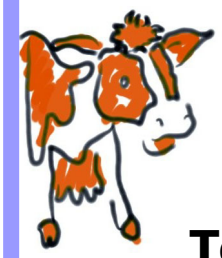

Wireless Data Communications Systems: Technologies, Challenges and Future Trends

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ABSTRACT

This paper presents an overview of the current technologies, some challenges and future trends of wireless data communication for portable systems. The paper highlights the current technologies and standards (IEEE 802.11, BRAN HIPERLAN/2, SWAP HomeRF and Bluetooth) of wireless data communication. It also describes current status of the markets of wireless data communication systems. The paper addresses some challenges and problems behind wireless data communication systems as well as future trends. Finally, the teaching and learning strategies for these technologies of wireless data communication systems are discussed.

Keywords: Wireless LAN, IEEE 802.11, HIPERLAN/2, HomeRF, Bluetooth, CSMA/CA.

1. INTRODUCTION

The need for data communication for mobile users (for instance; at the airport, hospital, warehouse, hotel, home and restaurant) is expected to accelerate the demand for wireless data communication systems. The wireless data communication industry has experienced rapid development in the past few years. Starting from the wireless local area network (WLAN) technology, more and more technologies and applications are developed for expanding the market (Rappaport 2002, Pahlavan 1997). With the finalisation of new series of IEEE 802.11 and high performance radio local area network (HIPERLAN) standards, WLAN is evolving into very high-speed data transmission supporting both data and voice (Mobileinfo 2002, Johnson 1999). These new trends of WLAN technology will certainly become the impetus for the fast development of markets. However, the slow deployment of WLANs in the past years has created opportunities for other technologies such as Bluetooth and HomeRF.

In this paper we provide an overview of the current technologies, some challenges and future trends of wireless data communication for portable systems. First an overview of the current technologies and standards of wireless data communication is presented. Then the current status of the markets of wireless data communication systems is described. Challenges and problems behind wireless data communication systems as well as future trends are discussed. Discussion on the teaching and learning strategies for these new technologies of wireless data communication systems is followed by a brief conclusion.

2. TECHNOLOGIES AND STANDARDS

In this section we provide an overview of current technologies and four standards of wireless data communication systems:

- Wireless LAN IEEE 802.11
- BRAN HIPERLAN/2
- SWAP HomeRF
- Bluetooth.

2.1 WIRELESS LAN IEEE 802.11

The WLAN is a local area network implemented without wires. The main advantages and benefits of WLAN are the mobility and cost-saving installation (Ciampa 2001, Hills 2001, Riezenman 2001). Many jobs require workers to be mobile, such as inventory clerks, healthcare workers, police officers, and emergency-care specialists. Wireless networking provides significant cost savings in the areas where cables cannot be easily installed, such as historical buildings, and residential houses. Conclusively, wireless networking is applicable to all situations where mobile computer usage is needed and/or the cable installation is not feasible. It can also be used as an extension to the wired backbone LANs.

The IEEE 802.11 standard will likely become the dominant standard for WLANs. It defines a local area network that provides cable-free data access for clients that are either mobile or in a fixed location. There are two possible architectures for a WLAN under the IEEE 802.11 specification as shown in Figure 1.

The stations can communicate directly with each other in ad hoc networks. In access point (AP) based networks (or infrastructure networks) the mobile stations communicate directly with an AP that is connected to the wired network. The maximum range from the AP to the computers is determined by the amount of interference (eg. concrete walls) but is typically 30 to 150 meters. More details about the IEEE 802.11 standard can be found in (ZDNet 2002). The channel access method of 802.11 is a scheme called Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA).

2.2 BRAN HIPERLAN

The broadband radio access networks (BRAN) specifies a family of wireless network standards, which are collectively referred to as high performance radio local area networks (HIPERLAN). The BRAN family of standards includes HIPERLAN Type 1 (high speed wireless LANs), HIPERLAN Type 2 (short range wireless access to IP and ATM networks) both operating in the 5 GHz bands. The HIPERLAN/1 standard was approved in 1996, but no products appeared in the market. The HIPERLAN/2, which is currently under development, is believed to be able to replace the old Type 1 standard (Johnson 1999).

HIPERLAN/2 has three basic layers namely, physical layer (PHY), data link control layer (DLC), and the convergence layer (CL). The DLC layer constitute logical link between an access point and mobile stations. The media access control (MAC) protocol is Time-Division Duplex (TDD) based dynamic Time-Division Multiple Access (TDMA).

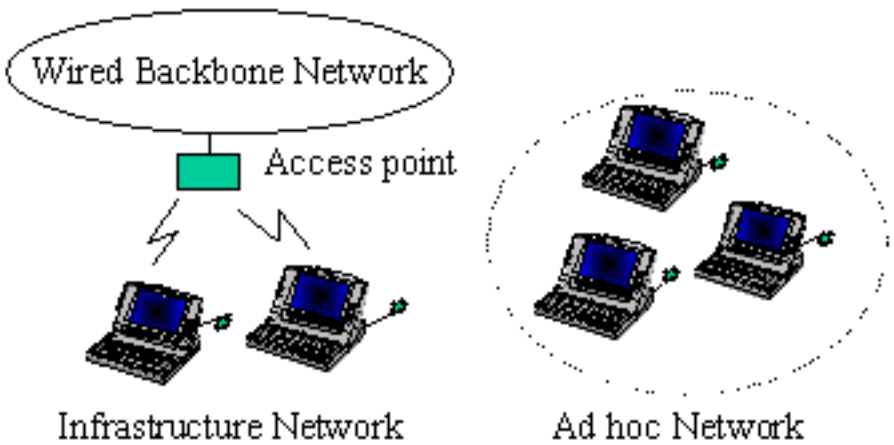

Figure 1. Architecture of IEEE 802.11 WAN

The time slotted structure of the medium allows for simultaneous communication in both downlink and uplink within the same time frame that is called MAC frame in HIPERLAN/2.

2.3 SWAP HOMERF

The home wireless network is based on the shared wireless access protocol (SWAP), which defines a set of specifications for wireless data and voice communications around the home. Devices for wireless home network can be as far as 45 meters apart, and can send and receive data up to 5 Mbps. Home networking devices include PC, laptop, printer, cordless telephone, and home entertainment equipment (eg. remote CD player).

The HomeRF consortium is an industry working group including major players in the PC industry (Compaq, Hewlett-Packard, IBM, Intel and Microsoft), and in the wireless telecommunication and consumer electronic industry (Ericsson, Motorola, Philips, Proxim and Symbionics). More details about home wireless networking can be found in the literature (Teger 2002, HomeRF Homepage 2002, HomeRF 1998).

The SWAP specification defines a common air interface that supports both wireless voice and LAN data services in the home environment. The SWAP operates in the 2.4GHz unlicensed industrial, scientific and medicine (ISM) band using digital Frequency Hopping Spread Spectrum technique. The SWAP supports both a TDMA service to provide delivery of interactive voice and other time-critical services, and a CSMA/CA service for delivery of high-speed packet data, such as TCP/IP.

The SWAP system can operate either as an ad hoc network or as managed network under the control of a access point. In an ad hoc network, where only data communication is supported, all stations are equal and control of the network is distributed between the stations. For time critical communication such as interactive voice, a access point is required to coordinate the system.

2.4 BLUETOOTH

The objective of Bluetooth technology is to replace cables and infrared links used to connect disparate electronic devices with one universal short-range radio link. Bluetooth enabled devices communicate using small radio transceivers, called radio modules, built onto microprocessor chips. Each Bluetooth device also uses a link manager, which is special software that helps identify other Bluetooth devices, creates the link with them, and sends and receives data. A Bluetooth device can transmit data at up to 1Mpbs over a distance of 10 meters. Bluetooth can send data through physical barriers such as walls and can send to one or many different devices all at the same time. A Bluetooth network is called a piconet and consists of no more than eight devices but can be linked to other piconets to form a larger network.

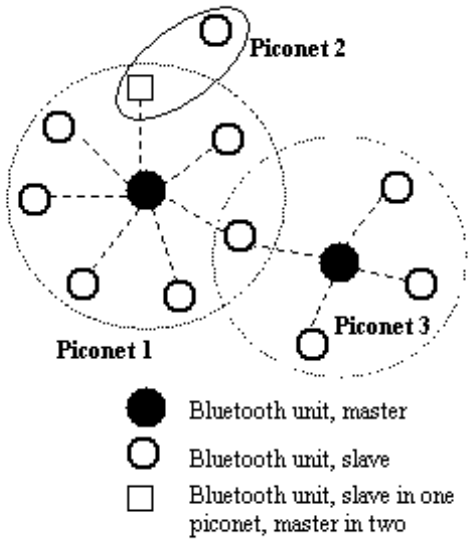

Figure 2. Architecture of Bluetooth networks

Figure 2 shows the ad hoc piconet architecture of Bluethooth (Johansson 2001).

Bluetooth is an unofficial standard but may soon be standardised as IEEE 802.15 (Bluetooth 2002). Bluetooth operates in the 2.4GHz ISM band using frequency hopping spread spectrum. TDD radio access scheme is used for full duplex transmission.

3. MARKETS OF WIRELESS DATA COMMUNICATION SYSTEMS

The wireless market over the past few years has been a particularly exciting environment with advancements in technology bringing mobile convenience to the hands of the customer. Nowadays 11 Mbps IEEE 802.11b based products are dominating the WLAN market. The emergence of

broad market and wide deployment of WLAN has been expected for so many years to date. But the development of WLAN market has been held back due to issues such as poor marketing, relatively high price and relatively low throughput (compared to the wired counterparts). Most recently with the standardization of HIPERLAN/2 and IEEE 802.11a (54 Mbps) and IEEE 802.11b (11 Mbps), a new fast development of market is being expected again.

According to a report from global research firm Frost & Sullivan, the market of Bluetooth is predicted to be $699.2 million by 2006 (Pearse 2000). The widespread industry support for the technology (including more than 1000 companies in the Bluetooth Special Interest Group) is believed to be the main force to ensure the successful future of tis new technology.

4. CHALLENGES AND FUTURE TRENDS

At present, one of the main challenges encountered by the wireless data communication industry is the interoperability between various standards, i.e. IEEE 802.11, HIPERLAN/2, SWAP HomeRF and Bluetooth. The IEEE 802.11 and the HIPERLAN/2 are incompatible and competing standards applying to almost the same wireless LAN applications. But with the increasing role of the laptops carried by business people and students in retrieving information through Internet, interoperability between these standards is greatly desired. If they are compatible, people can access Internet with laptops when one comes within a wireless LAN service (free or charge service) area in campus, office building, conference, meeting room, exhibition hall, airport, hotel, etc.

The market of HomeRF partly overlaps with wireless LAN and partly with Bluetooth. As a result, the same issue of interoperability exists for HomeRF. Users would not like three different technologies, which only means they have to buy three different things to do almost the same job. In the future, the 'plain' interoperability is most probably not a limiting issue due to multimode terminals (eg. by software radio technology) and intersystem-roaming possibility (Lettier, 1999).

Another main concern arises from Bluetooth. The intended Bluetooth devices (such as cellular phone, camera, notebook and headset) are mostly carried along by users. So, there are great chances that Bluetooth devices come into the service areas of wireless LAN or HomeRF. On the other hand, Bluetooth is always on and is designed to automatically configure itself into an ad hoc network as devices come within the range of each other. HomeRF and IEEE 802.11 frequency hoping system as well as Bluetooth system all operate in the unlicensed 2.4 GHz ISM band using Frequency Hopping Spread Spectrum (FH/SS) technology.

Fast hoping Bluetooth signal is very possible to kill wireless LAN packets, which has much slower hopping rate. In the long run, Bluetooth will have to become interoperable with wireless LAN and HomeRF. As the finalisation of IEEE 802.11a and HIPERLAN/2 approaches, one possible solution is that wireless LAN moves to the 5GHz band and thus avoiding interference. Major wireless LAN suppliers such as Proxim are already considering integrating Bluetooth and WLAN technology in the same radio transceiver to eliminate the possibility of interference (ZDNet 2002).

5. TEACHING AND LEARNING STRATEGIES

Approaches to teaching and learning wireless and/or mobile data communication networks have to be designed to provide students with both theoretical and practical knowledge of wireless technologies including hardware and software. Theory presented in lectures should be enhanced via laboratory demonstrations, and practical exercises. The following teaching and learning activities are recommended.

- Lecturer-led discussion and interactive presentation of information
- A guided tour to Vodafone and/or Telecom office (showcase)
- Setting up a prototype (test bed) wireless local area networks
- Live demonstrations using available hardware and software resources
- Analyse network performance using software package
- Small-group discussion of supplied technical articles and practical exercises
- Guest speaker from industry.

6. CONCLUDING REMARKS

An overview of the emerging applications, standards, current status and future trends of wireless data communication systems is presented. The great potentials of wireless data communication systems have not been fully exploited yet. With the emergence of new applications such as HomeRF and Bluetooth, the market has been growing fast and considerable interests of both researchers and service providers have been attracted to wireless data communication areas. However, developing new applications with and beyond the scope of wireless LAN, HomeRF and Bluetooth to further expand the market still remains as a challenging task for the industry. One of the important trends of wireless networks is the WLANs, piconet and cellular networks will be all integrated with the aid of emerging multimode terminals. Thus another challenging task would be cost-efficient manufacturing of multimode terminals to make interoperability possible and to make the fourth generation possible.

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