Calculation of the Signal Occupied Bandwidth for the FDD-based 4G Mobile Communication

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Abstract: - The new wireless multimedia environment is coming because of the variety of an user requirement and a traffic increase which we can not accept in the IMT-2000 present systems. To offer the wireless multimedia service the world wireless communication company which included the ITU-R is developing the standard and technique of 4G systems. We analyzed the technique criteria of the 4G wireless communication system in this paper which is based on that of WiBro System. The mobile communication traffic is predicted Up/Down-link of non-symmetric in the future. So, we considered the communication traffic of non-symmetric. And we proposed the PHY layer parameters of occupied frequency bandwidth of Up/Down-link with both 1:3 and 1:5. And we verified this through the simulation. So we proposed the occupied frequency bandwidth for 4G wireless communication in this paper.

Key-Words: - 4G, ITU-R WP8F, Standardization, Technical criterion , OFDM

1. Introduction

The new wireless multimedia environment is coming because of the variety of an user requirement and a traffic increase which we can not accept in the IMT-2000 present systems. To offer the wireless multimedia service the world wireless communication company which included the ITU-R is developing the standard and technique of the forth generation (4G) systems[1][2]. The voice was the driver for second-generation mobile and has been a considerable success. Today, video and TV services are driving forward third-generation(3G) deployment. And in the future, low cost, high speed data will drive forward the forth generation(4G) as short-range communication emerges.

Table 1. Paradigm shift form 1st generation toward 4G

1st generation	2nd generation	3rd generation	4th generation
Analog	Digital	Multimedia Communication	Ubiquitous Service
▪ circuit switched basic voice communication. ▪ Low capacity ▪ Limited coverage	▪ circuit switched voice plus basic data applications ▪ capacity enhancements from digital modulation & data compression	▪ digital packet and circuit switched data & multimedia applications ▪ global coverage ▪ global roaming	▪digital packet switched ▪ all IP based ▪ high quality multimedia services ▪ seamless service ▪ multimode terminal
AMPS	GSM, IS-95, IS-136	3GPP, 3GPP2, cdma2000	
FDMA	TDMA, CDMA	CDMA	OFDM + CDMA (?)
~ 8kbps	~ 144kbps	~2Mbps	~100Mbps/1Gbps

4G systems of ITU are doing to the goal to offer to that bit transmission rate of 1Gbps for user at a low speed movement and bit transmission rate of 100Mbps for user at a high speed movement[3][4]. We summarized an upside's content and arranged to the table 1.

2. 4G vision and requirement

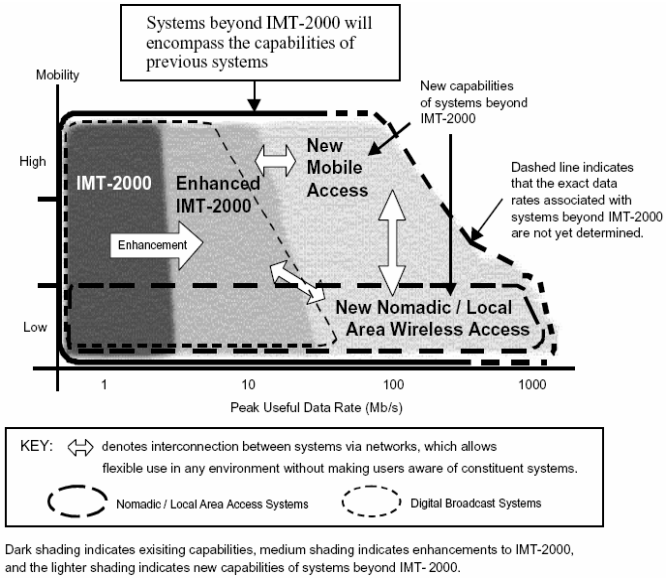

Figure 1. A facility area of B3G of ITU-R WP8F.

Figure 1 comes to divide 3 area. Each area means that.

- Future Development of IMT-2000 : This area means the existing IMT-2000 develops of the left area of the Fig. 1.
- New Capabilities of systems beyond IMT-2000 : New wireless communication technique will be desired about in 2010 years. This system's demand data rate offer to 100Mbps at high speed movement system and it offer to 1Gbps at low speed movement and fixed systems in ITU-R WP8F. This area is right and up area(at high speed movement system), right and down area(at low speed movement and fixed systems) of the Fig.1.
- Relationship of IMT-2000, systems beyond IMT-2000, and other access systems : Various wireless connection systems of WPAN, WLAN, Digital brodcasting will continue the relatin with systems beyond IMT-2000 as progress continuously.

The present communication system is not enough capacity for full multimedia service, high cost. So, the present communication system is developing toward the 4G[5].

Table 2. ITU-R 4G Vision

	3G Evolution (3.5G)	3G Revolution (4G)	
		Nomadic	Mobile (up to 250km/h)
	Enhancement of 3G	New radio interface is required	
Data rate	30Mbps	1Gbps	100Mbps (at 60km/h)
Bandwidth	5MHz	5~20MHz	
deployment	around 2005	after 2010	
standardization	3GPP, 3GPP2	TBD (after 2006)	

3. Design parameter of FDD-based occupied bandwidth for the 4G mobile communication system

Figure 2 is the data to forecast mobile communication traffic of Asia area of 2015 years in ITU-R WP8F. The forecast of traffic difference of Up/Down-link will enlarge from 1:1.26 to 1:5.2 according to figure 2 in 2010 year. The mobile communication traffic is predicted Up/Down-link of non-symmetric in the figure 2. So, we considered the communication traffic of non-symmetric in this paper. And we proposed the PHY layer parameters of occupied bandwidth of Up/Down-link with both 1:3 and 1:5. And we verified this through the simulation.

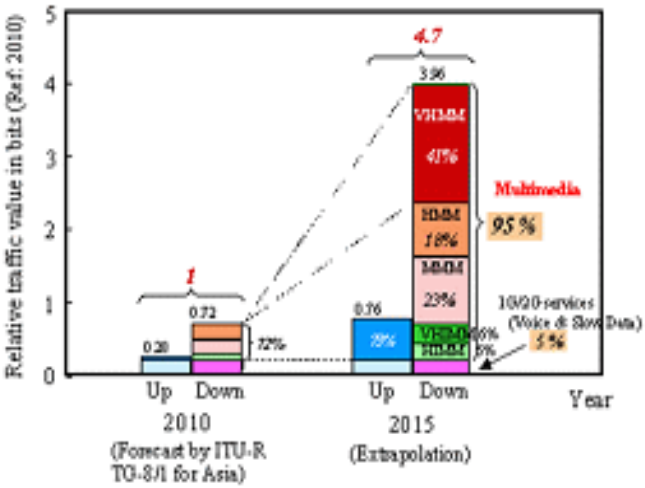

Figure 2. The traffic forecast of mobile communication in the Asia area.

We designed the bandwidth of Up-link of 10MHz. And we considered down-link each bandwidth of 30MHz and 50MHz.

We considered the FDD-based OFDM system. We selected the carrier frequency of the candidate bandwidth

(3.4~4.2GHz) on the 4G. The carrier frequency is used 3.6GHz at the Up-link and 4.0GHz at Down-link, respectively [6].

3.1 Design parameter of OFDM

Guard band duration is

$$T_G = \tau_{rms} \times K_M \quad (1)$$

Where τ_{rms} : 4us, K_M : Modulation factor(2~4).

OFMD symbol period select both equation (2) and (3).

$$10\log(\frac{T_{data,\min} + T_G}{T_{data,\min}}) \le L_{loss}(dB)$$
$$T_{data,\min} \ge T_G(1/(10^{L_{loss}/10} - 1)) \quad (2)$$

$$T_{data,\max} = T_C - T_G = 1/2f_d - T_G \quad (3)$$

Where Tc : coherence time, fd : Doppler frequency.
Total OFDM symbol period is guard band + symbol period.
Number of subcarrier is selected of 2^n by equation (4).

$$T_{data,\min} \times fs \le N_{data} \le T_{data,\max} \times fs$$
$$N = [[N_{data}]] \quad (4)$$

fs : sampling frequency

.

Table 3. Case 1 of OFDM Parameters

Parameter	Up-Link	Down-Link
Carrier frequency(fc)	3.6GHz	4.0GHz
Bandwidth	10MHz	30MHz
Occupied Bandwidth	9.741MHz	24.595MHz
Bandwidth efficiency	65%	82%
Sampling frequency(fs)	15MHz	30MHz
Number of FFT (N)	1607.5335<N<515520 2048 choice	3215.067<N<1031040 4096 choice
Number of sub-carriers(Nsc)	1330(65%)	3358(82%)
Sub-carriers spacing(df)	7.32439KHz	7.32439KHz
Data duration(Td)	107.1689us~34368us 136.53us choice	107.1689us~34368us 136.53us choice
Guard band duration(Tg)	23.47us	23.47us
Simbol duration(Tsym)	160us	160us
Loss of SNR by guard band	0.86dB	0.86dB
Coverage	1~10Km	1~10Km
RMS delay spread	4us	4us
Max. data rate	76.8Mbps (256QAM & code rate = 1)	167.9Mbps (256QAM & code rate = 1)

Table 4. Case 2 of OFDM PArameters

Parameter	Up-Link	Down-Link
Carrier frequency(fc)	3.6GHz	4.0GHz
Bandwidth	10MHz	50MHz
Occupied Bandwidth	9.741MHz	45MHz
Bandwidth efficiency	65%	75%
Sampling frequency(fs)	15MHz	60MHz
Number of FFT (N)	1607.5335<N<515520 2048 choice	6430.134<N<2062080 8192 choice
Number of sub-carriers(Nsc)	1330(65%)	6144(75%)
Sub-carriers spacing(df)	7.32439KHz	7.32439KHz
Data duration(Td)	107.1689us~34368us 136.53us choice	107.1689us~34368us 136.53us choice
Guard band duration(Tg)	23.47us	23.47us
Simbol duration(Tsym)	160us	160us
Loss of SNR by guard band	0.86dB	0.86dB
Coverage	1~10Km	1~10Km
RMS delay spread	4us	4us
Max. data rate	76.8Mbps (256QAM & code rate = 1)	307.2Mbps (256QAM & code rate = 1)

The table 3, 4 arranges the result to get by OFDM parameter selection of the front.

We considered bandwidth for Up/Down-link of non-symmetric. Table 3 is parameters of Up/ Down-link. The Up/ Down-link rate considered in the case 1 to be 1:3. And table 4 is parameters of Up/ Down-link, too. The Up/ Down-link rate considered in the case 2 to be 1:5.

4 Simulations

We proposed the PHY layer parameters of occupied frequency bandwidth of Up/Down-link with both 1:3 and 1:5. And we verified this through the simulation. The simulation block diagram is figure 3.

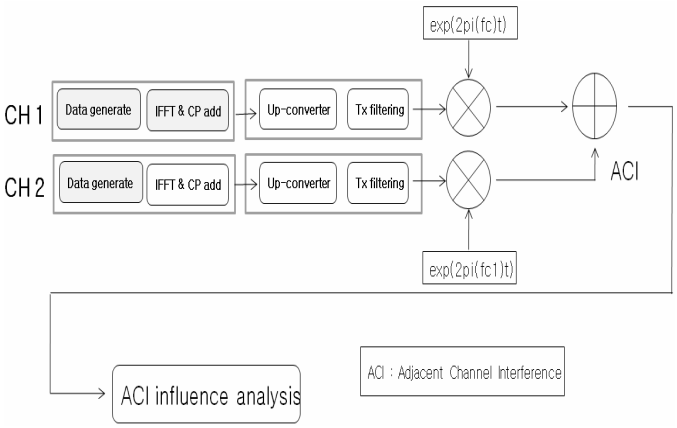

Figure 3. Simulation block diagram

4. 1. Up-link simulation result

The figure 4, 5, 6 are the results of the Up-link simulation output. The carrier frequency of standard signal is 3.6GHz. And the carrier frequency of interference signal narrowed for view of interference effect.

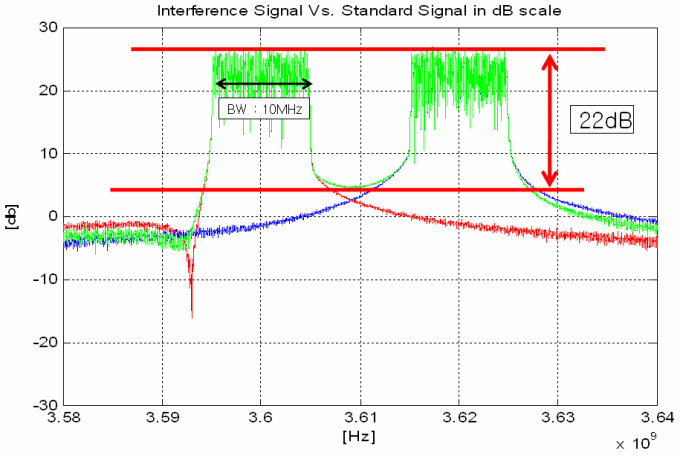

Figure 4. Simulation result of Up-link
(channel interval : 20MHz)

The figure 4 is OFDM signal which has the Up-link bandwidth of the 10MHz.
The output result of the case which is a channel interval of the 20MHz. The SNR(Signal to Noise Ratio) is interference signal and standard signal ratio of 22dB in figure 4.

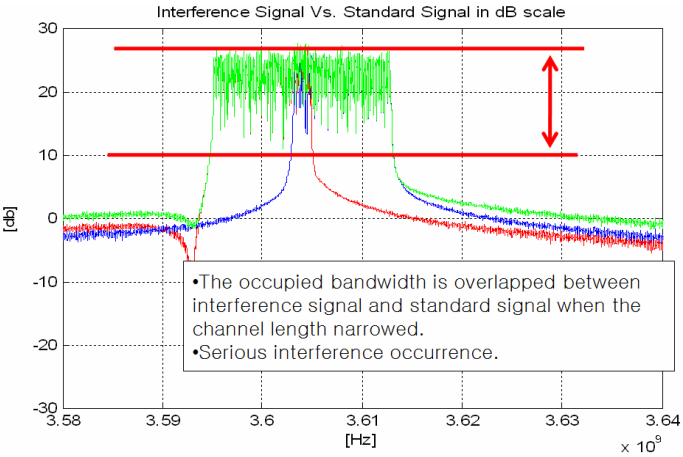

Figure 5. Simulation result of Up-link
(channel interval : 8MHz)

The figure 5 is the result when the channel interval is narrow than the occupied bandwidth. The occupied bandwidth is about 9.741MHz. And channel interval is 8MHz. A standard signal is namely the case to take serious influence by an adjacent channel.

4. 2. Down-link simulation result of case 1

The figure 6, 7, 8 are the results of the Down-link simulation output. The carrier frequency of standard signal is 4.0GHz. And the carrier frequency of interference signal narrowed for same reason of Up-link case.

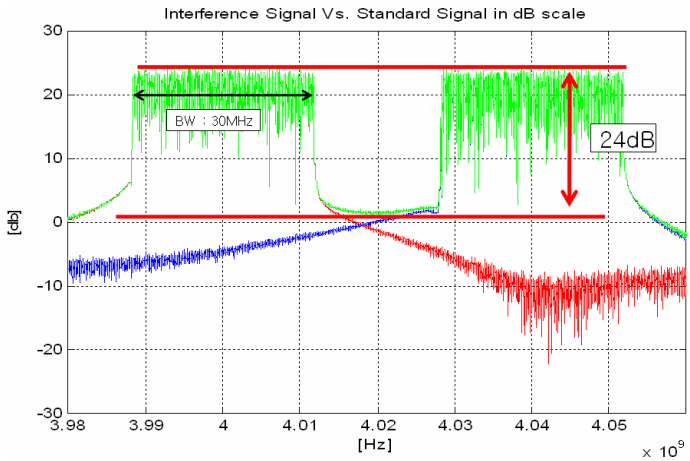

Figure 6. Simulation result of Down-link case 1
(channel interval : 40MHz)

The figure 6 is OFDM signal which has the Down-link bandwidth of the 30MHz.
The output result of the case which is a channel interval of the 40MHz. The SNR(Signal to Noise Ratio) is interference signal and standard signal ratio of 24dB in figure 6.

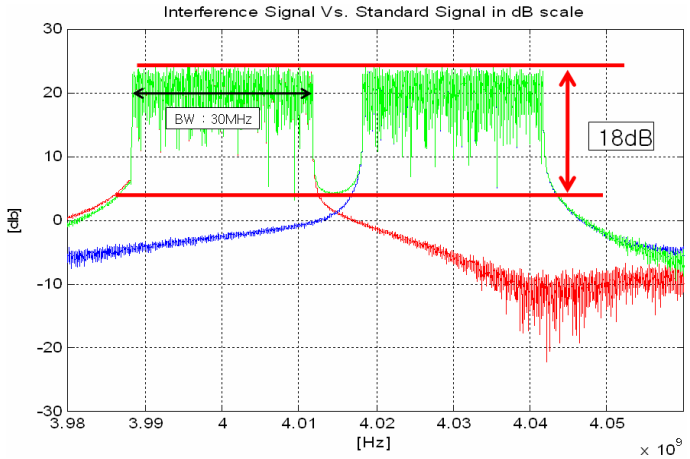

Figure 7. Simulation result of Down-link case 1
(channel interval : 30MHz)

The output result of the case which is a channel interval of the 30MHz. The SNR(Signal to Noise Ratio) is interference signal and standard signal ratio of 18dB in figure 7.

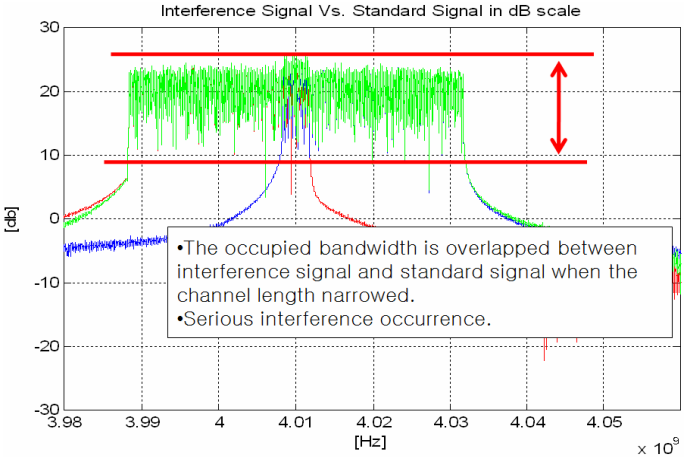

Figure 8. Simulation result of Down-link case 1 (channel interval : 20MHz)

The figure 8 is the result when the channel interval is narrow than the occupied bandwidth. The occupied bandwidth is about 24.595MHz. And channel interval is 20MHz. A standard signal is namely the case to take serious influence by an adjacent channel.

4. 3. Down-link simulation result of case 2

The figure 9, 10, 11 are the results of the Down-link simulation output. The carrier frequency of standard signal is 4.0GHz same.

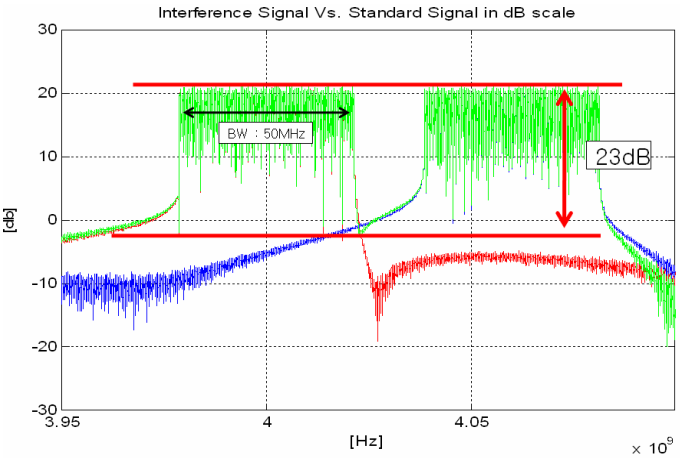

Figure 9. Simulation result of Down-link case 2 (channel interval : 60MHz)

The figure 9 is OFDM signal which has the Down-link bandwidth of the 50MHz.
The output result of the case which is a channel interval of the 60MHz. The SNR(Signal to Noise Ratio) is interference signal and standard signal ratio of 23dB in figure 9.

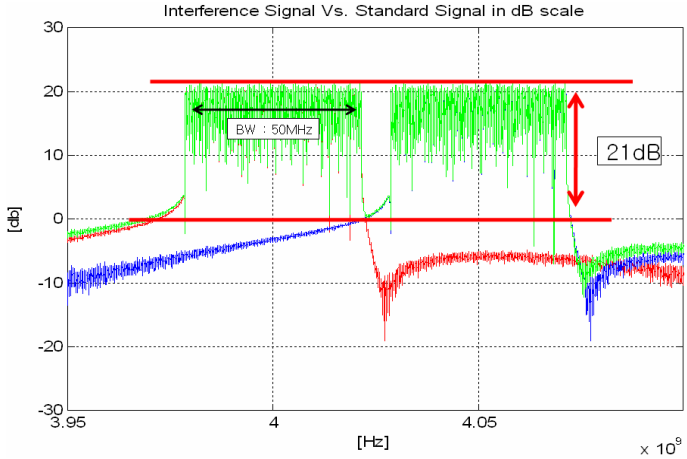

Figure 10. Simulation result of Down-link case 2 (channel interval : 50MHz)

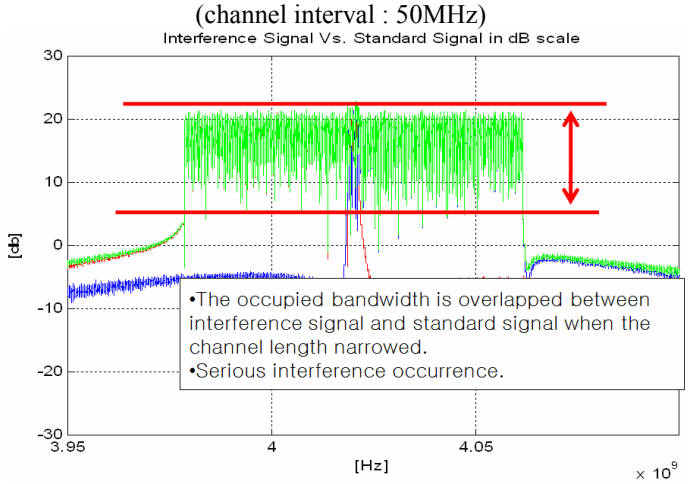

Figure 11. Simulation result of Down-link case 2 (channel interval : 40MHz)

The figure 11 is the results when the channel interval is narrow than the occupied bandwidth same of other results. The occupied bandwidth is about 45MHz. And channel interval is 40MHz. A standard signal is namely the case to take serious influence by an adjacent channel.

5 Conclusions

In this paper we studied occupied frequency bandwidth of common technique criteria among the technique criteria for the 4G mobile communication of Up/Down-link. And we calculated of FDD-based. The mobile communication traffic is predicted Up/Down-link of non-symmetric in the future. So, we considered the communication traffic of non-symmetric. And we proposed the PHY layer parameters of occupied frequency bandwidth of Up/Down-link with both 1:3 and 1:5. And we verified this through the simulation. So we proposed the occupied frequency bandwidth for the 4G mobile communication in this paper.

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