MIMO Radio Propagation Channel Measurements in a Small Urban Macrocell at 4.5GHz

Lawrence Materum

Some Introductions
Why model?

Channel Sounding Setup
MIMO Channel Sounder
Environment Setting
Parameter Estimation

Propagation Channel Scenarios
Some Remarks
XPR
RMS Delay Spread
CPR

Summary

Presented at

IEICE TR (AP 2007-02)

MIMO Radio Propagation Channel Measurements in a Small Urban Macrocell at 4.5GHz

Seminar, *Mobile Communications Research Group*
07 June 2007

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Why model?

One of the general goals of MIMO propagation channel modeling:

MIMO performance exploitation for future cellular communication systems

Double-directional channel model

antenna independent

4.5 GHz

- part of the spectrum proposed for 4G mobile networks by Japan
- not many channel sounding has been done at this frequency
  - especially in considering certain parameters based on the polarimetric information

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Why model?

Goal: show certain characteristics of selected propagation channels in terms of condensed parameters

- root-mean-square (rms) delay spread
- cross-polarization ratio (XPR)
- co-polarization ratio (CPR)

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How did we measure the channel?

Medav RUSK-Fujitsu MIMO Channel Sounder

Carrier frequency	4.5 GHz
Bandwidth	120 MHz
BS Antenna	*Uniform Rectangular Array* V & H polarization 4-x-2 patch antenna elements
MS Antenna	*Stacked Uniform Circular Array* V & H polarization 24-x-2 patch antenna elements
Tx Signal	*Wideband Multicarrier* *Spread Spectrum*
Tx Power	40 dBm
Maximum path delay	3.2 μs

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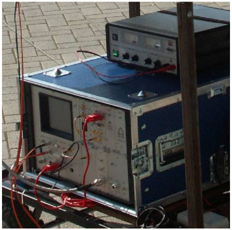
How did we measure the channel?

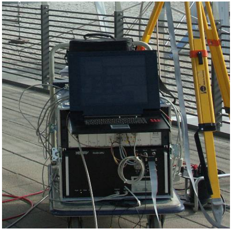
Medav RUSK-Fujitsu MIMO Channel Sounder

BS Antenna

MS Antenna



BS



MS

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- CPR

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Where and how did we measure the channel?

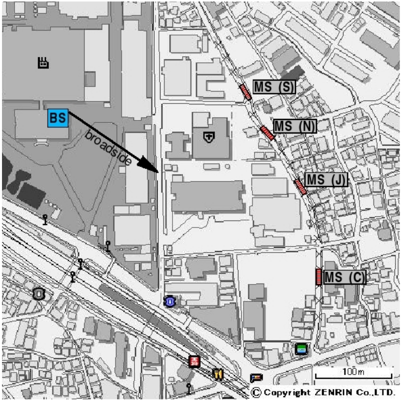
Measurement site

Kamikodanaka, Nakahara-ku, Kawasaki City

- a mix of residential, commercial, & industrial zones

Dynamic measurements

- 20-meter lengths
- performed after midnight



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Where and how did we measure the channel?

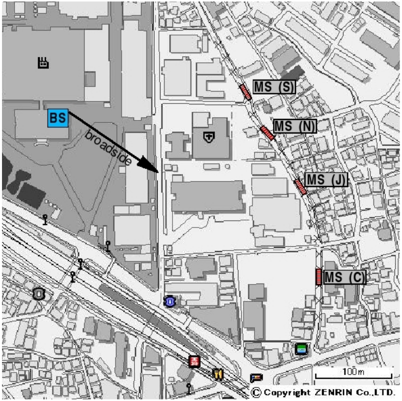
Small macrocell setup

BS height: ∼85 m

- highest location within the MS locations

MS height: ∼1.8 m

- nearest point: ∼215 m
- farthest point: ∼430 m



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How and what were the parameters extracted?

Offline data processing

- obtain parameter estimates of the propagation channel
- multidimensional maximum-likelihood algorithm
  - based on the double-directional channel concept

Estimated parameters of each radio path

- direction of arrival (DoA); azimuth & elevation
- direction of departure (DoD); azimuth & elevation
- delay time
- complex amplitude of the polarimetric components $(\gamma_{\mathrm{VV}},\ \gamma_{\mathrm{VH}},\ \gamma_{\mathrm{HV}},\ \gamma_{\mathrm{VV}})$

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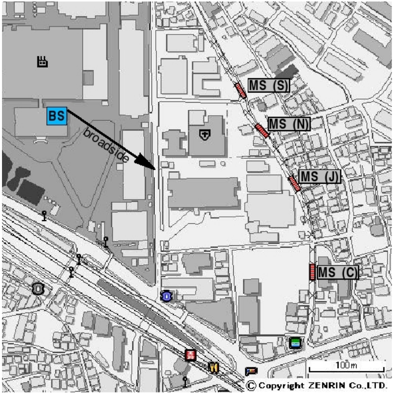

Channel Scenario Descriptions

Label	BS-MS distance (m)	Description
C	∼400	better LOS among the other scenarios
J	∼320	a building blocked most of the measurement —mostly NLOS-like scenario
N	∼267	main obstructions: trees & buildings, but they did not completely block the channel
S	∼232	better LOS than scenarios J & N

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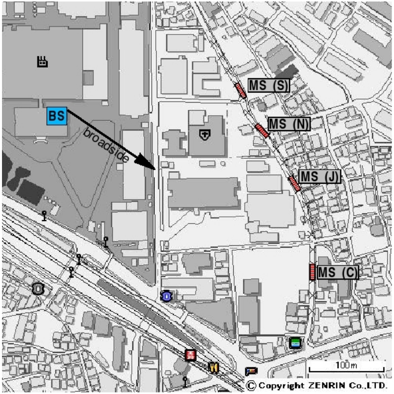
Some Remarks (1)



MS moved toward the BS

scenario C towards scenario S

Irregular measurement route

not like a Kyoto-street grid

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Some Remarks (2)

Computation of condensed parameters

- relatively strong paths—until 20 dBm below the normalized strongest path (0 dBm)
- considered specular paths only & not the diffuse components

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XPR - amount of polarization change of a signal from being V-polarized to being H-polarized, or vice versa

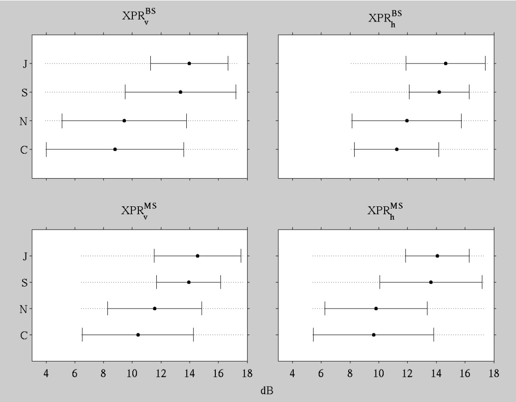
$$\mathrm{XPR(s)}_{\mathrm{V}}^{\mathrm{BS}} = 10\log_{10}\left(\frac{\sum_{l=1}^{L(s)} |\gamma_{\mathrm{VV},l}|^2}{\sum_{l=1}^{L(s)} |\gamma_{\mathrm{VH},l}|^2}\right) \text{ [dB]}$$

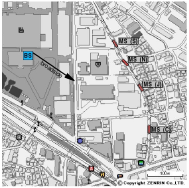
$$\mathrm{XPR(s)}_{\mathrm{H}}^{\mathrm{BS}} = 10\log_{10}\left(\frac{\sum_{l=1}^{L(s)} |\gamma_{\mathrm{HH},l}|^2}{\sum_{l=1}^{L(s)} |\gamma_{\mathrm{HV},l}|^2}\right) \text{ [dB]}$$

$$\mathrm{XPR(s)}_{\mathrm{V}}^{\mathrm{MS}} = 10\log_{10}\left(\frac{\sum_{l=1}^{L(s)} |\gamma_{\mathrm{VV},l}|^2}{\sum_{l=1}^{L(s)} |\gamma_{\mathrm{HV},l}|^2}\right) \text{ [dB]}$$

$$\mathrm{XPR(s)}_{\mathrm{H}}^{\mathrm{MS}} = 10\log_{10}\left(\frac{\sum_{l=1}^{L(s)} |\gamma_{\mathrm{HH},l}|^2}{\sum_{l=1}^{L(s)} |\gamma_{\mathrm{VH},l}|^2}\right) \text{ [dB]}$$

XPR





Most of the scenarios preferred V-polarized signals

Scenarios J & S

lower polarization change than in scenarios N & C

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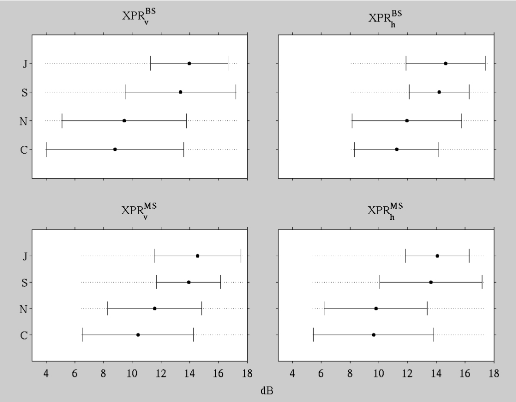

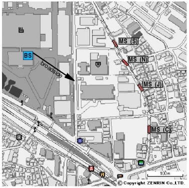

Scenario J

highest mean XPR; low variation

- interacting objects (IOs) of the building: mostly present throughout the measurement route

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Scenario J

IOs of the building: mostly present throughout the measurement route

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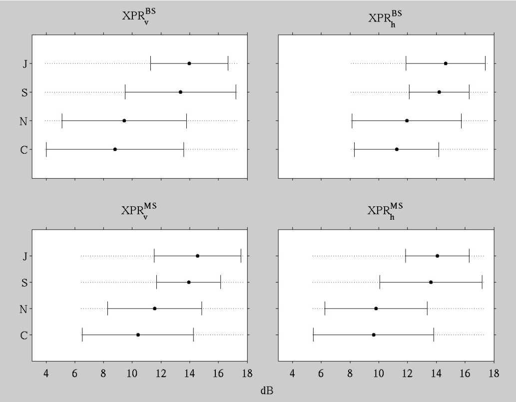

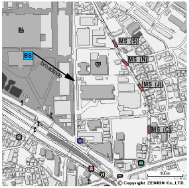

Scenario C

least mean XPR; highest variation

- LOS presence in most of the measurement route
  - preserved the co-polarized components

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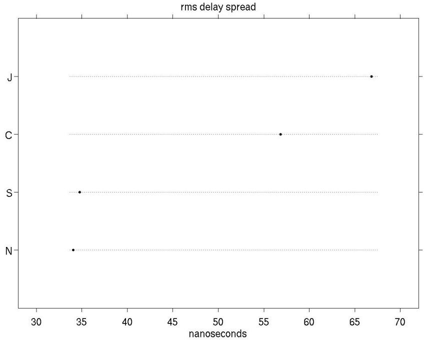
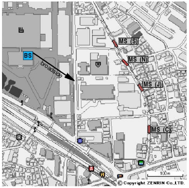
Scenario C

least mean XPR; highest variation

- LOS presence in most of the measurement route
  - preserved the co-polarized components
- positions of the IOs near the MS
  - contributed to changing the polarization
  - many horizontally oriented IO positions

RMS Delay Spread





Scenario J was the most spread

Scenarios N & S were the less spread

- relative nearness of the MS to the BS
- weaker LOS in scenario N than in scenario S

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RMS Delay Spread

Scenario N should had been more spread, but not in our case

- constructively rich scattering in scenario N
- scenario N had an obstructed line-of-sight-like (OLOS-like) setting

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CPR

The dB value of the CPR (like in XPR) was used for the statistics, assuming the log-normal distribution

$$\mathrm{CPR}(s) = 10\log_{10}\left(\frac{\sum_{l=1}^{L(s)} |\gamma_{\mathrm{VV},l}|^2}{\sum_{l=1}^{L(s)} |\gamma_{\mathrm{HH},l}|^2}\right)\ [\mathrm{dB}]$$

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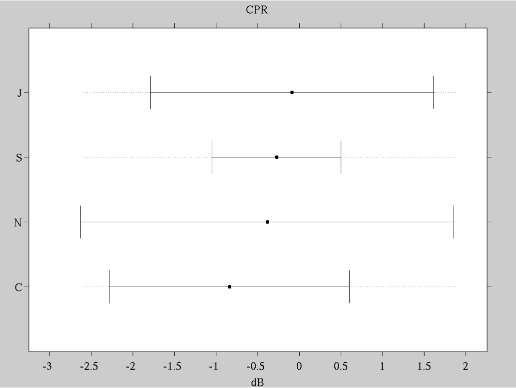

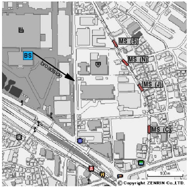

Scenario N

- fewer vertically oriented IOs than that in scenario J
- difficult to decide which of the IOs were predominant
    - highest CPR standard deviation

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Scenario N

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Conclusions

Polarization change

- LOS presence did not assure co-polarized components
- orientation of the IOs surrounding the BS or MS
- XPR higher in our NLOS scenario than in our LOS scenario

RMS delay spread

more spread in the NLOS scenario but lesser in the LOS scenario

Overall, the results follow the general channel behavior of macrocell scenarios

but, environment-specific circumstances make propositions about MIMO propagation channel characteristics difficult