D2D Communication Implementation for Future Cellular Networks (5G)

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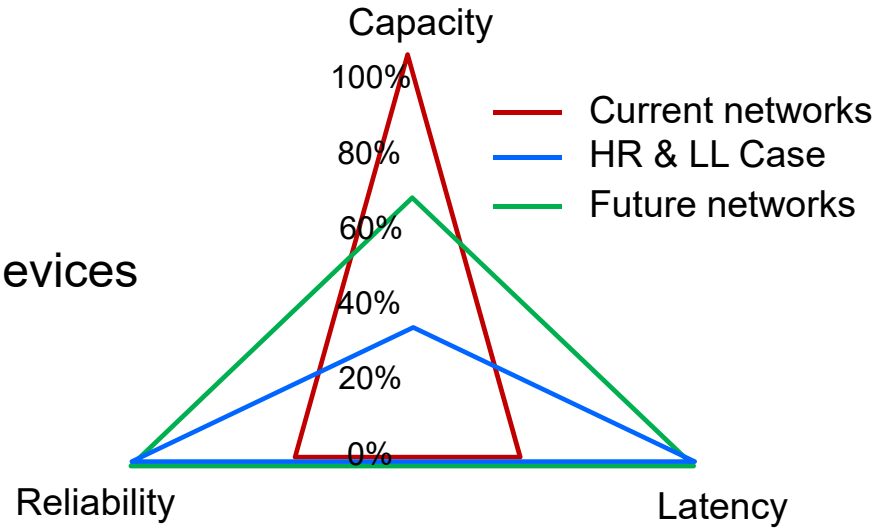
A. M. Waswa, D. M. Soleymani, Z. Shaik,
J. Mueckenheim, A. Mitschele-Thiel

HoME HOCHSCHULE MERSEBURG FH University of Applied Sciences
FACHBEREICH INGENIEUR- UND NATURWISSEN-SCHAFTEN

Motivation

- Future cellular networks
  - Real time applications
    - Low latency (LL)
    - High reliability (HR)
  - Massive number of connected devices
    - High capacity (spectrum)

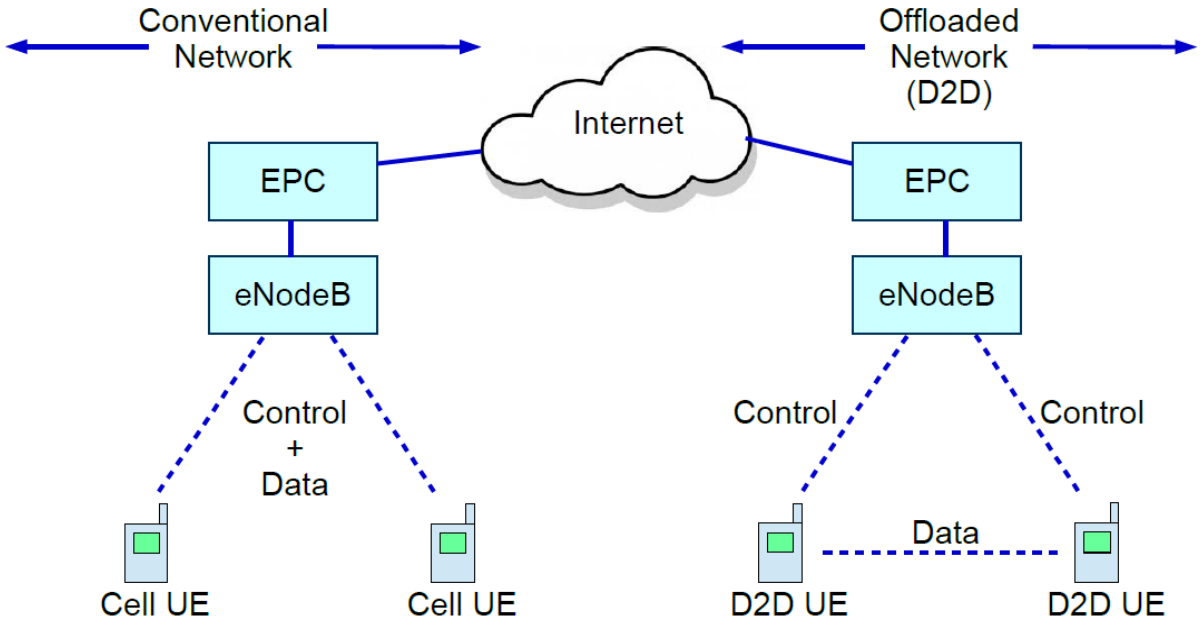


- D2D Concept
  - Integration within cellular networks
    - Promises quality of service (QoS) guarantees to above requirements
    - Efficient resource utilization

Outline

1. Introduction
   - D2D Communication
   - D2D Standardization
2. Radio Resource Management
   - Overlay D2D – Sub-granting
   - Underlay D2D – Resource reuse
3. D2D Communication Implementation
4. Conclusions & Outlook

Introduction – D2D Communication



EPC comprises of;
MME: Mobility Management Entity
HSS: Home Subscriber Server
S+PGW: Serving & Packet Date Network Gateway

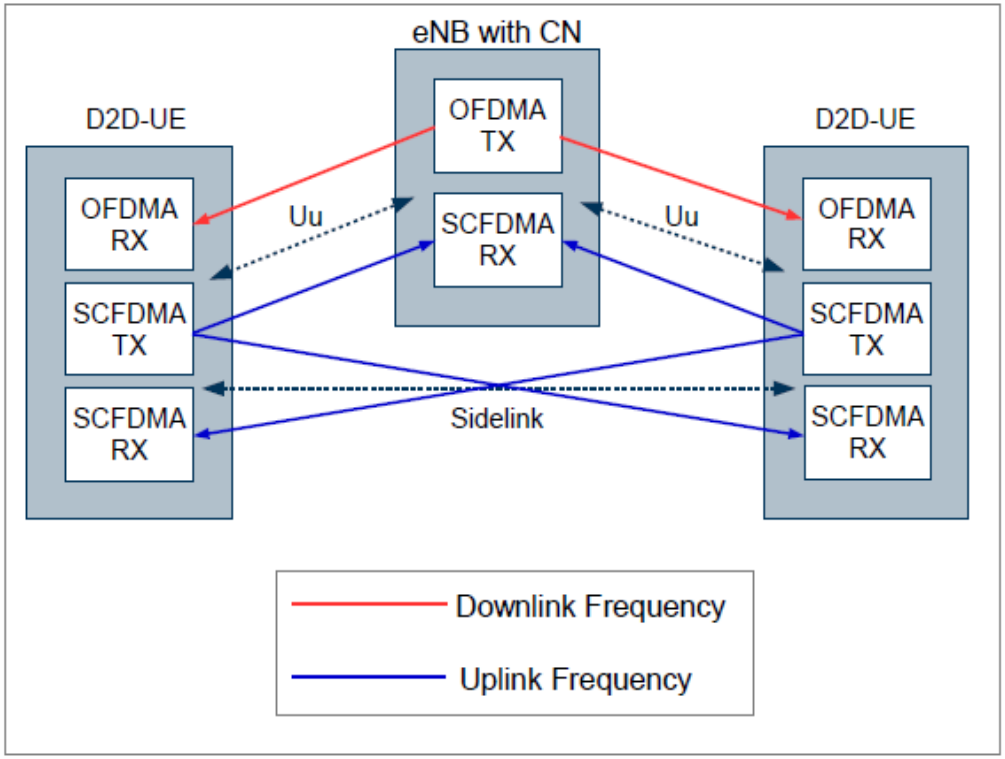
Key
Cell UE: Cellular User Equipment
D2D UE: D2D User Equipment
eNodeB: Base Station
EPC: Evolved Packet Core

- D2D Communication
  - Proximate devices communicated directly with some network control
  - Discovery and session initiation procedures

- D2D Benefits
  - Proximity gain: latency, power, & data rate
  - Resource reuse gain: spectral efficiency
  - Offload cellular networks

Introduction – D2D Standardization

- Proximity Services (ProSe)
- New Sidelink interface between UEs
- Use of Uplink (UL) Spectrum
  - New SC-FDMA receiver in UE



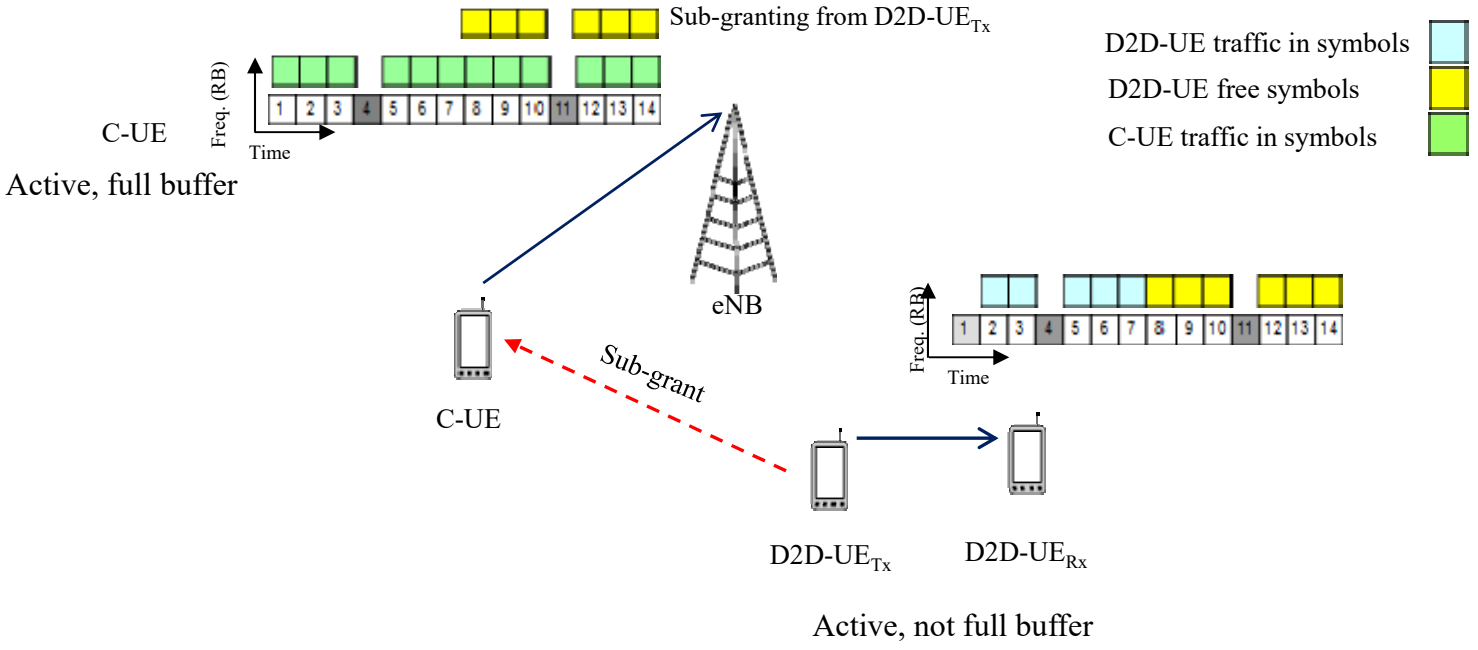
Radio Resource Management for D2D

- eNB controls radio resources in cellular networks
  - Ensure efficient use of resources & guarantee quality of service (QoS)
  - New schemes required for co-existence of both cellular and D2D users

- D2D communication RRM modes
  - Resource reservation, i.e. Overlay D2D
    - Appropriate for low latency & high reliability applications
    - Resource wastage in case applications have low payload
      - Sub-granting and shortening TTI (sTTI) schemes mitigate resource wastage
  - Resource sharing , i.e. Underlay D2D
    - Enhances system capacity through efficient resource utilization
    - Mutual interference limits extent of reuse
      - Power allocation & spatial allocation schemes limit interference

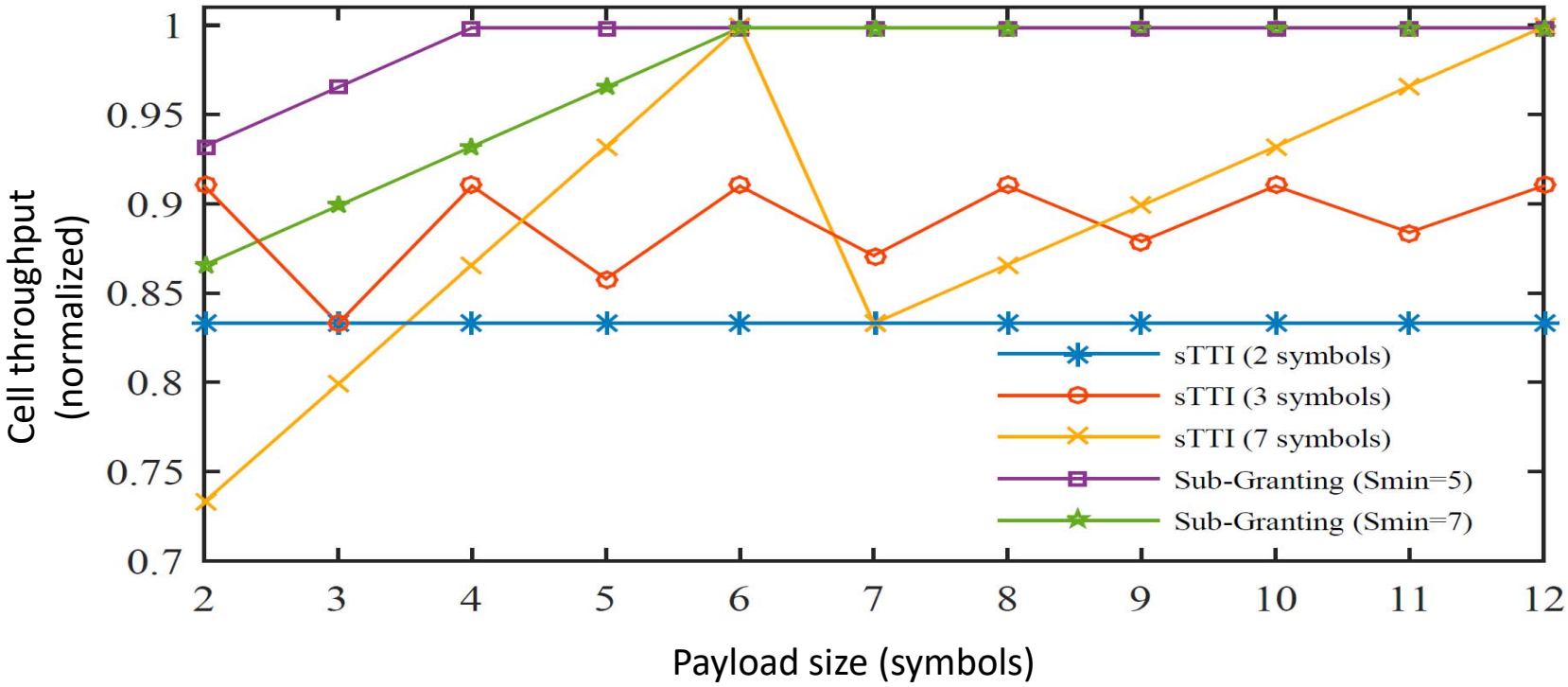
Overlay D2D – Resource Sub-granting

- Sub-granting principle
  - Small payload D2D UEs may not fully utilize their reserved resources
  - Reallocate/offer un-used resources to other full buffer users



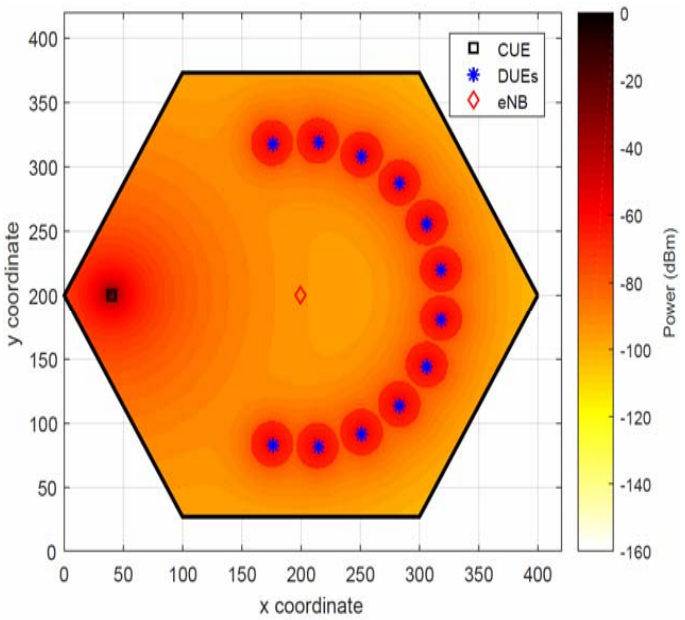
Overlay D2D – Sub-granting Throughput Comparison

- 40 resource blocks (RBs) reserved for D2D communication
- One D2D UE is allocated 1 RB

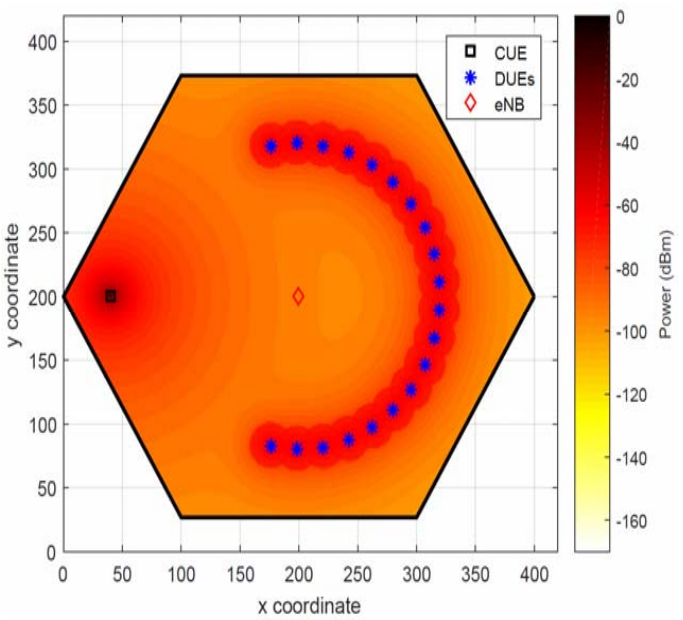


- 10% - 15% cell throughput improvement for sub-granting compared to sTTI
- Some time required to decode signaling and utilize the sub-granted resources

Underlay D2D – Resource Reuse



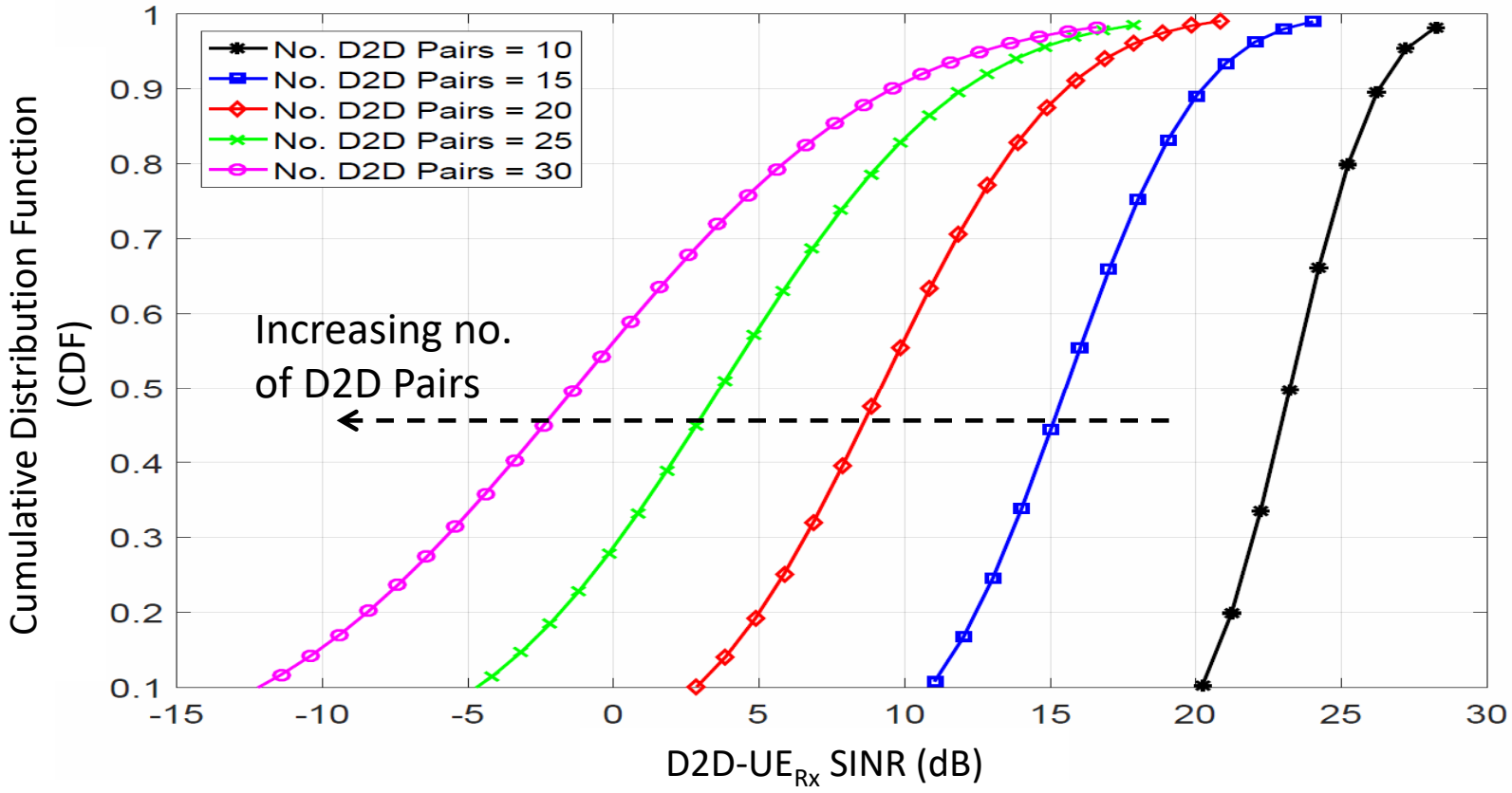
a) 12 D2D pairs



b) 20 D2D pairs

- Reuse generates interference among UEs
- Techniques needed to mitigate the interference
  - Power allocation strategies limit interference for cellular commumunication
  - Sufficient spatial DUE reuse limits mutual interference for D2D communication

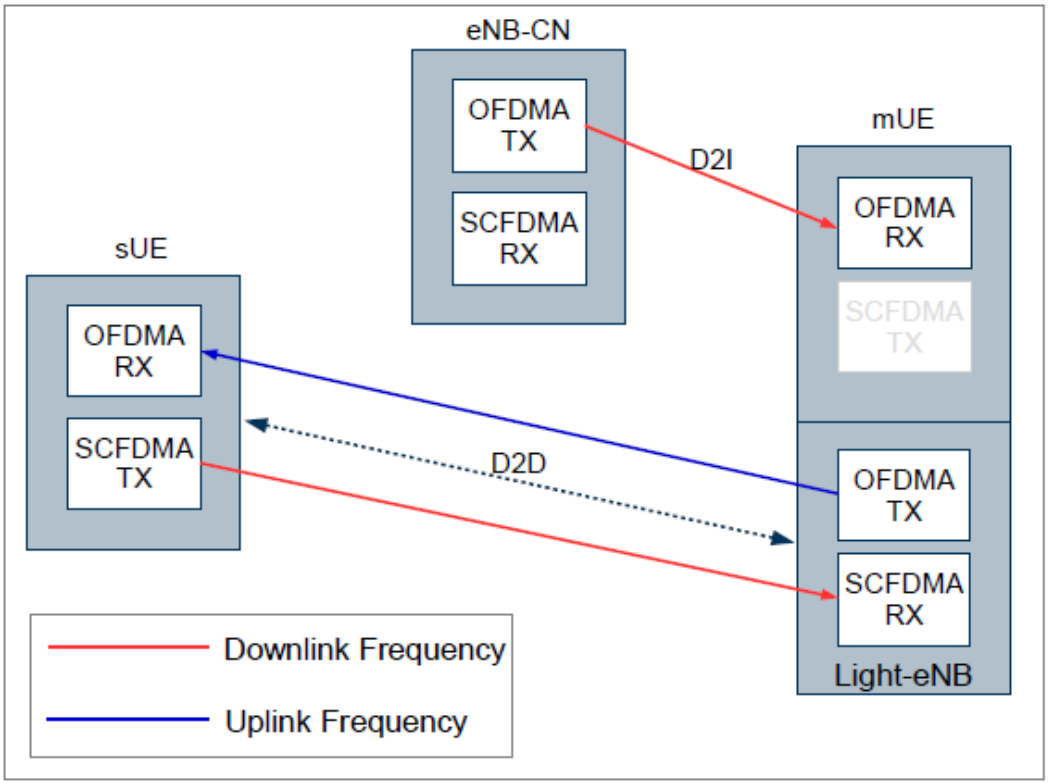
Underlay D2D: SINR CDF



- Small reuse → higher SINRs (above 10 dB) for all D2D pairs
- Increased reuse → decreased SINRs for some D2D pairs

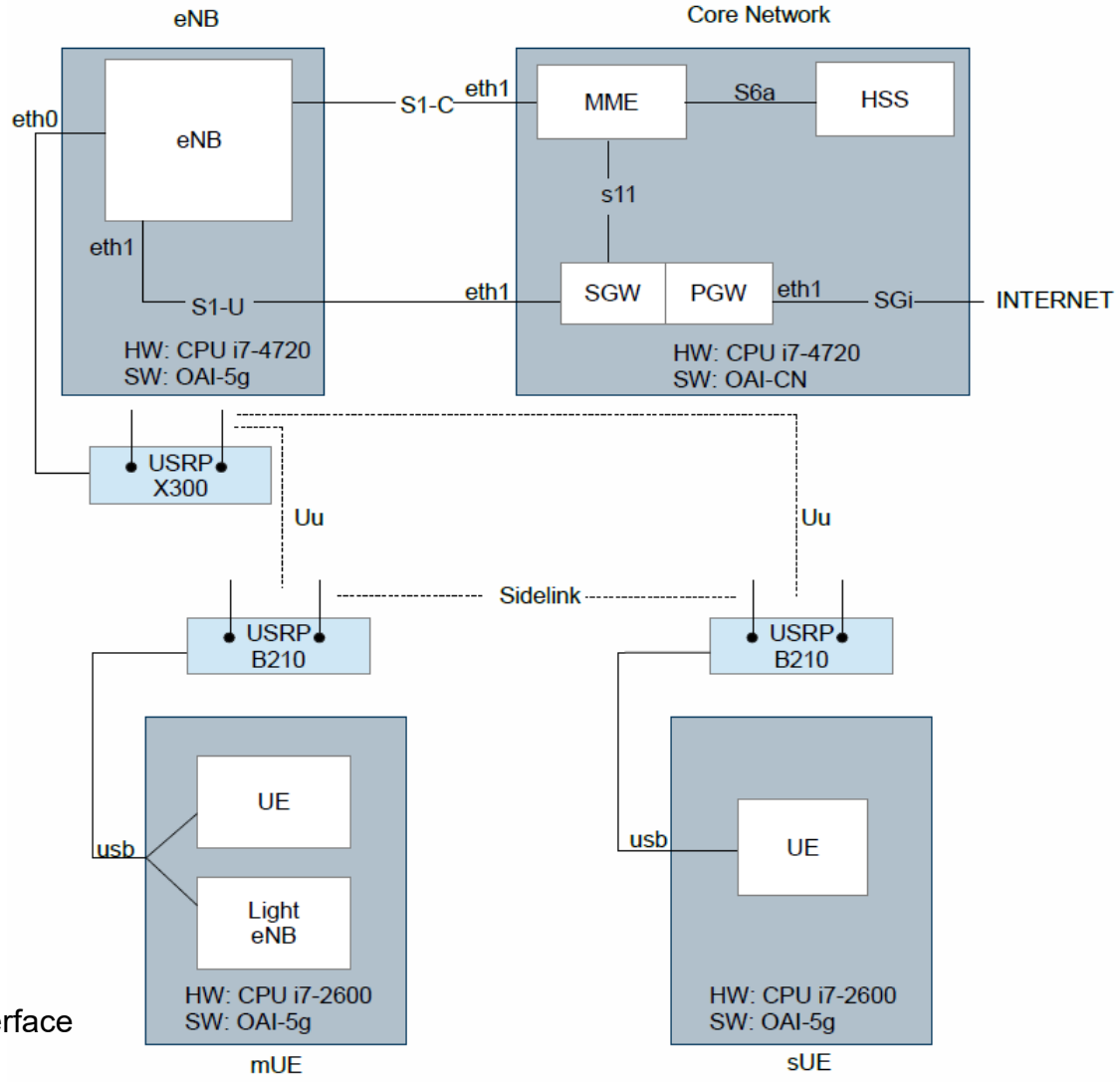
D2D Implementation Design

- Need for prototype to practically test D2D communication aspects
- D2D Communication based on master/slave principle
  - Software defined radio (SDR) based implementation
- At least one UE i.e. master UE (mUE) in network coverage
- Slave UE (sUE) can be in or out of coverage



Network Setup Implementation

- Carrier frequency
  - DL 2660 MHz
  - UL 2540 MHz
- Bandwidth
  - 5MHz
- Antenna Config
  - 1x1 SISO



Key

OAI – Open Air Interface

Results

- Experimental set-up
  - Only one-to-one sidelink communication
  - One UE i.e. mUE maintains connection to eNB
  - OFDMA transmission between mUE and sUE

	Cellular Communication	D2D Communication
Latency (Roundtrip)	24 ms	9 ms
Throughput	1.57 Mbps	1.92 Mbps

- 63% decrease in latency
  - Resource allocation time is not included
- 22% throughput improvement
  - Lightly loaded eNB, i.e. Only 2 UEs are served

Conclusions & Outlook

- Conclusions
  - o New schemes required to efficiently utilize radio resources
    - Sub-granting potentially reduces wastage of reserved resources
    - Optimal resource reuse schemes allow increased UEs‘ connectivity
  - o SDR based D2D communication is implemented
    - Throughput enhancement and latency reduction achieved
    - Implementation close to 3GPP standards
- Outlook
  - o RRM algorithms for D2D communication
    - Beneficiary UEs identification & signaling for sub-granting
    - Resource mapping between CUEs & DUEs for reuse
  - o Fully standards compliant D2D implementation
    - UEs‘ SC-FDMA reception
    - One-to-many connectionless sidelink communication

Thank You!

Fachgebiet Integrierte Kommunikationssysteme
Technische Universität Ilmenau

Prof. Dr.-Ing. habil. Andreas Mitschele-Thiel

Helmholtzplatz 5
D-98693 Ilmenau
fon: +49 (0)3677 69 2819
fax: +49 (0)3677 69 1226
e-mail: mitsch@tu-ilmenau.de
Internet: www.tu-ilmenau.de/ics

Fachbereich Informatik & Kommunikationssysteme
Hochschule Merseburg

Prof. Dr.-Ing. Jens Mueckenheim

Eberhard-Leibnitz-Str. 2
D-06217 Merseburg
fon: +49 (0)3461 46 2925
fax: +49 (0)3461 46 2900
e-mail: jens.mueckenheim@hs-merseburg.de
Internet: www.hs-merseburg.de/iks