On D2D-Communication for Resource Efficient Data Transmission of Delay-Critical Services

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Agenda

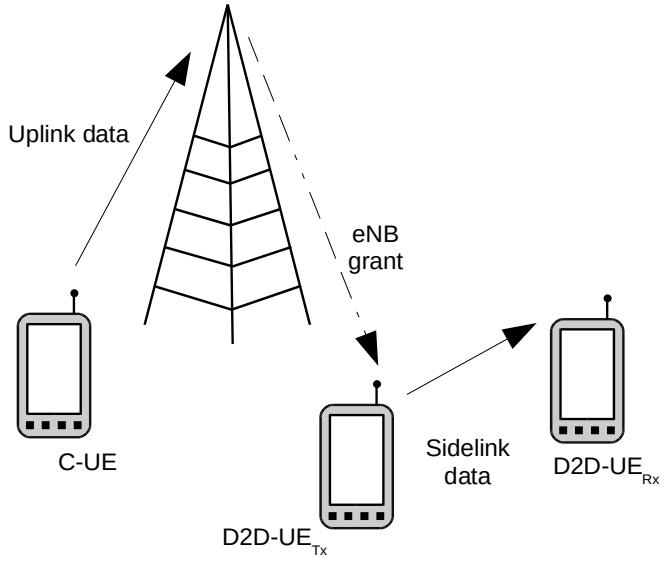
- Introduction
  - D2D Communication
- RRM for D2D Communication
  - New Principles/ Challenges
  - Intelligent Resource Sharing
  - Sub-granting for Resource Reallocation
- D2D Dynamic Simulations
  - Results of Interference Impact
- Conclusions/ Outlook

Introduction

- Future mobile communication networks will support a wide variety of new services.
  - Enhanced mobile broadband with data rates beyond 1 Gbit/s
  - Massive machine type communication
  - Ultra reliable and low latency communication
- New concepts are needed to support delay critical services.
  - Examples: Car2X, safety critical machine communication
  - Required overall latency down to 1 ms
  - Often low amount of data: 15 – 50 Bytes
- Current infrastructure based cellular networks (e.g. LTE) are not able to fulfill these demands.
  - Communication via complete core network: 70 … 100 ms
  - Enhancements to only communicate via eNB: ~20 ms

Device-to-Device (D2D) Communication

- D2D enables a direct communication between adjacent devices.
  - Avoid delays from infrastructure
  - Provide high data rate at low tx power
  - Allow reuse of resources
- 3GPP implementation
  - Proximity services
  - Communication over sidelink channels
  - eNB reserves D2D resources (eNB grant)



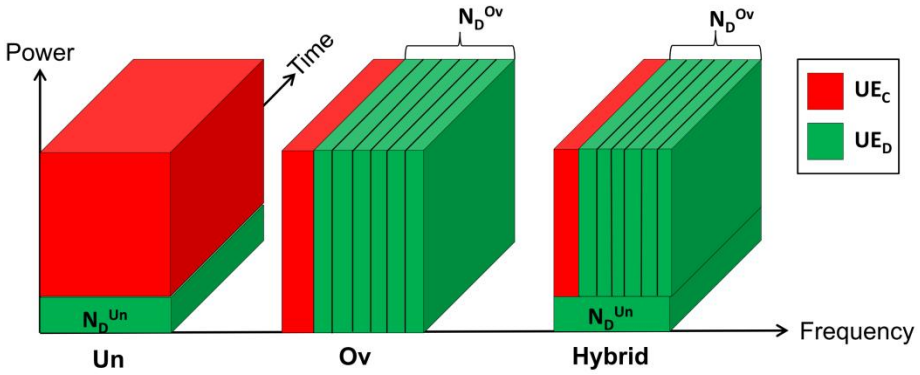
Principle of Sidelink Communication

The RRM Challenge for D2D Communication

- D2D communication introduces a new concept to the mobile cellular communication.
  - In traditional infrastructure based networks (e.g. LTE) most of the radio resources for C-UE controlled by the eNB
  - Some of the resource control now given to the D2D-UEs
- New RRM methods are required to efficiently allocate the radio resources of C-UE as well as D2D-UE.
  - Control of the resources by eNB (in coverage) or predefined resources (out-of coverage)
  - Selection of the most efficient transmission mode: D2D vs. cellular
  - Sharing of the resources between C-UE and D2D-UE: ***intelligent reuse***
  - Reallocation of unused D2D resources to C-UE: ***sub-granting***

Resource Sharing – Principles

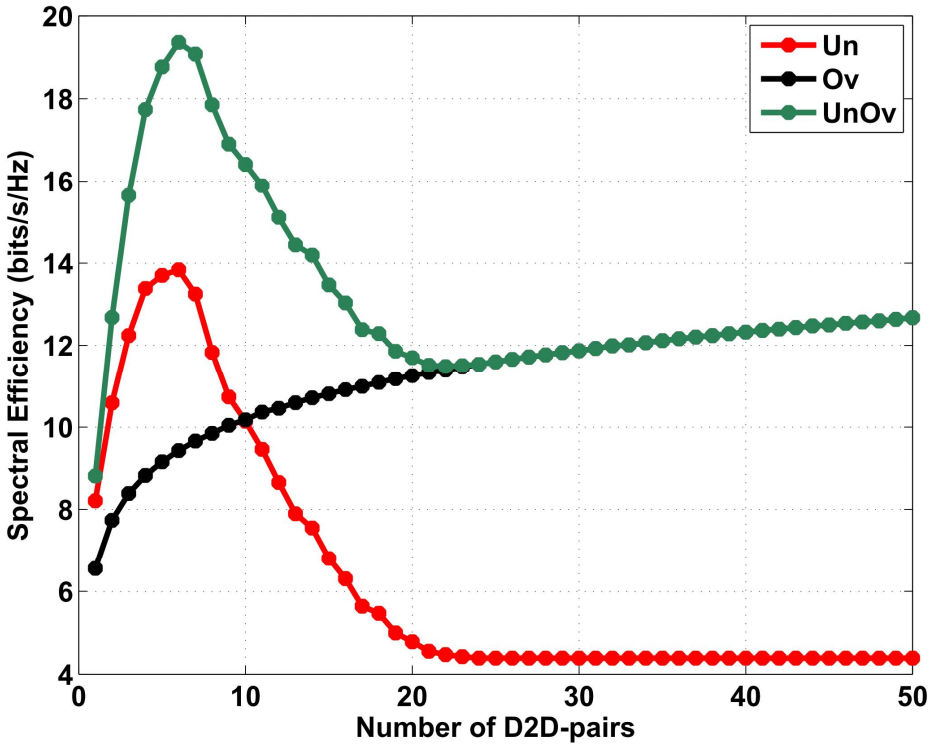
- Allocation done by means of Resource Blocks (RB)
- Overlay mode:
  - RBs divided between C-UE and D2D-UE
  - Clear separation
  - Risk of underutilization
- Underlay mode
  - Reuse of the RBs at higher distance
  - Chance for higher utilization
  - Possible interference between the groups



Resource sharing principles

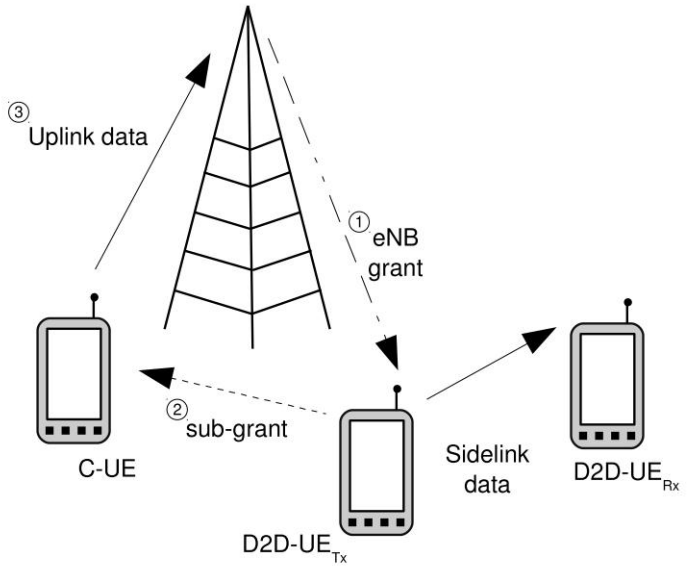
Resource Sharing – Hybrid Mode

- Idea: intelligent combination of both modes
  - UEs divided into two groups acc. to distance
  - Using underlay vs. overlay mode
- Performance results indicate significant gain
  - With low D2D traffic both schemes combined
  - At high D2D load allocation according to overlay mode



Resource Reallocation – Sub-granting

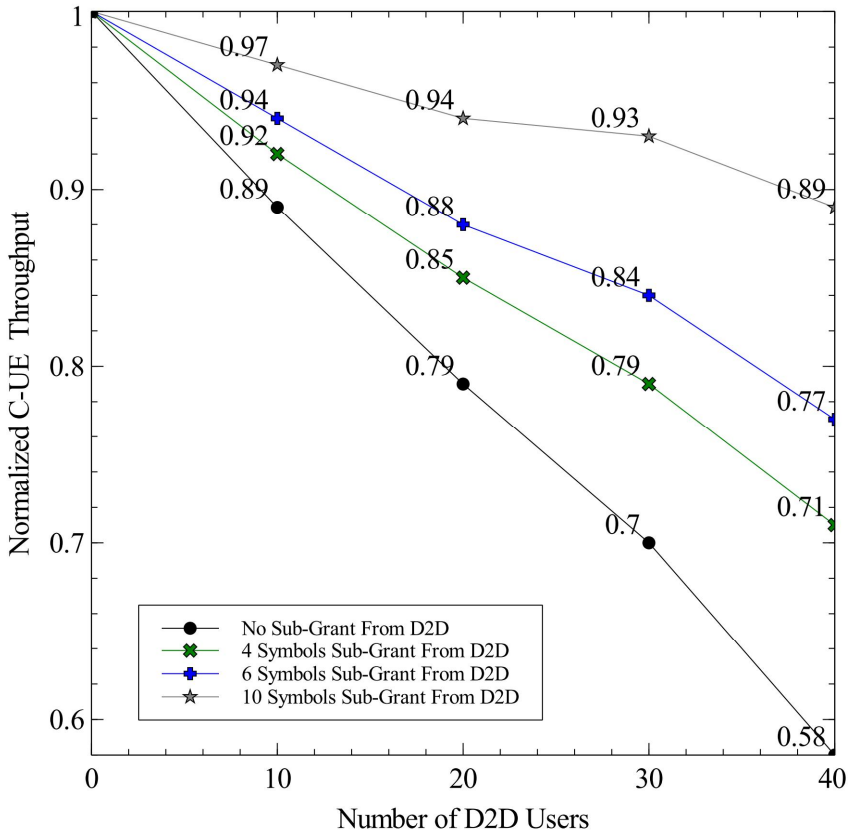
- Delay critical services with small messages, e.g. Car2X
  - Permanent allocation of resources for low latency
  - Data packets often smaller than filled by one RB
  - Unused resources wasted
- Idea: sub-granting
  - D2D-UE aware if not fully using assigned resources
  - Signaling of remaining resources to adjacent C-UE
  - C-UE adds the resources to its own transmission grants



Principle of Sub-granting

Resource Reallocation – Results

- Results show the impact of D2D-UE to C-UE
  - Overlay mode used
- Sub-granting scheme helps for better utilization of unused resources
  - Throughput may go down by 40 % with conventional allocation
  - With sub-granting throughput reduction is lower, e.g. 10% with 10 symbols reused

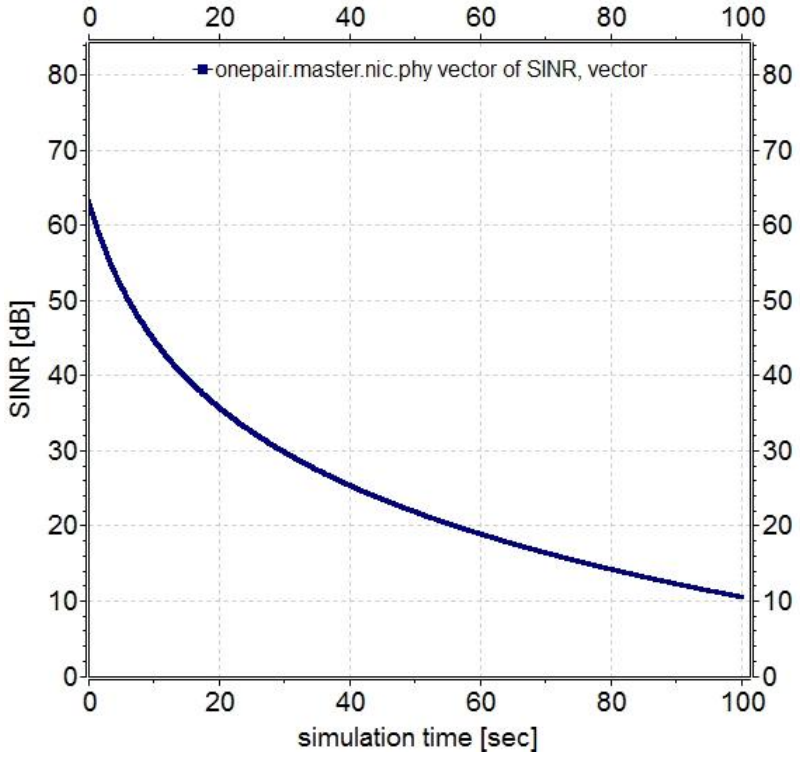


D2D Dynamic Simulations

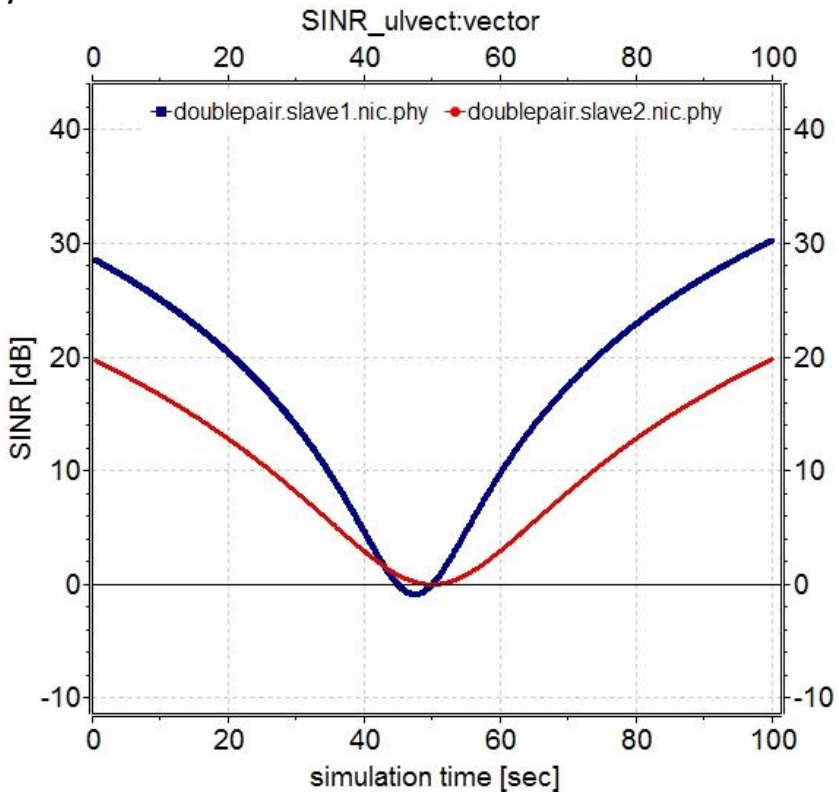
- Dynamic network simulations will be used for studying the behavior of D2D communication within the cellular network.
  - Investigations of the dynamics due to mobility, traffic, etc.
  - Interaction of the new D2D algorithms with the existing RRM methods, e.g. scheduling, power control, mode selection
- Open software based simulation tools for LTE networks can be enhanced for D2D communication.
  - Study the performance of specific RRM algorithms with simulation tools developed by open source community
  - Reuse of existing methods for mobility, transmission, etc.
  - Opportunity to compare different algorithms in the same simulation environment
  - Couple of simulation tools available, e.g. LTE-Sim, ns-3/ LENA, Omnet++/ SimuLTE

D2D Simulation Results

Basic D2D Implementation in Omnet++/ SimuLTE



One D2D-pair



Two D2D-pairs moving

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Conclusions

- Future mobile communication networks will support new data applications.
  - Incl. delay critical services, e.g. for Car2X communication
- D2D communication provides an efficient means to support such services.
  - Significant reduction of latency while bypassing infrastructure
  - Opportunity of increased spectral efficiency by resource reuse
- New methods are required to efficiently allocate the resources to D2D-UE as well as C-UE.
  - Intelligent resource sharing: hybrid allocation
  - Reallocation of unused resources: sub-granting
- Dynamic system simulations will be used to evaluate the performance.
  - Use of open software based simulation tools

Outlook

- Further analysis and refinement of the RRM methods
  - Comparison to other allocation schemes, e.g. short TTI
  - Algorithms for sharing mode selection, sub-granting
- Evaluation of D2D communication by means of dynamic system simulations
  - Implementation of the relevant RRM algorithms into existing simulation frameworks
  - Analysis of the algorithm performance, such as the impact of mobility effects, interaction with cellular traffic, etc.
  - Optimization of the RRM algorithms
- Investigation of the application and collaboration with SON approaches
  - Introduction of latency classes to prioritize critical services

Thank You !

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