Device to Device (D2D) Communication in 5G

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Previous Session

- Routing Algorithms

  - Static - Non Adaptive - Proactive

  - Dynamic - Adaptive - Reactive

- Routing Parameters

- Dijkstra's Algorithm

  - Forward Route - Source to Destination - Used for data packets

  - Backward Route - Destination to Source - Used for Control Packets (ACK)

  - Downstream (Forward Route) and Upstream (Backward Route)

Users Requirement

- Multimedia Rich Data Exchange.

- Fast Service.

- High quality voice calls.

- Newer and more demanding applications.

- Information at fingertips.

5G Verticals or 5G Allied technologies or 5G Components

- Heterogeneous Networks
    - Various Radio access Technology, different cells with different capacity of users.
- Massive MIMO
    - Large Antenna Arrays
- Cognitive Radio Networks
    - Intelligent spectrum allocation and usage.
- mmWave
    - 30 - 300 GHz.
- D2D Communication.

Introduction

- LTE - Long Term Evolution 2009

  - Requirements for the 4G standards was discussed in 1998 !!

- 3GPP (3rd Generation Partnership Project) Introduced Proximity Services in LTE Rel. 12 for in coverage D2D Communication (or LTE Advanced).

- LTE Rel. 13 extended D2D communication for out of coverage devices.

- LTE Rel. 14 extended D2D communication for Vehicle to Vehicle communication (V2V)

  - High speed high density

- D2D Communication is also called as *Sidelink* Communication.

ProSe [1, 2]

- *ProSe* enabled UE, works with close proximity UE devices.

- *ProSe* enables direct communication between nearby devices without the base station.

  - Hence, D2D communication,
  - Basically introduced for Public Safety
  - LTE Direct.

- Communication link is not established through the eNB.

  - eNB supports the communication, but, will not be part of it.
 - Unlike traditional cellular communication.

# Other Direct Communication Techniques [1]

- Bluetooth 5
  - 2 Mbps, 240m
- Wifi Direct
  - 250 Mbps, 200m
- LTE Direct
  - 13.5 Mbps , 500m
  - Quite less data rate !!
  - Meant for Public Safety - hence less data rate.

Public Safety Applications - The First Responders

- Large Events,

- Pandemics,

- Severe accidents,

- Environmental disasters,

- Law enforcement,

- Fire and emergency medical services

- Base station - evolved Node B - eNobeB - eNb - eNB
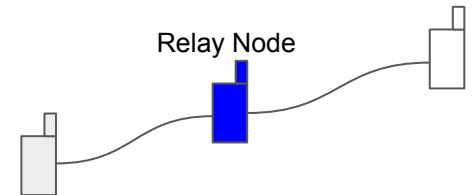- Mobile Node - User Equipment (UE)

CU

CU

eNb
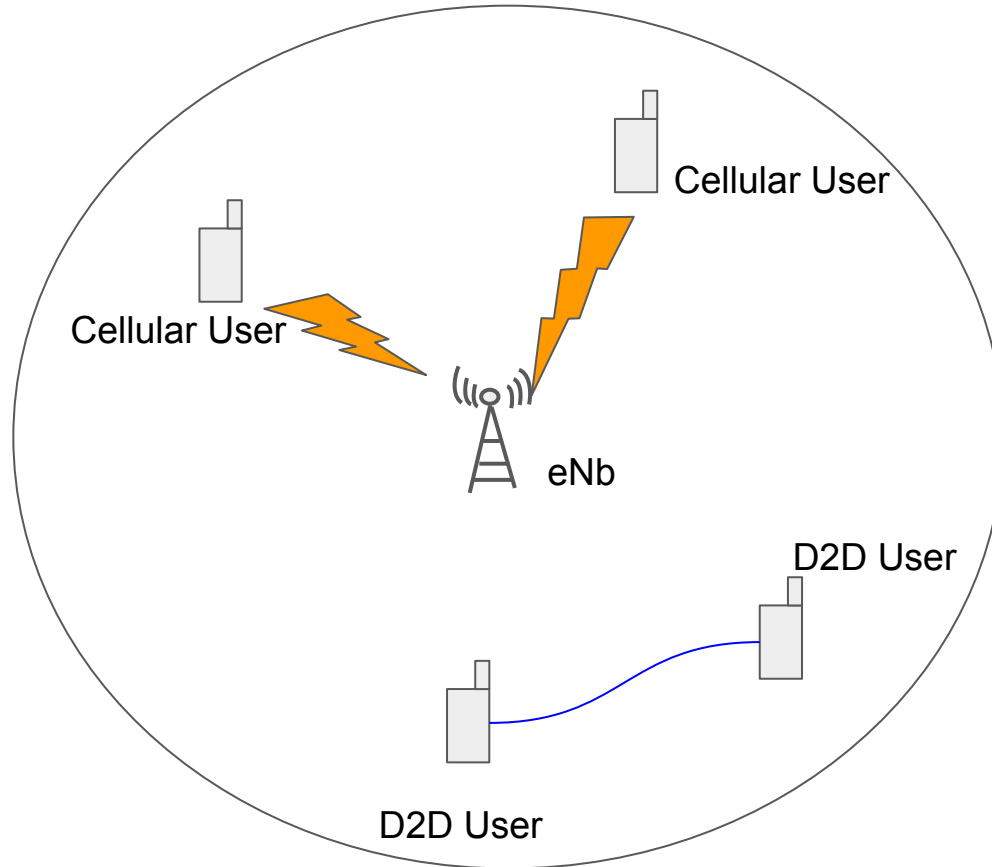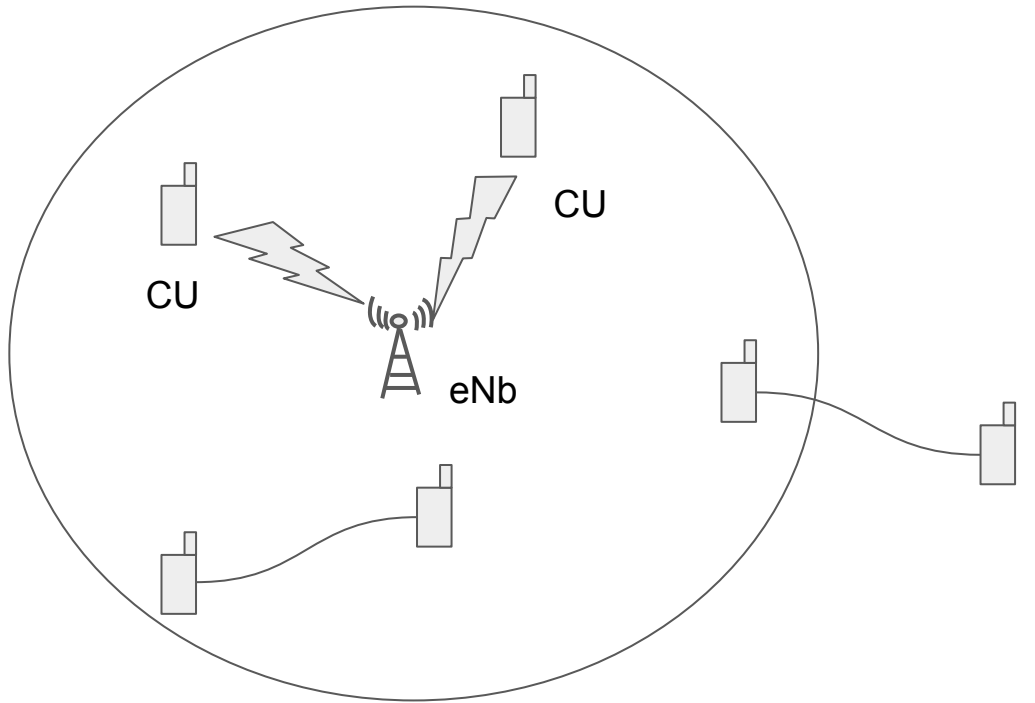
In Coverage

Partial Coverage

Out of Coverage

Relay Node

Relay Communication

Why D2D Communication ?

- Mainly public safety

  - Extended to commercial applications.

  - Advertising, Gaming, Social Networking

- Ultra Low Latency Communication

- Global synchronization of CUs is not required

  - Local synchronization among D2D users is enough.

- Offloading certain traffic from eNB

  - Mitigate Network Congestion

# Why D2D ? (Contd.)

- Coverage extension through relay nodes.

- High Spectral Efficiency
    - No. of bits transmitted per Hz

- High Energy Efficiency
    - No. of bits transmitted per Joule.

- Throughput is high.

Spectrum Allocation in D2D Communication [1]

- Inband
  - Licensed Spectrum, the spectrum used by the cellular user.
  - Spectrum can be further divided into
    - Overlay - Non overlapping spectrum, separate spectrum for D2D and Cellular users
      - Interferences will be less
      - If D2D users are not active, spectrum will be wasted.
    - Underlay - Same Spectrum for both D2D and Cellular.
      - Interferences will be more.
      - eNB will handle it to the maximum, but can not eliminate it.
      - Opportunistic, more efficient usage of spectrum.

- Outband
  - Unlicensed Spectrum
  - Cellular communication does not occur.
  - No interferences between Cellular users and D2D users
  - Controlled
    - Communication is controlled by Cellular network
  - Uncontrolled
    - eNB will not interfere in D2D communication.
    - Since the spectrum is unlicensed, anyone can use it, no restrictions
    - Hence, uneven transmissions, no synchronization, more interferences, more noise.

CU

CU

eNb

Advertising

CU

Gaming

D2D User

Social
Networking

SOS
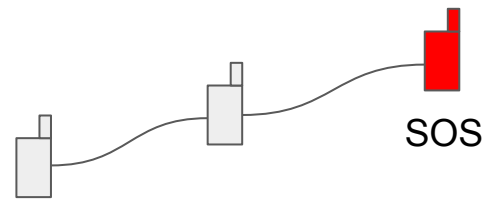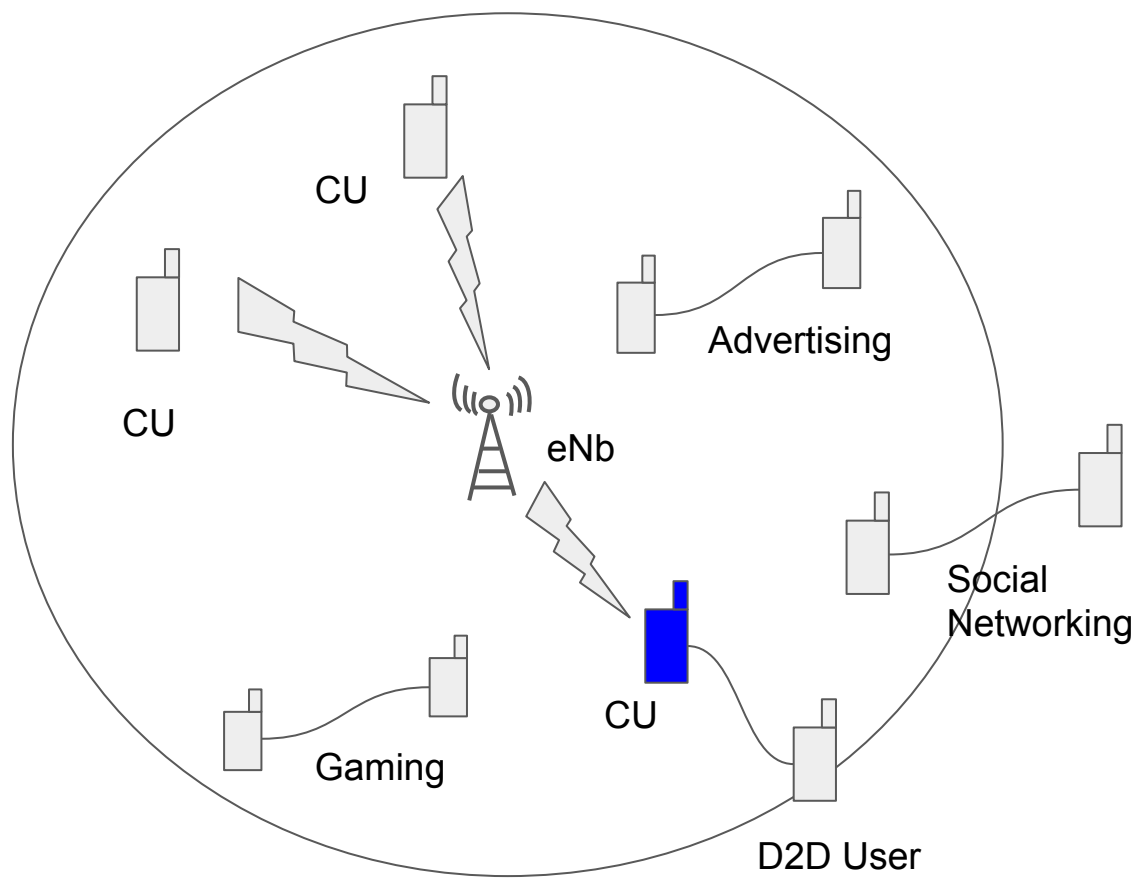
LTE D2D Functionalities [2]

- Discovery.
    - Information/Services provided by the other UEs
- Synchronization.
    - Common System Information
- Direct Communication.
    - Establish a direct communication link between the UEs without eNB.

D2D in NS3

- Go to NS3 App store

- Search for "Public Safety Communications" or D2D Communication

- Download

- You can copy the required files in to the NS3 folder

- Or, you can install it as a separate repository.

For installing it as a separate repository

Go to folder *psc-ns3-3.0.1* and follow the below mentioned steps.

Step 1: *./waf --build-profile=debug --enable-examples --enable-test configure*

Step 2: *./waf*

Step 3: execute the scratchsimulator.cc

    ./waf --run scratch/scratchsimulator

Next Session

- NS 3 Implementation of D2D Communication

- Course Project

References

[1] Udit N K and Debashri Kumar Sanyal, "*An Overview of Device-to-Device Communication in Cellular Networks*", ICT Express, Elsevier, 4(2018), 203-208

[2] Richard R, Fernando J C, Aziza B M, and Samantha G "*Implementation and Validation of an LTE D2D Model for NS3*", WNS3 2017, ACM

[3] Wikipedia