An Overview of Device-to-Device Communications
Technology Components in METIS

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Introduction

Proximal communication use cases:

- Machine type communication
- National security and public safety
- Vehicle-to-vehicle and intelligent transportation system

Introduction

Early D2D focused on:

- Proximity gain
- Reuse of cellular spectrum
- Hop gain

Recently D2D researches focuses on:

- Full duplex communications
- Multiple input-multiple output systems
- Advancements of user equipment capabilities

D2D COMMUNICATIONS AND NETWORK CODING FOR PROXIMAL COMMUNICATIONS

Sources for Traditional Cellular Networks:

1. Time Slots
2. Physical Resource Block
3. Uplink
4. Downlink

Both has Advantage at:
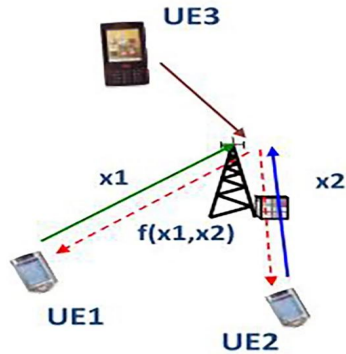
- Proximity
- Reuse Gain

Differ in taking advantage of hop gain

Advantage of the Overlay Device-to-Device Approach

- Increased Number of Connections
- Enhances Communication
- Device can assist communication between other device and base station
- Increases range

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MODE SELECTION FOR COOPERATIVE D2D SCHEMES (5 Mode)

Cellular Mode
- 4- Time slot(TS)
- Traditional cellular communication

2-TS, 3-TS and PLNC
- 2 TS and 3 TS
- Base station manages resources

D2D - No network coding
- Devices can manage link layer operations
- Traditional cellular communication

3-TS No network coding
- Device to device
- Base Station
- Network coded signal from BS, and signal from user equipment
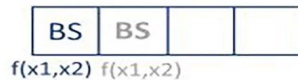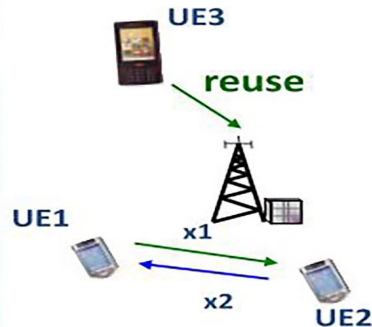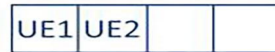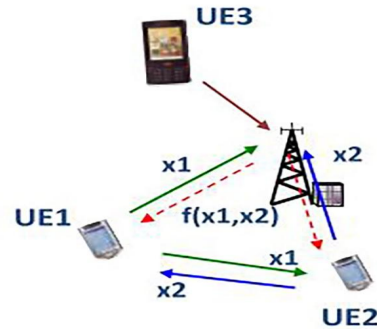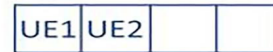
Overlay D2D with superposition coding
- Can transmit signal over other user equipment
- Orthogonal device can transmit signal and receive at the same time

Cellular Communications – 4 Time Slot

D2D – No NWC – 2 Time Slot

2 Time Slot Network Coding
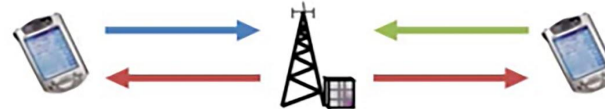
3 Time Slot Network Coding
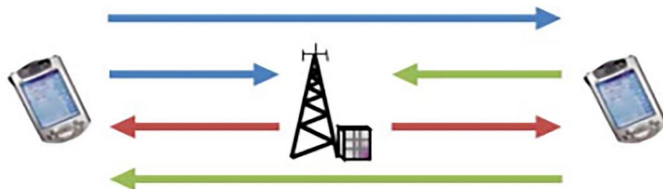
3 Time Slot Network Coding with Maximum Ratio Combining (MRC)

Legend:
- Time slot 1
- Time slot 2
- Time slot 3
- Time slot 4

NETWORK-ASSISTED MULTI-HOP D2D COMMUNICATIONS

- Range extension
- Multi-hop proximity communication

Requirements
- Mode selection
- Resource block allocation
- Power control

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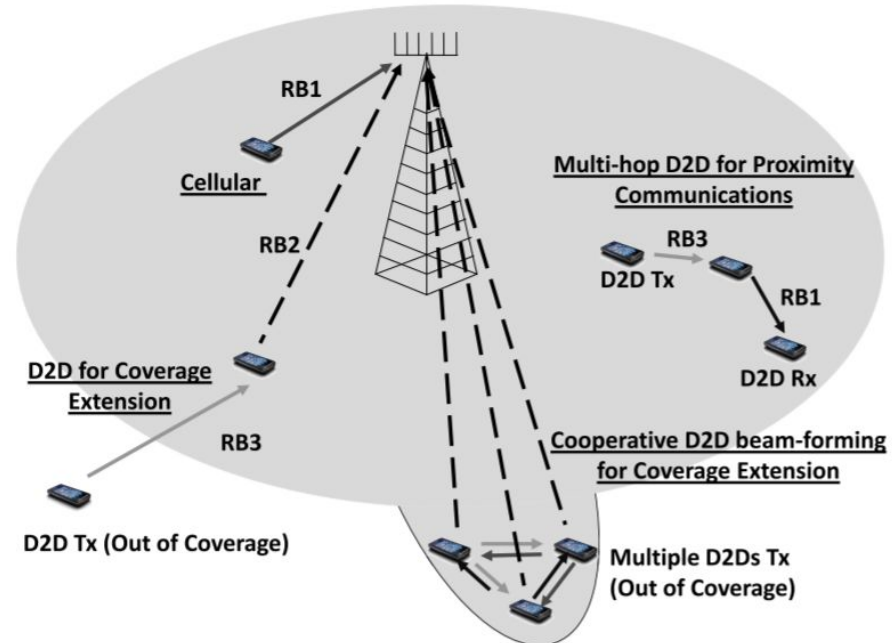
Challenges
- Users (UE)

Suggestions
- Reputation
- Virtual currency
- Operators

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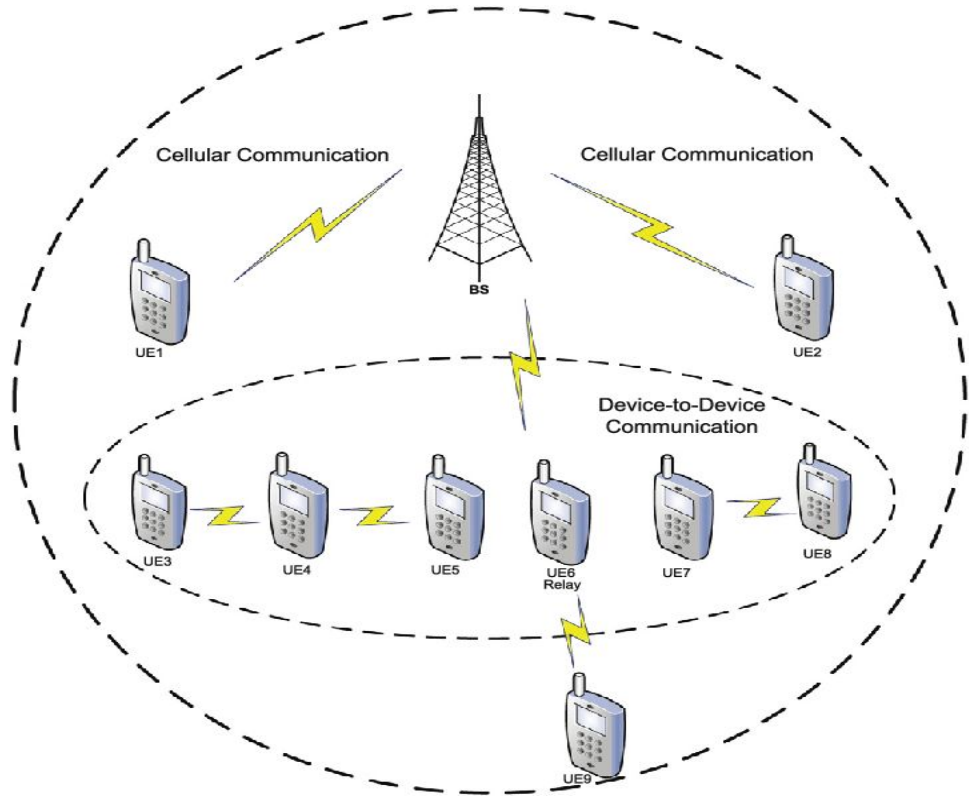
FULL-DUPLEX D2D COMMUNICATIONS
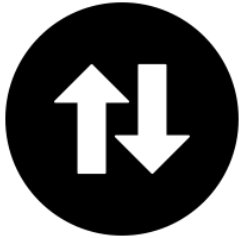
- send and receive at the same time

Efficiency
- 2 times better than conventional methods

FULL-DUPLEX D2D COMMUNICATIONS

Conventional
- Frequency Division Duplex
- Time Division Duplex

Problem of Conventional Methods
- Self interferences

Solution Stages
1. Separated antennas
2. Analog domain active cancelation
3. Digital domain cancelation

Integration of Multi-Antenna with D2D

- Devices such as cell phones that use D2D communication can benefit

- MIMO enabled devices with network coding can be better than normal systems without MIMO

- The D2D enabled systems can increase bandwidth efficiency and data transfer rate

Integration of Multi-Antenna with D2D

Multi-Hop MIMO D2D

- Normally UEs can provides virtual infrastructure which helps in cell edge performance, and are flexible, robust and reliable even though complex
- Because MIMO is good in spectral efficiency and link reachability
- MIMO can be used to boost performance in multiple Hop D2D communication
- Channel State information(CSI) needed in Multi Hop communication to take advantage of MIMO
- With the help of Space Time Coding(STC) CSI can be neglected
- Advantage! as STC provides better efficiency in UE mobility

Integration of Multi-Antenna with D2D

Cooperative D2D Beamforming For Coverage Extension

- Possible to extend D2D coverage

- By UE directing signal to Base station

- Can increase signal to noise ratio

- Similar to MIMO

- Helpful in crowded places like football stadium

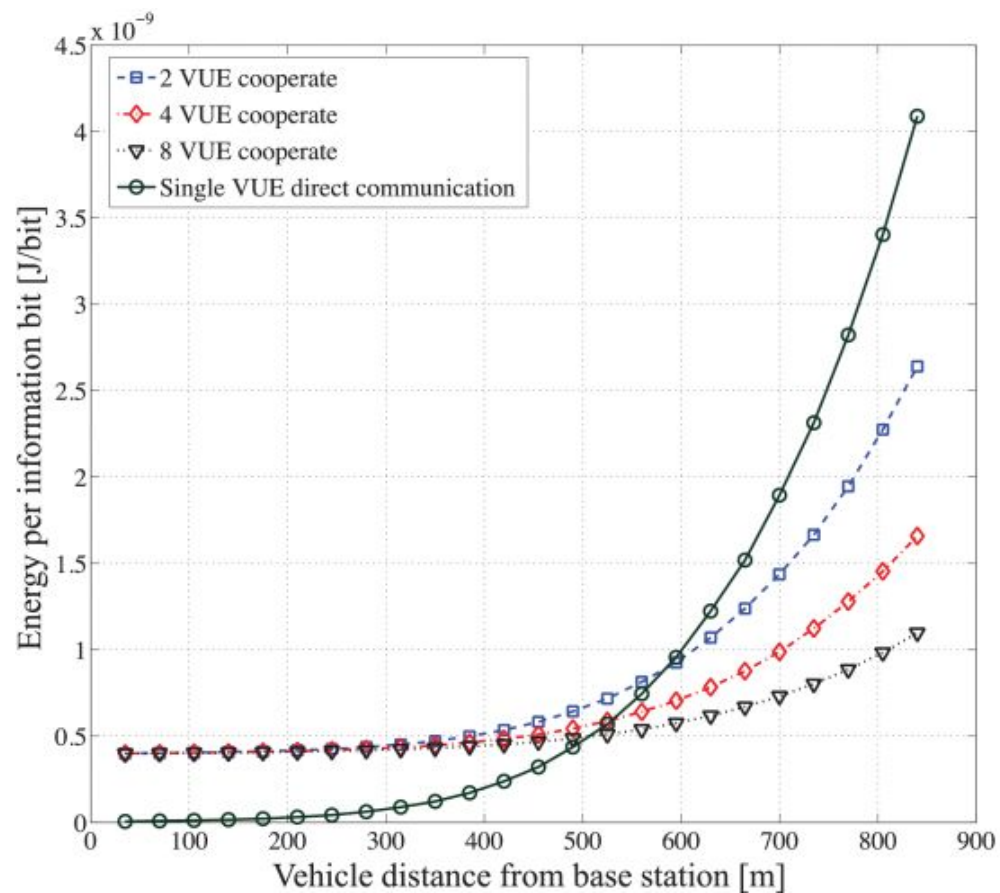# Enhancing Vehicle Users' Uplink Communication

Need

- Access remove services on the high speed vehicle

Problem

- VPL(Vehicular Penetration Loss)

Solution

- Cooperative D2D beamforming

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D2D Test-Bed

Three Tests:

- Impact to Interference Cancellation in Direct Network Controlled D2D
- Adding Mode Selection in First Test
- Heterogeneous Network

Conclusion

- Evolution from realizes proximity, reuse and hop gains to national security and public safety and intelligent transportation system
- Cooperative D2D communications extending the coverage

Thank You for Listening Us

Any Questions?