

A Quantitative Analysis of System-Level Performance of the Wireless LAN in Digital Home Environments

Byounghee Son and Hagbae Kim

Abstract—A digital home is a ubiquitous environment that is expected to be realized in the near future. All information appliances in a house are connected to each other through wired and/or wireless home networks. Authenticated user can access the various services provided by the digital home, and the access is not restricted by equipment, time, or location. The technologies that form the digital home can be grouped into two categories: wired networking technologies and wireless networking technologies. For the purpose of ubiquitous environments, wireless-networks offer suitable and seamless high-quality services. A wireless LAN can be created simply by equipping a single access point. For that reason, the cost of establishing such a network is low and using it is easy. Of course, there is an exciting new wireless technology. It is the Ultra Wide Band (UWB). However, it is not enough to bring wireless convenience, although offering a broad range of high-speed data transfer capabilities, Because of unstable. Thus, of the wireless-networking systems, we focus on the wireless LAN. We quantitatively analyze its capabilities. The dynamic and adaptive wireless LAN provides a foundation for the evolution toward the next generation of wireless and adaptive networks. The difference between wired LAN and wireless LAN in upload and download rates is small. Although the wireless LAN experiences a greater loss rate than the wired LAN, the difference is minimal. We conclude that a wireless LAN is suitable for use in an apartment environment.

Index Terms—Home networks, wired/wireless networks, WLAN, UWB, analysis of system level performance

1 INTRODUCTION

THE digital revolution is changing analog manufactured goods to digital ones. In line with this trend, appliances have been digitalized and have become smart. Evidence of this is the fast growth of home networks that connect each digital household device. In particular, the emergence of context-aware appliances enables users to set up a smart home networks easily. Such a home network allows smart appliances to be connected to wired and/or wireless networks and any authenticated user is supplied with various services by any device at any time in any place. This is the digital home.

One view, formulated in the IST-initiated,

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now independent, Wireless World Research Forum in their Visions of the Wireless World [1], is that there is a paradigm shift from wired to wireless networks. The shift is seen as driven by both a growing worldwide market for higher-quality, higher-speed wireless services, and a wireless technological revolution is combining all the various appliances in a home into one ubiquitous network.

To construct the digital home, not only inside home networks but also outside networks delivering for service to home, are needed, as are techniques for connecting home appliances, PCs, and sensors. The technologies that form the digital home can be grouped into two categories: wired-networking technologies and wireless-networking technologies. Today, wired networking technologies such as IEEE 1394 and Power Line Communications (PLC) are receiving a lot of attention as are wireless-networking technologies such as the wireless LAN, Bluetooth, Zigbee, and UWB.

Wireless networking technologies have advantages over wired-networking technologies in realizing ubiquitous environments. The wireless LAN benefits from low hardware and installation cost and ease of use. The wireless LAN involves the concept that the next generation of wireless communications will be a major move toward ubiquitous wireless communications systems and seamless high-quality wireless services. There have already been publications that review some technical areas and possible paths for the next generation of wireless systems and technologies [2] - [5]. New technologies are needed to provide truly ubiquitous services. Clearly one is the technology for the functional integration required to achieve a network of networks also called a multi-network. However, there is some security problems unsolved.

The paper focuses on only the technology of the wireless-networking system. Especially, it quantitatively analyzes capability of wireless LAN in an apartment environment.

2 THE APPROPRIATE NETWORK TECHNIQUE IN HOME NETWORK ENVIRONMENTS

In constituting a home network it is important to determine the most effective usable network technique given the current state of technological infrastructure. As we considered above, network techniques are divided into wired communication such as IEEE 1394, PLC and wireless communication such as wireless LAN, Bluetooth, Zigbee, and UWB. Now we can look into which one is the most appropriate in home network environments. In general, home networked appliances like TVs and DVD players are connected to the internet and communicate with each other through a home gateway or home server. Wired communications like cable modem, xDSL are generally used for connecting to outer networks and home gateways. However because of the complex environment inside the home, wired networking of home network appliances and home gateways is intrinsically limited. For example, for connecting a picture frame to a home gateway in a living room and TV in a bedroom,

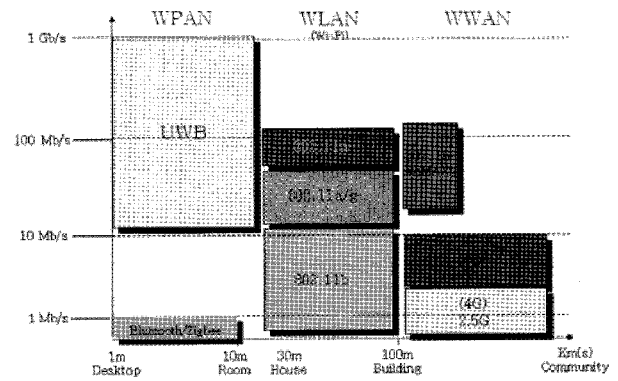


Fig. 1. The way of wireless networking transfer

additional LAN wires, which would be ugly and expensive, are needed. For that reason, even though the technique is useful, it is not preferable. Given this environment inside the home, wireless home networking techniques may be favorably applied to home gateways and home servers. As we considered above, there are various wireless techniques. Home network appliances include entertainment appliances like TVs, radios, DVD players, home game systems, etc. and communication devices like telephones, Fax machines, intercoms, etc. When connecting these appliances with home gateways, different techniques may be differently applied according to the specific requirements of each device. For the entertainment appliances which are mainly fixed and used in isolated rooms, wireless LAN's usable in every area in home and high speed transfer is appropriate. Likewise, for communication appliances which are mobile inside home, wireless LAN also is appropriate. However, Bluetooth is not an appropriate means of connecting home appliances because of its short transfer distance and low transfer speeds. Though Zigbee is used to transmit sensor data with the merit of low power usage, it also is not appropriate because of short transfer distance and low transfer speeds. As well as, UWB is not enough to bring wireless convenience, although its supporting transfer rate is until 1Gbps, because of unstable. That's the value of theory as following Figure 1. Therefore, until now, wireless LAN techniques are the most appropriate in home network environments.

TABLE 1
The way of home-networking transfer

Section	Type	Standard	Transfer Rate (Mbps)	Max. Transfer Distance (m)
Wired	PLC		1~2	100
	IEEE 1394	IEEE 1394	100~400	72
Wireless	Wireless LAN	IEEE 802.11	5.5~54	50
	Bluetooth	V 1.0	1	10
	Zigbee	IEEE 802.15.4	0.005	10
	UWB	IEEE 802.15.3a	1000	10

3 ANALYSIS OF SYSTEM-LEVEL PERFORMANCE OF THE WIRELESS LAN

3.1 The test environment

A notebook PC equipped with a general purpose wireless LAN card was used to test the capabilities of the wireless LAN as shown in table 2.

3.2 The appropriate network technique in home network environments

Figure 2 shows the layout of the rooms and Access Point (AP) position. The AP is in the middle of the apartment.

The test specifications are for connection capability, safety, compatibility, and management functionality using wireless LAN and wired LAN in respectively. One more thing, UWB is tested in Room 3 and Room 4. The graph in Figure 3 is the result of tests ascertaining real internet usage by transmitting data to and from the notebook PC. It shows the rate at which data was transferred during download/upload tests on the test server and notebook PC. The X-axis is the experiment times.

We measured the packet response period and the packet loss rate when transmitting and receiving for ping packets with a 60-byte payload at 50 packets/second for 200 seconds.

TABLE 2
The test environment

International Standard	IEEE 802.11b/IEEE 802.11g
Transfer Way	Direct sequence spread spectrum
Frequency Range	2.4~2.485GHz
Number of channels available	13 channels
Method of IP acquisition	Bypass-DHCP, PPPOE
Security and Certification	ESSID, SSID, MAC Filter, WEP Key, Gem
Signal Intensity	20dB
Power	DC 12v, 1A
Roaming	Positive
Transfer rate	54Mbps

The graph in Figure 4 is the result of tests ascertaining real internet usage by transmitting data to and from the PC. It shows the rate at which data was transferred during download/upload tests on the test server and PC. The X-axis is the experiment times.

The difference between wired LAN and wireless LAN in upload and download rates is

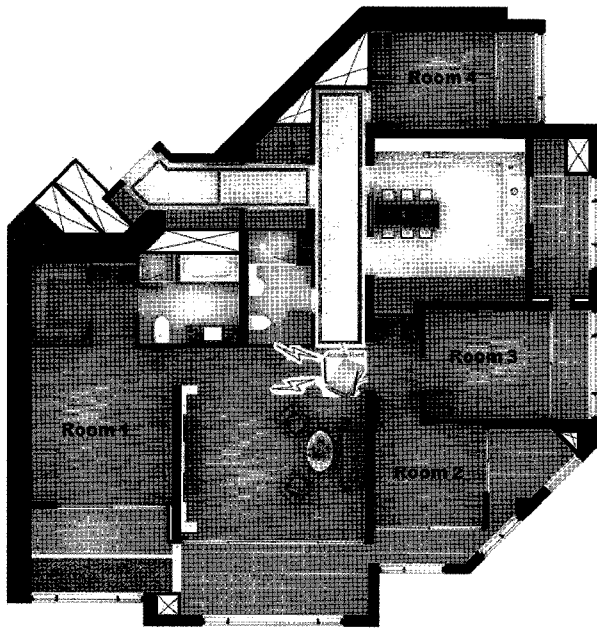


Fig. 2. A floor plan

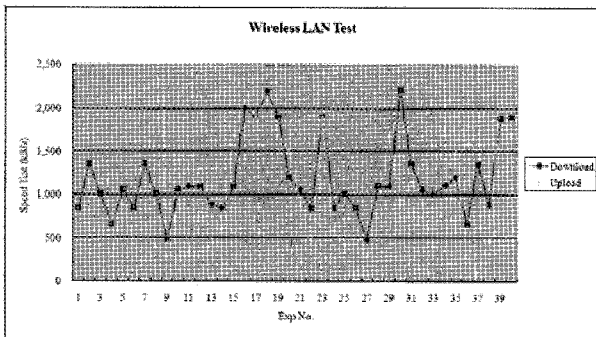


Fig. 3. Wireless LAN test

small. Although the wireless LAN experiences a greater loss rate than the wired LAN, the difference is minimal.

UWB is defined as any radio technology having a spectrum that occupies a bandwidth greater than 20 percent of the center frequency, or a bandwidth of at least 500 MHz. It is not enough to bring wireless convenience, although its supporting transfer rate is until 1Gbps, because of unstable. After experimenting, it is proved that it supports under the values of standards as Figure 5. Finally, UWB will be just replaced the cables.

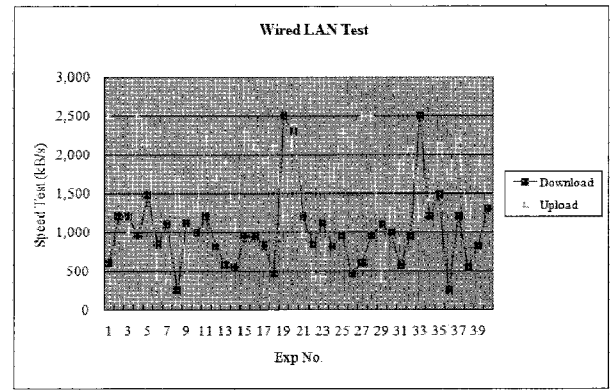


Fig. 4. Wired LAN test

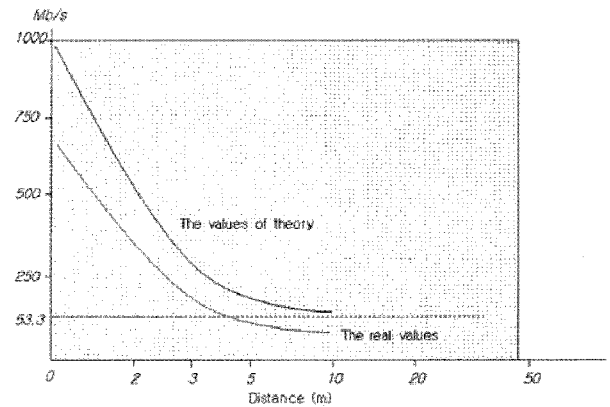


Fig. 5. UWB test

4 CONCLUSION

There are many home-networking techniques in the digital home. The digital home is a ubiquitous environment that is expected to be realized in the near future. In digital home environments, all information appliances in a house are connected to each other through wired and/or wireless home networks. Authenticated user can access various services provided by the digital home, and the access is not restricted by equipment, time or location. The technologies that form the digital home can be grouped into two categories: wired networking technologies and wireless networking technologies. Today, wired networking technologies such as IEEE 1394 and PLC are receiving a lot of attention as are wireless-networking technologies such as the wireless LAN, Bluetooth, Zigbee, and UWB. Furthermore, the cost of establishing such a network is low and using it is easy.

In particular, wireless networks techniques are suitable for ubiquitous environments. The difference between wired LAN and wireless LAN in upload and download rates is small. Although the wireless LAN experiences a greater loss rate than the wired LAN, the difference is minimal. And the expecting UWB technology is unstable although it brings the promise of freedom from the cables and simplicity in networking. However, the line of sight doesn't go through walls or through obstacles by now. It is just instead of the cables. Therefore, user are switching from wired to wireless LANs in the digital home environment because of cast effectiveness and greater ease of use when connecting to other networks compared to wired LAN. Thus, Industry has quickly moved to accommodate consumer's wireless LAN preferences.

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