Towards 100 Gbps: Ultra-high Spectral Efficiency using massive MIMO with 3D Antenna Configurations

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Eckhard Grass,

grass@ihp-microelectronics.com
grass@informatik.hu-berlin.de

IHP
Leibniz-Institut für innovative Mikroelektronik
Im Technologiepark 25
15236 Frankfurt (Oder), Germany

Humboldt-Universität zu Berlin
Institut für Informatik
Rudower Chaussee 25
12489 Berlin, Germany

Cooperative Project „maximumMIMO“

Maximum Spectral Efficiency Through Parallelized Multiple-Input-Multiple-Output Transmission Using High-Resolution 3D Antenna Topologies

Project of the DFG Priority Programm 1655: **Wireless 100Gb/s and beyond**

Principal Investigators:

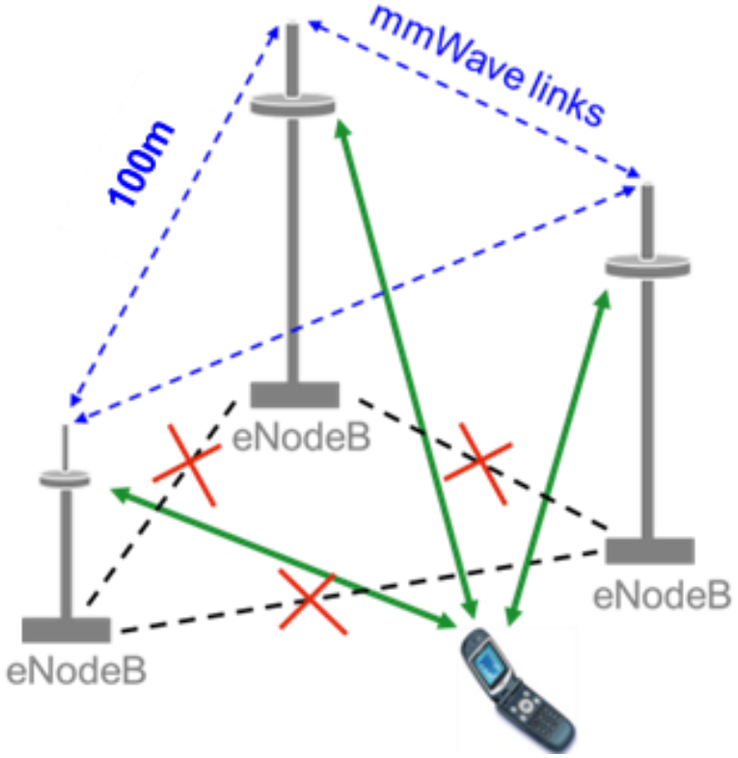
Gerhard P. Fettweis
Technische Universität Dresden

Eckhard Grass
Humboldt-Universität zu Berlin

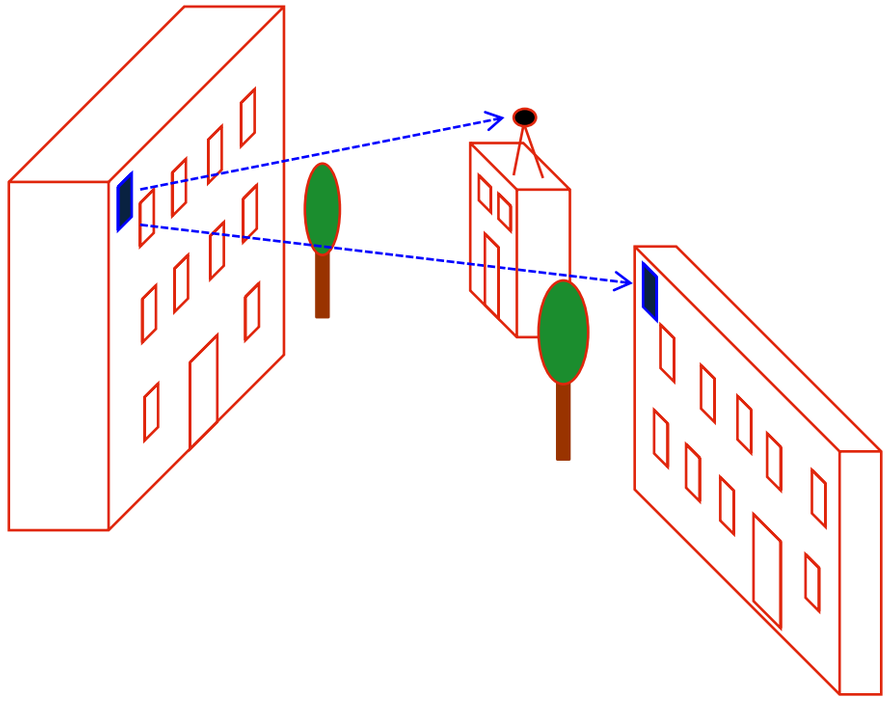
Berthold Lankl
Universität der Bundeswehr München

Application Scenarios Targetted

Wireless Backhaul,
LTE-Advanced, …

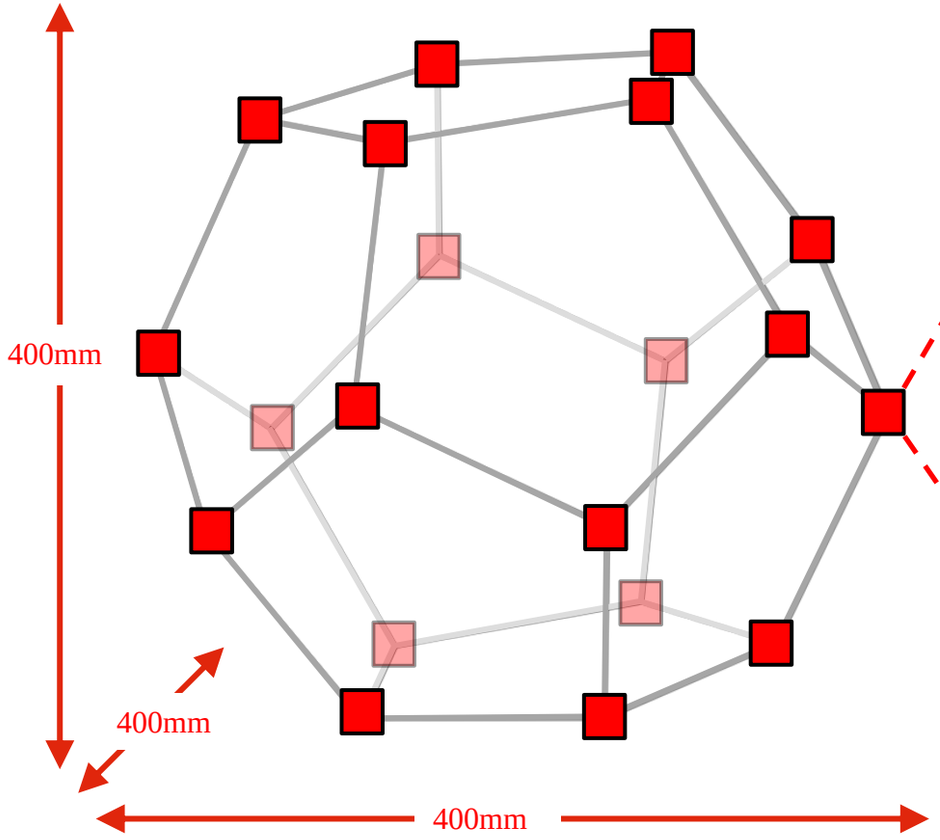


Urban P2P Links,
Campus Networks, …

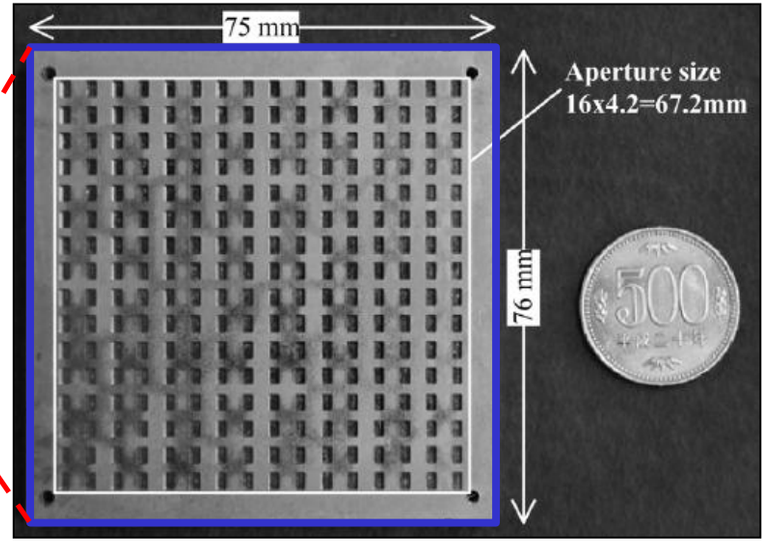


3D Antenna Topology for LOS-MIMO

Example: dodecahedron of 20 antenna elements



16 x 16 antenna element: 32dBi gain



Y. Miura, J. Hirokawa, M. Ando, Y. Shibuya, G. Yoshida,
"Double-Layer Full-Corporate-Feed Hollow-Waveguide
Slot Array Antenna in the 60-GHz Band,"
IEEE Trans. on Antennas and Propagation, 59(8), 2011.

Initial Link Budget Analysis

Systen parameters	Modulation alphabet	-	4-QAM	4-QAM	4-QAM	4-QAM	4-QAM
	Modulation raw spectral efficiency	**bpcu**	**2**	**2**	**2**	**2**	**2**
	Number of spatial streams	**-**	**41**	**55**	**82**	**163**	**325**
	Channel bandwidth	GHz	2,16	1,62	1,08	0,54	0,27
	Symbol rate	GHz	1,728	1,296	0,864	0,432	0,216
	Code rate	-	3/4	3/4	3/4	3/4	3/4
	Frame overhead (preamble, pilots, etc.)	%	*5,0*	*5,0*	*5,0*	*5,0*	*5,0*
	Effective data rate	**Gb/s**	***100,96***	***101,57***	***100,96***	***100,34***	***100,04***
	Spectral efficiency	bit/s/Hz	*46,74*	*62,70*	*93,48*	*185,82*	*370,50*
Ant. Gain	Tx Antenna element gain	dBi	35	35	35	35	35
	Rx Antenna element gain	dBi	35	35	35	35	35
Tx Power	Ouput power of the amplifier	dBm	-11,1	-12,4	-14,1	-17,1	-20,1
	Tx power (EIRP) per stream	dBm	23,9	22,6	20,9	17,9	14,9
	Tx power density (EIRP) per stream	dBm/MHz	-9,1	-10,4	-12,1	-15,1	-18,1
	Tx power (EIRP) <= 40 dBm !	**dBm**	**40,0**	**40,0**	**40,0**	**40,0**	**40,0**
Path loss	Reference distance	m	0,10	0,10	0,10	0,10	0,10
	Path loss at ref. distance	dB	47	47	47	47	47
	Path loss exponent		2	2	2	2	2
	Margin for rain attenuation	dB	3	3	3	3	3
Noise and impl. losses	Thermal noise power (-174dBm/Hz)	dBm	-81	-82	-84	-87	-90
	Rx noise figure	dB	8	8	8	8	8
	Average noise power	**dBm**	**-73**	**-74**	**-76**	**-79**	**-82**
	Analog losses (fronted, antenna)	dB	**6**	**6**	**6**	**6**	**6**
	Digital losses (sync, channel estimation, etc.)	dB	**3**	**3**	**3**	**3**	**3**
BER 10^{-4}	Required SNR (AWGN channel)	dB	11,4	11,4	11,4	11,4	11,4
	Operating range	**m**	**114,23**	**113,56**	**114,36**	**114,50**	**114,64**

← 40 … 400 antenna elements

← 2 … 0.2GHz bandwidth

← 100Gb/s PHY throughput

← min. 35dBi ant. element gain

(German regulation for 60 GHz outdoor P2P links)

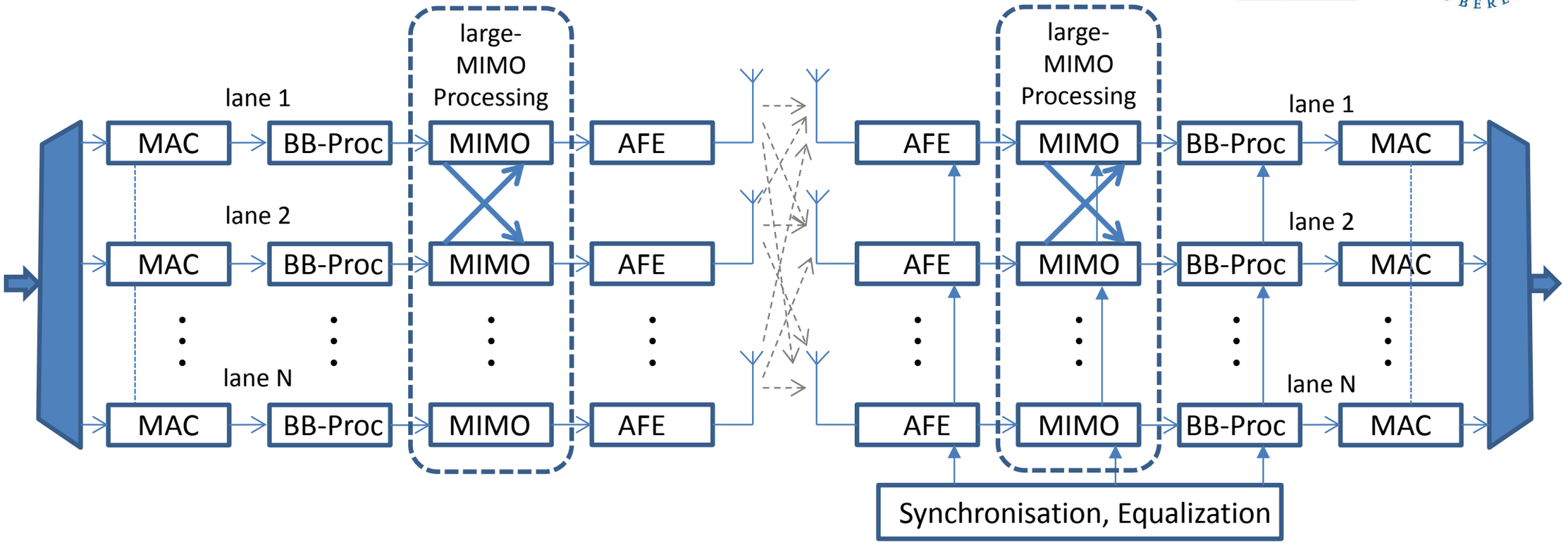
← max. 40dBm EIRP

(German regulation for 60 GHz outdoor P2P links)

← 100 m range

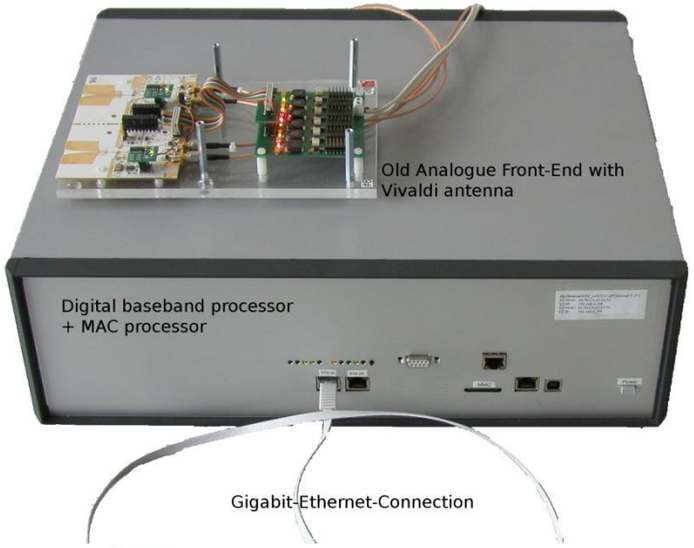
→ *It can be done !*

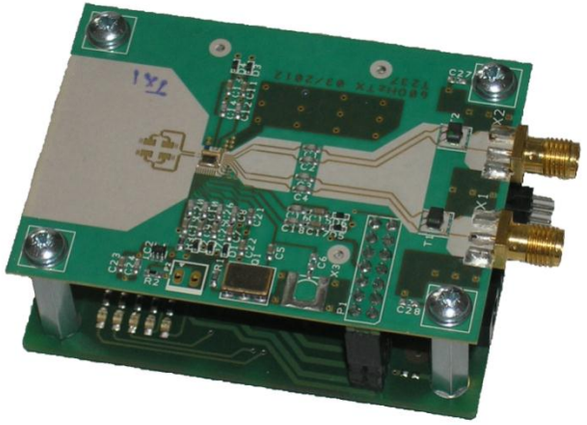
Architecture of the maximumMIMO System

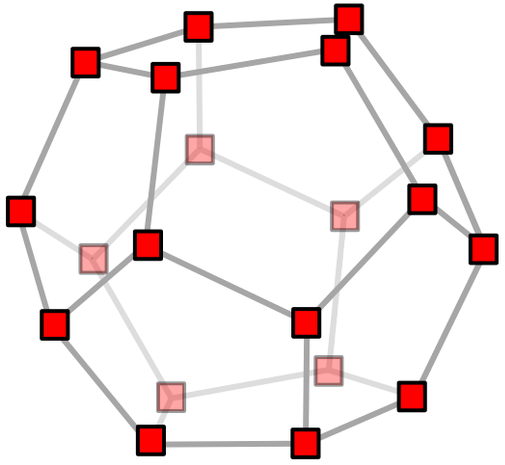


Challenges:
- Antenna design and optimisation (partitioning)
- Channel characterisation (for LOS-MIMO + 3D Antennas)
- massive MIMO processing (algorithms + implementation)
- Scalable parallel implementation of BB-processor and MAC, …

Planned Demonstrator Based on 60 GHz AFE



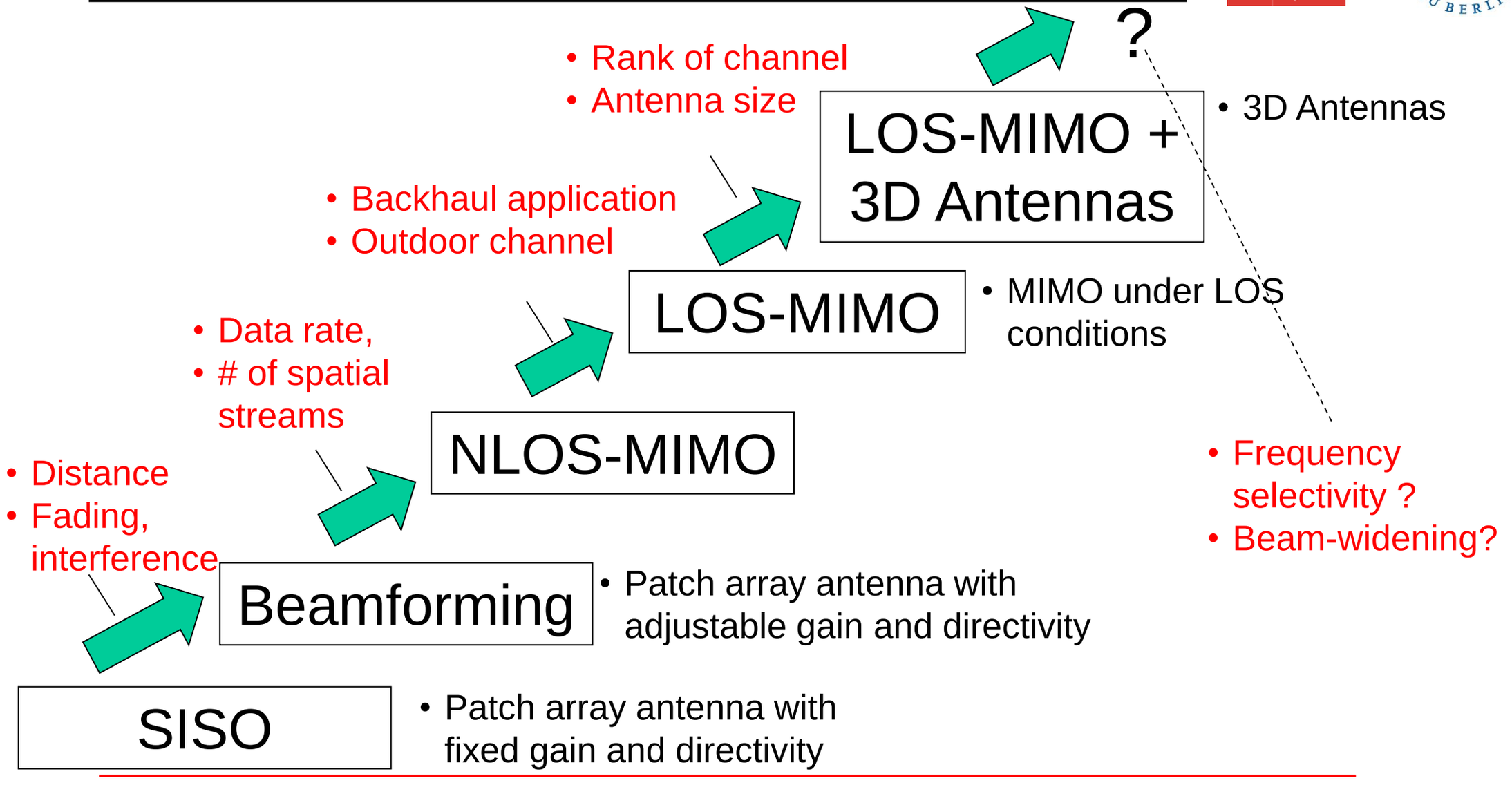




Available compact 60 GHz frontend module with patch array antenna and power supply

Planned small scale demonstrator using 60 GHz technology and 4 … 8 antennas

Trends: Transmission Schemes



Targetted Outcome: maximumMIMO will …

… identify fundamental design paradigms for wireless communication systems that use very large antenna arrays with 3D topology at the transmitter and receiver to maximize the bandwidth efficiency.

… derive information-theoretic concepts for robust 3D antenna topologies and highly-parallelized MIMO processing schemes, focusing on the fundamental limit for an arbitrary number of antenna elements.

… validate the theoretical concepts for practical applications, i.e., for antennas with 50 to1000 elements.

… consider LOS transmission at 60GHz as an application example, which will be extended to non-LOS transmission, e.g., for 100 Gb/s cellular communications, in the second phase of the project.

Thank You
Questions ?