5GHZ WIDEBAND CHANNEL MODEL IN APARTMENT BUILDING

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ABSTRACT

This paper reports the empirical 5GHz wideband channel model in apartment building. The channel measurement system is based on the pseudo-noise (PN) correlation method. In measurements, transmitter is fixed at two different positions in a house while receiver moves from the rooms of the house to those of nearby houses in each transmitter position. From measurement results, propagation loss and wideband channel characteristics are analyzed. As a result, we found that the signal reflected to neighboring buildings proffered other clusters. Especially, in cases of the receiver positions where with a big window and large away from the transmitter, this phenomenon is emphasized. And transmitter located at the biased position, could cause the imbalance of received signal level in a single house and the interference to neighboring houses.

Key Words

Wideband channel model, Wideband channel characteristics, Measurement and modeling, ray-tracing simulation and 5GHz WLAN

1. Introduction

As demand for the high data rate communication system in mobile situation increases, the importance of Wireless Local Area Network (WLAN) is attended. But, the lower frequency band is fully used for existing communication system, so 5GHz band is suggested for new WLAN system. In Korea, 5GHz ISM band is reserved for new WLAN system as HYPER LAN system in Europe and Unlicensed National Information Infrastructure (U-NII) band in USA. So, some papers deal with the relative works for 5GHz channel modeling [1]~[2]. But, in case of apartment building, the most common dwelling type in Korea, it has not totally analyzed yet. Unlike the channel model in any other dwelling types, that of apartment is regarded independently because so many houses in single building are located closely each other. Furthermore, in Korea, the residents living in apartment generally have more interest in new communication system rather than people in other dwelling types. So, it is predicted that the demand for new WLAN system design in apartment will be urgent.

So, we focus on the 5GHz wideband channel modeling in apartment for WLAN engineering. The wideband channel model is the fundamental resource for efficient WLAN system in aspects of cell planning, interference problem and performance analysis. For this purpose, firstly, we constructed channel sounding system using PN method. Then we measured the power delay profiles while the transmitter is located in the center of house or in a room, which WLAN will be frequently used. In each transmitter position, receiver position is located not only in house with transmitter but also in nearby houses. Propagation loss and channel characteristics are analyzed via post processing. Measurement results are compared with the simulation results obtained by ray-tracing tool [9].

The recentralder of this paper is organized as follows: Section 2 covers the measurement system, environment and scenario. Then, section 3 gives the results and analysis of measurements. Finally, We conclude in section 4.

2. Measurement system, environment and scenario

A. Measurement system

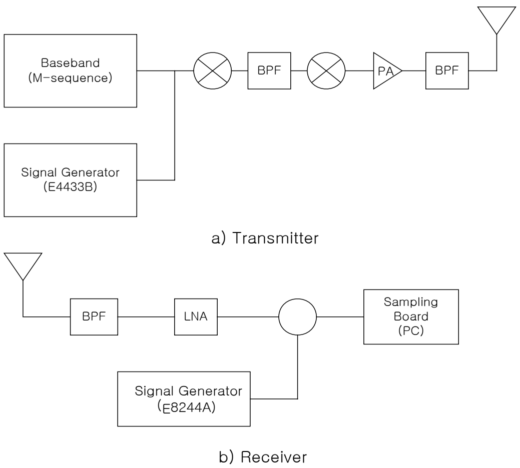


Fig.1. Block diagram of measurement system

The diagram of measurement system, based on the PN correlation method, is illustrated in Fig. 1 [3]. In baseband system, 50MHz oscillator generates a M-sequence, which will be up-converted to 5.8GHz by signal generator. Then, this signal passes through the power amp (PA) linearly operates within 30dB, and is followed by the band pass filter (BPF) with 100MHz bandwidth. In the receiver system, the received signal is driven to the BPF and amplified by Low Noise Amplifier (LNA). After LNA, it is down-converted to 300MHz intermediate frequency and sampled with 2GHz sampling rate to be saved into laptop computer. The channel impulse response is obtained by cross correlation between received signal and the original M-sequence. The antennas used in measurements are omni-directional with 4.6dBi gain and located in height 1.7m.

B. Measurement environment, scenario

Measurements were performed at a newly constructed apartment building in Suwon, South Korea. It is a ferroconcrete building of twenty stories with three elevators. The ground plan of a house is illustrated in Fig. 2.

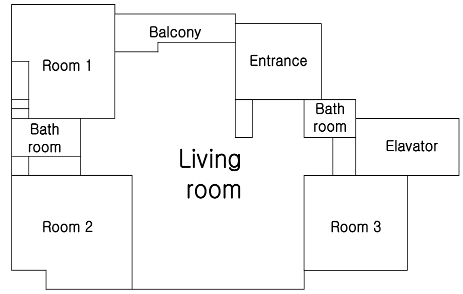
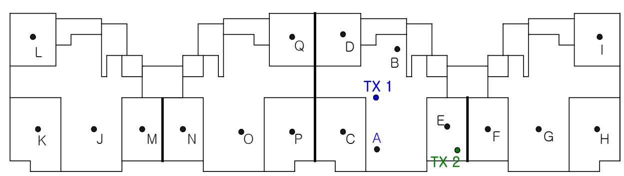


Fig. 2. Ground plan of single apartment house

The material of wall is concrete and wall thickness is from 20cm to 30cm. There was no furniture and glass windows are set irregularly. But in the house with transmitter (central house), all glass windows in house were set.

In measurements, we assumed that the Access Point (AP) and portable terminal are operating together in single house. The transmitter (Tx) plays role of AP and the receiver (Rx) plays of portable terminal. To analyze the effect of transmitter position, we selected two transmitter positions. The one is the case of in the center of house and the other is the case of in the room which WLAN system is most frequently used. For assuming real establishment, transmitter is located near a



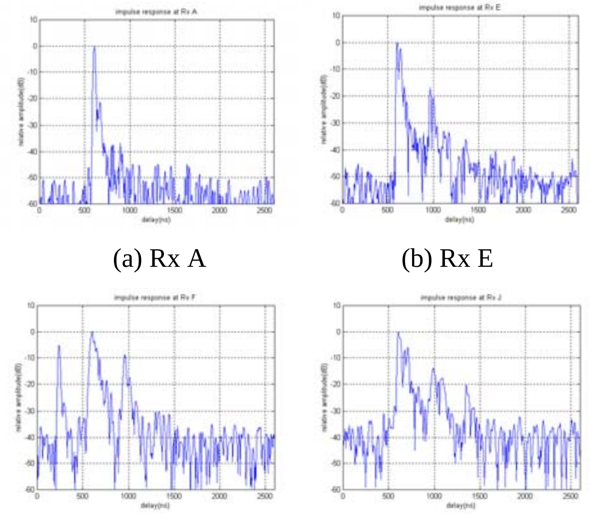
wall in each case.

Fig. 3. Transmitter/Receiver positions

Fig.3 represents the transmitter and receiver positions in measurement scenario. We put the transmitter in two positions of the central house then measure the channel response in the central house and neighboring 3 houses. The fist transmitter position is in center of the house (Tx1 case). And the second transmitter position is decided after considering the frequency of use (Tx2 case). It means that this transmitter position is in the room where WLAN system is frequently used. In 2 cases, wideband channels of 33 receiver positions are totally analyzed.

3. Measurement results and analysis

A. Transmitter in center of central house (Tx 1 case)



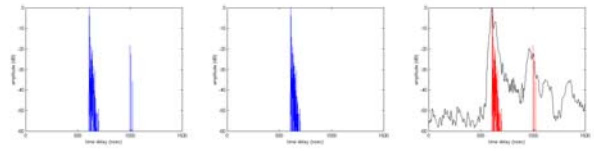
(a) Rx A (b) Rx E

(c) Rx F (d) Rx J

Fig. 4. Power delay profiles in Tx 1 case

Fig 4. represents the power delay profiles in Tx 1 case. To compare the relative power strength and delay, we set the maximum received signal level equals to 0dBm and delay of the maximum received signal to 600ns in each power delay profile.

In receiver position A, the line of sight (LOS) signal is dominant. But, in position E also located in the central house, there are two clusters [4]. The one is from maximum power signal, passing through the wall, and the other is from the signal reflected by neighboring building. The supposition is made based on the delay between maximum signal and second one is approximately 381ns, which is calculated from the distance between two buildings, 57.2m. And it is also supported by the simulation result using ray-tracing tool. Fig. 5 compares the simulation results and measurement results [9]. The first figure describes the simulation result considering the existence of front and back buildings. The second one is from the simulation ignoring the existence of two buildings. In comparison, we confirm that the neighboring buildings cause the second cluster.



a) b) c)

Fig. 5. Simulation results: (a) result considering the existence of two buildings (b) result ignoring the existence of front building and (c) application result of (a) to measurement result

In position F, it reveals that the signal reflected from neighboring buildings is stronger than any other signals including the directly received signal, which passed through the multi walls. And the third cluster from the twice-reflected signal exists. In positions J, three clusters are also observed.

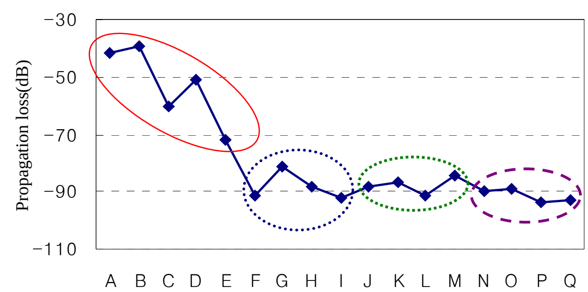


Fig. 6. Propagation loss in Tx 1 case

Fig. 6 shows the propagation loss calculated from the received signal of each receiver position. Noise threshold is set to 30dB below the strongest signal in positions of central house, 20dB below in another positions. The reason why the threshold is different due to receiver position is the received signal level and the number of effective signals are different in each receiver position. The received power level in position B is the highest because it is LOS and the nearest to the transmitter.

In central house, the received powers in positions C, D, E (non-LOS, a wall between Tx and Rx) are 10~30dB below that in position A, B (LOS). Especially, received power level in position E is low because a wooden door doesn't exist in direct path between Tx and Rx, while in positions C and D, a door exists in direct path. In receiver positions of other houses, received power level in position G, where near a large window facing to the front building, is the highest though it is barely –80dBm. In any other positions, it is about –90dBm.

The delay parameters are calculated from measured data via formulas in [7,8] and represented in Fig. 7. The receiver positions having the high delay parameters are affected by the reflected signal. Those positions are with big window to the front building or large distance from the transmitter.

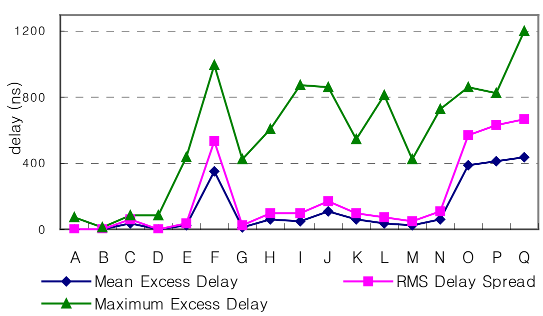


Fig. 7. Delay parameters in Tx 1 case

Table. 1 Cluster numbers in simulation and measurement

RX	Simul-ation	Measur-ement	RX	Simul-ation	Measur-ement
A	1	1	J	3	3
B	1	1	K	2	2
C	1	1	L	3	2
D	2	1	M	2	2
E	2	2	N	3	2
F	3	3	O	3	2
G	3	2	P	3	3
H	3	2	Q	4	4
I	2	3			

Table. 1 compares the cluster number of simulation results and that of measurement results. There is no big difference between simulation and measurement. Generally, in case of positions having many clusters, delay parameter values are high.

Table. 2. Grouping receiver positions according to delay parameter values

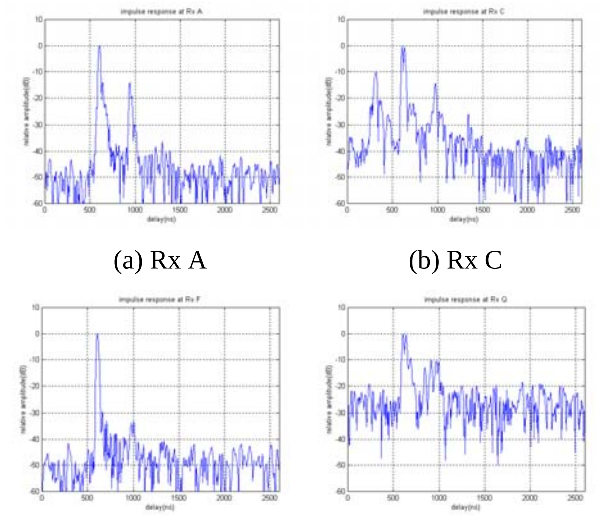
Group	Rx Positions	Propagation Characteristics	Spatial Description
I	A, B, C, D	Dominant direct signal	In the central house
II	E, G, H, K, M	Effective multipaths	Window to the front building
III	F, O, P, Q	Many multipaths Delayed Max. Peak	Near the transmitter
IV	I, J, L, N	Weak Max. Peak Many multipaths	Away from the transmitter

From these wideband characteristics, we divided receiver positions into 4 groups as shown in Table. 2.

- The receiver positions in Group I are located in the central house. So, the signal via direct path plays the dominant role and the effects of other multipaths are relatively very weak.
- But, in the case of position E, which is also located in the same house, the reflected signal from front building exerts huge influence on delay characteristics. It's because there is a large glass window in the room. Any other Rx positions in Group II (G, H, K, M) also have a glass window faced the front building.
- The Group III positions are not so much away from the transmitter. But, the multiple walls makes the direct signal weaker while the effect of reflected signal from front building gets less weaken. So the reflected signal is strongly measured.
- In Group IV, direct signal works relatively strong. And the weak multiple reflected signals also exist. So the maximum excess delay value is very high.

B. Transmitter in biased position of central house (Tx 2 case)

In this case, transmitter is located in a small room, biased position of central house. The power delay profiles from measurements are illustrated in Fig. 8.



(a) Rx A (b) Rx C

(c) Rx F (d) Rx Q

Fig. 8. Power delay profile in Tx 2 case

The receiver position A, which was LOS in Tx 1 but NLOS in Tx 2, has the second power level cluster 15dB below to the strongest cluster. As like receiver position E in Tx 1 case, the second level signal is the reflected one from the front building. However, in position C in central house, the reflected signal is more powerful than the direct signal passed through two walls. In position F of neighboring house, as the separation distance of the transmitter and receiver reduces, the effect of direct signal increases. In position Q, the number of clusters grows smaller.

Table. 3 Cluster Numbers in simulation results and measurement results

RX	SIM.	MEA	RX	SIM	MEA.
A	2	2	J	2	2
B	1	2	K	2	1
C	2	3	L	2	2
D	3	2	M	2	2
F	1	1	N	3	2
G	1	3	O	3	2
H	2	2	P	3	2
I	3	1	Q	3	2

Table.3 designates the increased cluster numbers of receiver positions in central house. As the transmitter goes away from the receivers and hides behind the wall, the effect of direct signal decreases and the effects of multipaths increase. In receiver positions of other houses, no significant change in cluster number except position F and I. At both positions, unlikely in Tx 1 case, the direct signal plays the dominant role as the transmitter get closer.

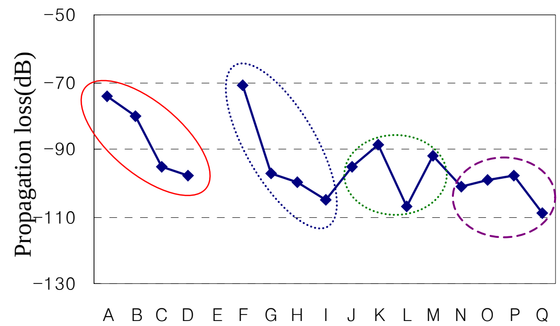


Fig. 9. Propagation loss in Tx 2 case

Fig. 9 reveals the received signal power disparity of received signal in central house and the interference to neighbor house. Because of biased transmitter position, the received signal levels in receiver positions of the central house are lower than those of Tx 1 case. But in position F of the neighbor house, it grows bigger since the transmitter becomes closer. In other positions, received signal powers show a slight decline.

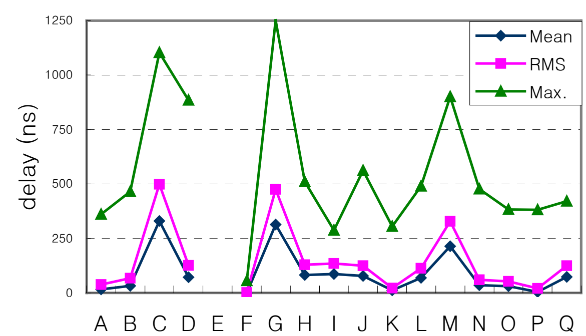


Fig. 10. Delay parameters in Tx 2 case

Fig. 10. represents the delay parameters in Tx 2 case. Delay parameters are likely increased in A, B, C, D, G positions in which reflected signals involved more than Tx 1 case. But in positions F and I where direct wall penetration signal works more brilliantly, delay parameters are decreased. In other