Millimeter-wave overlay HetNet for 5G

—System level simulation for spectrum assessment—

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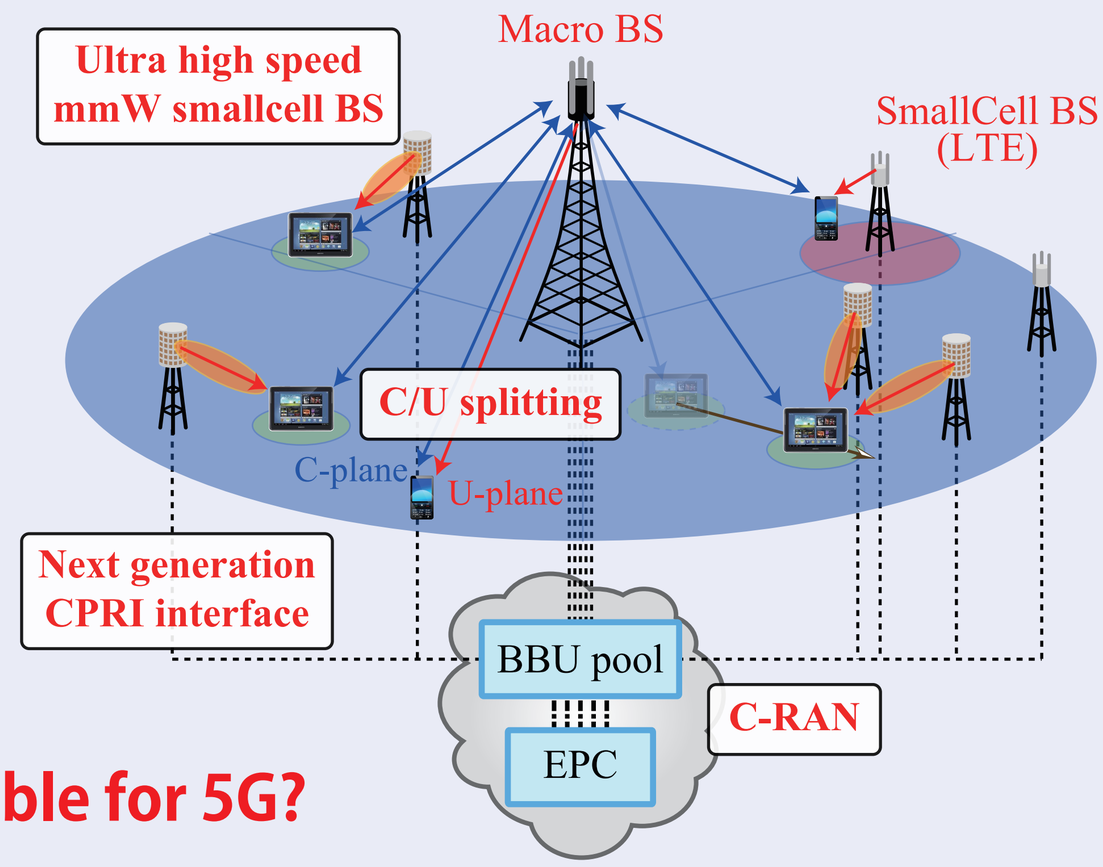
Mobile traffic grows exponentially every year and current cellular network cannot deal with this traffic explosion. In order to overcome this problem, many researchers try to achieve more than 1000x higher system rate by using ultra wideband millimeter wave technologies.

Millimeter-wave HetNet architecture

- C-plane/U-plane splitting
- Next generation CPRI interface
- C-RAN (Cloud RAN) driven network
- Ultra high speed mmW smallcell basestation



Which band in mm-wave frequency is suitable for 5G?

Spectrum allocation status in US, EU and JP

	Frequency [GHz]	Bandwidth [GHz]	Allocation status JP	US	EU
	27.94-29.45	1.5	FIXED-SATELLITE	FIXED-SATELLITE	AERONAUTICAL RADIONAVIGATION
①	31.8-33.4	1.6	Unused	RADIONAVIGATION SPACE RESEARCH INTER-SATELLITE	RADIONAVIGATION EARTH EXPLORATION-SATELLITE (active) SPACE RESEARCH (active)
	40.5-43.5	3	FIXED	FIXED-SATELLITE	FIXED, RADIONAVIGATION
②	45.5-47.0	1.5	Unused	MOBILE	FIXED
③	47.2-50.2	3	Unused	FIXED	FIXED
④	55.78-57.0	20.22	FIXED MOBILE	EARTH EXPLORATION-SATELLITE (passive)	MARITIME RADIONAVIGATION
	57.0-66.0		Unlicensed	Unlicensed (-64)	Unlicensed
	66.0-71.0		Unused	FIXED	FIXED
	71.0-76.0		FIXED, MOBILE	FIXED	FIXED
⑤	81.0-86.0	5	FIXED MOBILE	FIXED	EARTH EXPLORATION-SATELLITE FIXED RADIO NAVIGATION

From the point of view of this allocation status, ①31.8-33.4, ②45.5-47.0, ③47.2-50.2, ④55.78-76.0, ⑤81.0-86.0 are useful bands.

Pathloss model for mm-wave bands

Pathloss model is generated by using frequency domain interpolation

NYU 28GHz: $PL_{28\mathrm{GHz}} = 72.0 + 29.2\log_{10}\left(d / d_{0,28\mathrm{GHz}}\right)$

MiWEBA 60GHz: $PL_{60\mathrm{GHz}} = 82.02 + 23.6\log_{10}\left(d / d_{0,60\mathrm{GHz}}\right)$

NYU 73GHz: $PL_{73\mathrm{GHz}} = 82.7 + 26.9\log_{10}\left(d / d_{0,73\mathrm{GHz}}\right)$

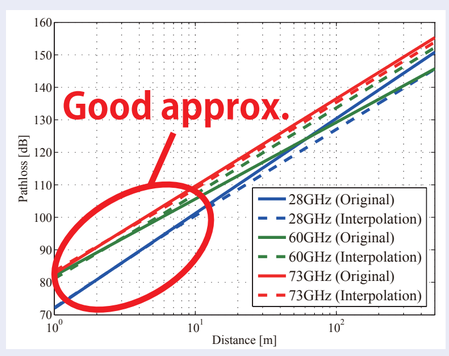
Original model

$$PL = a\log_{10}(f) + b$$

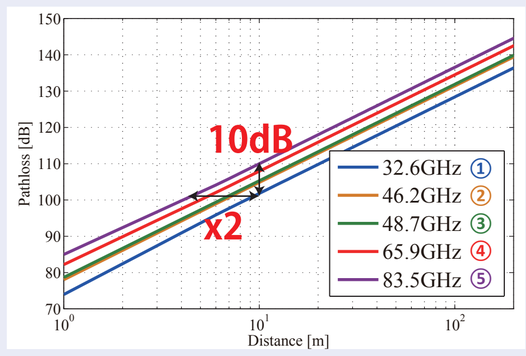
$$J(a(d), b(d)) = \sum_{i=1}^{I}\left(PL_o(f_i, d) - PL(f_i, f)\right)^2$$

$$\left(\hat{a}(d), \hat{b}(d)\right) = \arg\min_{a(d),b(d)} J(a(d), b(d)) \quad \text{subject to } a(d) \geqq 20$$

Least square method



Original



Candidate bands

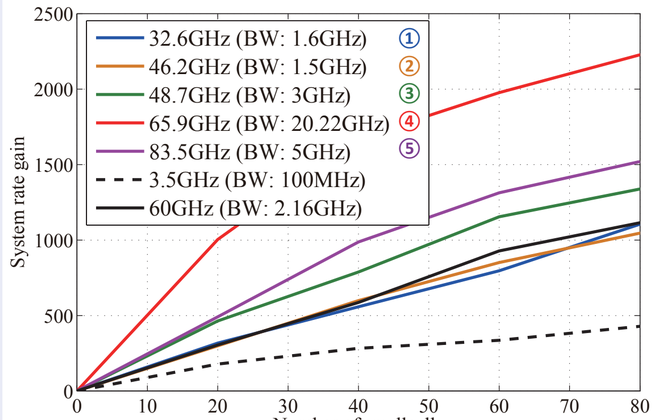
System level simulation

By using our developed system level simulator, we assessed each candidates from two aspects

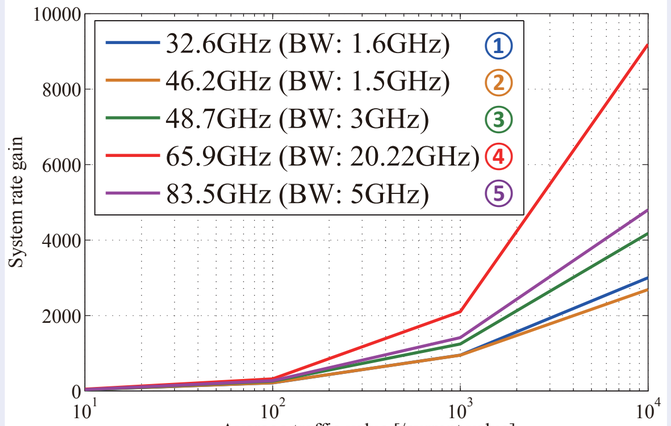
1. System rate gain vs Number of smallcell BSs
2. System rate gain vs Average traffic demand

Symulation parameters

Parameter	Value
Number of macro BSs	7 (evaluate: 1, interference: 6)
Number of smallcell BSs	0-80 / macrocell
BS antenna height (macro / small)	25 m / 4 m
Number of UEs	5000
Number of BS antennas (macro / small)	4 / 1
Number of UE antennas	2
Macro ISD	500 m
Antenna beam pattern	3GPP / 11ad
Antenna gain (macro / small)	17 dBi / 25dBi@60GHz
Tx power (macro / small)	46 dBm / 10 dBm/channel
Average traffic demand (current / 10 years later)	62 kbps/user / 62 Mbps/user



System rate gain vs Number of smallcell



System rate gain vs Average traffic demand

Although coverage becomes narrower as carrier frequency increases, the difference of total bandwidth is dominant in the result of comparison with number of smallcells. Additionally, the difference of the system rate gain is very big in high traffic case. Therefore 66GHz band (④) which has 20GHz bandwidth should be selected for the future 5G cellular network.