MIMO Models for Smart On- and Off-Body Communications

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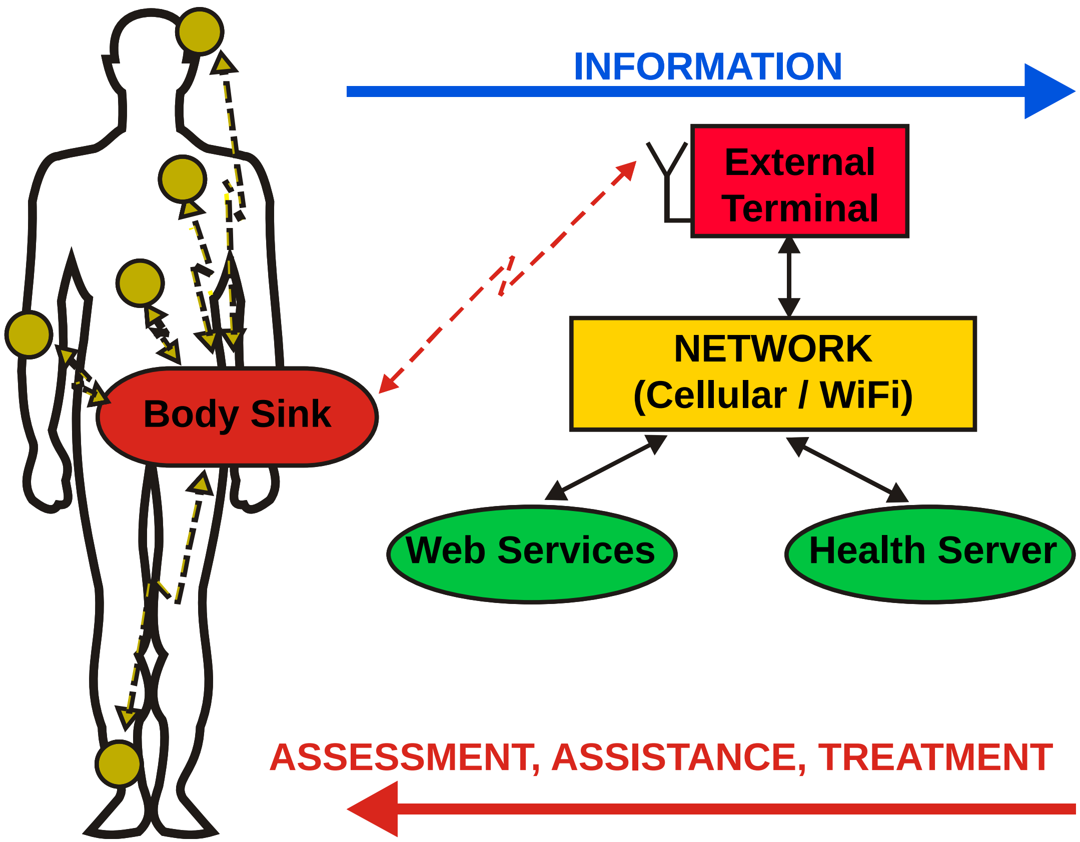
Outline

- Scope and Objective
- Models and Scenarios
- On-Body Channel
- Off-Body Channel
- Optimum 2×2 Placements
- Conclusions

Scope

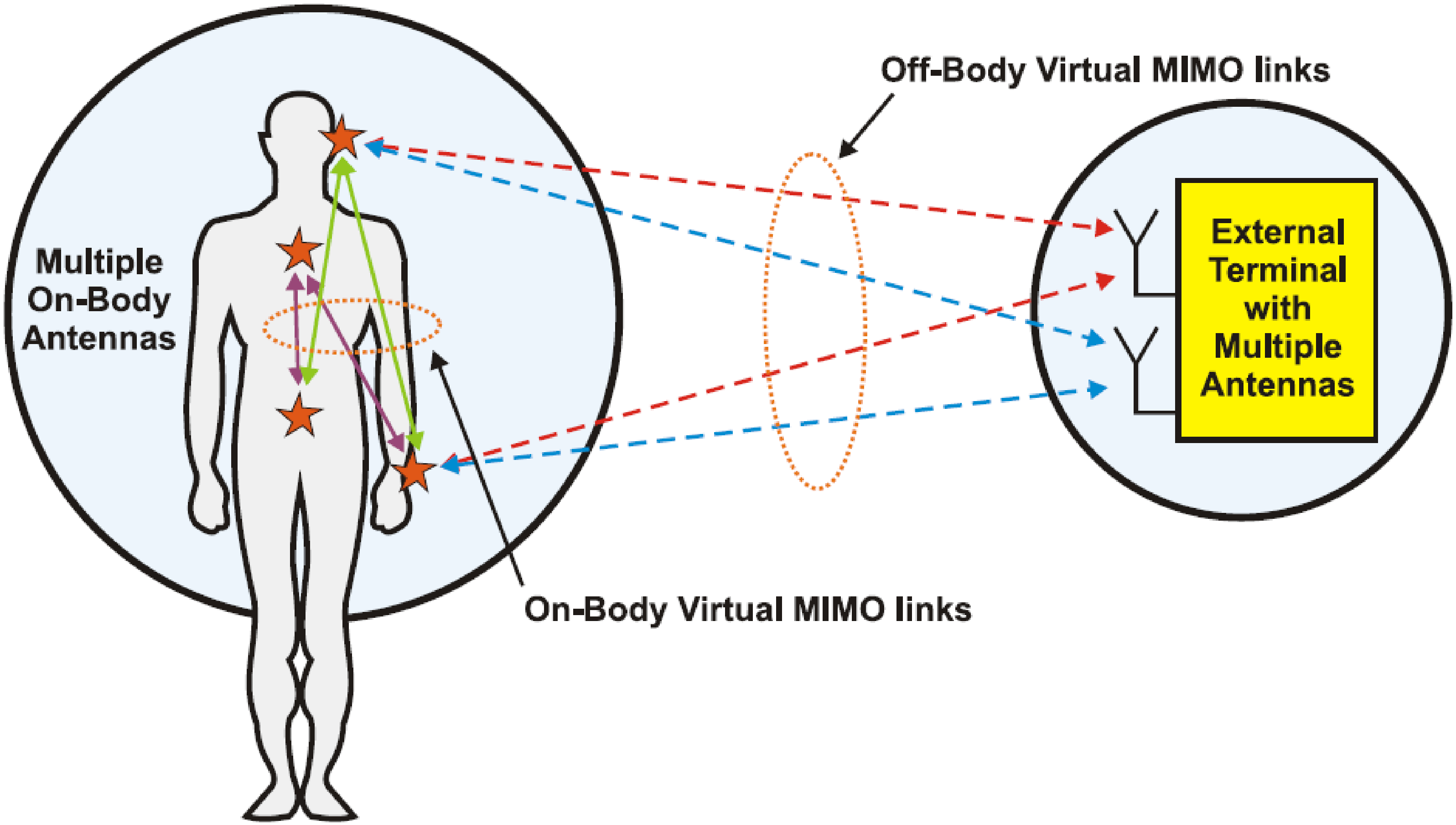
- Body Area Networks will boost a new era of services and applications, in an enhanced user interaction with the “smart” society.



Objective

- BANs experience challenging propagation characteristics, demanding a statistical channel characterisation, as well as the use of cooperative strategies.
- This work accounts for the variability of on- and off-body channels (including mobility and the environment), and considers the use of MIMO, developing strategies for optimum antennas selection.

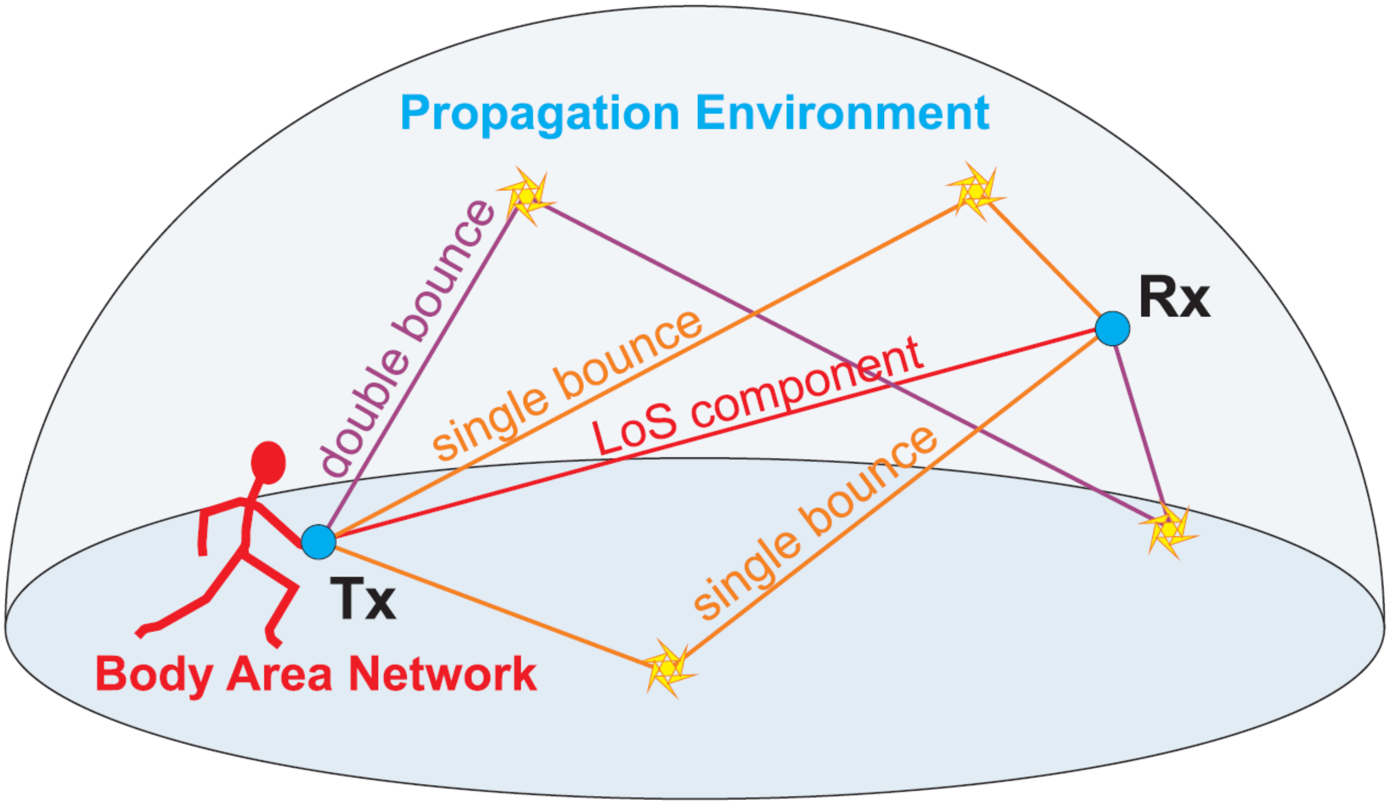
Virtual MIMO



- Virtual MIMO consists of clusters of antennas, on Tx and Rx sides, to behave like a multi-antennas system.

GBSC Model for BANs

- The Geometrically Based Statistical Channel approach is used to model the propagation environment (clusters of scatterers).



On-Body Model

- The received signal is composed of the on-body signal and the environment multipath components:

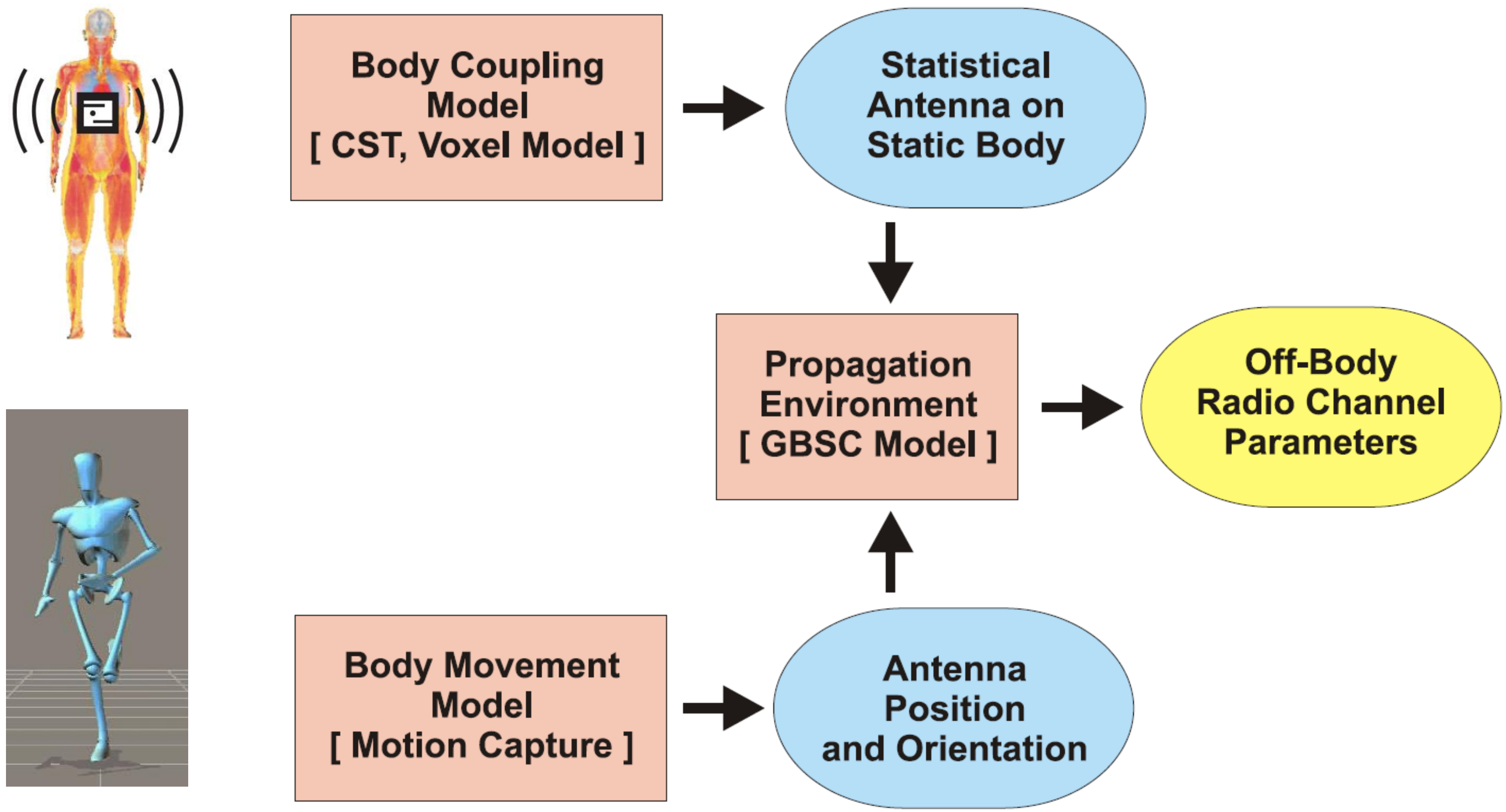
$$h(\tau) = h_{body}\delta(\tau - \tau_1) + \sum_{k=2}^{N_m} h_k \delta(\tau - \tau_k)$$

Full Wave Simulation

Geometrically Based Statistical Channel Model

Off-Body Model

- The modelling of wearable antennas in BANs is separated into antennas in the vicinity of the body and propagation environment.



Output Parameters

- The folowing parameters are calculated:
  - Propagation conditions (*i.e.*, LoS or NLoS)
  - Received Power and Power Imbalance
  - Delay Spread
  - Spread of the Direction of Arrival
  - Correlation between Received Signal Envelopes
  - Correlation between CIR
  - MIMO Capacity

MIMO Performance

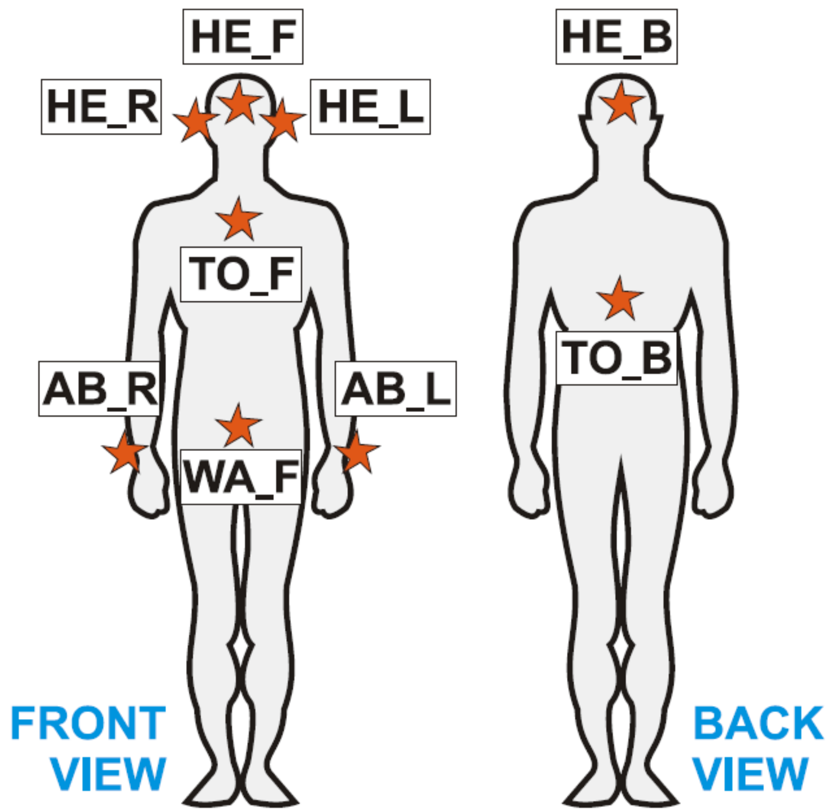
- Statistics of the 2×2 MIMO capacity are calculated over time, and for several randomly generated scatterers.
- The metric BAN MIMO capacity gain evaluates the performance of a given 2×2 combination of TXs/RXs:

$$C_{G_{BAN}} = (C - C_{lower})/(C_{upper} - C_{lower})$$

- $C_{G_{BAN}}$ ranges in [0, 1], corresponding to MIMO lower or upper bounds, respectively.

Scenario (1)

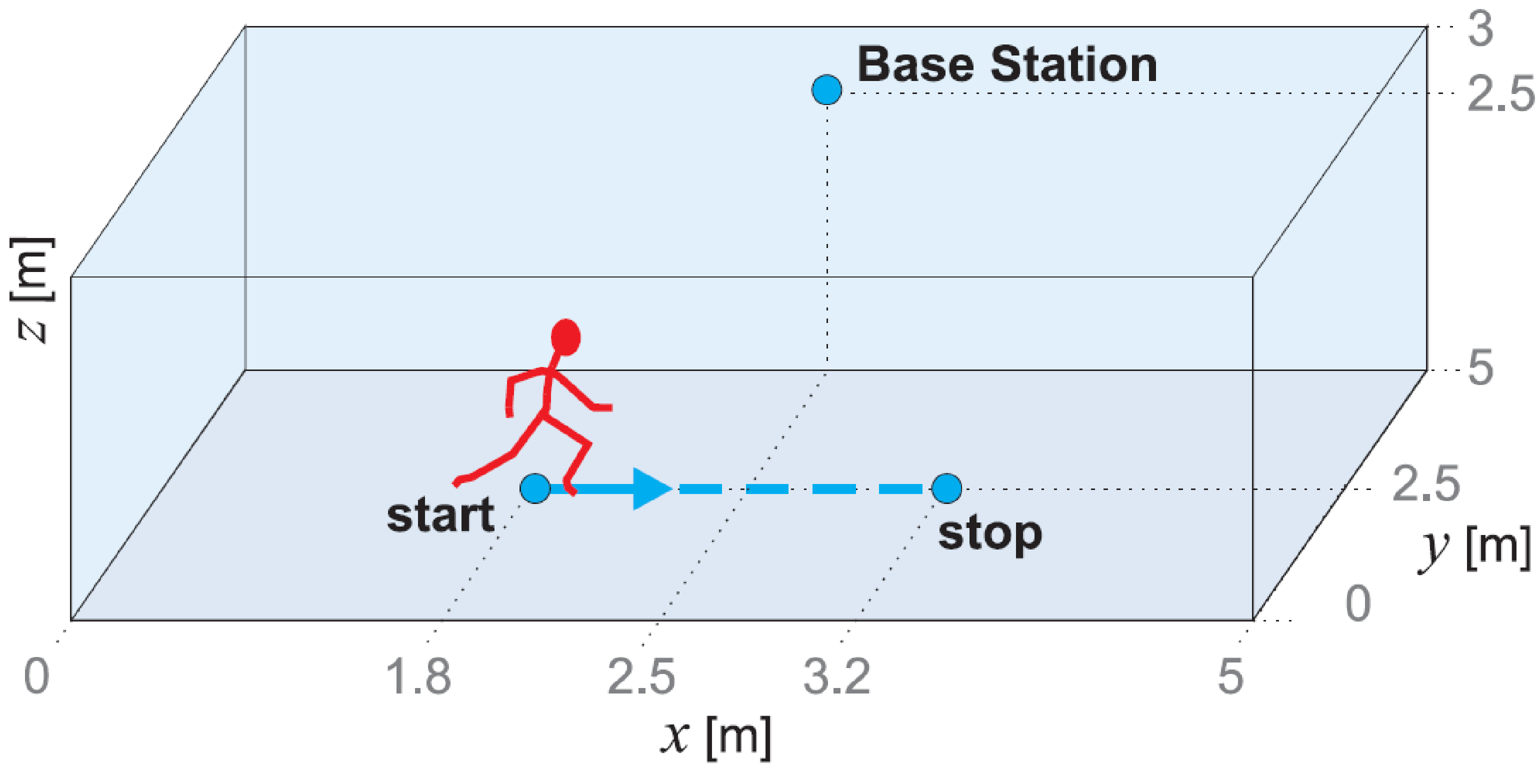
- The study of a BAN operating at 2.45 GHz is performed, with 9 placements of patch antennas, for a Walk scenario.



Walk

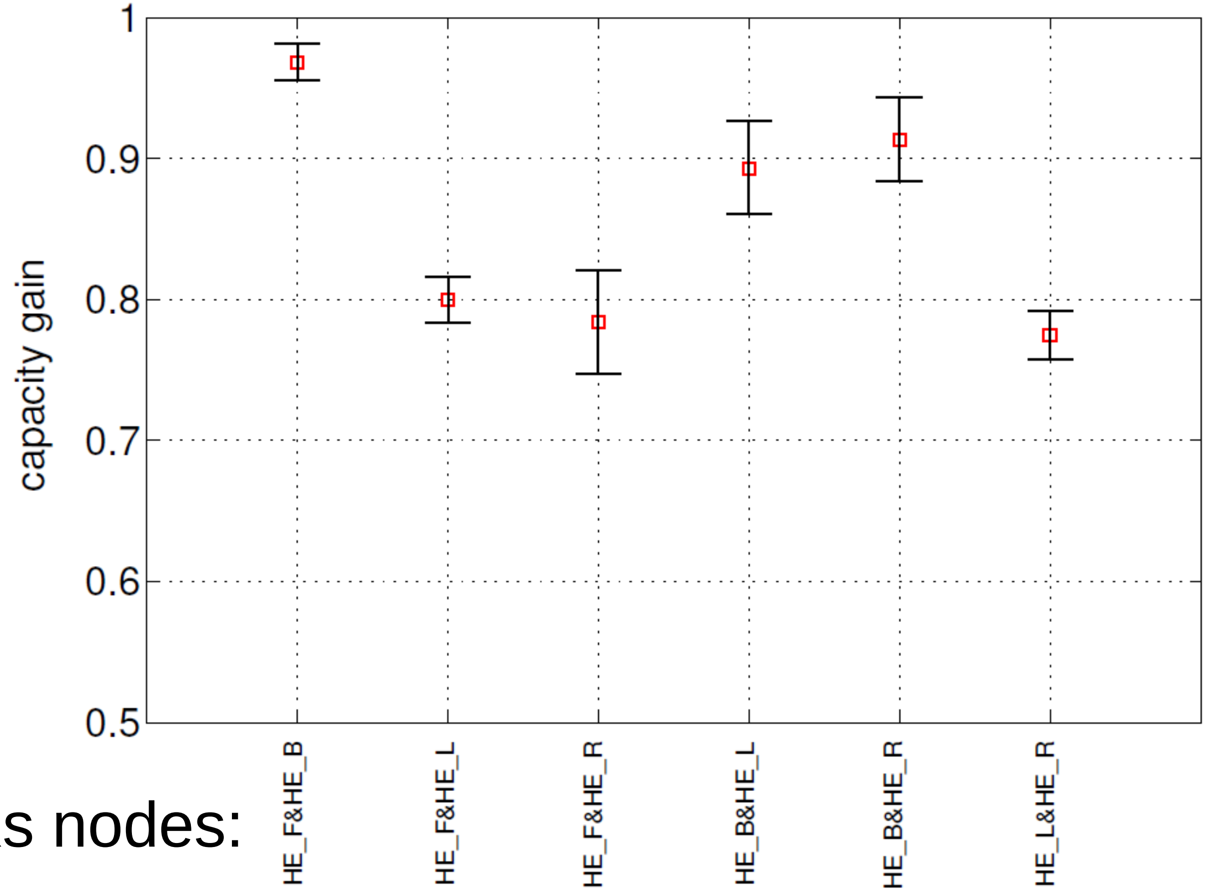
Scenario (2)

- The walking scenario in an indoor room has been considered, including a set of 6 clusters, of 3 scatterers each.



On-Body Capacity (1)

- The sink nodes location on the front and back (RXs: TO_F & TO_B) of the body enables balanced and uncorrelated signals.



TXs nodes:

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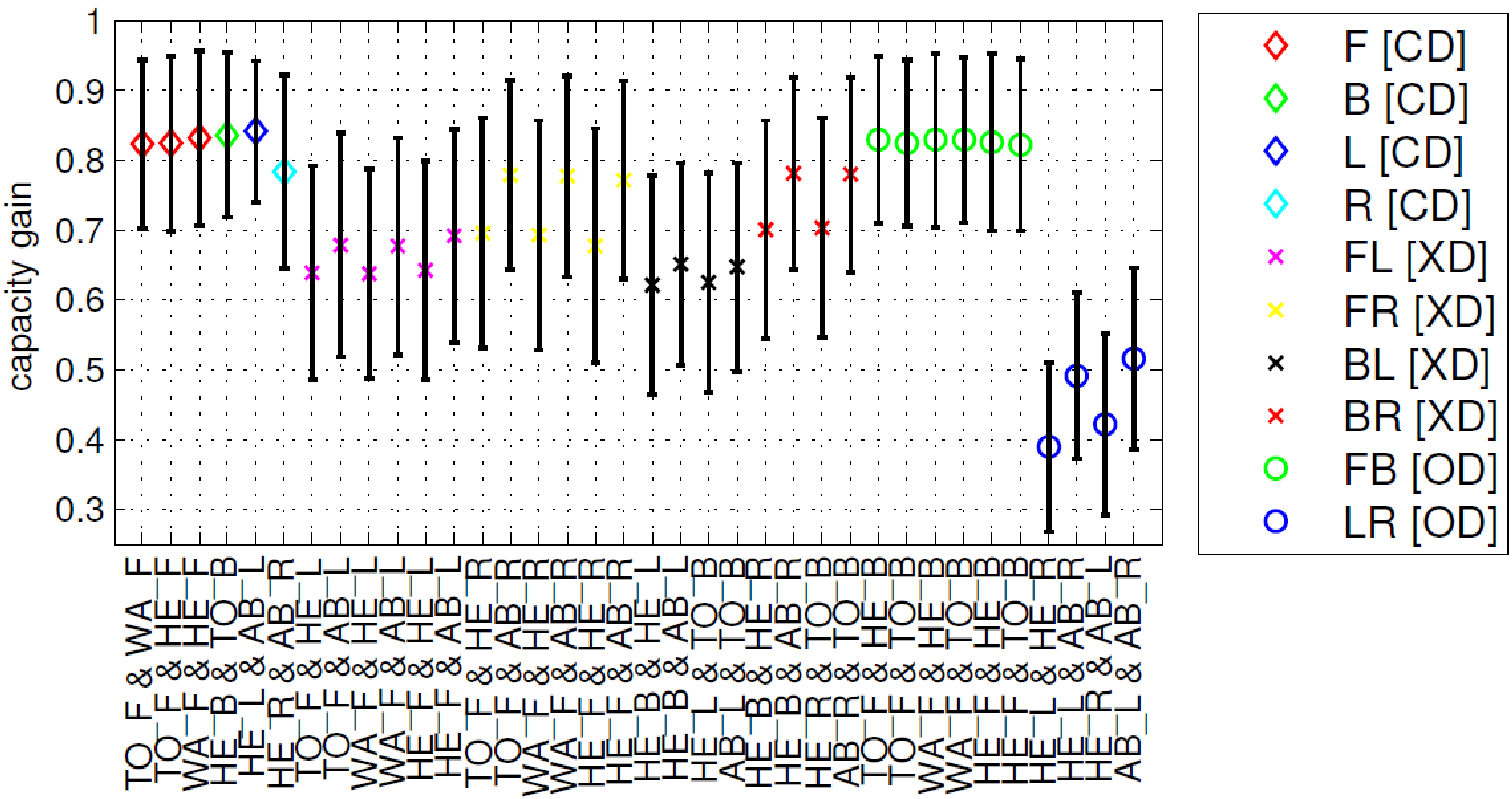
On-Body Capacity (2)

- When the sensors are on the ears (i.e., HE_L & HE_R), the symmetry is high, and branches are correlated, thus, capacity gain is the lowest (0.77).
- The best capacity gain (0.97) is achieved with the sensors on the front and back of the head (i.e., HE_B & HE_F), and the sink nodes on front and back of the body (i.e., TO_B & TO_F). The low standard deviation (0.01) shows that this configuration is stable, not fluctuating with the environment, neither with the body dynamics.

Off-Body Capacity (1)

- The HE_L & AB_L pair (L class) outperforms the others, with a capacity gain of 0.84.



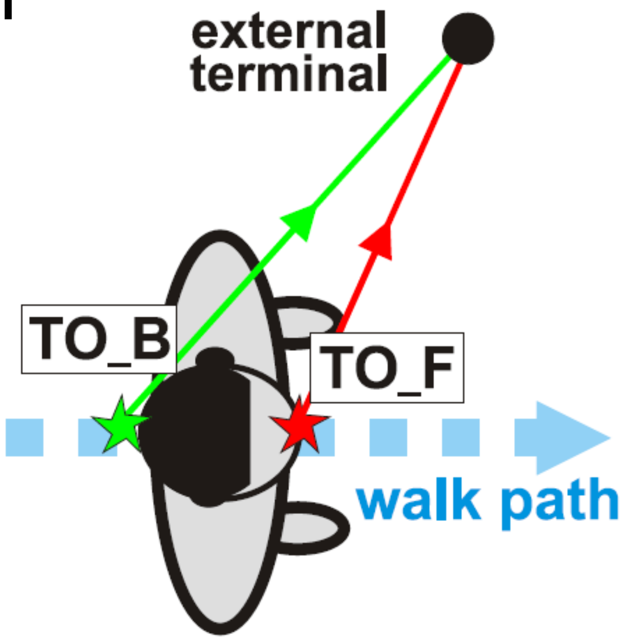
Off-Body Capacity (2)

- For antennas with strong power imbalances (i.e., LR case), the capacity is the lowest, 0.45.

Class	$\overline{C_{G_{BAN}}}$	$\sigma_{\overline{C_{G_{BAN}}}}$
F	0.83	0.12
B	0.84	0.12
L	0.84	0.10
R	0.78	0.14
FL	0.66	0.15
FR	0.73	0.15
BL	0.64	0.15
BR	0.74	0.15
FB	0.83	0.12
LR	0.45	0.13

Optimum Antenna Placement

- The best performance is obtained when the sink is on the front and back of the user, and data sensors are on the head, with a capacity gain of 0.97.
- This configuration also enables a good connectivity with an external base station, reaching a capacity gain of 0.83.



Conclusions

- This work analyses the 2×2 MIMO capacity of on- and off-body communications, in an indoor multipath environment, using an adaptation of a Geometrically Based Statistical Channel model.
- Based on proper metrics, optimum on-body antenna placements are suggested, enabling a good connectivity with an external base station.
- The sink on the front and back of the user (i.e., TO_F & TO_B), is a promising candidate, with an average capacity gain of 0.83.

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