

Performance evaluation of a reconfigurable radio platform in a field test and in a simulation utilizing measured channel data

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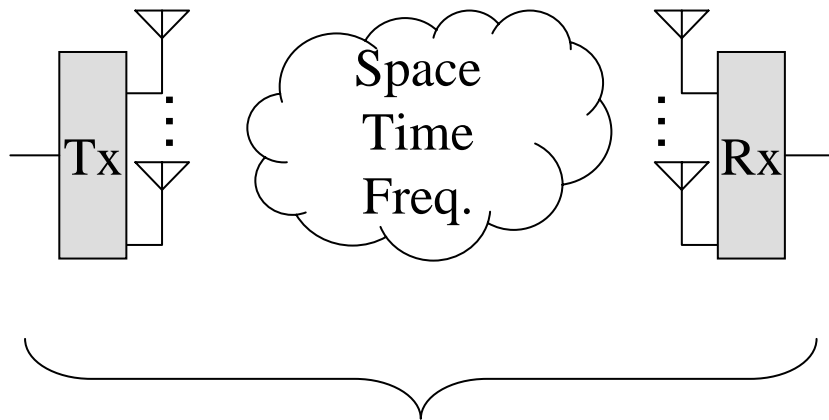
Elektrobit Testing Ltd., Finland

Outline

- Background
- Concept of real-time hardware simulation using a reconfigurable radio platform
- A field test and a laboratory test using measured channel data
 - The reconfigurable platform
 - Setups for the tests
- Results
- Conclusion

Background

Evaluation of multi-antenna transmission techniques



Software simulations require unacceptably long time

Real-time hardware simulations

- A reconfigurable radio platform
- Measured channel data

Realistic channel model

- complexity of modelling

Measured channel data

Various algorithms

Heavy signal processing

Low bit error rates

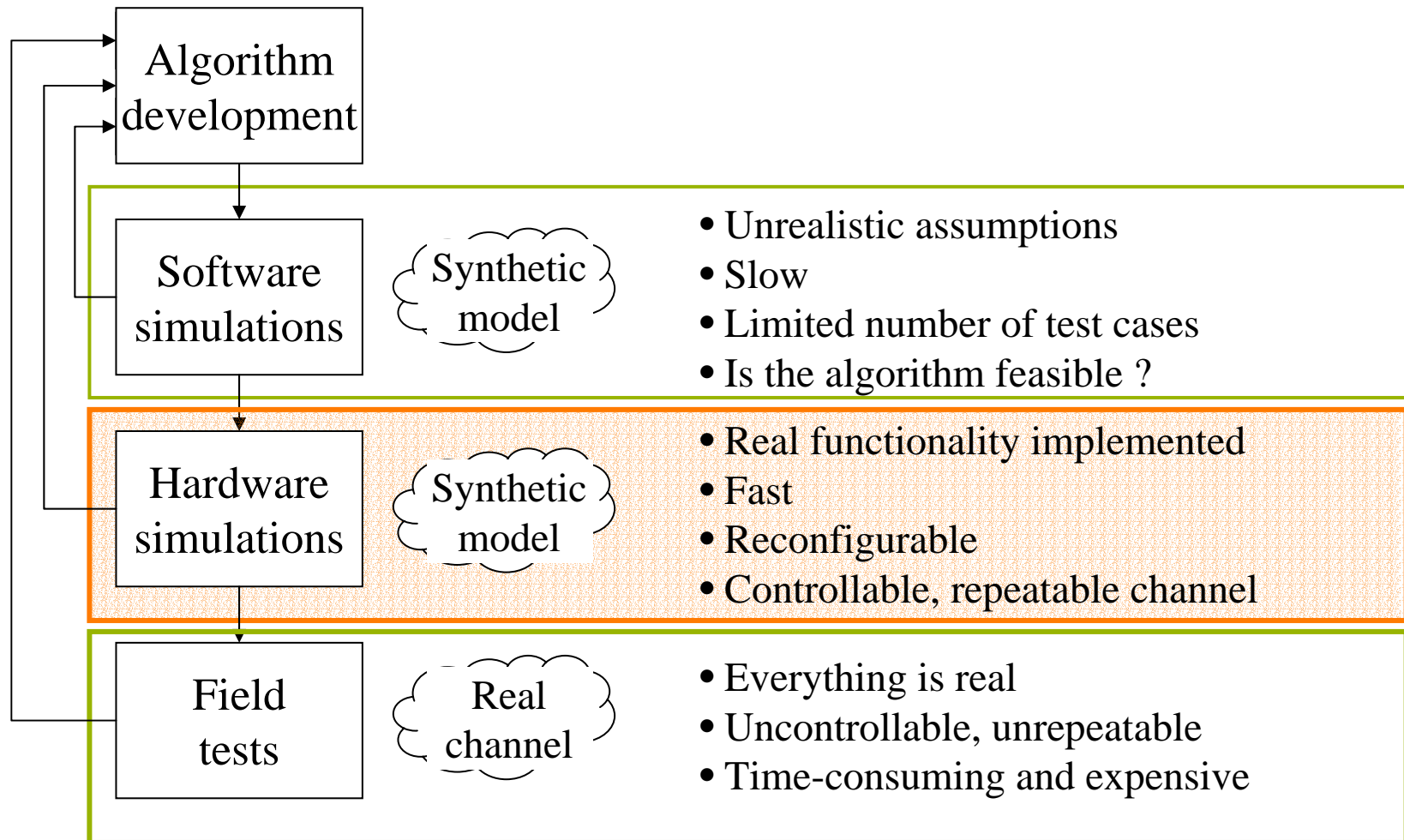
A field test in a real environment

 Comparison

A simulation utilizing measured channel data

Benefits of real-time hardware simulations

Performance evaluation phases



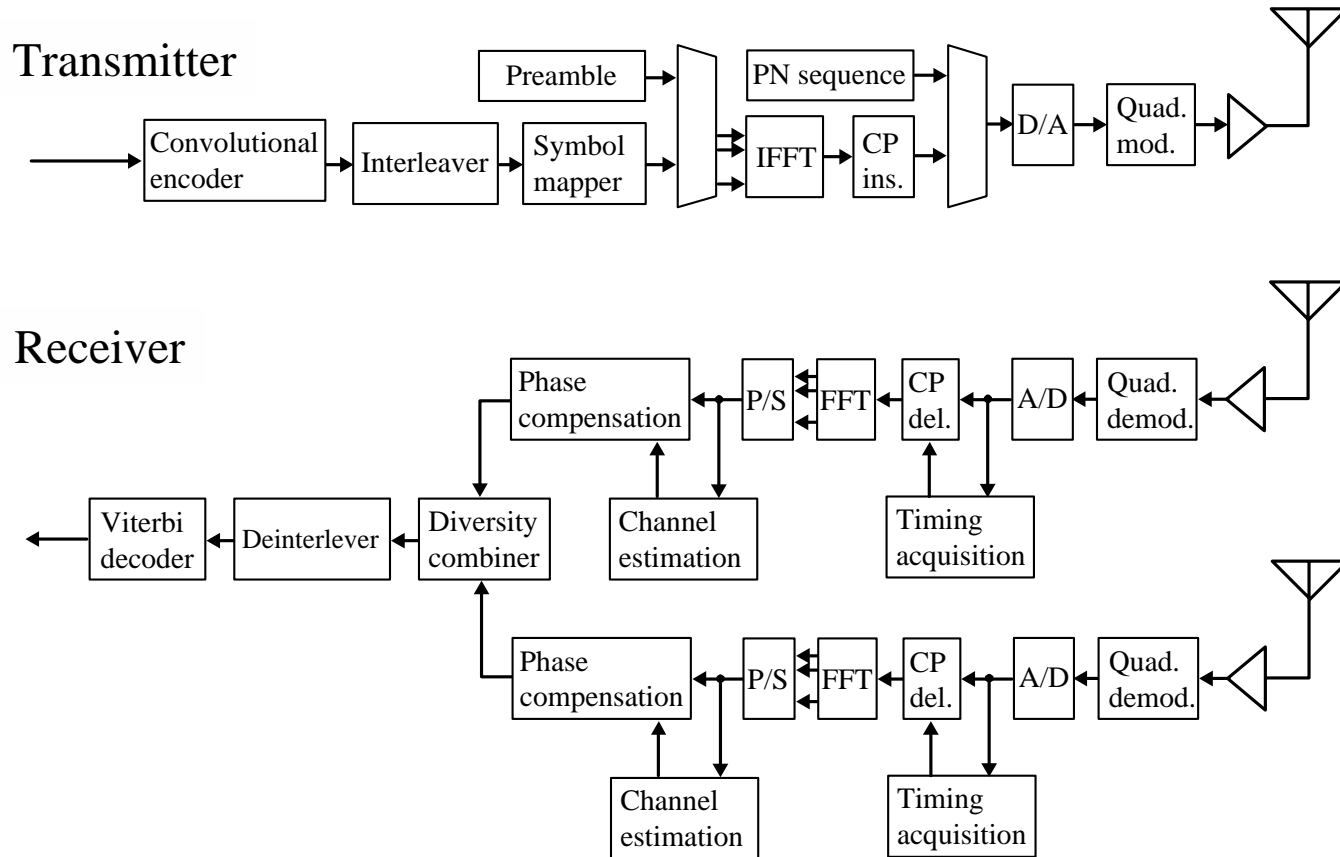
Validation of the hardware simulation using measured channel data

Impact of antenna spacing on BER when receive diversity is employed in an OFDM transceiver

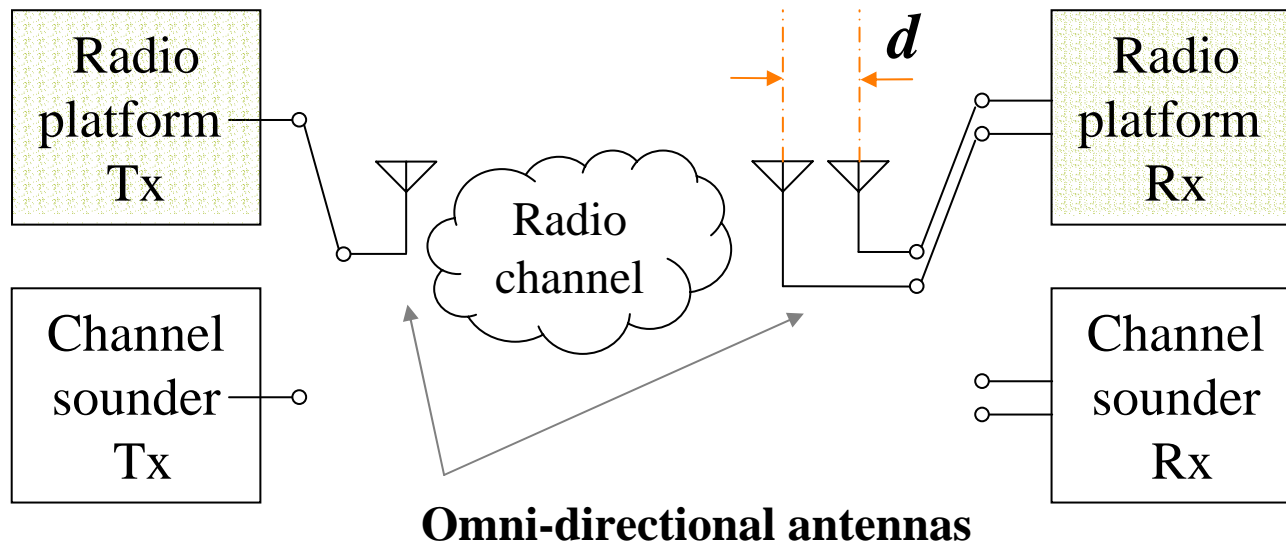
- Field test
 - Reference results
- Channel measurement
 - The same setups as in the field test
 - Environment, antenna positions
 - Antennas, cables
- Hardware simulation in a laboratory
 - The recorded channel data is played back in a hardware channel simulator

The reconfigurable radio platform

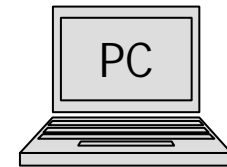
- Base-band signal processing implemented in FPGA devices
- Wideband ADC and RF interface



Setup for field test and channel measurement



- BER
- I-Q constellations
- Channel estimates



- Complex channel impulse responses

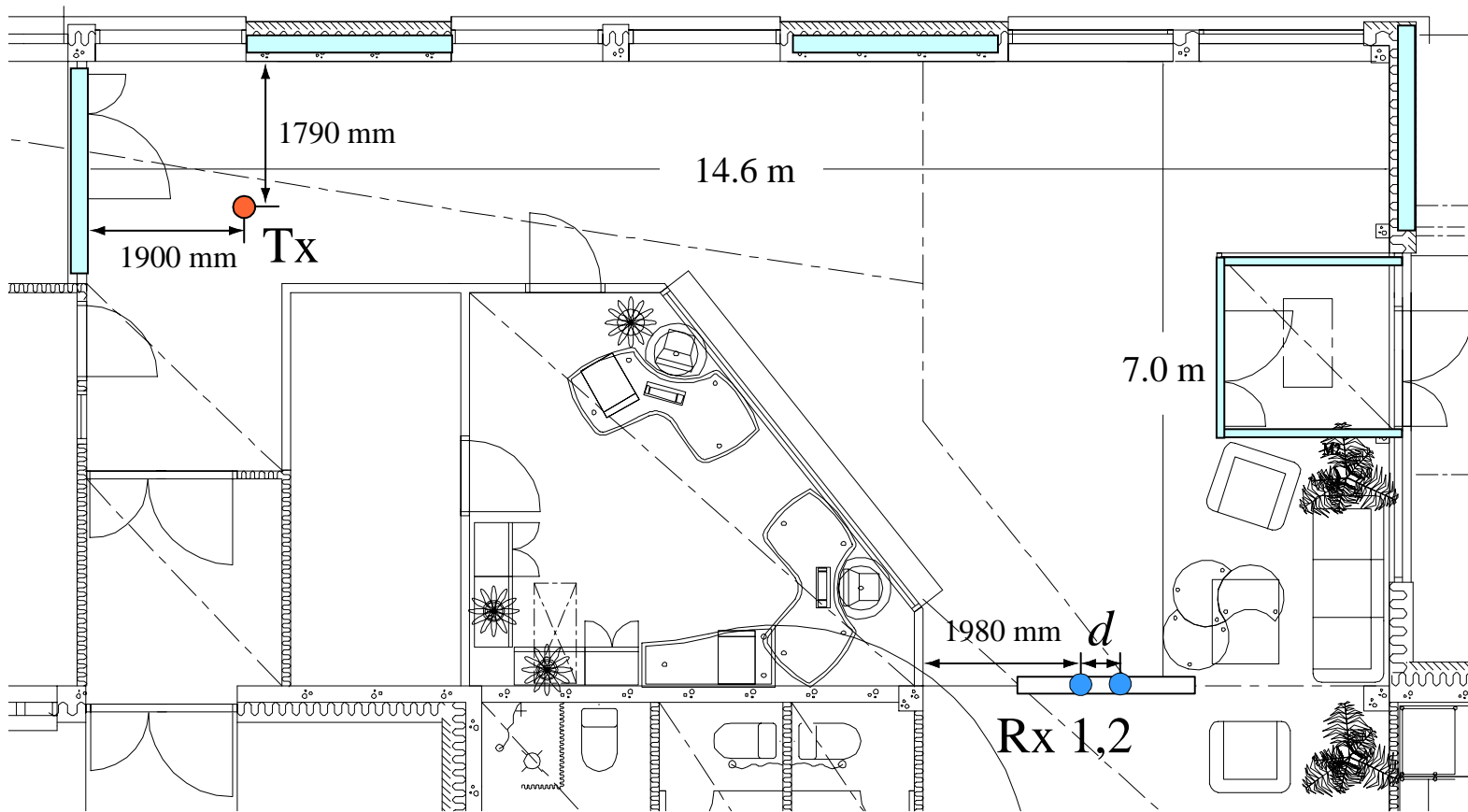
Field test

- Receive diversity (EGC)
- BERs for different antenna spacing d

Channel measurement

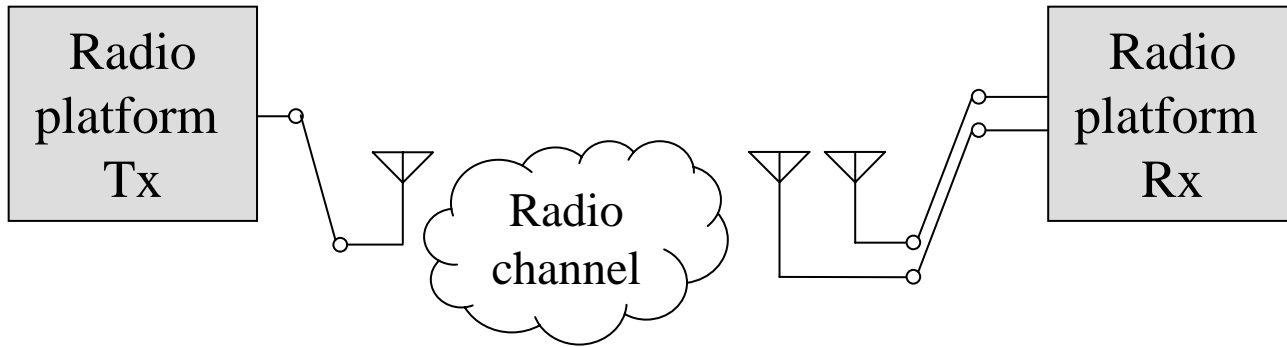
- Direct sequence / spread spectrum (DS/SS)
- 100 Mchips/s chip rate
- Impulse responses for different d

The test environment (an entrance hall)

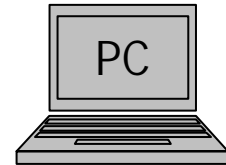


- NLOS
- Concrete walls, glass windows, metal objects
- No moving objects
- Antenna height 1.5m

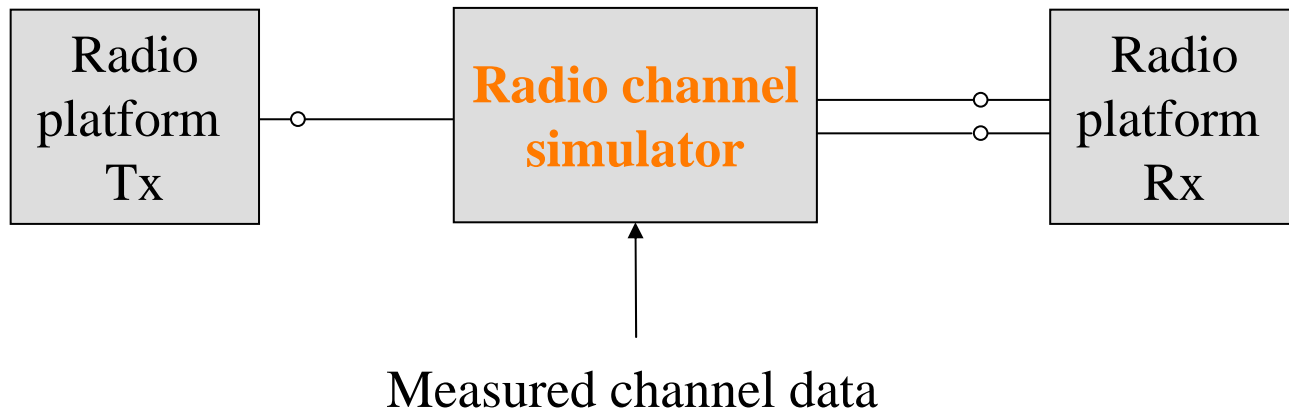
Setup for the laboratory test



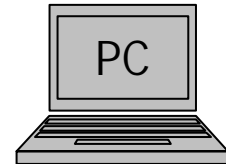
- BER
- I-Q constellations
- Channel estimates



Setup for the laboratory test



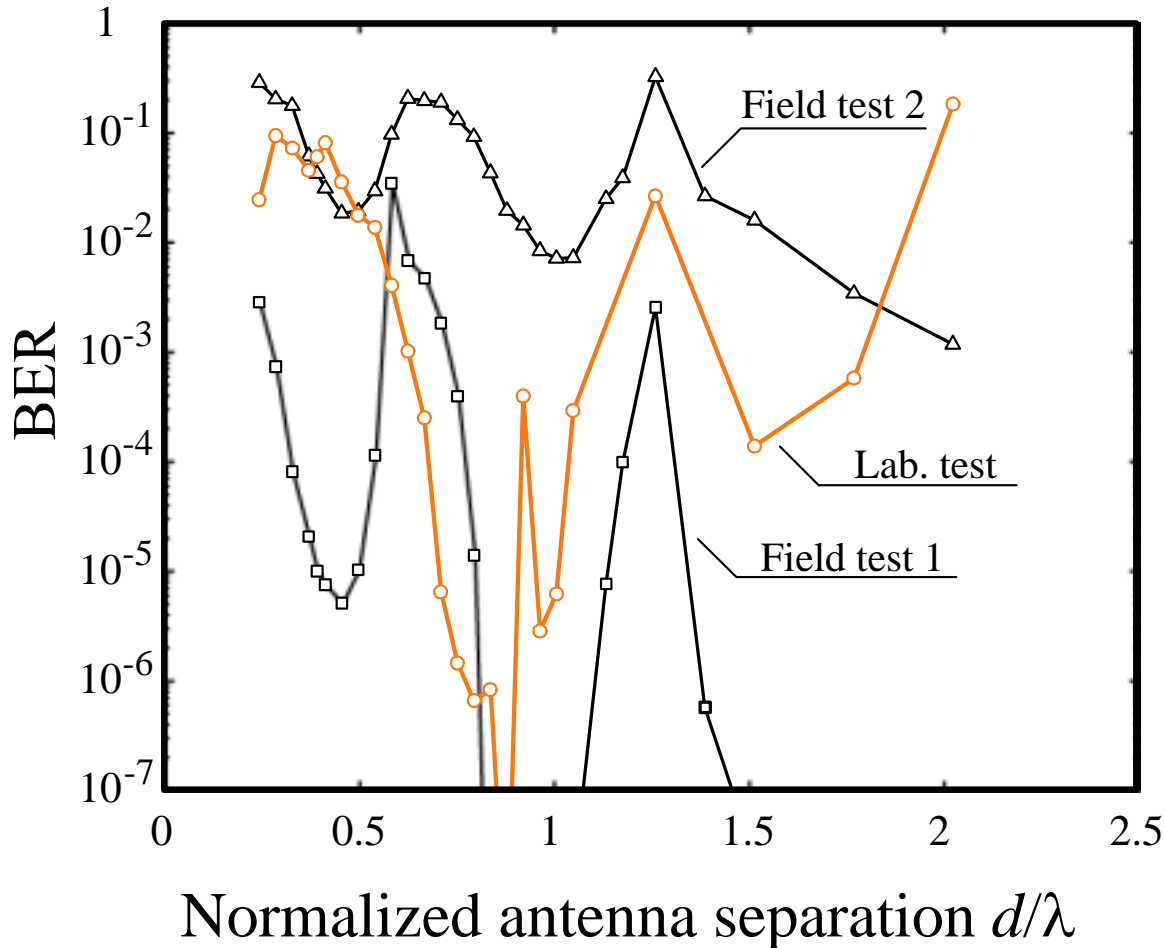
- BER
- I-Q constellations
- Channel estimates



Parameters for the OFDM air interface

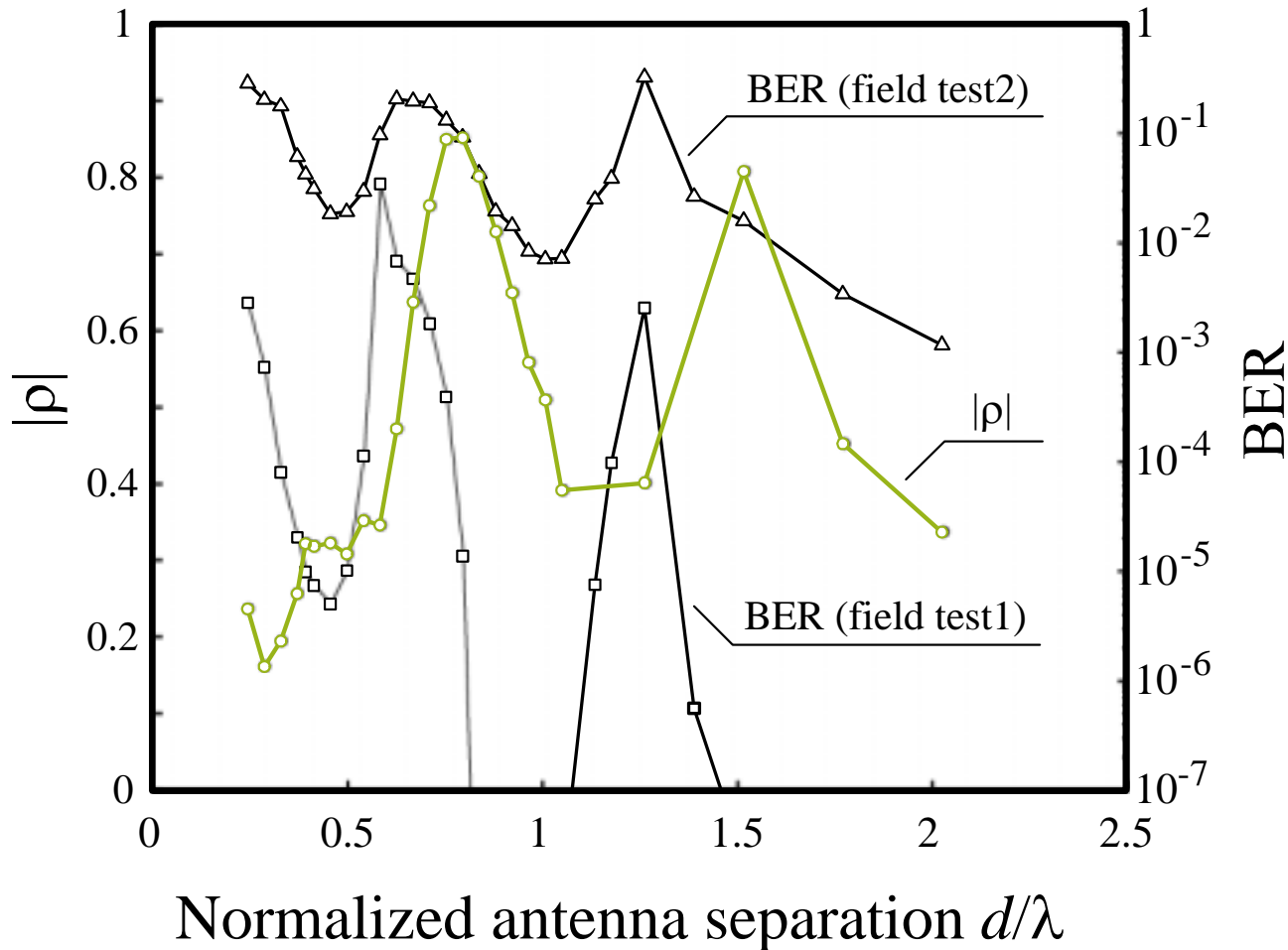
Parameters	Specifications
Center frequency	2.45 GHz
IFFT/FFT points	64
Number of subcarriers for data	52
OFDM symbol rate	250 ksps
OFDM symbol + Cyclic postfix	$3.2 \mu\text{s} + 0.8 \mu\text{s}$
Signal bandwidth	16.9 MHz
Frame length (preamble + data)	$16 \mu\text{s} + 64 \mu\text{s}$ (16 OFDM symbols)
Channel coding	Convolutional code ($r = 1/2$, $K = 7$)
Interleaving	On
Modulation	Coherent BPSK
Rx diversity	Post-FFT, equal gain combining (EGC)

The effect of antenna spacing on BER



- Strong correlation between two curves from field tests
- Strong correlation between field test and lab test. ($d/\lambda = 0.6 - 1.5$)
- The channel in the real environment was accurately measured and regenerated in the lab.

Calculated spatial correlation $|\rho|$



- No correlation found between $|\rho|$ and BER
- Low correlation for $d/\lambda < 0.5$
 - Mutual coupling
- Periodical shape
 - Reflection at antennas

Conclusion

- Validation of real-time hardware simulation using measured channel data
 - Acceptably good correlation between BER curves from the lab test and the field test
 - The simulation method is a fast and effective way to get reliable results
 - Fast because it replaces field tests and works in real time
 - Effective because different algorithm can be tested in the same platform
 - Reliable because measured channel data can be applied

View from Tx antenna



- Corridor-like place
- NLOS (The Rx antenna are located around the corner.)
- Some metal objects (heaters, window frames, rack, etc.)

View from Rx antennas



- NLOS (The Tx antenna is located around the corner.)
- Some metal objects (heaters, window frames, rack, etc.)

Picture from the entrance hall



Antennas

	Tx	Rx
Model	Aerial AV1479	Aerial AV1433
Frequency	2.4 – 2.5 GHz	2.4 – 2.5 GHz
Bandwidth	100 MHz	100 MHz
Polarization	Vertical	Vertical
E-plane 3db bandwidth	80 degree	70 degree
H-plane 3db bandwidth	-	-