network management tools.

The Wireless Local Area Networks (WLAN's) are a less expensive option and more importantly revolutionize university teaching by providing a previously impossible degree of flexibility.

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Conventional classrooms are used not only for lectures but also can be converted into computer laboratories. The concept brings not only a more effective use of teaching space but also enriches the teaching process.

Students bring laptop computers with wireless network cards to the classroom and gain immediate access to lecture materials and application software.

A lecturer or tutor can conduct student assessments, such as multiple-choice tests, with an immediate evaluation of responses.

Multimedia presentations, based on the wireless broadband technology, are another possibility.

Wireless access points, located at strategic locations of the university campus, give students and staff access to all network services, including library catalogues, on-line enrolments and the Internet.

Regular university events, such as enrolment days, require access to a secure computer network. The wireless technology allows a quick deployment of a network in any temporary location — gymnasium, lecture theatre, cafeteria, etc — without the need for expensive permanent cabling for data and voice communications. The *voice over IP* technology integrates telephony and computer networks.

In case of a multi-campus institution, such as Edith Cowan University, a single set of equipment can be moved easily between campuses, eliminating the need for expensive duplications.

Once the teething problems of the new technology — lower speed and lack of a universal standard — are solved, a wireless university campus can become the norm rather than exception.

Wlan Frequency Spectrum

The frequency spectrum, which determines the present and future potential of wireless communications, has become a scarce and precious commodity.

For a short-range system, such as Wireless Local Area Network, it is possible

to share the spectrum with the *Industrial, Scientific and Medical* (ISM) bands allocated by the International Telecommunications Union, an agency of the United Nations. Unfortunately, as Tables 1 and 2 indicate, there is no agreement between the European and the U.S. legislators about the frequency ranges for ISM bands.

As the name indicates, ISM bands are not entirely available to wireless communications but shared with industrial, scientific and medical equipment, such as microwave ovens and medical scanners. Overcrowding and interference problems have forced the legislators to allocate additional bands for high-speed Wireless Local Area

Table 1. ISM Bands Recommended by the European Telecommunications Standards Institute (ETSI) [1].

Band	Frequency Range	Bandwidth
ISM-900	890-906 MHz	16 MHz
ISM-2.4	2.4-2.5 GHz	100 MHz
ISM-5.8	5.725-5.875 GHz	150 MHz

Table 2. ISM Bands Recommended by the U.S. Federal Communications Commission (FCC) [1].

Band	Frequency Range	Bandwidth
ISM-900	902-928 MHz	26 MHz
ISM-2.4	2.4-2.4835 GHz	83.5 MHz
ISM-5.8	5.725-5.850 GHz	125 MHz

Networks. As for ISM bands, there are discrepancies between the world regions (Table 3).

The European HiperLAN band has its U.S. counterpart called U-NII (Unlicensed National Information Infrastructure). The HiperLink band extends the WLAN range, allowing communications between rooms and floors of a large

Table 3. Frequency Bands for High-speed WLAN's [1].

Band	Freq. Range	Bandwidth	Available
U-NII	5.15-5.35 GHz	200 MHz	U.S.
HiperLAN	5.15-5.3 GHz	150 MHz	Europe
HiperLink	17.1-17.3 GHz	200 MHz	Europe
MBS	57-61 GHz	4000 MHz	Worldwide

building.

In future, the Mobile Broadband System (BMS) will significantly increase the WLAN bandwidth.

Wlan Standards

A major problem facing Wireless Local Area Networks is the multiplicity of standards. Most standards are authored by the Institute of Electrical and Electronics Engineers (IEEE) and the European Telecommunications Standards Institute (ETSI) — see Table 4.

The oldest standard — IEEE 802.11 – is based on the Frequency Hoping Spread Spectrum (FHSS) or the more advanced Direct Sequence Spread Spectrum (DSSS).

Table 4. WLAN Standards [1].

Standard	Band	Speed
IIEE 802.11 (FHSS)	ISM-2.4	1 Mbps
IIEE 802.11 (DSSS)	ISM-2.4	2 Mbps
IIEE 802.11b	ISM-2.4	11 Mbps
IIEE 802.11a	U-NII	54 Mbps
HiperLan 1	U-NII	23.5 Mbps
HiperLan 2	U-NII	54 Mbps
HomeRF	ISM-2.4	1 Mbps

The Direct Sequence Spread Spectrum method, used also by IEEE 802.11b, increases the transmission speed from 1Mbps to 2 Mbps or 11 Mbps.

The highest transmission rates of 54Mbps, still below the common 100MBps for the wired Local Area Networks, are achieved by the IEEE 802.11a and HiperLan 2 standards.

The HomeRF standard, as the name indicates, has been specifically developed for home users.

Despite its significance, the **Bluetooth** [2] standard is not listed in Table 4 because it has been developed for so called Personal Area Networks, rather than full-scale Local Area Networks. A Personal Area Network connects not only Personal Computer and printers but also mobile phones and Personal Digital Assistants (PDA's), and in fact, any digital device which can accommodate a Bluetooth chip. Such a chip will offer transmission speed of 1 Mbps with the range of 10 m at the cost of five dollars. Other key features of the Bluetooth technology, operating in the unlicensed ISM-2.4 band, are robustness, low complexity and low power consumption — an important characteristic for battery driven devices. The standard provides a built-in data encryption scheme.

Equipment

The simplest case is an ad-hoc network consisting of a small number of computers equipped with wireless network cards (see Figure 1).

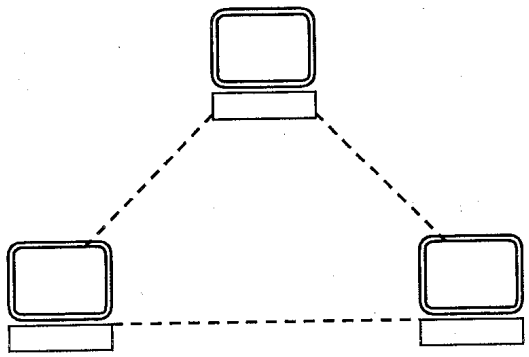

Figure 1. Ad-hoc network.

In case of the HiperLAN standard it is possible to extend the network range by relaying data from one computer to another [1] (see Figure 2).

A campus-wide WLAN requires a large number of access points, strategically located in buildings and open areas. Access points not only extend the range of wireless communications but also constitute a gateway to the conventional wired Local and Wide Area Networks (see Figure 3).

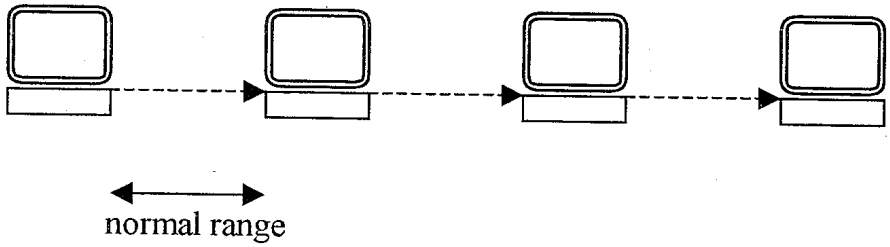

Figure 2. Extending the network range.

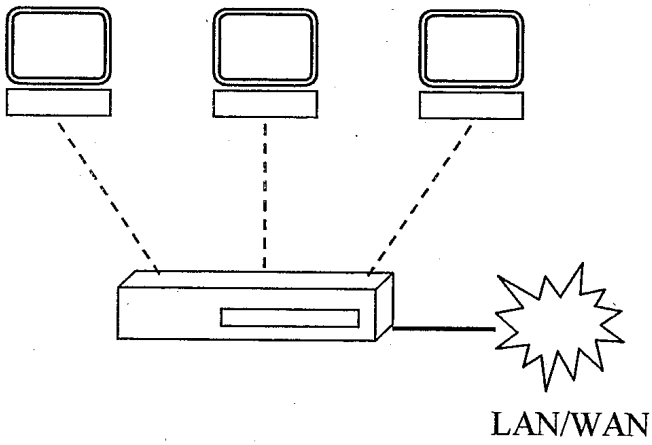

Figure 3. Wireless network with an access point.

Wireless Local Area Networks are not necessarily less secure than their wired counterparts. Most WLAN's use the spread-spectrum radio transmission, a technology resistant to interference, jamming and unauthorized detection [3].

Another security mechanism is Wired Equivalent Privacy (WEP) protocol for user authentication and data encryption.

Typical characteristics of the WLAN modules are listed below.

Wireless LAN Card [4]

- Type II PC card
- IEEE 802.11b standard, 11Mbps
- Internal antenna plus a connector for an external antenna
- Ad-hoc networking support and access to wired networks via access points
- Wired Equivalent Privacy (WEP) protocol
- 128-bit key encryption.

Access Point [5]

- IEEE 802.11b standard, 11Mbps
- Backward compatible with IEEE802.11
- Supports up to 50 nominal users who are mostly idle waiting for e-mails
- Supports 25 mainstream users who download or upload medium-size file
- Supports 10–20 power users who download or upload large files
- Maximum range for 11 Mbps: 30 meters
- Maximum range for 2 Mbps: 90 meters.

Additional access points can be used to increase the network capacity.

Application of the wireless communication is not restricted to the Local Area Networks (LAN's). A LAN-to-LAN bridge can connect two campus buildings. Wireless Metropolitan Area Networks (WMAN's) and Wireless Wide Area Networks (WWAN's) expand the range to a metropolitan area, or even a whole country. Table 5 outlines differences in range and transmission speed.

Table 5. Differences between wireless technologies [3]

	WLAN	LAN-LAN bridge	WMAN	WWAN
Range	Building or campus	Building to building	Metro area	Country
Typical speed	1-11 Mbps	2-100 Mbps	10-100 Kbps	1-32 Kbps

Two Examples of Campus-Wide Wireless Local Area Networds

An early example of a campus-wide wireless network is the so called *Wireless Andrew* implemented at the Carnegie Mellon University [6].

The development of this large-scale network began in 1994 under the umbrella of a research project funded by the U.S. National Science Foundation.

Back in 1994, as is the case today, wireless technology was a new and untested territory and therefore Wireless Andrew was developed in close partnership with an industry partner.

The partner's commitment to innovations and close cooperation with the University was critical for a successful completion of the project.

Wireless Andrew is a case study of good project management. The network had been developed in stages, starting from a pilot sub-network covering three floors of a university's building. The pilot installation provided invaluable experience in optimal distribution of access point leading to the next development stage with 100 access points, covering six buildings or 50% of the University teaching, research and office space.

Access points were connected to the conventional wired campus network through building hubs and a router.

The university implemented the mobile IP protocol allowing a user to have a single IP address at any campus location and connection type (wireless or wired).

The final stage will cover all 28 academic and administrative buildings of the 40-hectare campus, servicing 10,000 students and staff [7].

In Australia, the University of Wollongong and Nortel Networks are developing a broadband WLAN with IP VPN (Internet Protocol Virtual Private Network) capabilities. Students and staff will use laptop computers or Personal Digital Assistants (PDA's) to access the Internet, electronic mail, databases, interactive applications and remote printers. Access to these services will be provided by

access points with the range between 60 and 90 metres inside buildings and up to 600 metres in the open space [8].

Also Edith Cowan University (ECU) has a partnership arrangement with Nortel Networks. Nortel has been selected as the preferred supplier of a multi-million dollar upgrade of the ECU network servicing 20,000 students, including 4,000 studying in the on-line mode. All students have access to course materials via the ECU Virtual Campus system.

Conclusions

The growth of Wireless Local Area Networks is hampered by the lack of a common standard. The U.S. supports the new generation 54 Mbps IEEE 802.11a standard while Europe promotes HiperLan 2 (see Table 4). Nevertheless, the wireless technology is spreading rapidly and university educators should not ignore its benefits manifested by the fact that:

- Students and staff gain access to information anywhere on campus which provides enormous educational benefits;
- Temporary networks can be deployed anywhere on campus during students enrolments at the beginning of an academic year or when we want to convert a conventional classroom into a computer laboratory;
- Total Costs of Ownership (TCO) is reduced, despite higher costs of the WLAN equipment;
- WLAN's are scalable, supporting a few users of an ad-hoc network or thousands of users of a campus-wide network.

Acknowledgment

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