A Hierarchical Radio Resource Management Scheme for Next Generation Cellular Network

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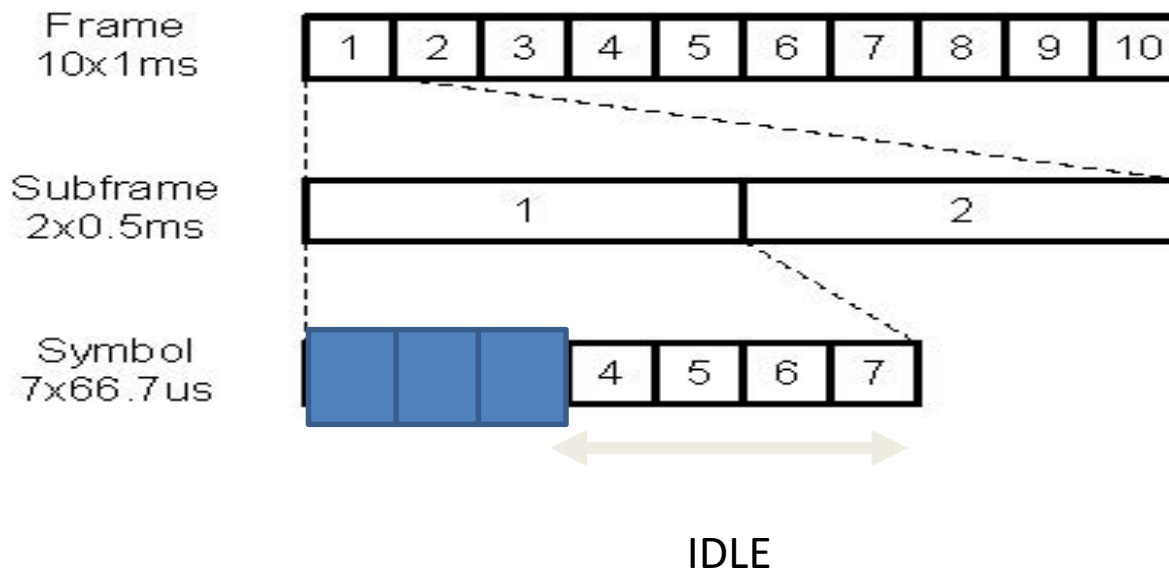
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Motivation

- Low latency and high reliability applications
  - Device to Device (e.g. Machine to Machine (M2M) application)
  - Resource reservation
- M2M applications have low payload

Application Type	Packet Size (Byte)	Cycle Time (ms)
Printing Machine	30	2
Machine Tools	50	0.5
Packaging Machines	15	5

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Motivation (cont.)

- Waste of radio resources
  - E.g. for 64QAM → ~50 bytes per PRB (resource block)

IDLE

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Predicted Resource Wastage

- Spectral efficiency loss for low sub-frame utilization rate
- Throughput is reduced by 50% if 6 symbols are not used

3rd Generation Partnership Project (3GPP), "TS 36.213: Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer procedures (Release 12)," Oct. 2015.

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Goals and Challenges

- Goals
  - Efficient resource utilization
  - Capacity improvement
- Challenges
  - Processing time in physical layer
  - Pairing of Cellular UE (C-UE) in vicinity
  - Signaling overhead due to resource reuse

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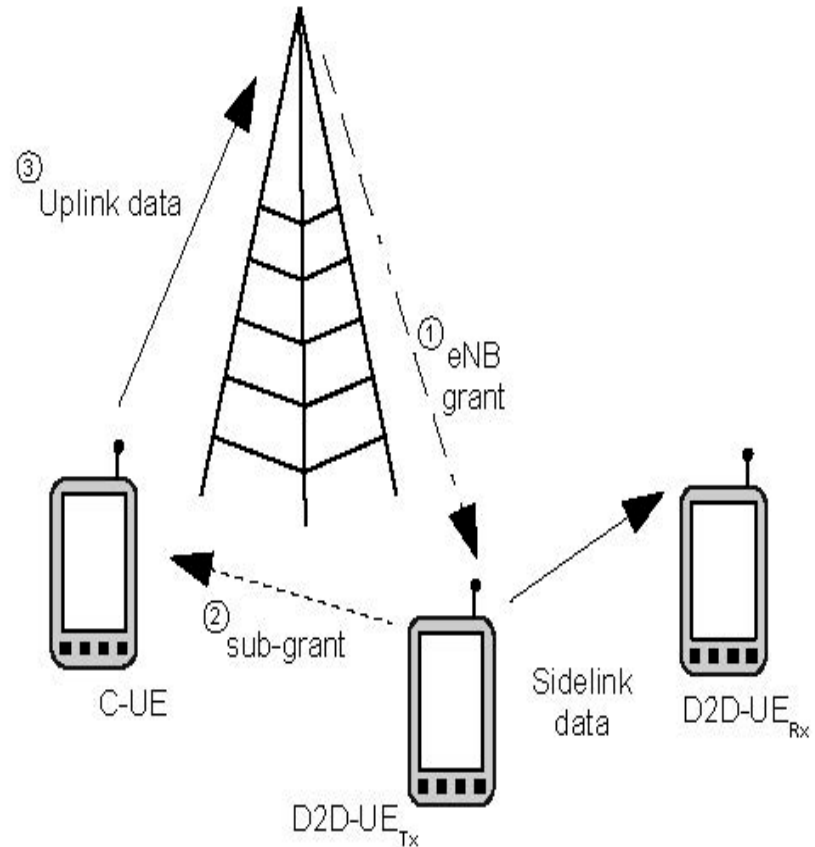
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Model Assumptions

- One C-UE , and m D2D-UEs
- Reserved Resource Blocks (RB)
  - No spatial reuse of assigned RBs
- Paired users (C-UE and D2D-UEs)
  - Similar radio condition
- Customized framing mechanism
  - Cellular user identification
  - Unused symbols start point

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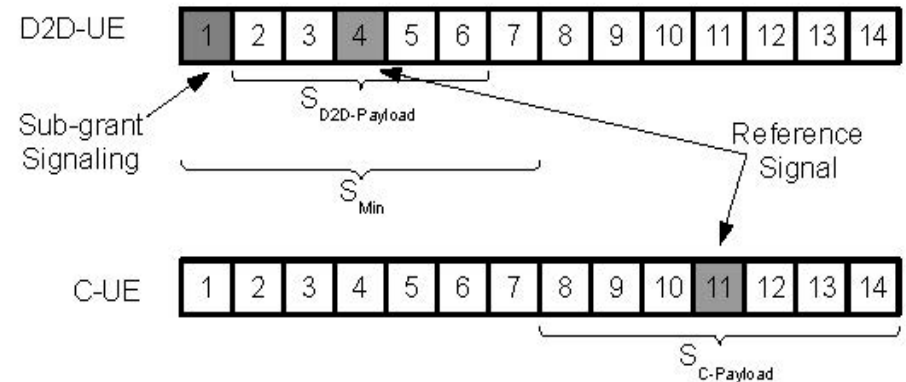
Principal of Operation

Hierarchical scheme
1. eNB:
   - Resource allocation
2. Sub-grant provider
   - Inform free symbols to C-UE
   - D2D-UE communicates through sidelink
3. Sub-grant beneficiary
   - Monitors assigned D2D-UEs
   - Transmits uplink data on sub-grant

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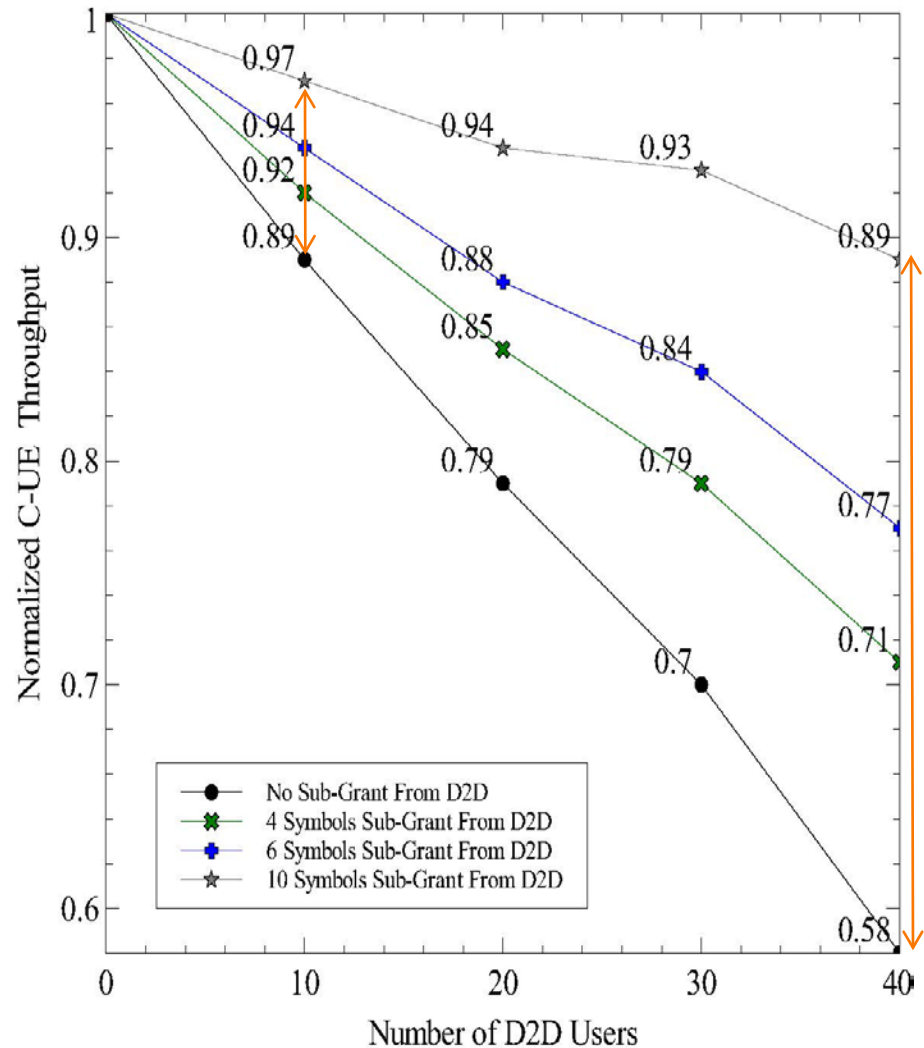
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Proposed Sub-grant Scheme

- To avoid signaling overhead in-band signaling is used

  - A marker at beginning of D2D transmission (C-UE ID, start of sub-grant)

  - S_{Min}: a minimum time for processing of received data in C-UE

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Sub-grant Gain

- Varying number of sub-grant provider (D2D-UE)
- Varying number of sub-grant size (4-10 symbols)
- 10% to 30% of C-UE throughput improvement

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Conclusions and Future Works

- Small size M2M application
  - High reliability & low latency → reserved radio resources
  - Radio resource being wasted
- Hierarchical radio resource reuse scheme
  - Better radio resource utilization (e.g.,10% to 30% throughput improvement)
- Future study
  - Determine maximum number of C-UE or D2D-UE reusing a sub-grant
  - Imposed signaling overhead during discovery and pairing procedure
  - Study different scenarios

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Thank You
Questions?

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Backup

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Algorithm I

Algorithm 1 Sub-grant provider

1: **procedure** SUB-FRAME TRANSMISSION
2: $Discovery \leftarrow$ (C-UE IDs and CQIs)
3: **while** $(HaveSchedulingGrant)$ **do**
4: $S_{FT} := 0$ $\triangleright$ normal sub-frame
5: **if** $(HaveFreeSymbols)$ **then**
6: $S_{FT} := 1$ $\triangleright$ customized sub-frame
7: $S_{CUE\_ID} \leftarrow Selected\ C\text{-}UE$
8: $S_{FFS} \leftarrow First\ Free\ Symbol$
9: **end if**
10: $TransmitSubFrame()$
11: **end while**

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Algorithm II

Algorithm 2 Sub-grant beneficiary

1: **procedure** SUB-GRANT REUSE
2:     $Discovery \leftarrow$ (D2D-UE resource grant)
3:             $\triangleright$ assign potential D2D resource to C-UE
4:     **while** $(NewSubFrame \;\&\; AssginedForResue)$ **do**
5:         **if** $(S_{FT} == 1)$ **then** $\triangleright$ customized sub-frame
6:             **if** $(S_{CUE-ID} == \text{myID})$ **then**
7:                 $TransmitSubFrame(offset=S_{FFS})$
8:             **end if**
9:         **end if**
10:    **end while**

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