Applications of Medical Wireless LAN Systems (MedLAN)

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ABSTRACT

In this paper the Wireless LAN (WLAN) networking principals are presented along with some of the implementation scenarios dedicated for Accidents and Emergencies wards. Preliminary simulation results of the MedLAN concept are also presented together with ongoing and future work in this area.

Keywords: Telemedicine, WLAN, IEEE802.11b, telecare, Hiperlan/2, IEEE1394

INTRODUCTION

The applications of emerging wireless technologies for medical environments is a new and evolving area of telemedicine that exploits the recent developments in mobile networks for telemedical applications in general [1], [2].
The aim of this paper is to present the main design and development elements of an integrated mobile WLAN system dedicated to accident and emergency wards and describe the anticipated challenges from both the telemedical and telecommunications point of view.

In typical medical scenarios, WLANs represent a practical and highly flexible way of transmitting data. This can be attributed for the following reasons:

- Older hospital structures and buildings are not suitable for cabling and wired LAN applications, with cost effective installations.
- Mobility issues, where staff on the move can access their patients from different access points in complete roaming capabilities.
- Installation flexibility as the network can reach places the wire can not.
- Scalability, as the network can be configured to various topologies to suit the changing needs of a hospital
- A wireless LAN can work as an independent network, as well as in conjunction with an already existing LAN [Fig. 2]

WIRELESS LANs STANDARDS AND NETWORK TOPOLOGIES

There are four main wireless LAN standards ranging from the already established IEEE802.11 to the very new and still unstandardised Hiperlan/2.
Table 1 presents an overview of the four most well known wireless LAN technologies along with their basic communication characteristics. [3]

	IEEE 802.11a	IEEE 802.11b	Hiperlan1	Hiperlan2
Frequency band	5GHz	2.4GHz	5GHz	5GHz
License (ISM)	No (Not applicable in Europe)	No	No	No (not applicable in Japan)
Frequencies	5.15-5.30 & 5.47-5.725 (Non-Europe) 12 channels	2.4-2.483 GHz, 3 non overlapping channels	5.15-5.30 GHz 5 channels	5.15-5.30 & 5.47-5.725 (Europe)
Max capacity	20Mbps	11Mbps	20 Mbps	54Mbps
Intermediate speeds	6, 9, 12, 18, 24 Mbps	1, 2, 5.5, 11 Mbps	6, 12, 24 Mbps	6, 9, 12, 18, 27, 36, 54 Mbps
Modulation	BPSK, QPSK, 16QAM, 64QAM	DBPSK, DQPSK, CCK	GMSK	BPSK, QPSK, 16QAM, 64QAM
MAC	Ethernet based	Ethernet based	Ethernet based	ATM based
Typical Power	25mW	30mW	0.1-1W	25mW
QoS	Low	Low	Medium	High
Possible Interference	Satellite com (not for open environments)	Microwave ovens, cordless phones, Bluetooth, fluorescent lamps	Satellite com (not for open environments)	Satellite com
Types of applications	WLAN, real-time	WLAN, real-time	WLAN	WLAN, video, broadcast, MPEG
Typical radius	20-100m	30-200m	20-100m	20-100m
Cost today	Low	Low	Medium	High
Number of applications today	Medium	High	Low	Low

Table 1. Comparison of WLAN standards and technologies

A brief discussion of these standards is given here for completeness:

- IEEE802.11a is mainly used in the US. It is a protocol capable of transmitting up to 24Mbps of data (with some being used to control the traffic), using the 5GHz band.
- IEEE802.11b is the former protocol's equivalent to the European market. Its speed is limited to 11Mbps, as it uses the 2.4GHz band, but there are products on the way, that will increase its speed to 20Mbps. Plenty of devices are available to the market, supporting this protocol that is the European standard nowadays.
- Hiperlan/1 was established by the ETSI at 1996. Using the same band as IEEE802.11a, it provides similar characteristics.
- Hiperlan/2 is the new protocol that promises high data rates with unparalleled QoS, suitable for telemedical applications. Specifications and working parameters of this standard are currently under development. [4]

MedLAN: SYSTEM DESIGN AND MODELLING ISSUES

The current system's design and research methodology is divided into three main tasks representing the pyramid development procedures of such application:

- Modelling and simulation studies to define the biomedical digital signal processing requirements for internetworking operational modes with 2G and 3G mobile systems [2], [3], [Fig. 4]
- System hardware and software design to implement a mobile MedLAN system capable of transmitting several channels of medical data and information
- Clinical testing and evaluation of the prototype MedLAN model, radio link and data acquisition server.

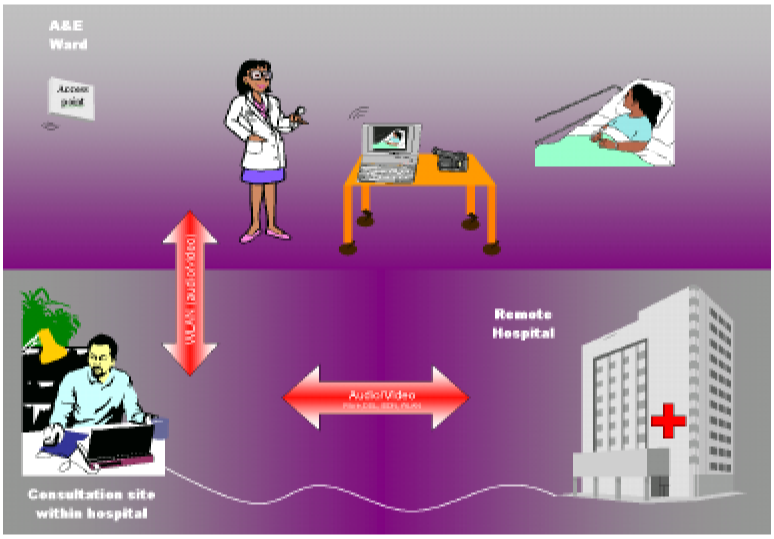

Fig. 1. Schematic of the MedLAN system

A schematic of the MedLAN system, is shown in Fig. 1. It consists of the two main parts: The mobile trolley that exists in the Accident & Emergencies ward (A&E) and the consultation point, within the hospital.
The mobile trolley consists of a high performance laptop computer that is equipped with a WLAN PCMCIA card (initially using the IEEE802.11b protocol) that will permit total mobility within the A&E room and beyond. An access point within the A&E room, acts as a transiver for the network data to be transmitted to and received from the rest of the network structure. A high quality digital camcorder is connected to the laptop and with the use of the IEEE1394 protocol, high-resolution video and audio is transmitted. Additional medical instruments (like otoscopes, dermascopes etc) are also connected to the laptop providing a low-weight compact roaming system. It is expected that the weight of the contents of the mobile trolley would not exceed 4 kg.

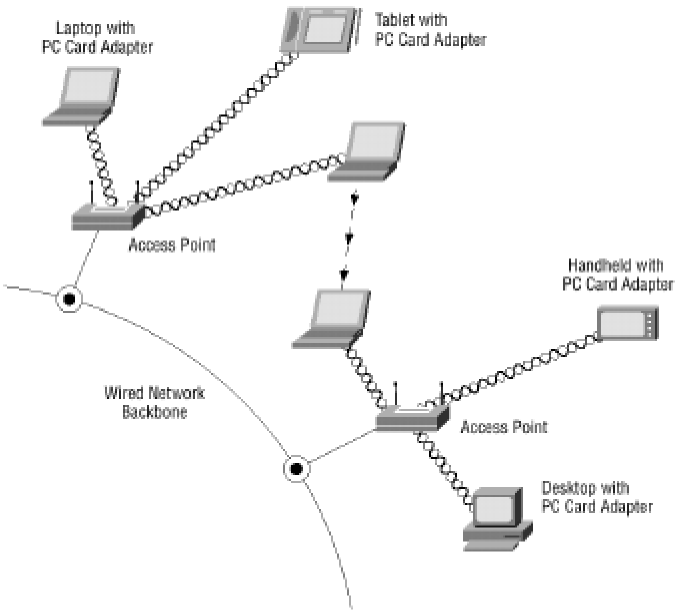

Fig. 2. Connection network topology of the MedLAN system

In the consultation point (that can be at any location within the hospital) the consulting physician can have a choice of teleconferencing either from a fixed computer within the existing hospital network, or a mobile laptop, sharing the same mobility advantages as the former laptop. It will even be capable of transmitting video to a PDA pocketsize computer [Fig. 2], thus taking advantage of the recent developments in PDAs. This way (and by placing additional access points to the general area where the consulting doctor would be), the doctor can move around the area while only carrying a 200 gr PDA. The PDA will be equipped with a PCMCIA card and it would be able just to receive video.
A simple block diagram of the system is presented in Fig. 3. It displays the two main areas (A&E ward and Consultation point), along with the basic components of the system.

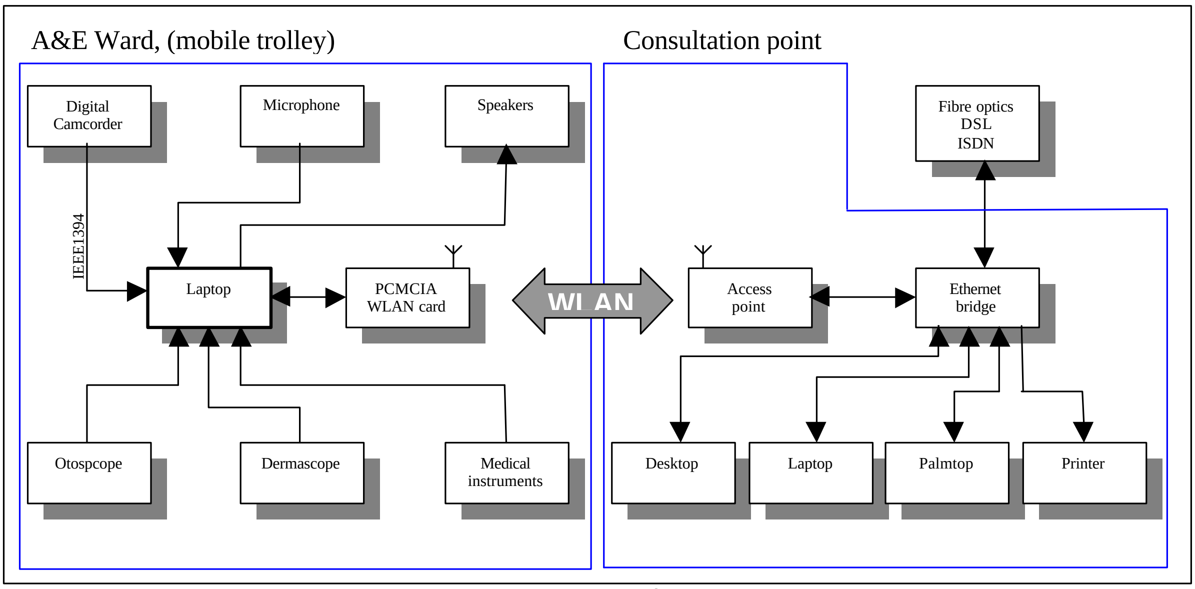

Fig. 3. A simple block diagram of the MedLAN system

For the modelling purposes of this project, OPNET Modeler 7.0 was chosen. This software package includes a radio library that permits simulation of Wireless networks.

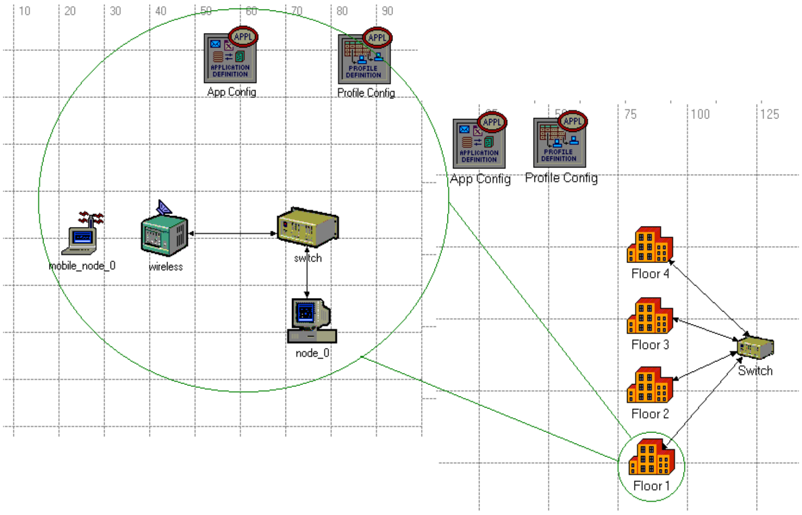

Fig. 4. MedLAN model using OPNET Modeler

Fig. 4 shows the model created. It consists of a wireless node (mobile_node_0) that represents the laptop computer that roams around the A&E ward, an access point that will probably be placed in the centre of the ceiling of the A&E ward (wireless), a fast switch responsible for distributing the data (switch) and a desktop computer (node_0) that will be placed in the consultant's office. All the possible applications that the units can use, are stored within "App Config" while the settings for the applications that were used in this specific model, are within "Profile Config". Overall, the modelling of the system produced encouraging results, proving the feasibility of the MedLAN project.

DISCUSSION

The work is currently ongoing on the implementation of the system in a typical West London hospital: Central Middlesex Hospital, Accidents & Emergencies ward.
Although there are numerous possibilities about the use of WLAN in such environments, applications can be summarised as follows:

- Rescue services to main base A&E Department.

Rescue services like the fire-brigade go to main A&E departments so that there is no delay in the extrication of casualties. It would be useful to transfer image and conversation from the accident scene to the base hospital. An example would be for a doctor to authorise a simple removal of the casualty from the car through the door, instead of cutting off the roof. The time is bound to come when drugs and therapy will be delivered in the home, instead of going through the delay of bringing the patient to the hospital.

- Point of care clinical protocols or medical information

Some doctors and nurses already use PDAs for this purpose but the use becomes restricted because of the limitation of storage capacity on a PDA, so it is easier to link a notebook or a PDA through WLAN to a central resource. This removes the need for the doctor to move to a fixed computer point to access such information.

- Inventory checks and maintenance schedules

These involve data entry on pieces of paper and subsequent tallying, much of which can be streamlined as in supermarkets.

- Medical availability

Doctors now aspire to a leisure-orientated time-restricted lifestyle but they would like to be available from a variety of locations. The use of notebooks, sub-notebooks or PDAs would be a perfect way of maintaining that contact with their peers or base.

- Virtual hospital bed

Although we envisage that in the future this will be a reality, there will remain an application of WLAN for low dependency areas in the short term with WLAN devices on carts with option of addition of peripherals like otoscopes, opthalmoscope, etc for enhancement of the ability to establish a diagnosis.

- Patient transfers

At the moment transfers from one part of the hospital to another can be so bureaucratic and so fraught with loss of information, current state of the patient etc, that it would be easier to transfer a WLAN device to transmit patient information, images etc.

- Multi-professional education

Emergency medicine is one area in which there have been significant advances in teaching nurses to perform doctors' work. This has brought the need of multi-professional education to the fore. Currently there are difficulties of scheduling doctors' and nurses' study time together, but it is easy to envisage that in the future a group of hospitals would band together to achieve this and still leave enough persons on the shop floor.

Another important aspect of this research in this area will be the design of a system that remains compatible with future developments in mobile radio networks. This is particularly important considering the speed of the progress that the wireless products have experienced over the last few years.
The future promises new wireless devices (that will adopt the Bluetooth protocol), higher bandwidth (after the final release and commercialisation of Hiperlan/2) and smaller and more convenient PDAs that will eventually replace laptop computers in telemedicine scenarios.
HiperLAN/2 is increasingly getting the interest of the engineering community. With its official release, it will offer much higher bandwidth (up to 54 Mbps), but most importantly, Quality of Service (QoS); a function that is missing from today's protocols [Table 1]. This way, the user will be able to select tasks that are more important than others, thus decreasing the fluctuation that the network suffers from and offer higher bandwidth to the real time applications. Additionally, HiperLAN/2 will internally support IEEE1394 protocol that MedLAN uses for video transfer, and will lead to the elimination of the protocol conversions and the increase of the video quality. Finally and most importantly, HiperLAN/2 will act as a bridge between WLANs and UMTS thus being able to transmit video in any cellphone, anywhere in the world.

CONCLUSIONS

This paper presents the design concepts of MedLAN system dedicated to a wireless networking system in A&E hospital wards. This system demonstrates a new and emerging type of mobile telemedical services and attempts to show that there are important benefits of exploiting the emerging wireless LAN technologies in hospital environments.
The preliminary modelling results has shown that the MedLAN network can provide a working system in typical A&E wireless traffic scenarios, with acceptable performance.

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