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Advanced Techniques for Improved Spectral Efficiency in E-UTRAN

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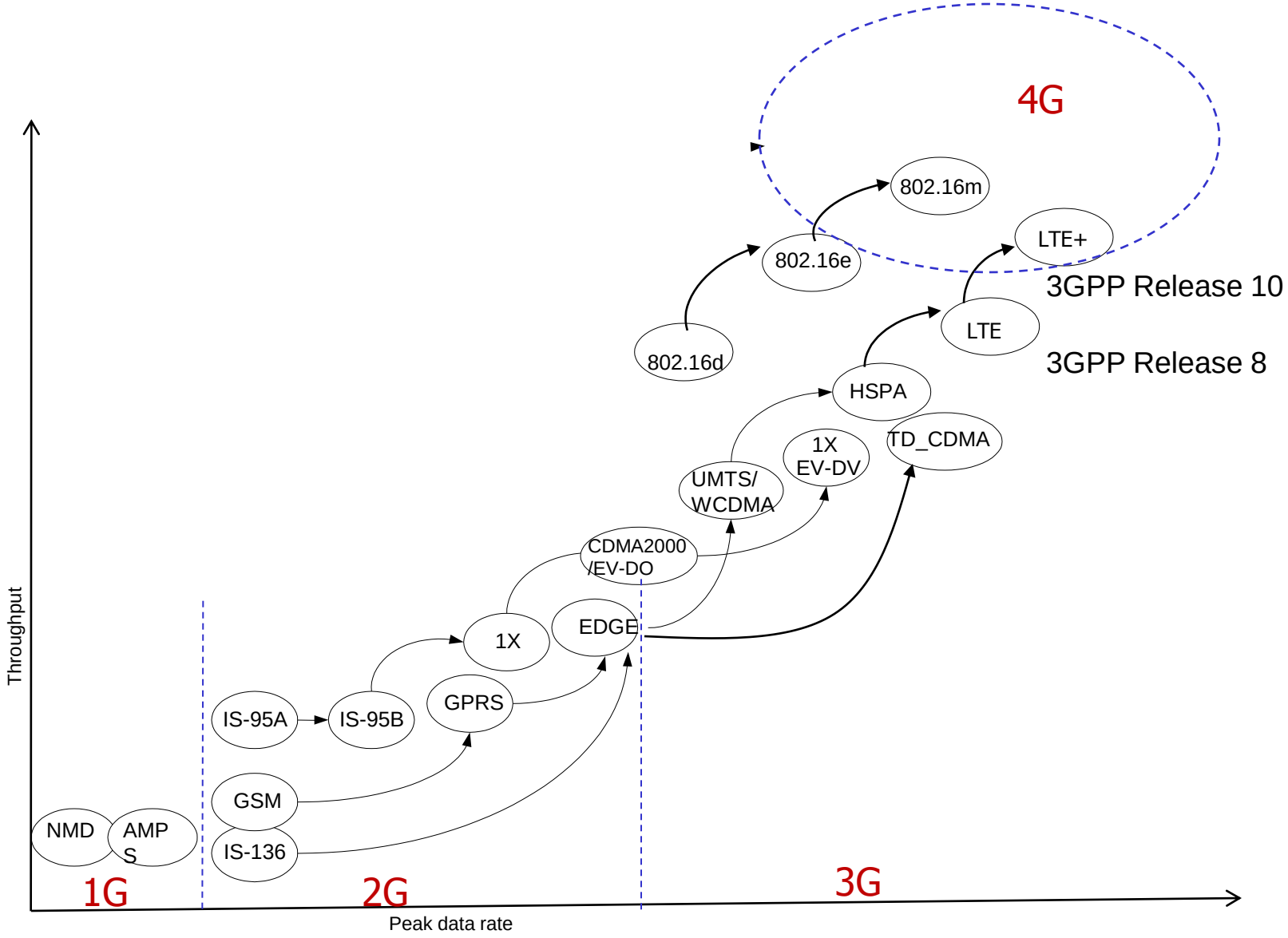
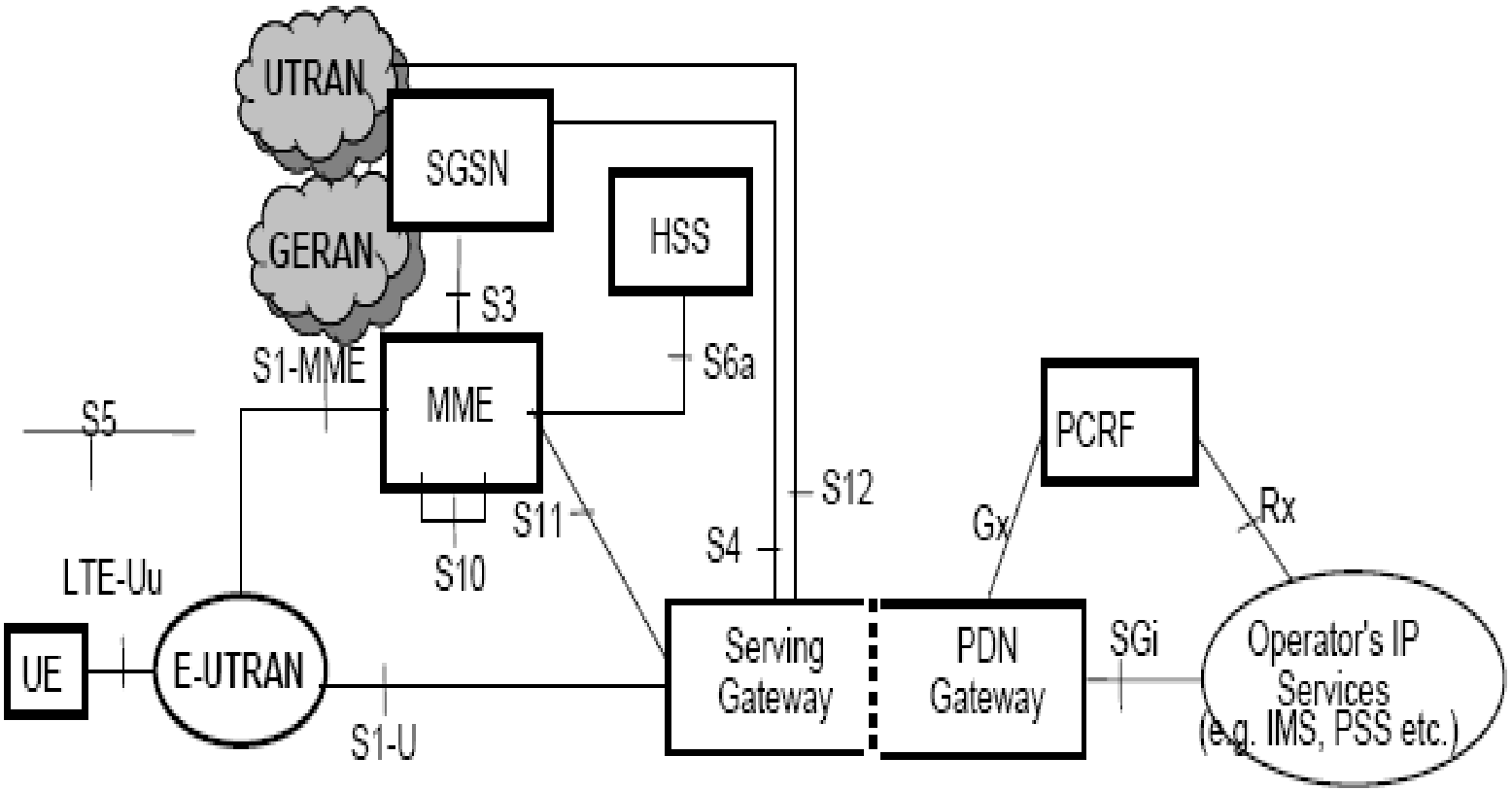
Evolution of Wireless Data Systems

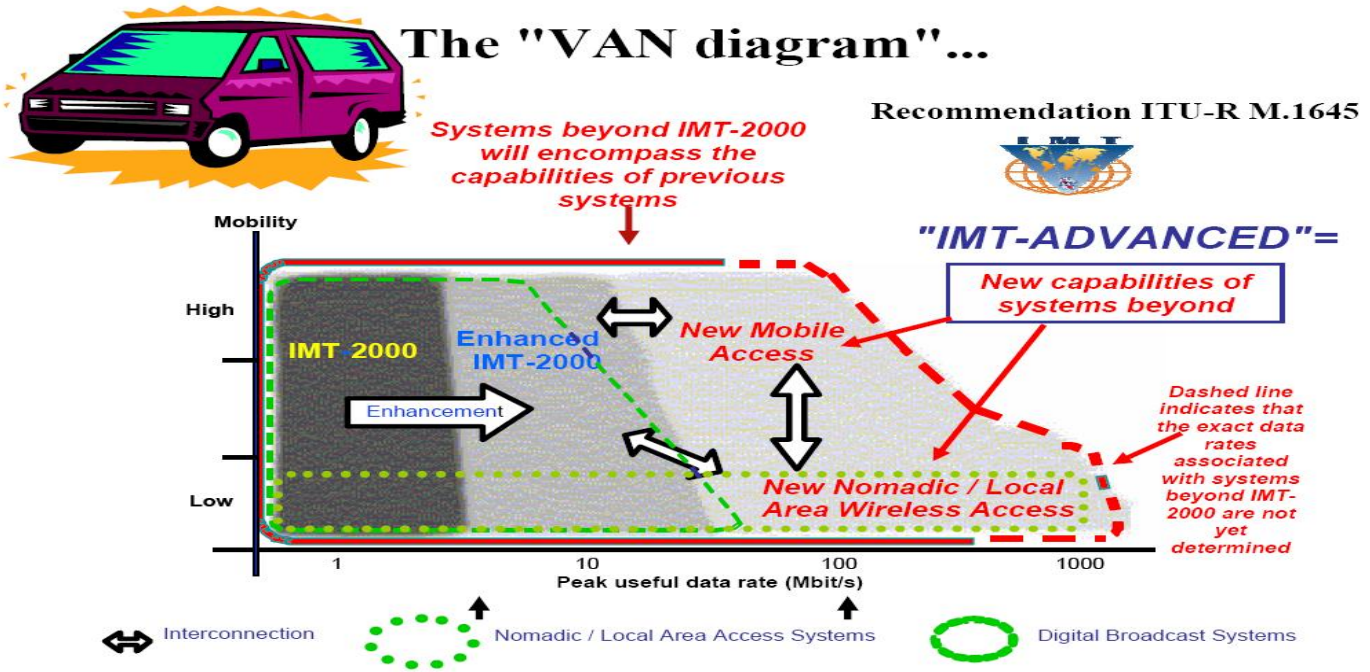


EPC and E-UTRAN Architecture



Courtesy: 3GAmericas.org

Expectations for LTE, LTE-Advanced and IMT-Advanced



		Rel. 8 LTE	LTE-Advanced	IMT-Advanced
Peak data rate	DL	300 Mbps	1 Gbps	1 Gbps(*)
	UL	75 Mbps	500 Mbps	
Peak spectrum efficiency [bps/Hz]	DL	15	30	15
	UL	3.75	15	6.75

Courtesy:
3rd Workshop on IMT-Advanced
15 Oct. 2009

How do we improve data rate?

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Increase spectral efficiency

OFDM in DL
DFT-S-OFDM in UL

$$E = B \times L \times \log(1 + S/(I+N))$$

Increase L

- **MIMO (spatial multiplexing) (1)**
- **Multi-BS MIMO (CoMP with data sharing) (3)**
- **Relays (4)**
- **Femtocells (5)**

Decrease I (the effect of)

- **Interference mitigation using resource management techniques**

-- Coordinated multipoint Transmission (CoMP) without data-sharing (2)

Increase S

- **MIMO (Orthogonal STBC) (1)**
- **Beamforming**
- **Relays (4)**
- **Femtocells (5)**

- **Leverage channel dependent scheduling techniques to improve cell throughput (6)**

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MIMO Configurations -- (1)

- LTE – up to 4 streams in DL per user, single stream in UL per user in SU-MIMO mode, support for MU-MIMO in DL and SDMA in UL (single stream per user)

- LTE-A – up to 8 streams in DL per user, up to 4 streams in UL per user in SU-MIMO mode, MU-MIMO up to 8 streams in DL and UL

Average Spectral efficiency

		Ant. Config.	Rel. 8 LTE*1	LTE-Advanced*2	IMT-Advanced*3
Capacity [bps/Hz/cell]	DL	2-by-2	1.69	2.4	–
		4-by-2	1.87	2.6	2.2
		4-by-4	2.67	3.7	–
	UL	1-by-2	0.74	1.2	–
		2-by-4	–	2.0	1.4
Cell-edge user throughput [bps/Hz/cell/user]	DL	2-by-2	0.05	0.07	–
		4-by-2	0.06	0.09	0.06
		4-by-4	0.08	0.12	–
	UL	1-by-2	0.024	0.04	–
		2-by-4	–	0.07	0.03

x1.4-1.6

Courtesy:
3rd Workshop on IMT-Advanced
15 Oct. 2009

Challenge: SU-MIMO - Receiver design and codebook design
MU-MIMO – Accurate CSI feedback required

Coordinated Multipoint Transmission Techniques
CoMP without data-sharing – (LTE, LTE-A) -- (2)

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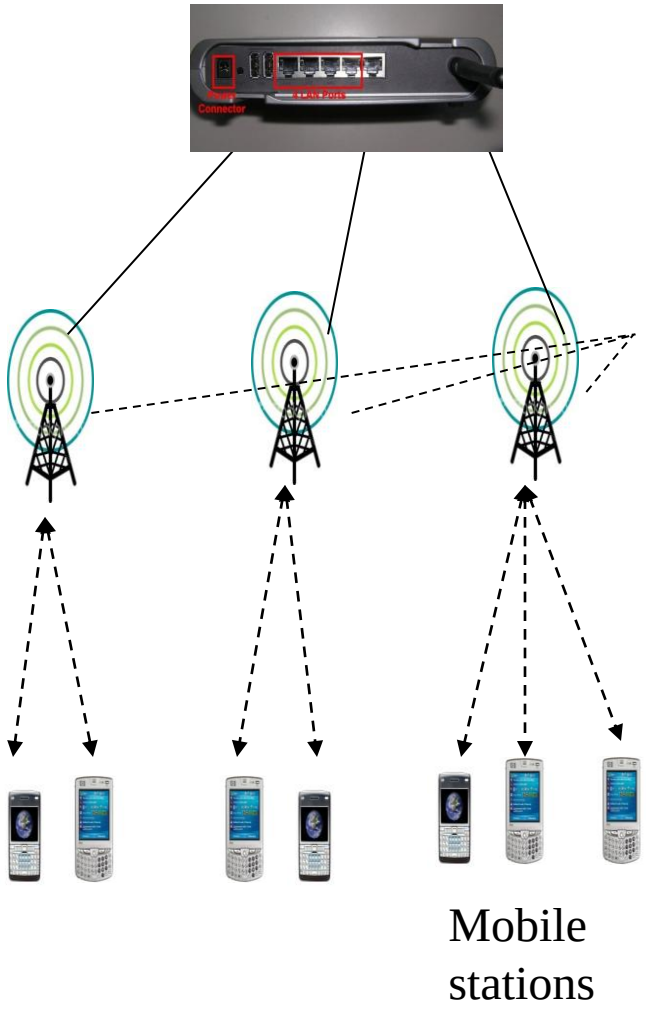
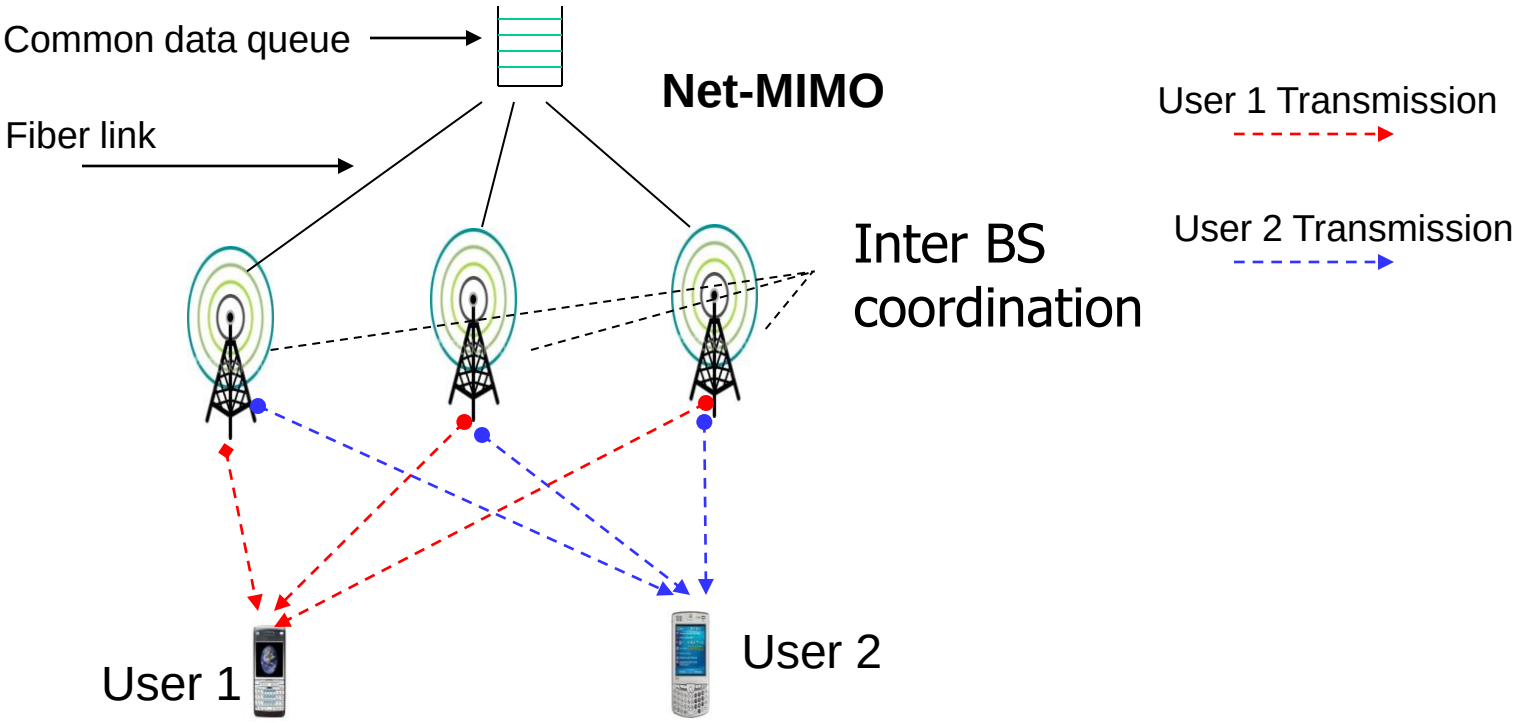
- CoMP with no data-sharing
  - Interference mitigation
    - Fractional frequency reuse (dynamic in LTE-A?)
    - Semi-static (LTE) and dynamic (LTE-A) coordinated power control
    - Coordinated beamforming (LTE-A)
  - Load Balancing
    - Centralized user allocation
    - Network controlled handoff



Challenge: Coordination among base-stations at fine time scale

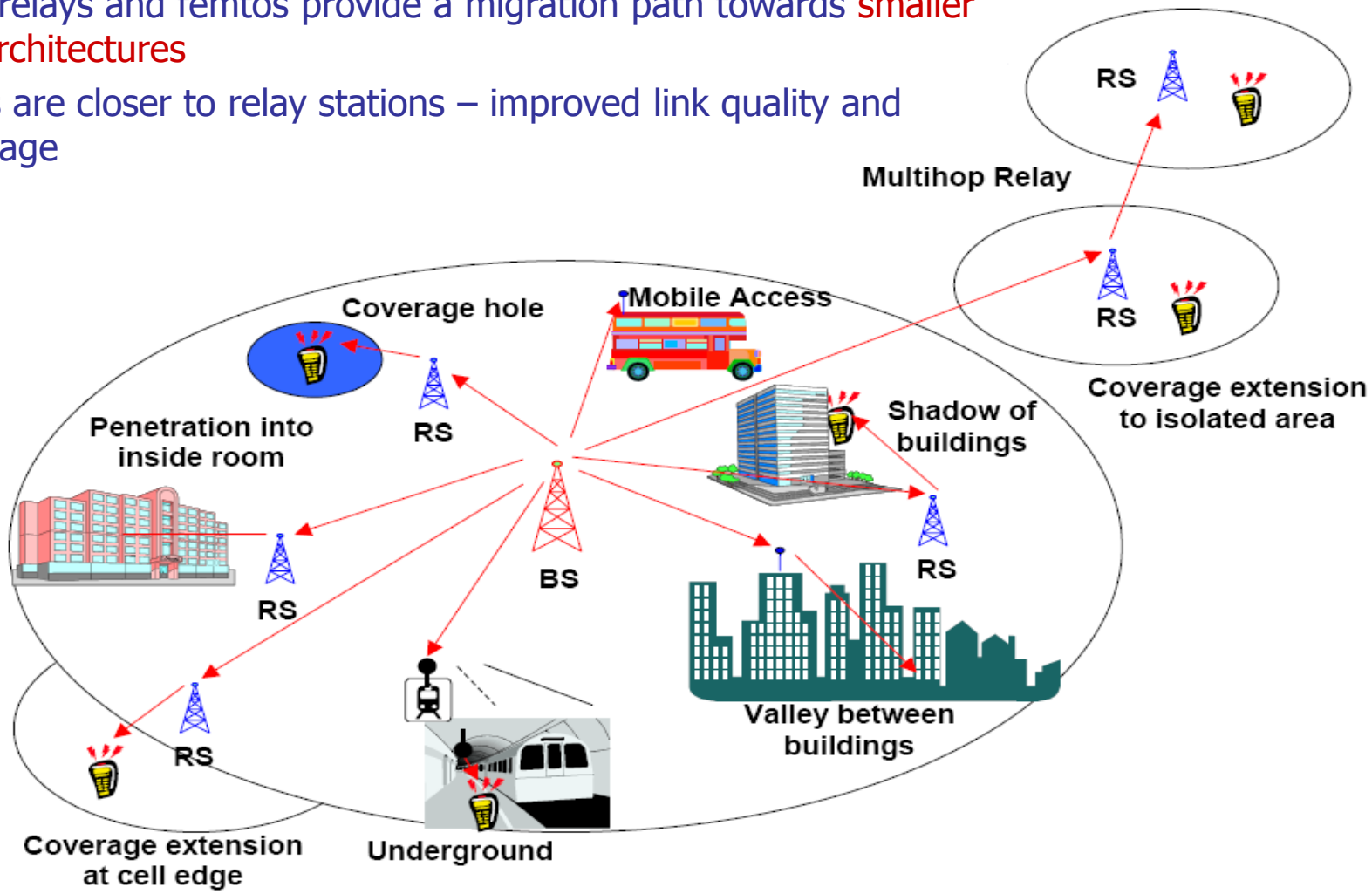
Coordinated Multipoint Transmission Techniques
CoMP with data-sharing (LTE-A) -- (3)



Challenges: Synchronized data transmission from multiple BSs
Low-delay and high bandwidth requirement in the backhaul

Deployment of relays – (4)

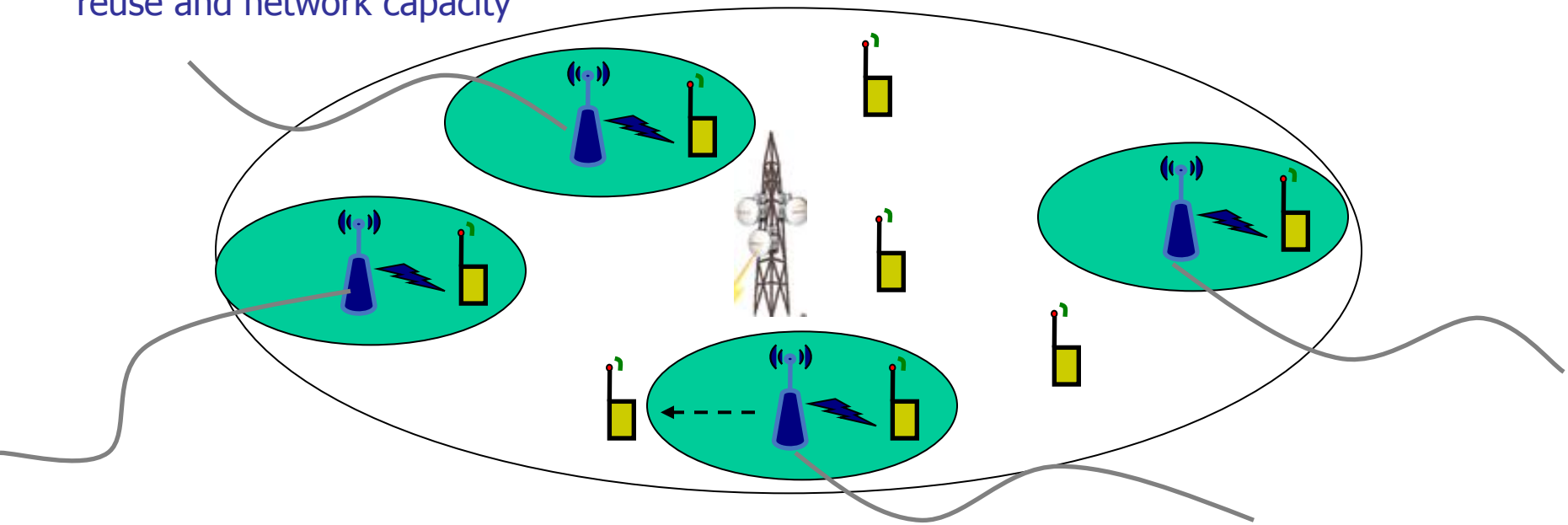
- Both relays and femtos provide a migration path towards smaller cell architectures
- Users are closer to relay stations – improved link quality and coverage



Challenge: Multi-hop scheduling to leverage channel and user diversity

Deployment of femtocells – (5)

- Users are closer to femto BSs – improved link quality and coverage
- Smaller cell – lower transmit power – lower interference – improved spatial reuse and network capacity



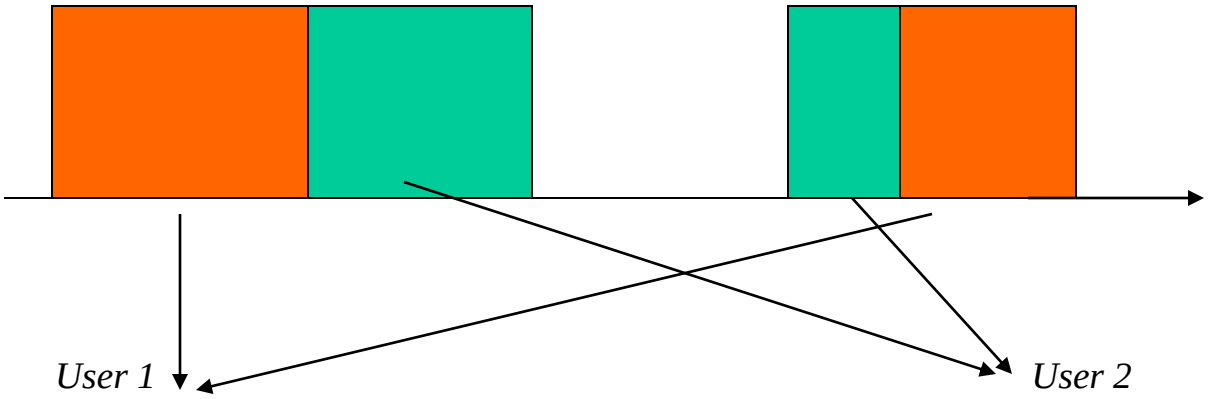
Challenges: -- Resource allocation between macro and femtocells

Need efficient resource balancing to adapt to load dynamics for better spectral efficiency

-- Interference mitigation among femtocells

Channel dependent scheduling in the DL (LTE, LTE-A) – (6)

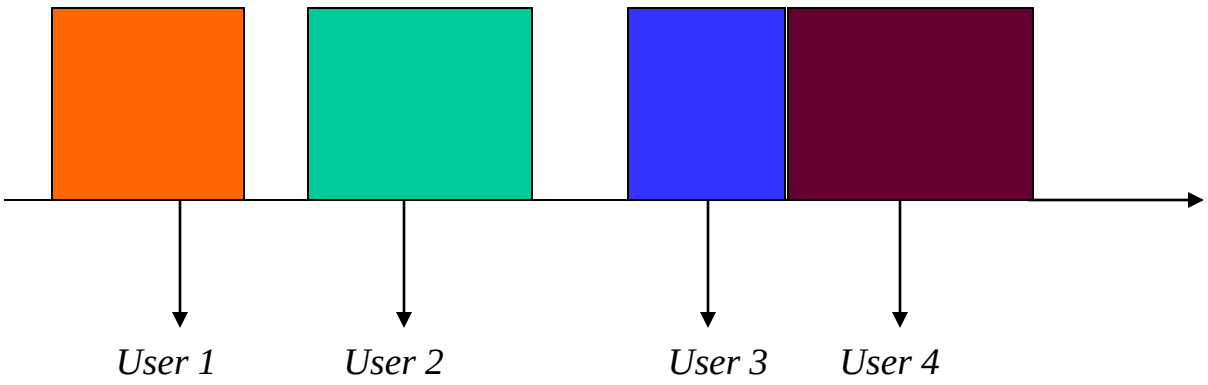
- A resource block (RB) consists of multiple contiguous OFDM subcarriers
- The scheduling granularity is a 1 ms frame
- Multiple non-contiguous chunks of RBs can be allocated to a user
- Each chunk of RBs can be variable size (no restriction on number of chunks per user)



Challenges: -- User selection (signaling constraint)
-- Scheduling of chunks of RBs to users to leverage channel diversity
-- Common MCS selection

Channel dependent scheduling in the UL (LTE) – (6)

- DFT-S-OFDM is used
- Only a single chunk of contiguous RBs can be allocated to a user to reduce Peak-to-Average Power Ratio (PAPR)
- Each chunk of RBs can be variable size of the form 2^a 3^b 5^c

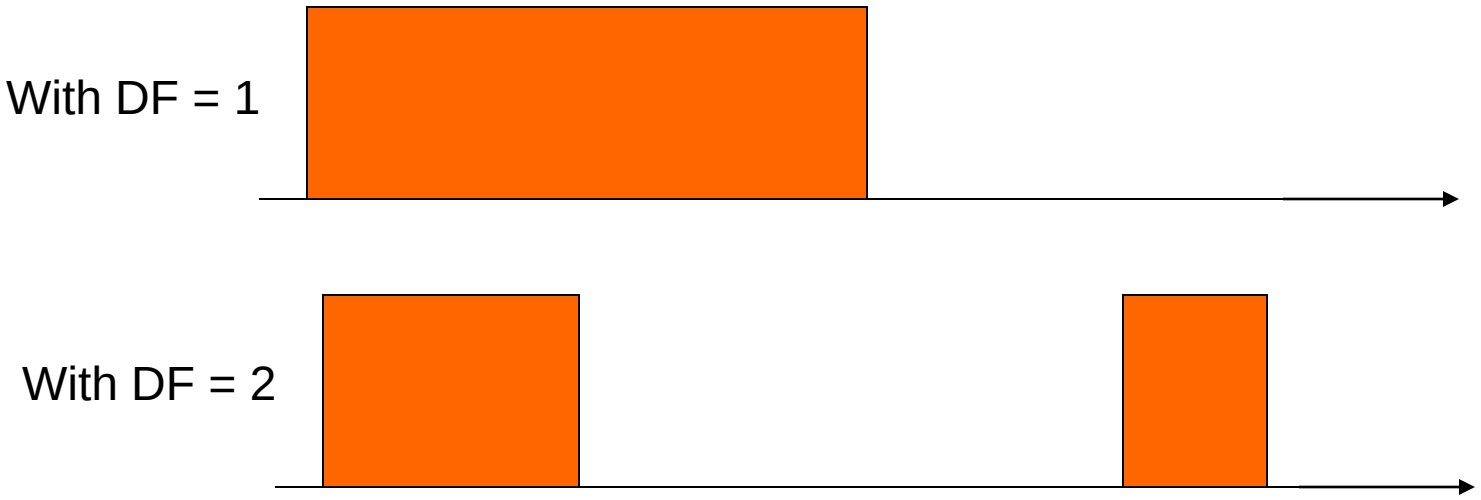


Challenges: -- User selection
-- Contiguity constraint on the RBs with the chunk size constraint
-- Common MCS selection
-- Scheduling of chunks to users to leverage channel diversity

Channel dependent scheduling in the UL (LTE-A) – (6)

- DFT-S-OFDM is used
- Multiple (but limited) number of chunks of RBs (using a "division factor" – DF) can be allocated to a user
- The DF value can be user specific
- Each chunk of RBs can be variable size

Allocation to a user



Challenges: -- User selection
-- Selection of multiple chunks with the chunk size constraint
-- Common MCS selection
-- Scheduling of chunks to users to leverage channel diversity

Discussion – Q&A