ISS Research Overview

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ISS Mission

Contribute to the advancement of communication system design

ISS Research Team

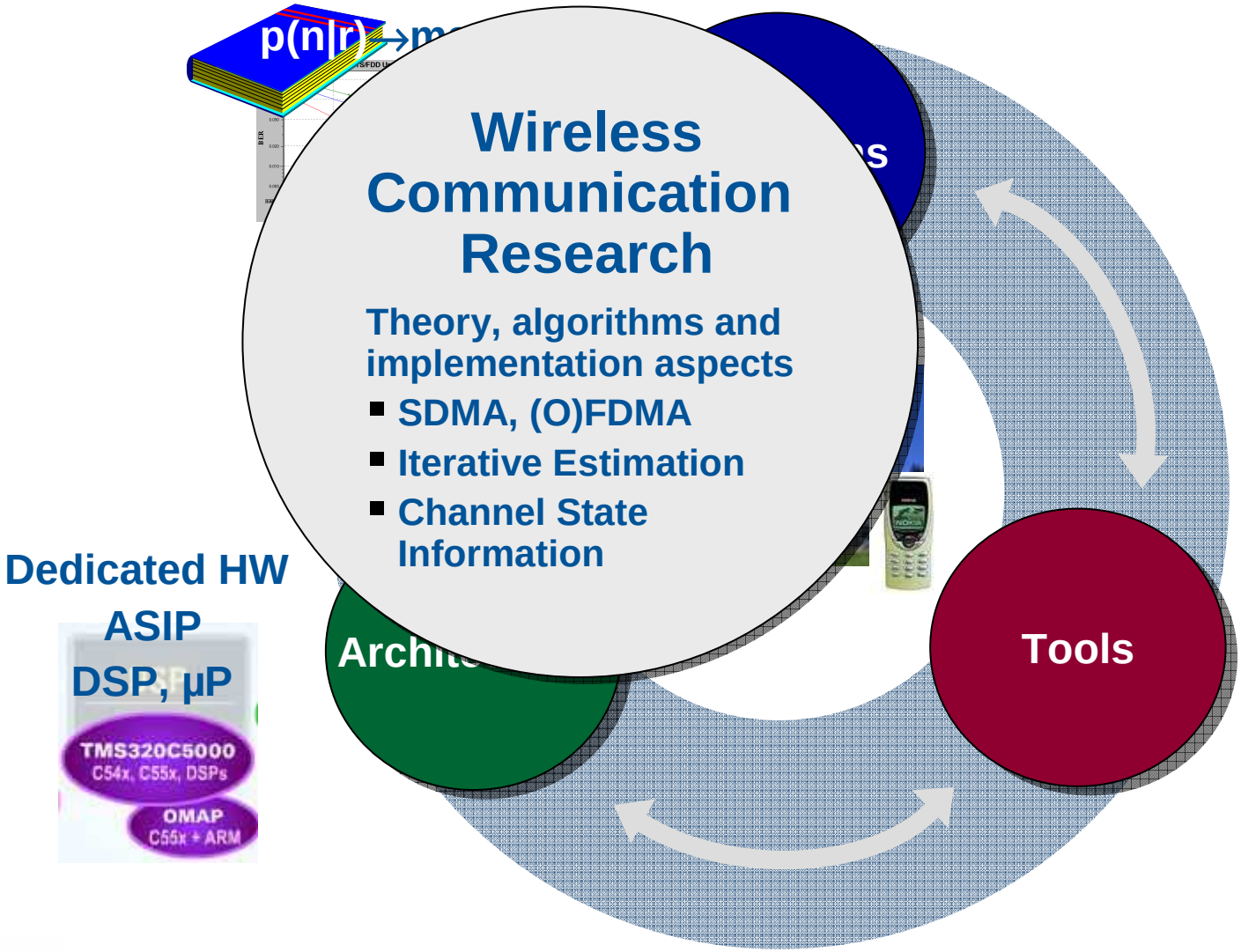
Professors

Gerd Ascheid
Rainer Leupers
Heinrich Meyr

23 PhD Students (13+10)
(Researchers)

\+ Master students

Advancement of Communication System Design

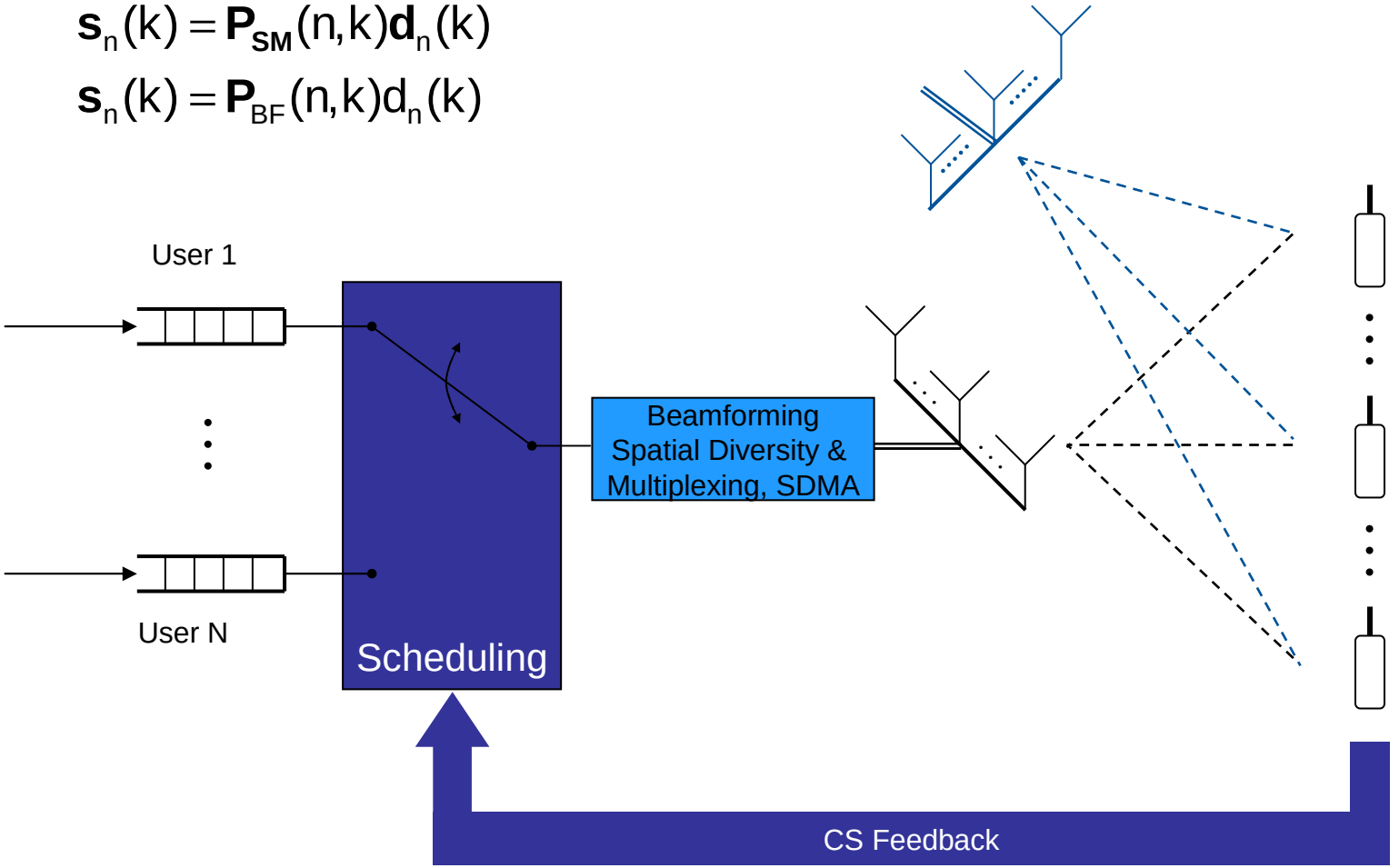


Algorithm Group Topics

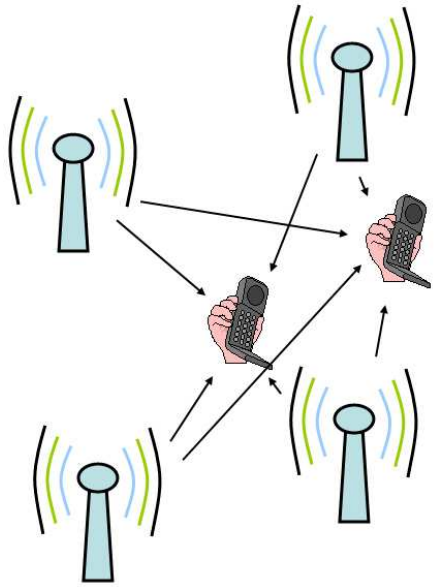
- The link limits (e.g. capacity) are known, for higher QoS and data rate we need to make better use of the spatial dimension

$$\mathbf{s}_n(k) = \mathbf{P}_{SM}(n,k)\mathbf{d}_n(k)$$

$$\mathbf{s}_n(k) = \mathbf{P}_{BF}(n,k)d_n(k)$$



Single Frequency Network with Beamforming

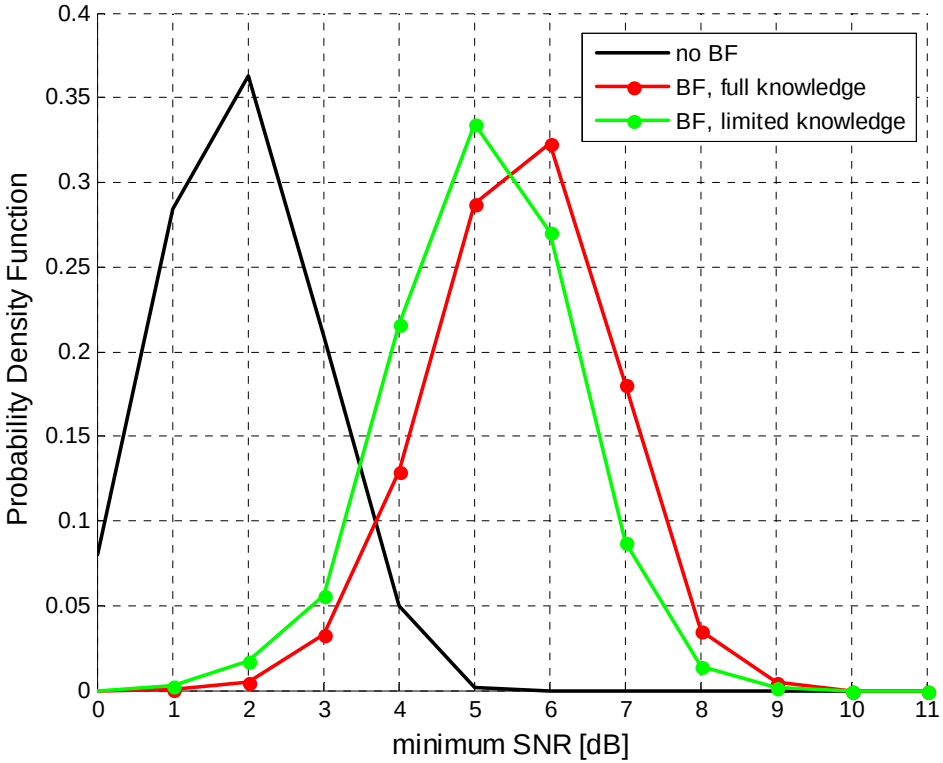


Simulation Parameters:

- N_U = 64 users
- N_T = 4 antennas per cell
- N_C = 21 beamforming cells

Conclusion:

- The minimum SNR may be increased by 3..4 dB even with a high number of users and only limited knowledge of the spatial correlation



PDF of the minimum SNR [dB]:

Black: all cells transmit omnidirectionally

Red: beamformed transmission, each spatial correlation matrix known

Green: beamformed transmission, only two matrices known per user

We assume the channel is known ...

Mutual Information

$$I(x;y) = \underbrace{I(x;y,h)}_{h(y|h)-h(y|x,h)} - \underbrace{I(x;h|y)}_{\text{“Loss” due to}}$$

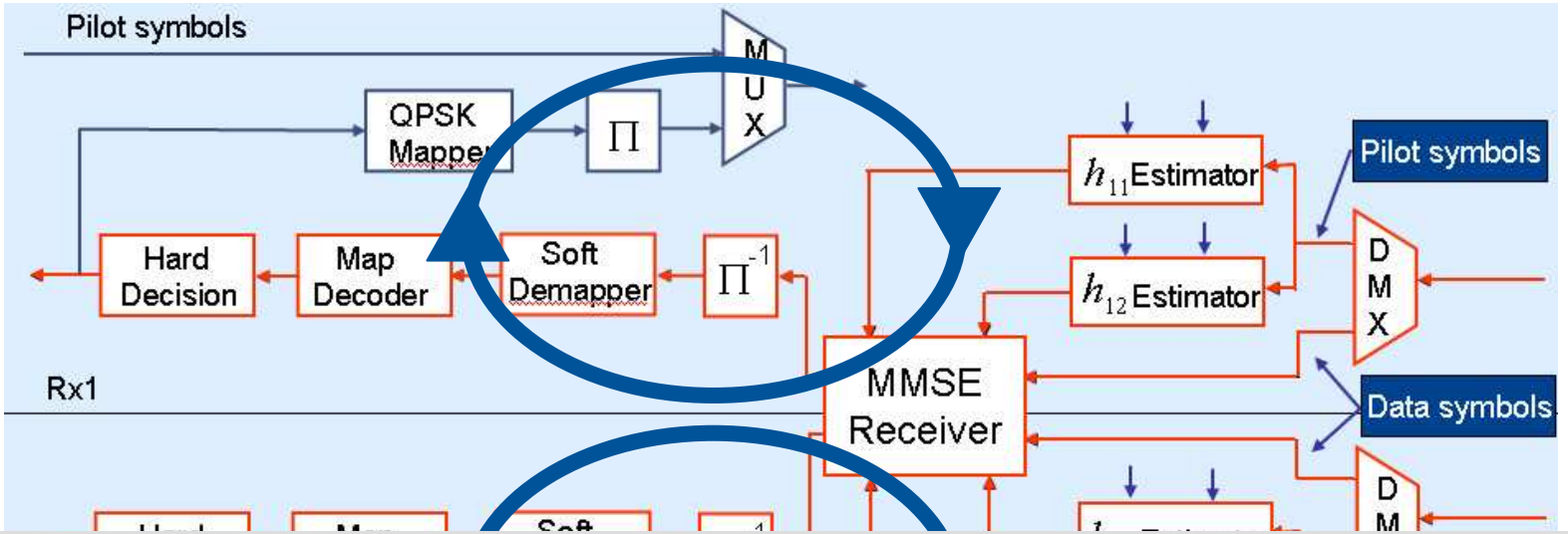
$h(y|h)-h(y|x,h)$: Perfect channel knowledge

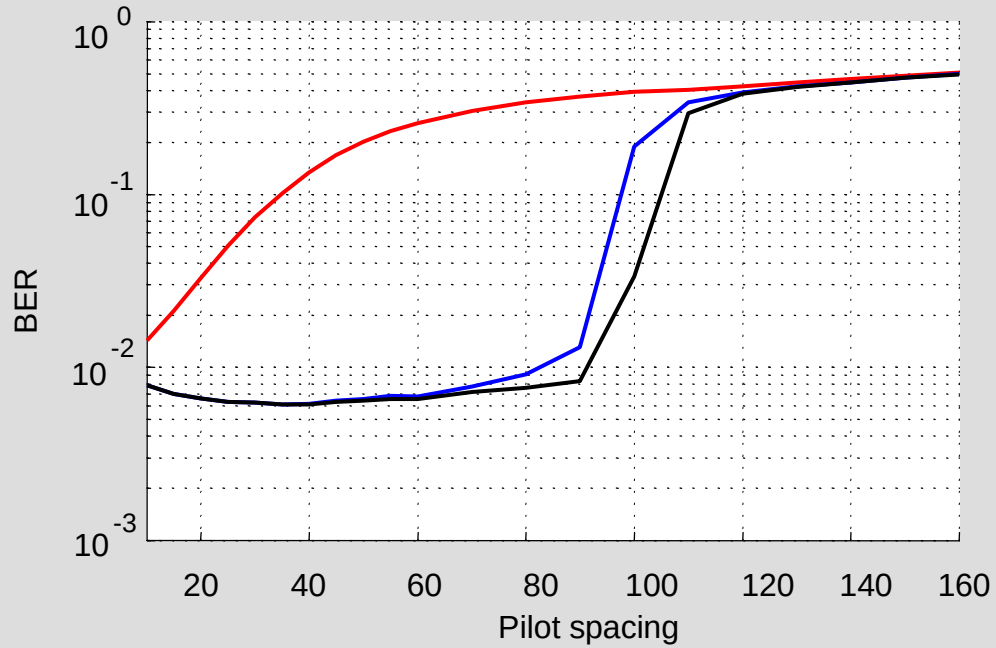
“Loss” due to unknown channel

Solution:

- Pilots for channel estimation
- Iterative receivers: joint data/channel estimation

Iterative Channel Estimation (2x2 MIMO Example)





Data-aided PSAM

Code-aided; 10th iteration

Code-aided; 20th iteration

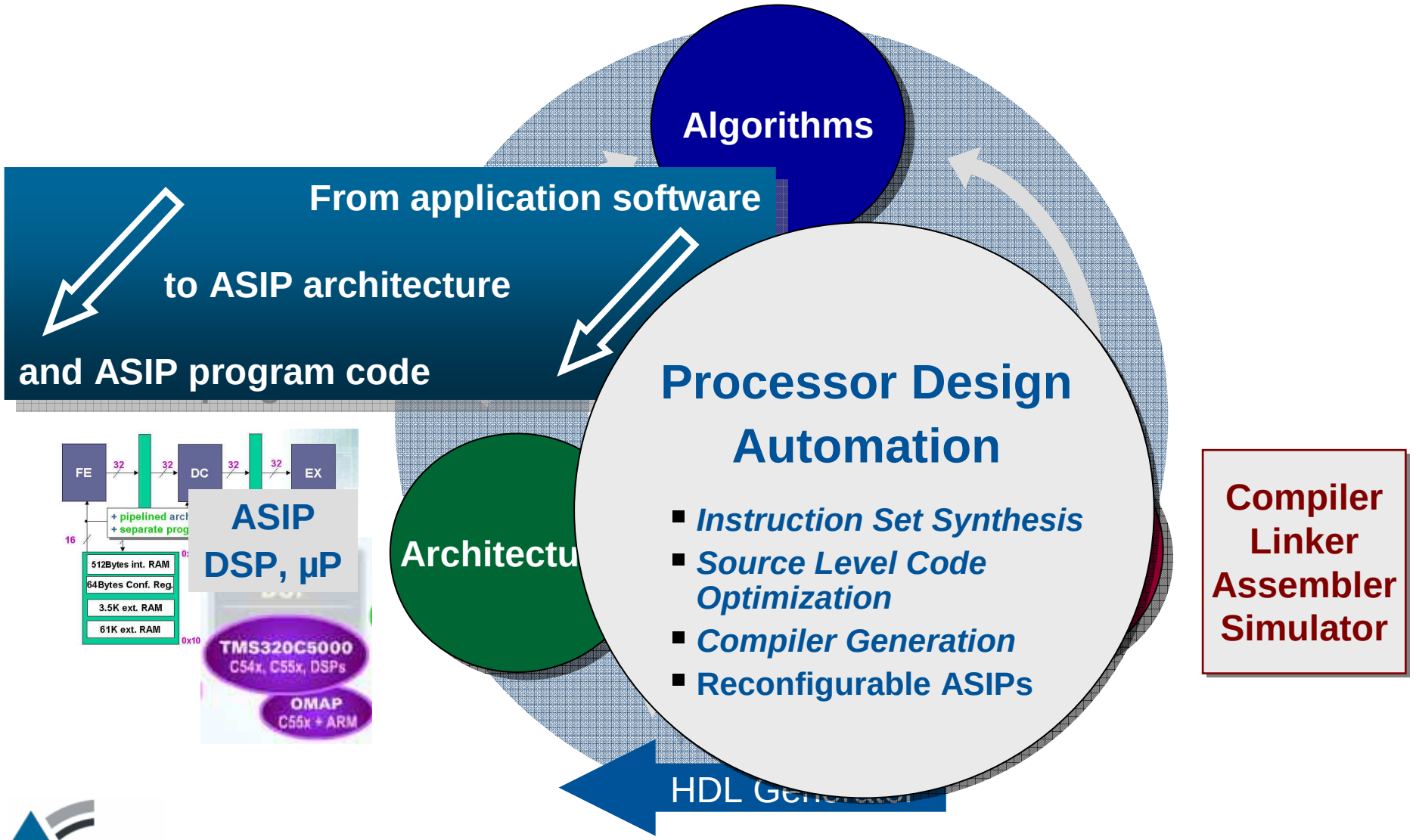
E_b/N_0 = 7dB, f_d =0.005

Algorithm Group Topics

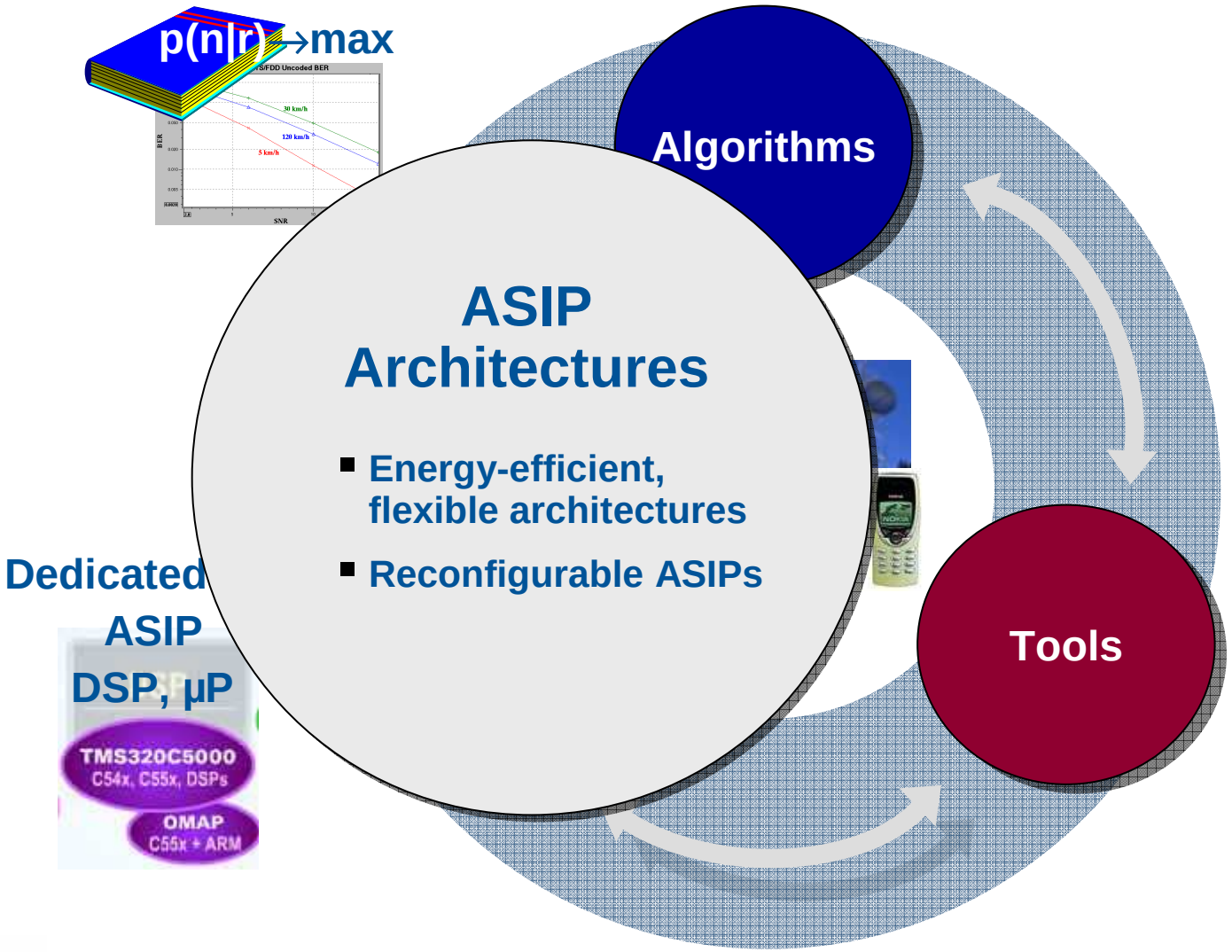
- SDMA, (O)FDMA
  - High data rates for many users requires optimum use of resources: power, space, frequency and time
    - Beamforming
    - Spatial Multiplexing, spatial diversity
    - MIMO
    - Scheduling
  - ⇨ Extension of single cell to multiple cell scenarios

- Channel State Information
  - Theoretical bounds (achievable rates, capacity) without assumption of known channel
  - Iterative Estimation
    - Channel
    - Interference
  - Information feedback issues
    - Throughput reduction, processing effort
    - Processing and feedback delay vs. channel dynamics

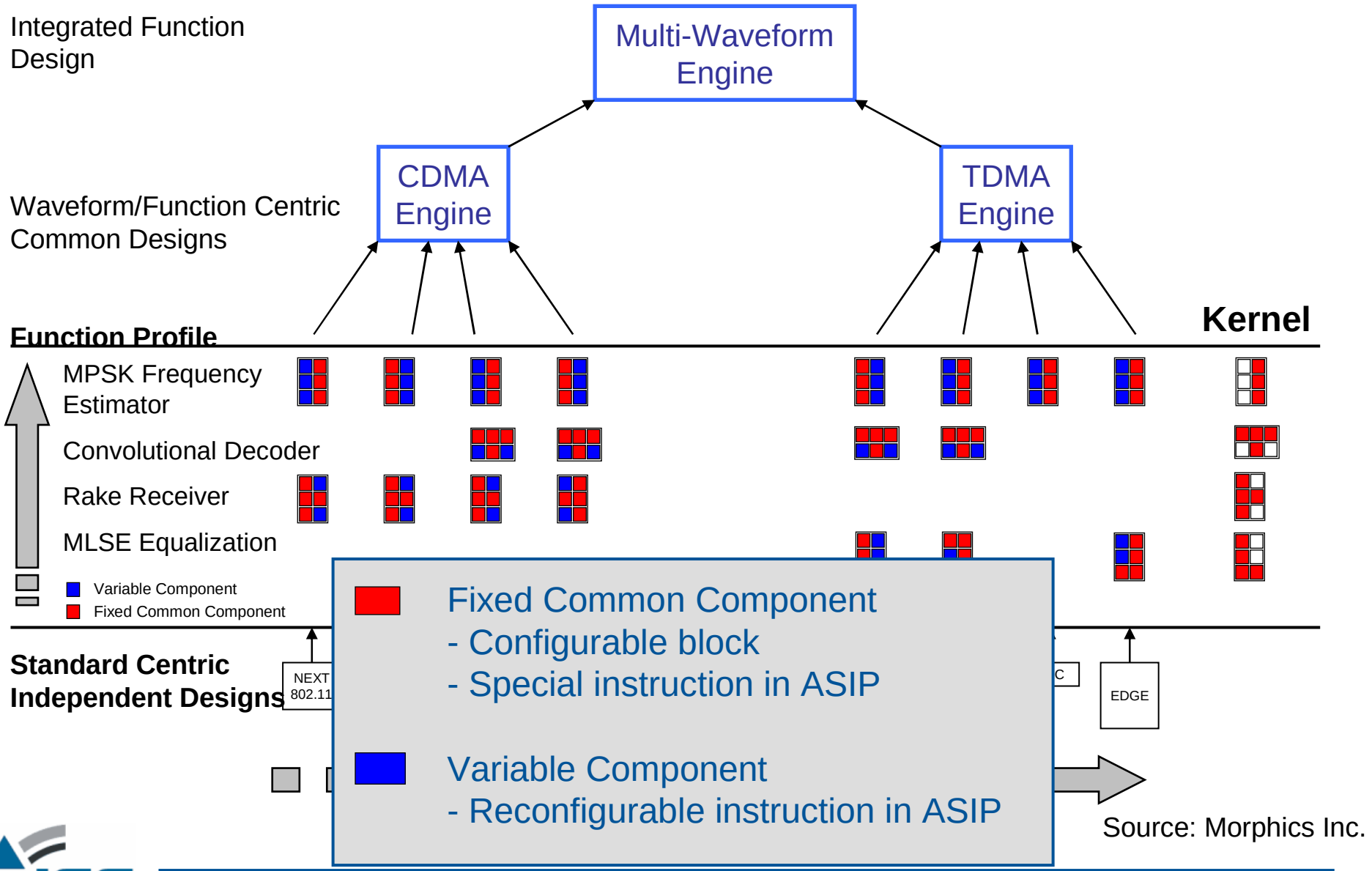
Advancement of Communication System Design



Advancement of Communication System Design

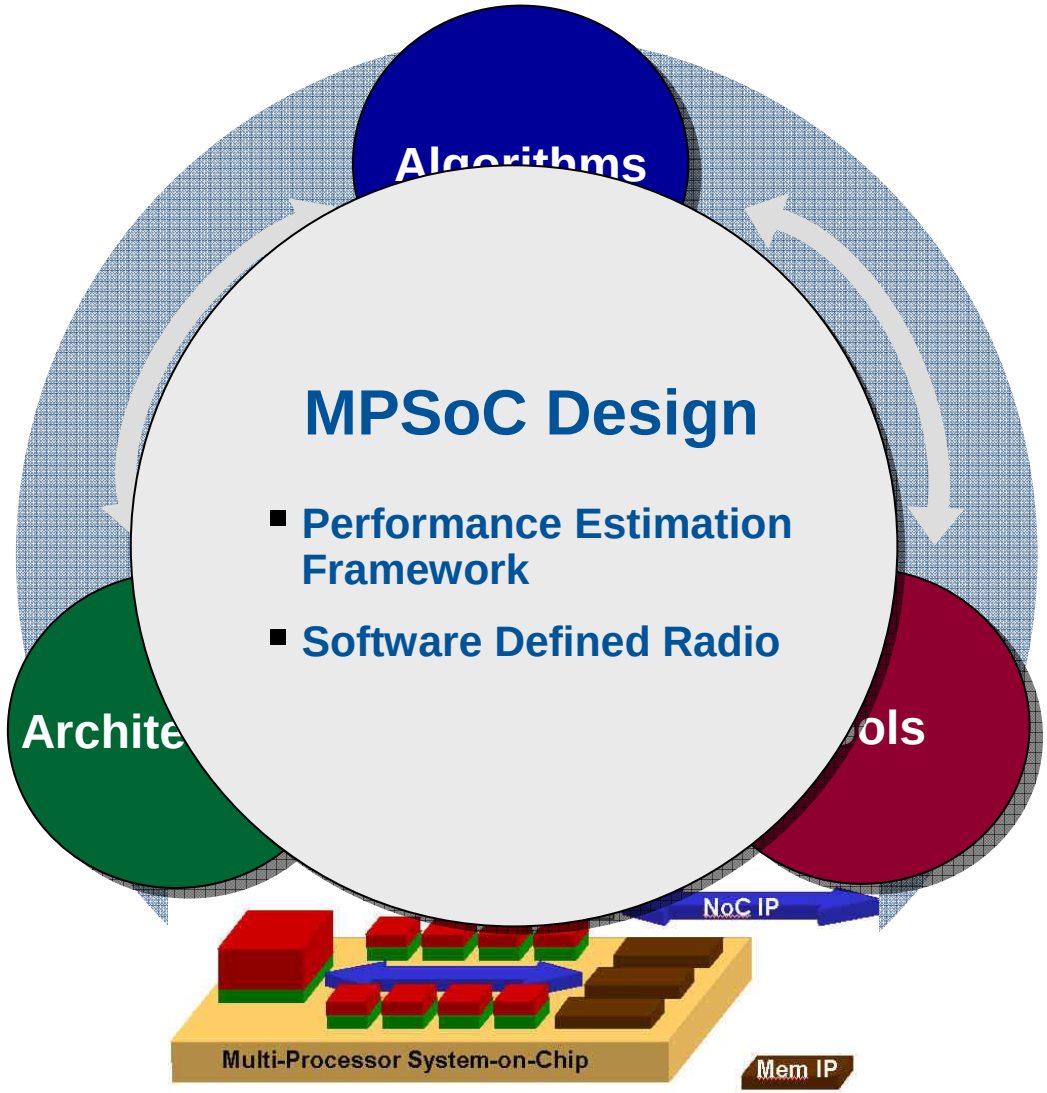


HW/SW Partitioning: Spatial and Temporal Mapping



Source: Morphics Inc.

Advancement of Communication System Design



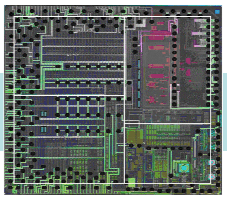
SDR: Mapping of Baseband Processing

Communication System (Standard)

Waveform description
- Functional description
- Performance requirements

Hardware description
- Element abstraction:
  - processing elements
  - communication
  - memories
- Feature description

Mapping
- Spatial and temporal
- Compliance check



SDR Hardware Platform

Coordination of Cross-Disciplinary Research

UMIC:

Ultra High-Speed Mobile Information and Communication

(Cluster of Excellence) with participants from

- Computer Science
- Electrical Engineering and Information Technology

Thank you !