D2D communications

TELCOMA

D2D communications

Device to device :

- It enables user equipment to communicate directly with other UE's without or with partial involvement of network infrastructure.
- Direct communications between nearby mobile devices will improve spectrum utilization , overall throughput and energy efficiency while enabling new peer to peer and location based applications and services.

Device to device :

- D2D enabled LTE devices are capable for fall back public safety networks.
- This technique opens new device centric communication that often requires no direct communication with the network infrastructure.

Use cases ：

- Local data services
  Information sharing
  Data and computation offloading
- Coverage extension
- Machine to machine communications

Spectrum allocation

Spectrum allocation :

In terms of spectrum usage , D2D communication is primarily classified into two types :

- Inband D2D communication
- Outband D2D communication

Inband D2D communication :

- Cellular communication and D2D communication use the same spectrum licensed to cellular operator.
- The licensed spectrum may be either divided into non-overlapping portions for D2D and cellular communication respectively.

Outband D2D communication :

- It uses unlicensed spectrum where cellular communication doesn't occur.
- It helps in eliminating the interference between D2D and cellular users although interference is present in electronic devices (bluetooth and wifi) operating in this band.
- Outband technology is further divided into controlled and autonomous types.

D2D communication in LTE-A :

- It specifies a general concept of proximity based services that allows physically close devices to discover themselves and communicate via direct links.
- ProSe is meant for public safety communication as well as commercial applications on public safety only.
- D2D discovery and D2D communication are defined as support for ProSe.

Architecture

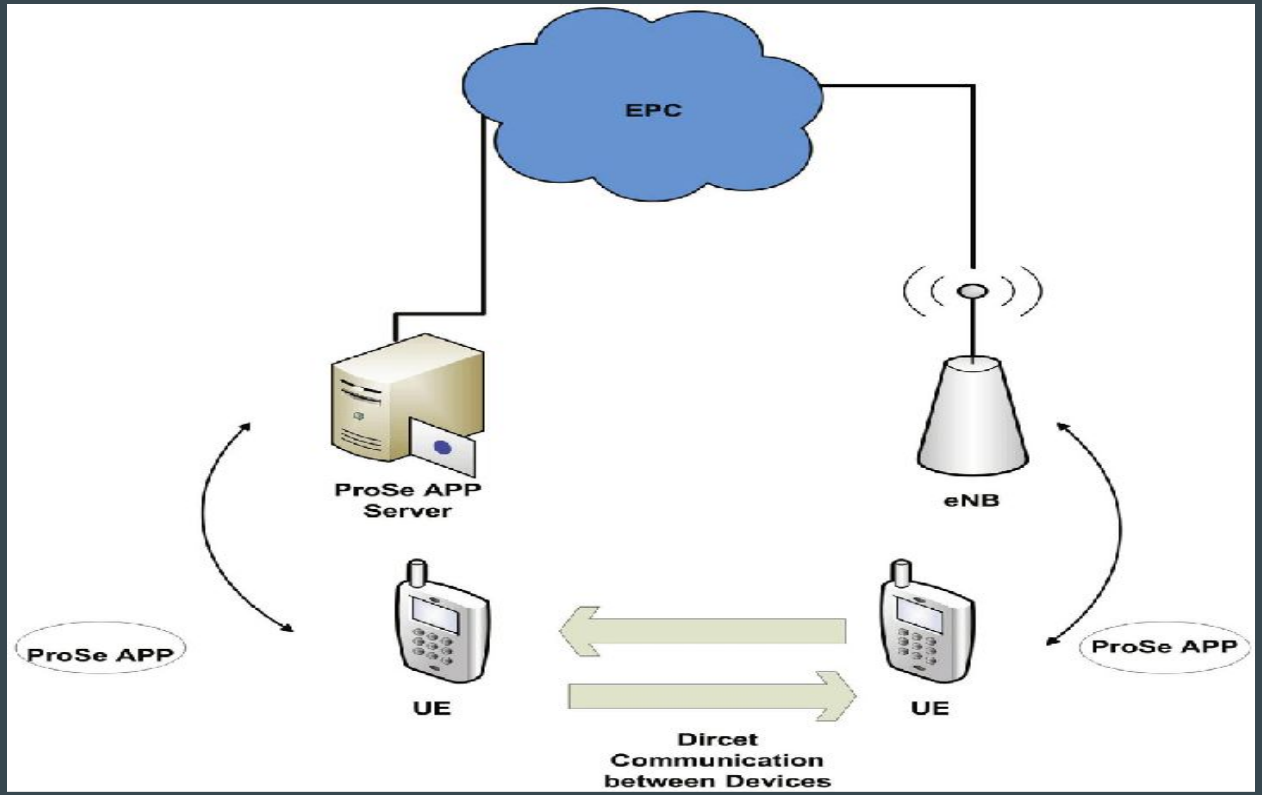
Architecture :

- BS or eNB connected to EPC can communicate with a UE directly using cellular communication.
- Additionally, UE's can also communicate via direct D2D links.
- Direct link between two UE's called as sidelink.

Architecture :

- When a UE wants to communicate with its peer UE, the ProSe APP in it requests for expression codes of itself and its target peer from the server.
- A UE can also obtain the expression codes from the proximity function in the eNB.
- After the expression codes are retrieved, the UE initiates the discovery procedure by announcing its own expression codes or inquiring if that target UE is present.
- After device discovery, UE's can communicate directly.

Architecture :



Architecture :

- D2D communication occurs using open loop communication in layer it means that D2D receiver doesn't send any feedback to the D2D transmitter.

D2D communications

Single-hop & multi-hop networks :

- A D2D link connects a transmitter UE with its intended receiver UE resulting in single hop communication.
- A multi-hop network composed of D2D links, MANET (mobile ad-hoc network).

D2D synchronization :

- Devices in D2D communication can synchronize is the same way as that of cellular communications as long as they belong to same BS.
- Global synchronization among all UE's in a network is not required in case of D2D communication.
- In this local synchronization among neighboring devices is required.

Peer discovery :

- UE should be able to discover other nearby UE's quickly and with low power consumption.
- Two types of peer discovery techniques restricted and open .
- Peer discovery can be controlled by BS

Mode selection :

- Mode selection can be done by the network or by UE.
- For mode selection, one may associate a decision variable with each UE, that captures the selected mode and then add a variety of objectives and constraints.
- Channel gain of selected mode should be higher than other modes.

D2D communications

Resource allocation :

- It is an important factor in creating and maintaining direct links between D2D pairs in cellular networks.
- Different resource allocation schemes can be designed by changing optimization objectives and adding various constraints.

Interference management :

- Careful scheduling of transmissions helps to minimize transmissions.
- Suitable modulation and coding schemes and hybrid automatic repeat request increase the robustness of the transmitted signal against noise.
- Mode selection , resource allocation and interference minimization are closely related and often jointly optimized.

D2D with mobility :

- Most D2D related research has focused on static users while cellular networks essentially cater to mobile users.
- Interference handling and handover mechanism are needed as UE's move in and across cells.

Pricing :

- Most pressing issues to cellular operators.
- Operators may use UE's as relays for other devices and may give financial incentives to relay UE's.
- How D2D UE's in a cluster may buy or sell data items.

Security :

- D2D communication affords stronger anonymity and data privacy compared to conventional cellular communication since data is not stored in cellular location.
- Various attacks can paralyze D2D links.

D2D communication & 5G network :

- 5G network will contain umbrella of technologies including Hetnets , cognitive radio, massive MIMO, D2D communications etc.
- The mmwave spectrum in 5G can be used to form short range D2D links between UE's.
- Mmwave suffers low multi user interference , many mmwave D2D links can operate concurrently thus improving network capacity.

D2D: from 4G to 5G

D2D : from 4G to 5G :

- Local traffic offloading
- Management of traffic at central network nodes becomes easy.
- Wireless user device D2D capability have dual role: either acting as an infrastructure node or as an end device in a similar way as traditional device.
- Direct D2D communications facilitates low latency communications due to local communication link between users in proximity.

D2D scenarios

- Local data sharing
- Relaying
- Single or multi-hop local proximity communication.
- D2D discovery

D2D air interface design

- In order to simplify design and implementation , air interface for D2D communication is derived from cellular communications.
- SC-FDMA based D2D signalling is employed for all data carrying physical channels.
- Can operate in licensed and unlicensed spectrum.

D2D standardization : 4G LTE D2D

- LTE D2D is an add on feature in 4G LTE systems.
- It is operated in a synchronous way.
- Either UL spectrum (FDD) or UL subframes (TDD) can be used for D2D transmissions.
- D2D is running within a dedicated resource pool where D2D enabled UE's will get resource pool configuration information from eNB.

D2D synchronization

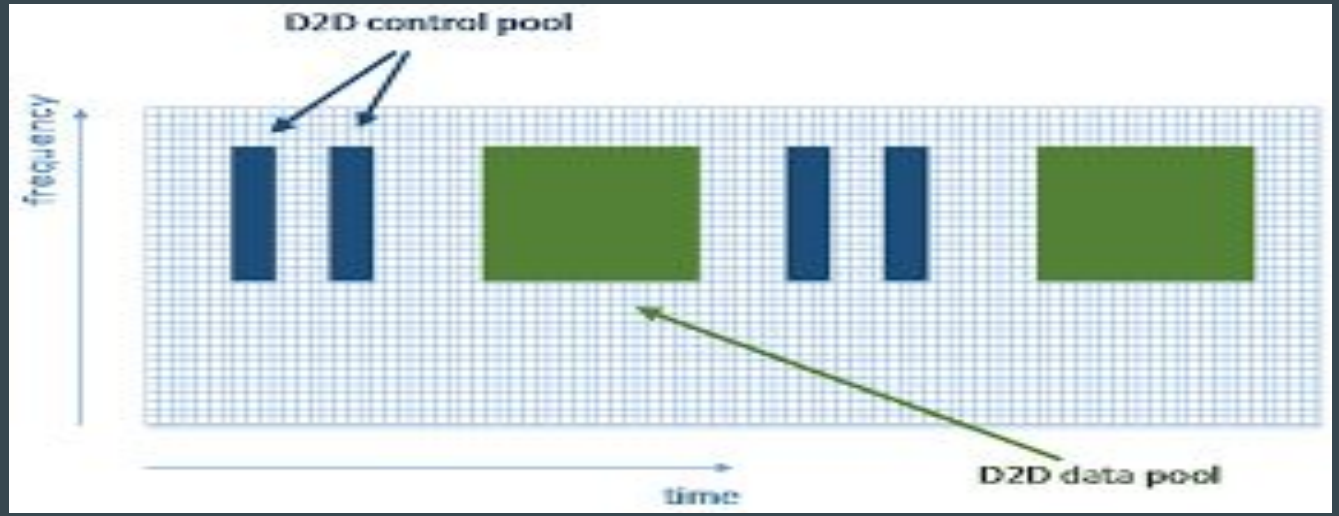
- Sidelink synchronization signal is used for time & frequency synchronization .
- Sidelink sync signal composed of primary sidelink sync signal & secondary sidelink sync signal.
- Both eNB and UE can act as synchronization sources.

D2D communication

- It is based on physical layer broadcast communication, i.e a physical layer broadcast solution is used to support broadcast, unicast , multicast services at application layer.
- Targeted group ID or user ID is indicated in higher layer message.
- No physical layer control loop exists.
- The air interface is based on Uu interface and UL channel structure is extended to D2D communication.

D2D communication

- D2D communication is based on resource pool concept.
- The resource pool information is carried over broadcast messages i.e system information block.



D2D discovery

- Discovery is applicable only to UE's with network coverage.
- The connected UE's can be either in RRC_idle or RRC_connected state.
- The resource pools are defined with the parameters including discovery period, discoveryoffsetindicator , and subframe bitmap.

D2D in 5G

D2D operation is an integral part of 5G systems, Main potential gains that could be achieved are:

- capacity/throughput gain
- Latency gain
- Availability & reliability gain
- Enabling new services

RRM in D2D

RRM for mobile broadband D2D

- RRM algorithms and techniques for D2D underlay communications can be classified depending upon optimization metrics and tools for improved performance.
- The most common objectives or optimization metrics of RRM algorithms and techniques are: spectral efficiency, power minimization and performance with QoS constraints.

RRM techniques

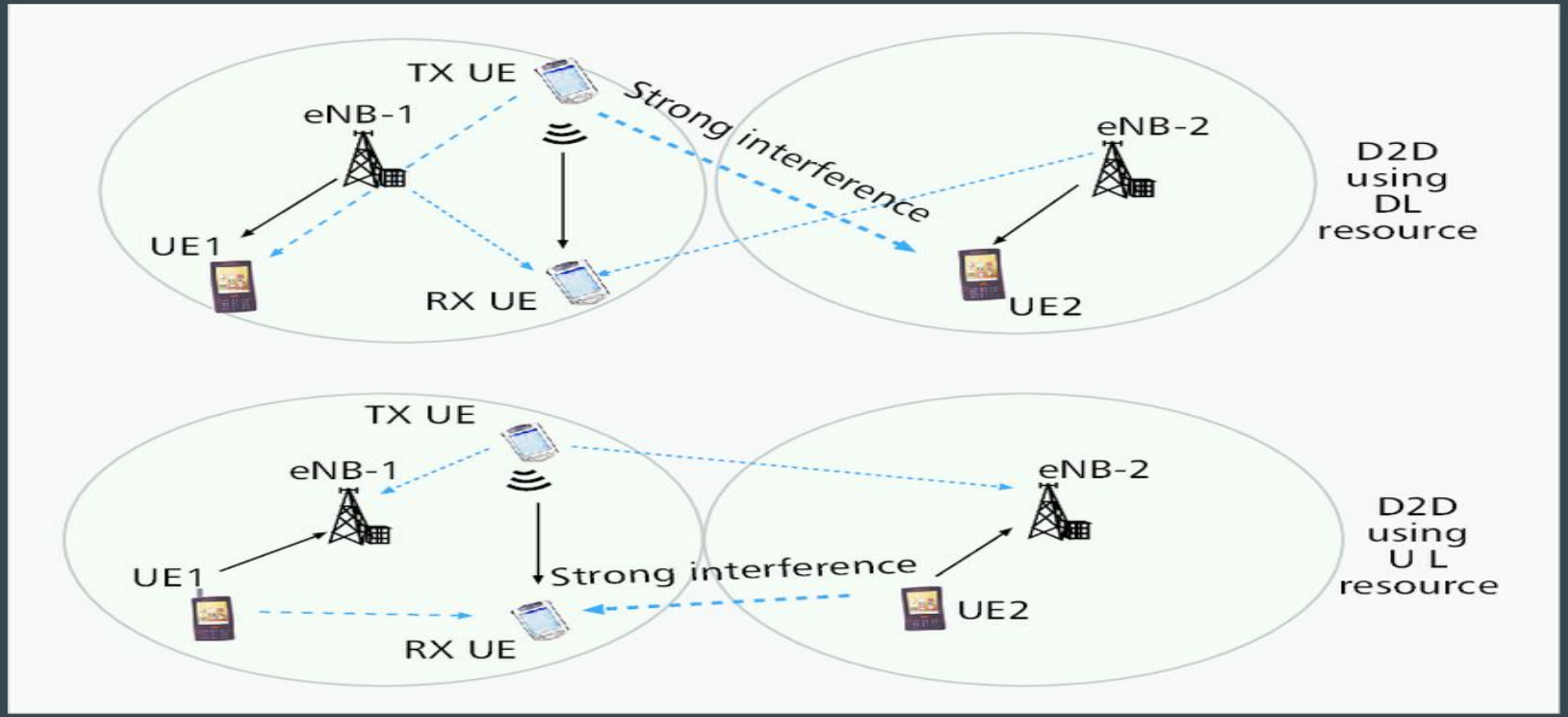
Available RRM techniques are :

- Mode selection
- Resource allocation
- Power control

Flexible UL & DL TDD concept for D2D

- UL & DL dynamic TDD concept for D2D is based on a MIMO - OFDMA air interface.
- D2D communication is integrated into TDD frame by considering D2D users in addition to cellular users.
- The schedular decides among UL, DL and D2D.

Multi cell D2D



Decentralized & centralized schedulars

- Centralized is coordinated mode
- Decentralized is uncoordinated mode.
- The schedular decides for each available resource block which link should make use of it, either UL, DL or D2D.

Mode selection

It is especially relevant when the separation distance between users increases. Various modes are :

- Direct D2D only
- Indirect D2D only (device infrastructure device , DID)
- Path loss based, slow mode selection
- Fast mode selection

Multi -hop communications for proximity & emergency services

Mode selection

- Both D2D discovery and radio resource management for multi-hop connections should benefit from network assistance when cellular infrastructure should inact.
- NSPS and PPDR scenarios pose a number of specific requirements that are not typically found in cellular communications.

Device discovery without & with network assistance

- Peer and service discovery is a key design issue both in mobile ad-hoc networks operating in unlicensed spectra and in cellular network assisted D2D communications.
- Peer discovery without network support is time and energy consuming.

Network assisted multi-hop D2D communications

- Multi-hop D2D communications requirements have been primarily defined with NSPS scenarios in mind, commercial and broadband internet services can also benefit from range extension or multihop proximity communications.

Multi operator D2D communications

- For vehicle to vehicle communications, inter operator D2D communications is required.
- D2D support in inter operator scenarios becomes more complex as compared to single operator D2D.

Multi operator D2D communications

- Distribution of time and frequency distribution .
- D2D discovery should rely on both sides of D2D links and on both operators.

D2D communication propagation channels

Propagation channels

- In D2D communications, transmit and receive antennas are at low heights, and hence there is more interaction between devices in the surroundings.
- Outdoor D2D communications is V2V communications which implies high mobility.

Propagation channels

- Pathloss
- Delay dispersion
- Temporal variations

Neighbor discovery & channel estimation

Neighbor discovery

- It is the first task that must be performed in the network , since it enables all operations.
- Devices have to make themselves known to the infrastructure.
- Each device has to find its neighbors in a cell.
- Network discovery classified into two types:
- Network based
- Direct discovery

Channel estimation

- It is the first task that must be performed in the network , since it enables all operations.
- Devices have to make themselves known to the infrastructure.
- Each device has to find its neighbors in a cell.
- Network discovery classified into two types:
- Network based
- Direct discovery

Applications

Content distribution in social networks

- In-band D2D communication, consists of two layers: logical network layer & logical physical layer.
- Logical connection among social network service participants for content distribution.

Video distribution

- The demand for video content distribution has increased as video sharing over the internet has become popular.
- Proposed D2D based solutions can enhance multicast schemes which results in energy savings & time savings.

Roadside infostations

- These aim to deliver an efficient and scalable delivery system for location aware data for mobile users, especially the users in cars.
- A roadside infostation could be deployed a few miles ahead of highway.

Applications

- Emergency communications
- Distributed storage systems
- Smart grid

thanks..