Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

Submission Title: Self Spatial Filtering Scheme for PAC
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Re: TG8 Call for Proposal (IEEE P802.15-13-0069-05-0008)

Abstract: Technical Proposal of Self Spatial Filterinig Scheme for PAC

Purpose: Proposal for discussion

Self Spatial Filtering Scheme for PAC

Byung-Jae Kwak, Kapseok Chang

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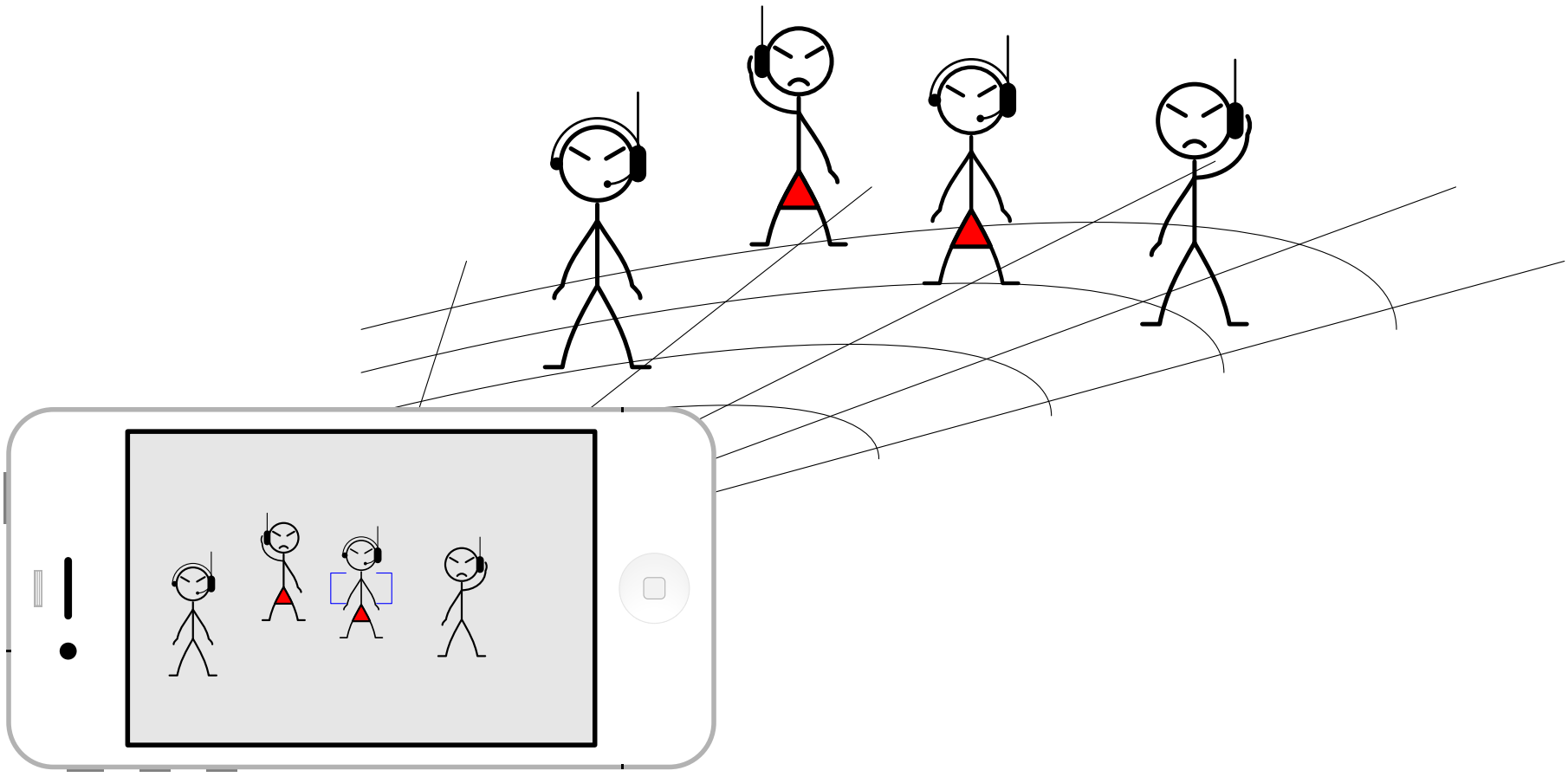
Daejeon, Korea

July 2013
IEEE 802.15 Plenary
Geneva Switzerland

Outline

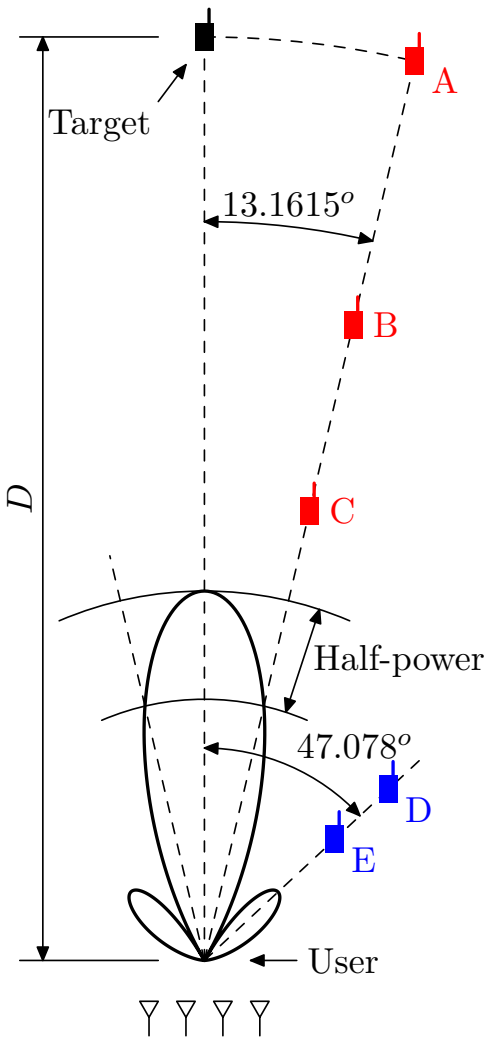
PAC Usage Scenario with Spatial Filtering



Spatial Filtering: Benefits and Requirements

- Benefits
  - Minimize signaling overhead
  - Minimize interference
  - Faster discovery
  - Improved user experience
- Spatial filtering scheme should
  - have good spatial resolution
  - minimize the harmful influence of sidelobes
  - be independent of the RSS or SNR (i.e., distance)
- H/W requirement
  - Transmitter: array antenna
  - Receiver: single antenna

Conventional Beamforming Does Not Work



4 antenna ULA

- Half-power beam width: 26.323°
- Side lobe at 47.078°
- Free-space path loss assumed

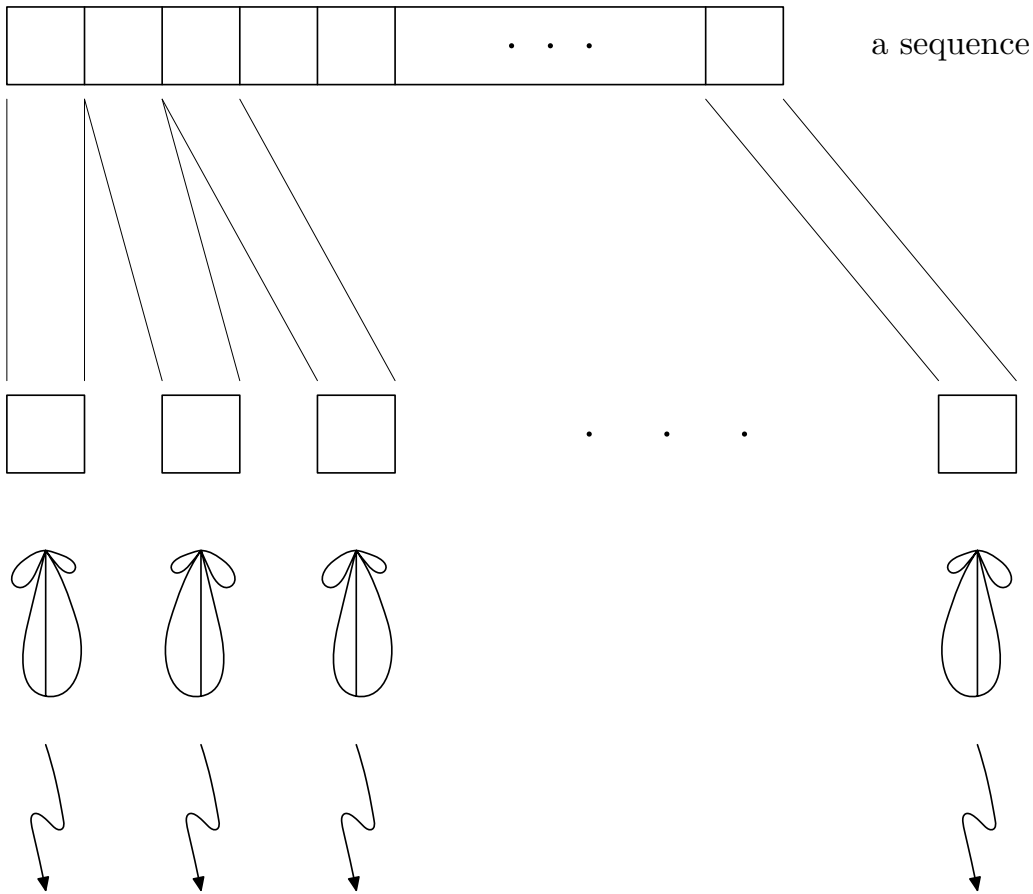
	Distance from user	SNR [dB]
Target	D	SNR_T
A	D	$\text{SNR}_T - 3$
B	$D/\sqrt{2}$	SNR_T
C	$D/2$	$\text{SNR}_T + 3$
D	$0.2722D$	SNR_T
E	$0.1925D$	$\text{SNR}_T + 3$

Problems

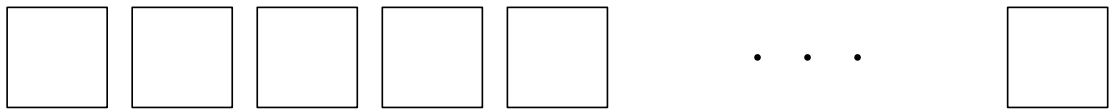
- Beam resolution not high enough
- Impossible to control/know the SNR of interfering devices
- Subject to the harmful effect of side lobes

Outline

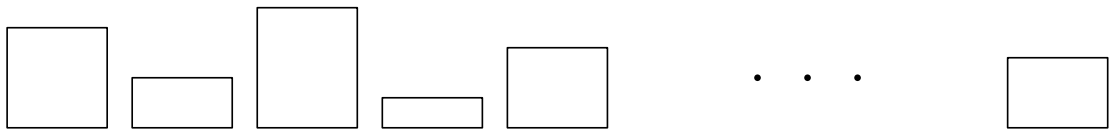
Transmission



Received Signals

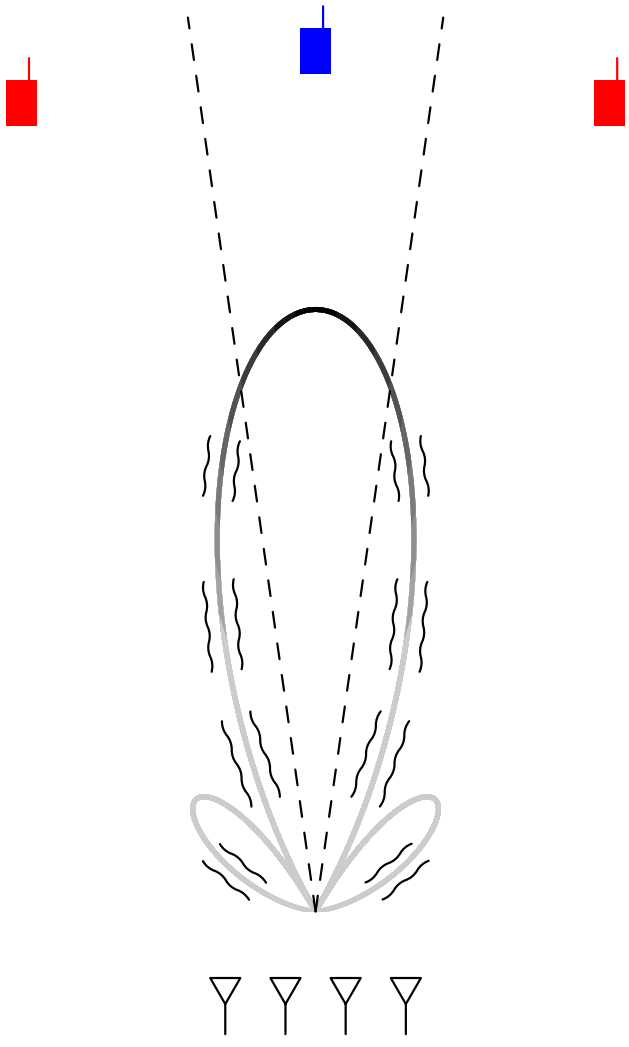


The received symbols in the look direction



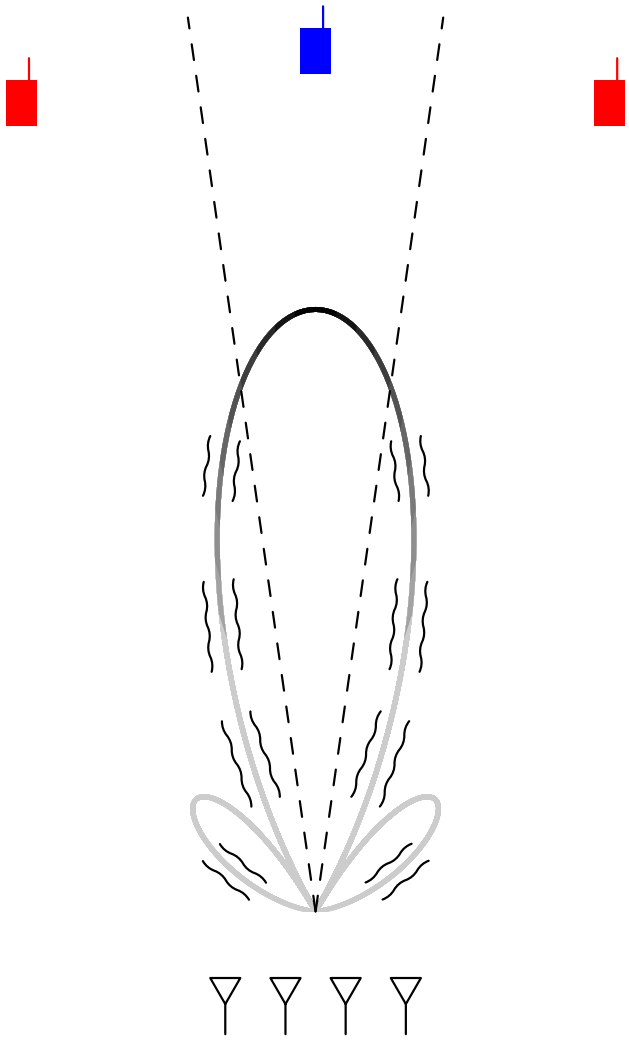
The received symbols not in the look direction

The Effect



"It is a terrible thing
to see and have no vision."
– Helen Keller

The Effect



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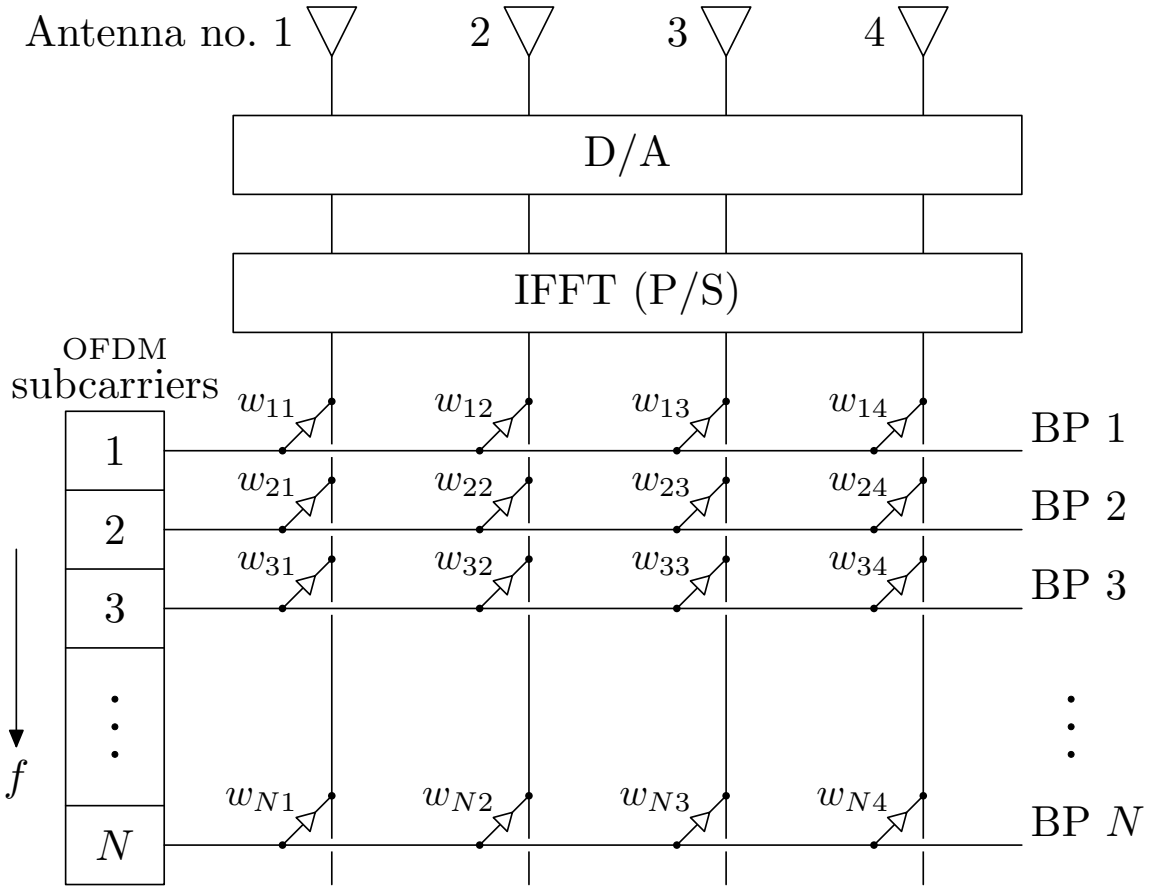
Transmitter Structure

OFDM transmitter structure for RJBF



Same structure as a single stream MIMO-OFDM transmitter

Reception of RJBF Signals

- No special hardware required
  (an omni-directional single antenna suffices)
- Receiver calculates ρ

$$\rho = \frac{< \vec{x}, \vec{r} >}{\sqrt{< \vec{x}, \vec{x} > \cdot < \vec{r}, \vec{r} >}} \quad \gtrless \quad \text{threshold}$$

  where $\vec{x}$: (known) transmitted sequence
  $\vec{r}$: received sequence

- $0 \leq \rho \leq 1$: $\rho \approx 1 \Rightarrow$ I'm the target! :-)
  $\rho \ll 1 \Rightarrow$ I'm not the target. :-(
- ρ: function of θ only, independent of SNR, and immune to sidelobes

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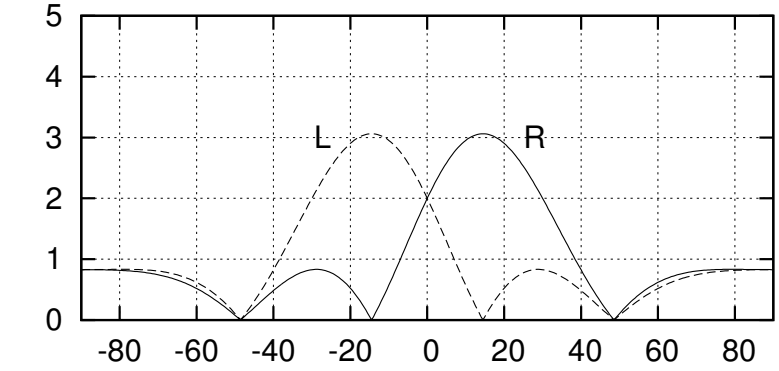
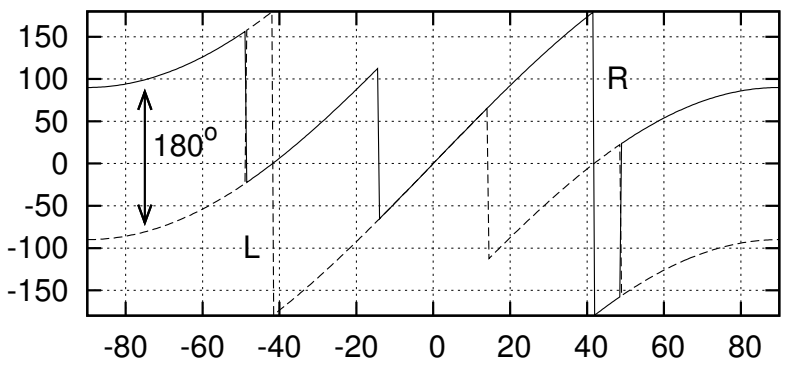
Pre-defined Beampatterns: Examples





4 ant. ULA

ant. spacing $= 0.5\lambda$

$K = 2^{\dagger}$

Null locations

Beam L:
$\sin^{-1}((2i-1)/4)$
$i = -1, 1, 2$
Beam R
$\sin^{-1}((2i-1)/4)$
$i = -1, 0, 2$

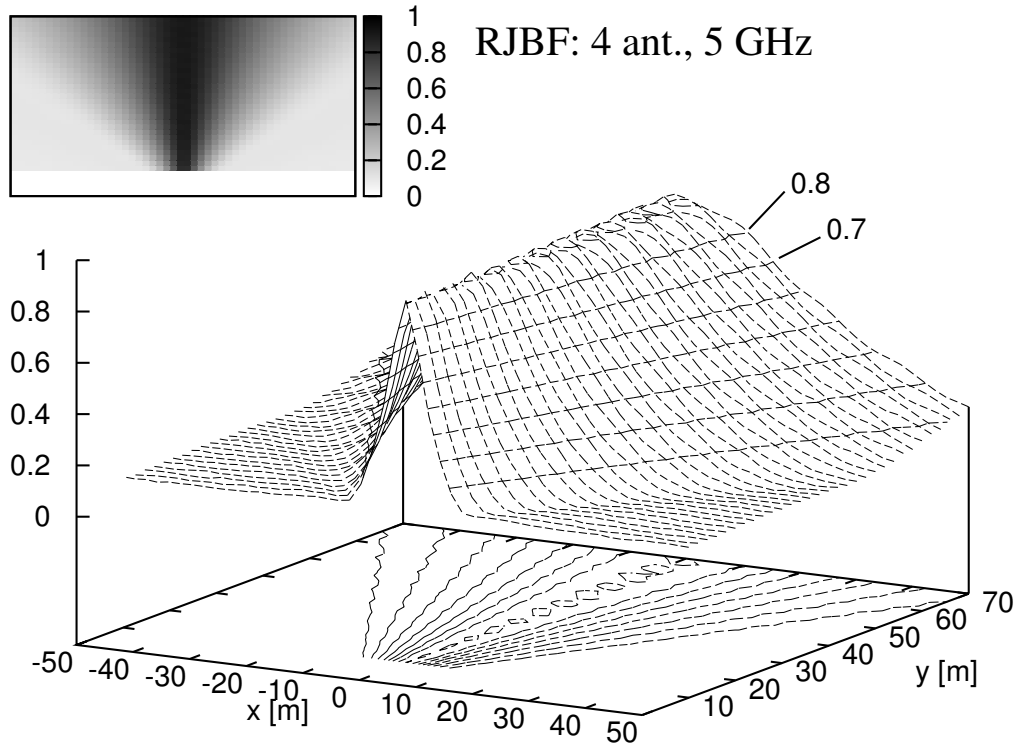
†: RJBF with $K = 2$ shows good performance when the beam patterns are well designed

Outline

Simulation Parameters

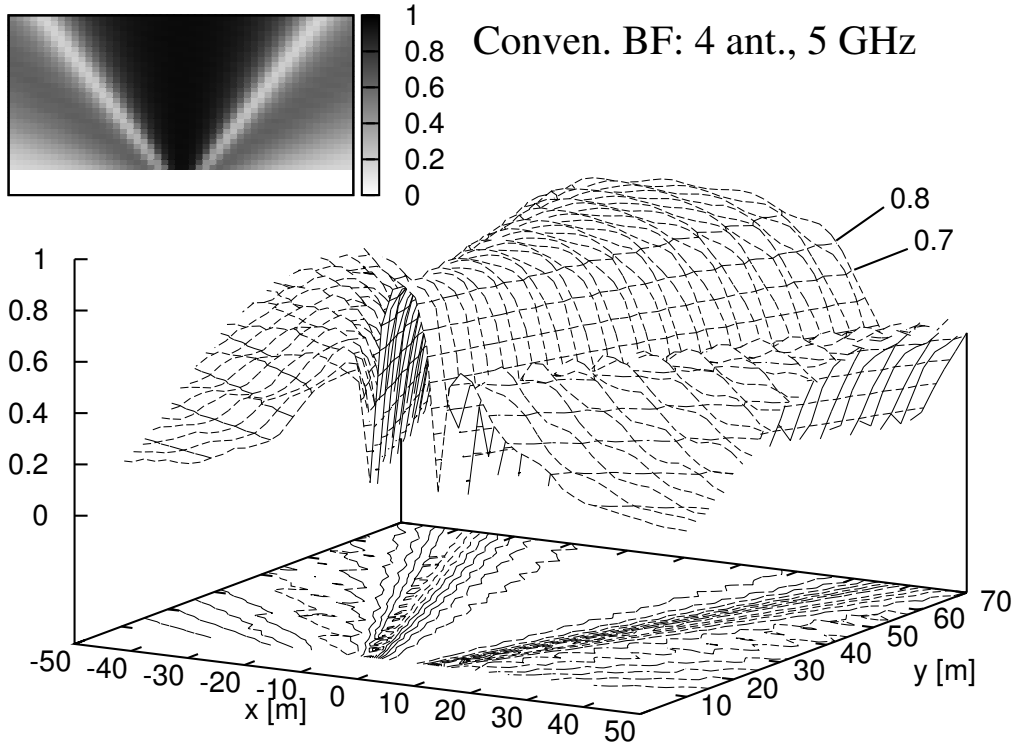
- 4 ant. ULA @ 5 GHz
- OFDM with 64 sub-carriers in 20 MHz band
- 100 mW transmit power
- Noise floor at the receiver: -88.9 dBm
- Channel Model: ETSI BRAN Channel D with LOS (Ricean $K = 10$ dB)
- 52 bit sequence with BPSK modulation
- 1000 independent runs for sample average

4 Ant. ULA: RJBF



Threshold	Filtering angle
0.8	$\approx 8^\circ$
0.7	$\approx 12^\circ$

4 Ant. ULA: Conven. BF



Threshold	Filtering angle
0.8	$\approx 21^\circ$
0.7	$\approx 23^\circ$

Outline

Bibliography

[1] “Channel models for TG8,” IEEE 802.15-12-0459-05-0008, Sep. 2012.

[2] “ETRI Technical PHY Proposal for IEEE 802.15 TG8 PAC Standard,” IEEE 802.15-13-0373-0x-0008, July 2013.

[3] “A Feasible and Efficient Channel Access Scheme for PAC Networks,” ETRI 802.15-13-0374-0x-0008, July 2013.

Thank You!