

From D2D to V2X

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Acknowledgement to Mei-Ju Shih

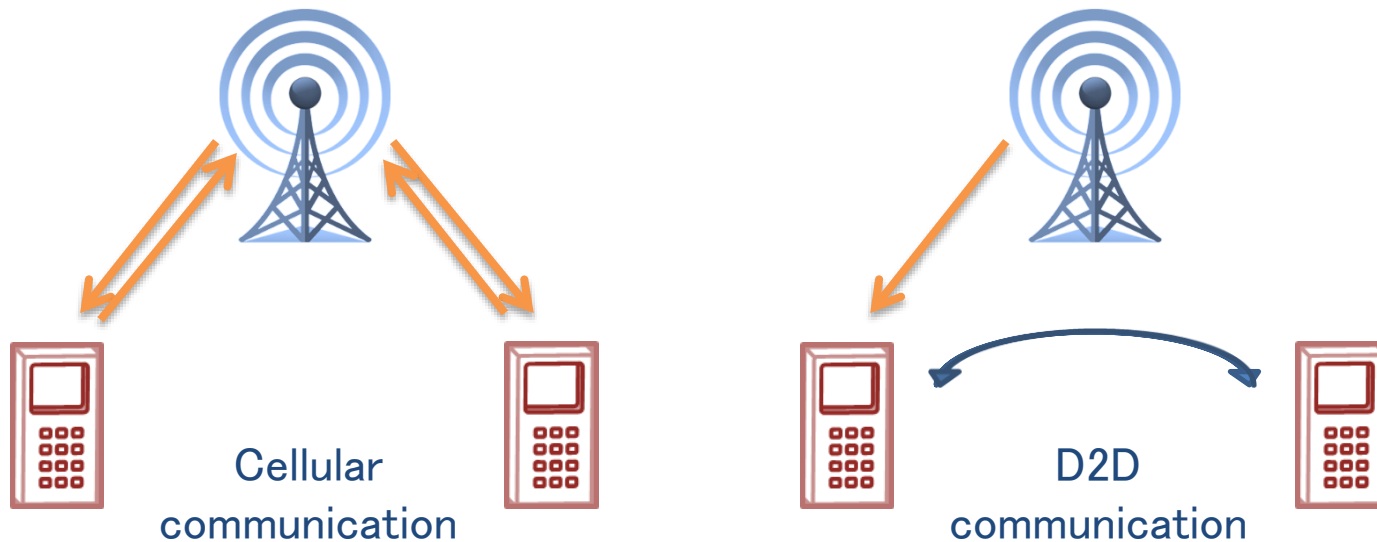


OUTLINE

- Preview
- RAN2#91 Rel-13 eD2D
 - General
 - **UE-to-Network Relays**
 - ProSe discovery in partial- and outside network coverage
 - **Discovery in inter-carrier and inter-PLMN**
 - **Group Priority for Communications**
 - Other
- V2X

Device-to-Device Communications

- Short range communications
 - Distance
 - Offloading



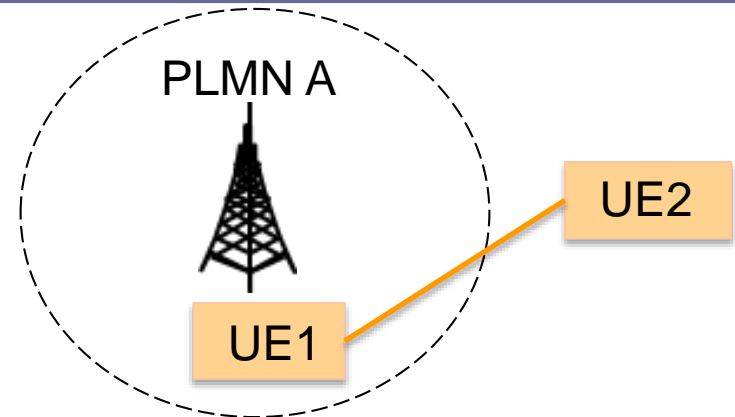
Services

- Proximity-based applications and services
 - Abbreviated as “ProSe”
 - Commercial usage
- Public safety (PS)
 - SP-120456
 - MoU between TETRA & Critical Communications Association (TCCA) & the National Public Safety Telecommunications Council
 - S1-121247
 - TCCA
- Compatible to the LTE standard (TR 36.843)
 - D2D discovery
 - D2D broadcast communication

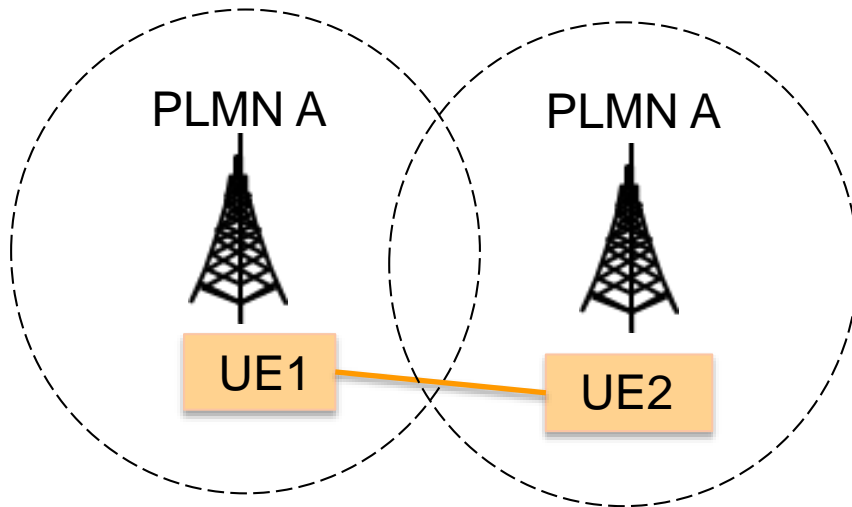
ProSe Direct Communications Scenario



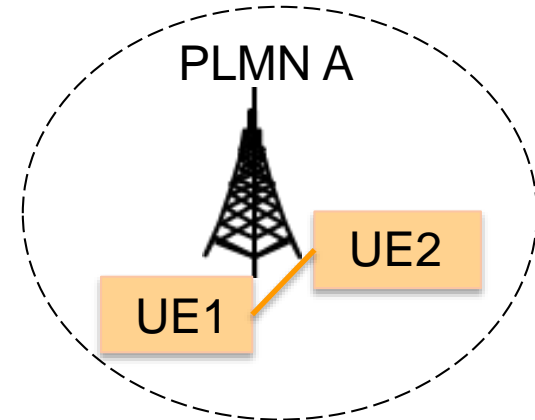
- Both out-of-coverage



- one out-of-coverage, one in-coverage

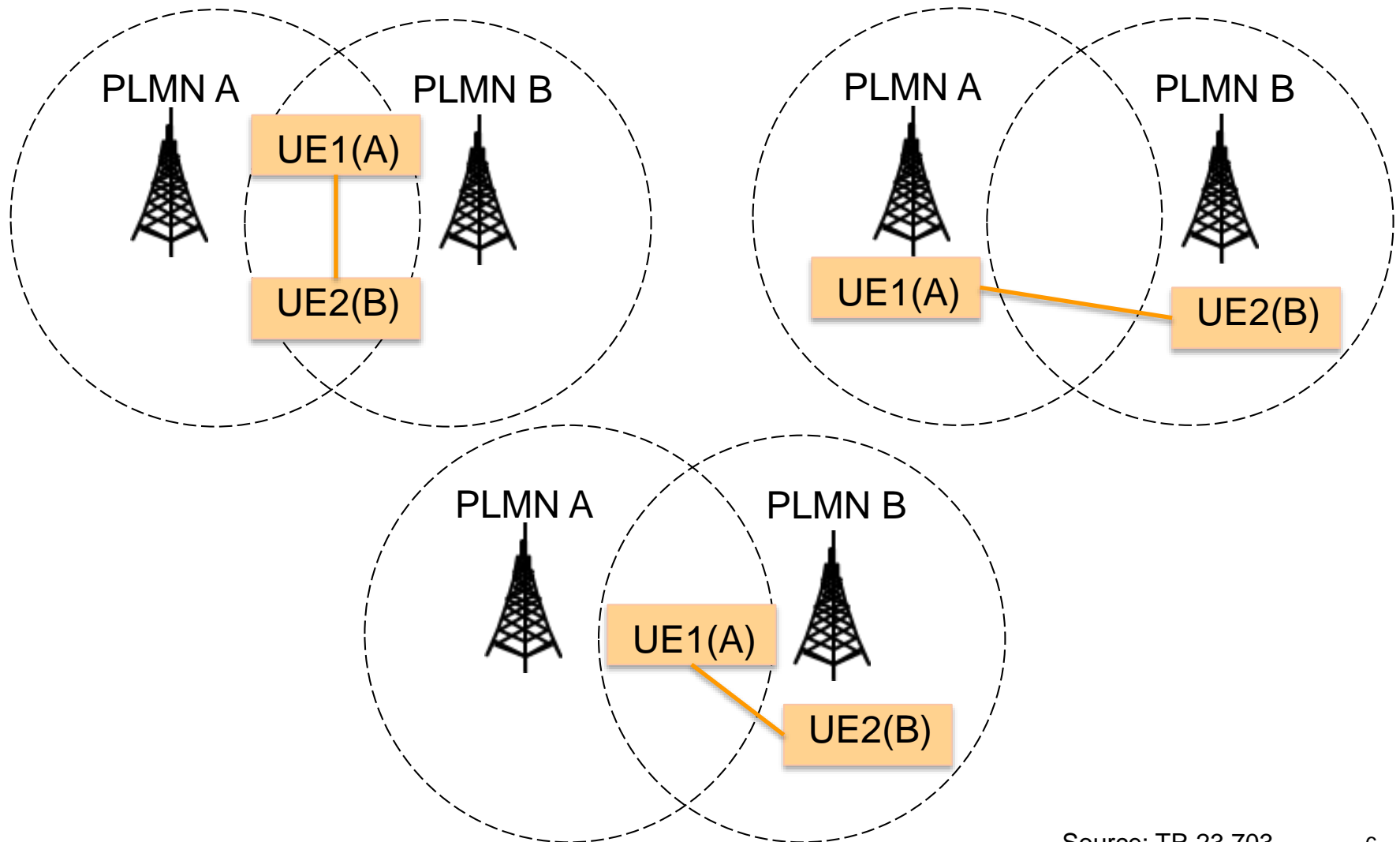


- Both in-coverage
 - Same PLMN
 - Different cells



- Both in-coverage
 - Same PLMN
 - Same cell

ProSe Direct Communications Scenario: Different PLMNs



R12 Working Item :

LTE Device to Device Proximity Services

- Approved in RP-140518
 - Mar. 2014, RAN#63
- RAN1 leads this working item
 - Qualcomm Incorporated

R13 Working Item :

Enhanced LTE Device to Device Proximity Services

- Approved in RP-150441
 - Dec. 2014, RAN#66
- RAN2 leads this working item
 - Qualcomm Incorporated

R12 Working Assumption

- D2D operates in uplink spectrum (FDD) or uplink sub-frames (TDD)
 - SC-FDMA
- D2D UEs are half-duplex
- No closed loop physical layer feedback
 - No feedback messages
- Blind retransmission of D2D broadcast data communication transport blocks



Rel-12 Scope in RAN1

- *Discovery (No out-of-network discovery)*
 - *in network coverage (intra-cell and inter-cell)*

- *Communication (PS ONLY)*
 - *in network coverage (intra-cell and inter-cell),*
 - *in partial network coverage*
 - *outside network coverage*

Classification

<u>PS case</u>	In-coverage	Partial	Out-of-coverage
Discovery	R12 (Inter-cell, intra-cell) R13 (inter-carrier, inter-PLMN)	R13 (type 1)	R13 (type 1)
Communication	R12 (Inter-cell, intra-cell)	R12	R12
	R13 (UE-to-Network relay, Group priority communications)		

<u>Non-PS case</u>	In-coverage	Partial	Out-of-coverage
Discovery	R12 (Inter-cell, intra-cell) R13 (inter-carrier, inter-PLMN)	x	x
Communication	x	x	x



Rel-13 Scope

- **Type 1 discovery (Public Safety)**
 - Partial network coverage
 - Out-of-network coverage
- **Communication enhancement**
 - Coverage extension
 - L3-based UE-to-Network Relays for service continuity
 - Voice, video
 - Priority of different groups
- **D2D discovery for multiple carriers and PLMNs**
 - In a non-serving carrier
 - In a secondary cell
- **ProSe related MCPTT requirements**

Resource Allocation Mechanism

□ Distributed

■ Type 1 discovery

- Resources are allocated on a non UE specific basis

■ Mode 2 broadcast communications

- A UE on its own selects resources from resource pools to transmit direct data and direct control information

Resource Allocation Mechanism

- eNB centralized resource allocation
 - Type 2 discovery
 - Resources are allocated on a **per UE specific** basis
 - Type 2A: Resources are allocated for each specific transmission instance of discovery signals
 - Type 2B: Resource are semi-persistently allocated for discovery signal transmission
 - Mode 1 broadcast communications
 - eNB or Release-10 relay node schedules the exact resources used by a UE to transmit direct data and direct control information

Discovery Terminology

- Model A
 - I am here !
- Model B
 - Who is there ?

Current Status



Based on 3GPP RAN2#91 meeting
(2015.08 Beijing)

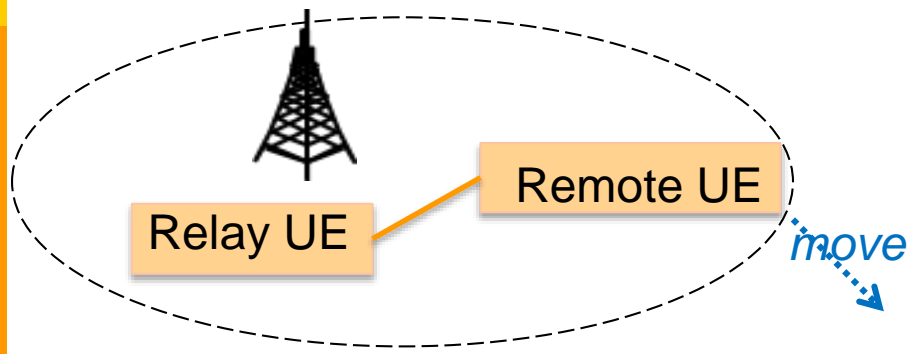
General Issues

- [R2-153734](#) Running stage 2 CR **TS 36.300** to capture agreement on eD2D
- **ProSe Per-Packet Priority**
 - A scalar value associated with a protocol data unit that defines the priority handling to be applied for transmission of that protocol data unit.
- **ProSe UE-to-Network Relay**
 - A UE that provides functionality to support connectivity to "unicast" services for Remote UE(s).
- **Remote UE**
 - A ProSe-enabled Public Safety UE, that communicates with a PDN via a ProSe UE-to-Network Relay.

UE-to-Network Relays

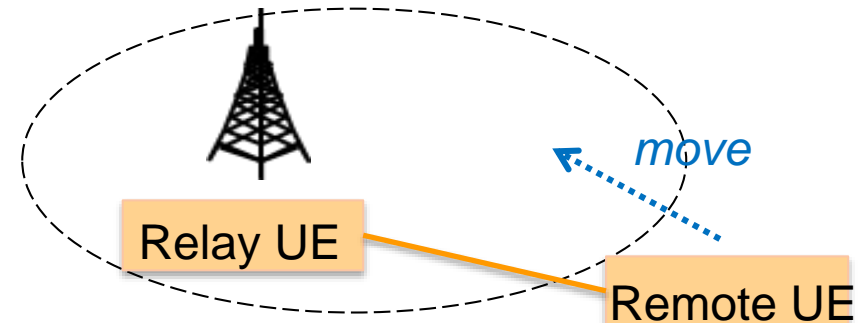
Scenario

□ In-coverage



➤ **In-coverage** to out-of-coverage

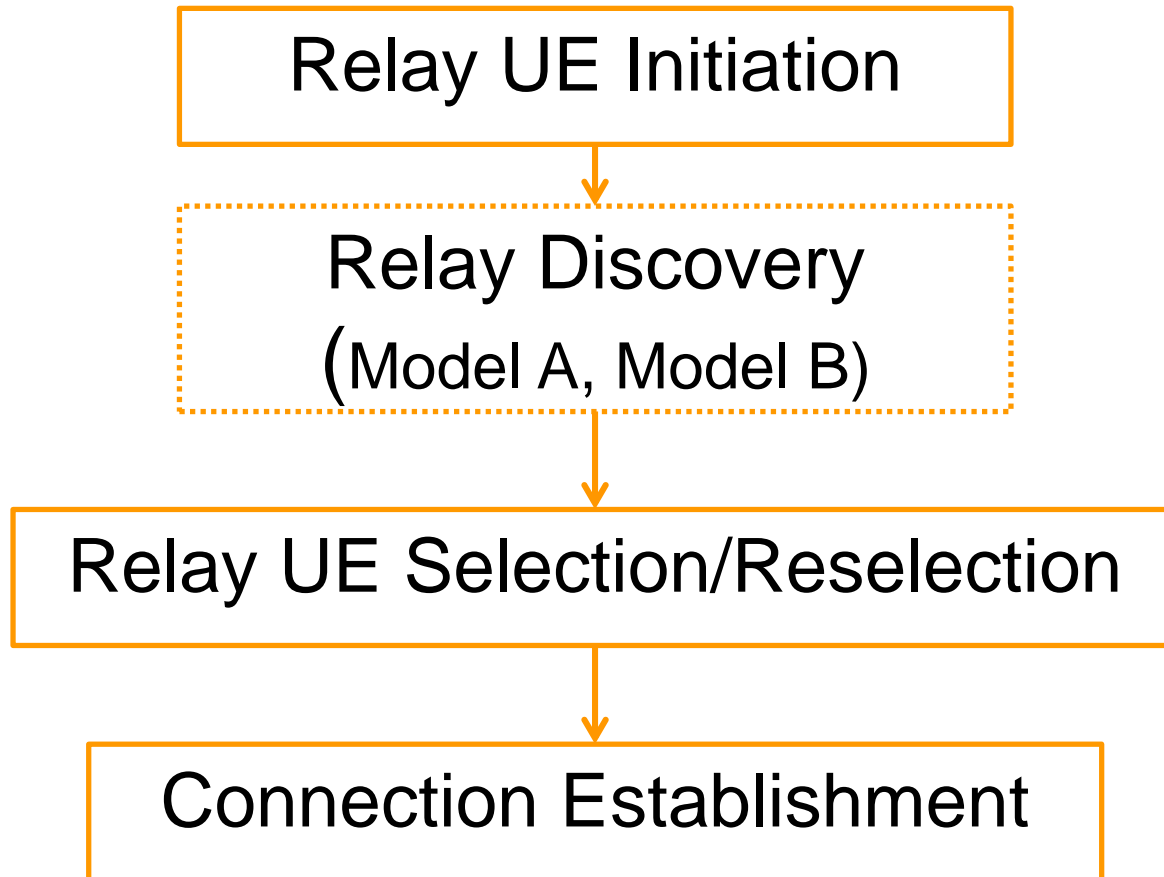
□ Out-of-coverage



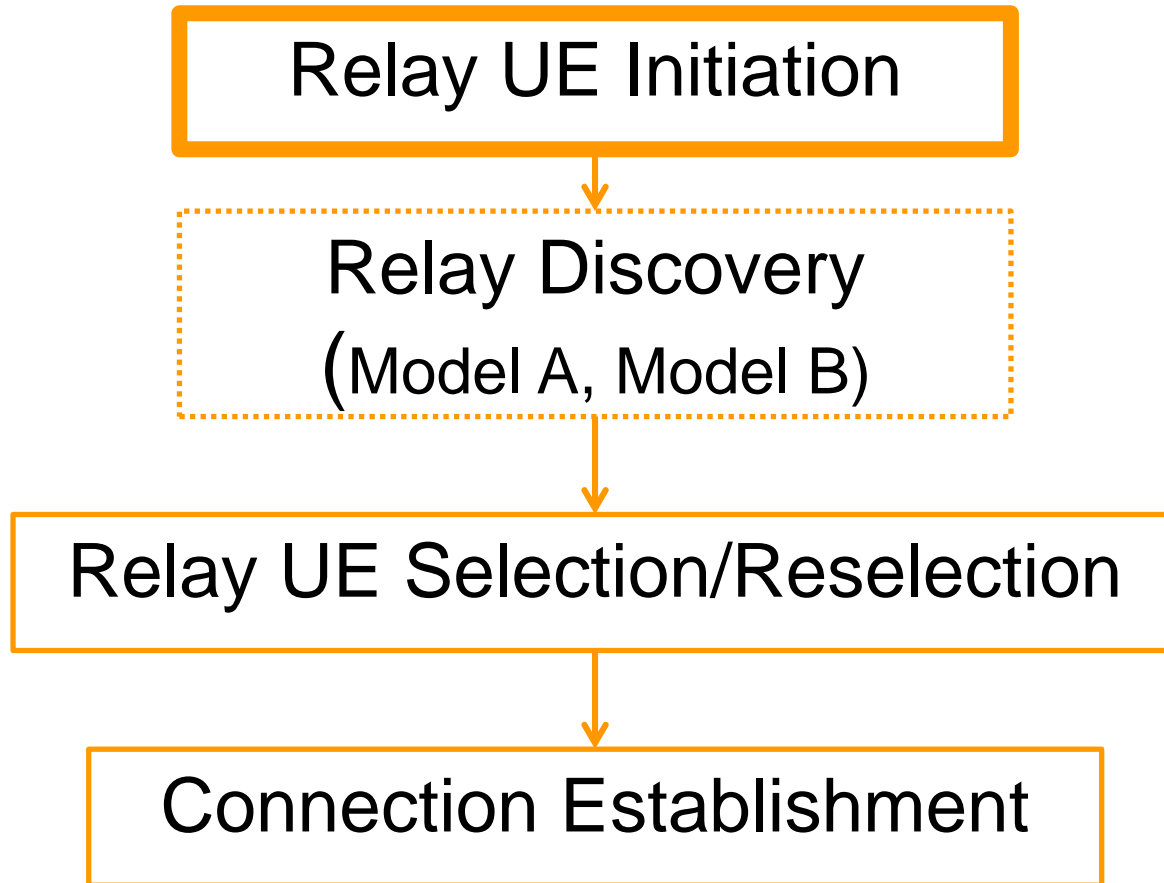
➤ **Out-of-coverage** to in-coverage

- Relay UE will always be in-coverage
- The eNB at the radio level can control whether the UE can act as a relay

Steps



Steps



Support Relay Initiation ?

- If **the eNB** doesn't **broadcast** any information associated to **relay operation**, then relay operation is not supported.

Relay Discovery Resource Pool

- A **sidelink discovery resource pool** specific for at least relay discovery will be defined.
 - FFS: only for relay operation? PS discovery services? For remote UEs? For relay UEs?

Reception pools

- The **reception pools for relay discovery** are provided by **broadcast signalling**

Transmission Resource Pool

- The eNB can broadcast that relay operation is supported and **broadcasts tx resource pool(s)** for relay discovery.
 - The eNB may broadcast **a minimum and/or a maximum Uu link quality (RSRP/RSRQ) thresholds** that UEs need to respect to autonomously **start/stop the relay discovery procedure** using the broadcasted information. The network has the option to configure none, one or both thresholds.
 - FFS if the eNB can control the UEs on an individual basis if it is broadcasting relay discovery resources. FFS if a UE in connected mode can use the broadcast relay discovery resources.

Transmission Resource Pool

- The eNB can broadcast that relay operation is supported and but **does not broadcast a tx resource pool** for relay discovery.
 - In this case the UE can **initiate a request** for relay discovery resources, by **dedicated signalling** and **the eNB can configure the UE to become a relay by dedicated signalling**.
 - FFS if the eNB can optionally broadcast a minimum and/or a maximum Uu link quality (RSRP/RSRQ) thresholds that UEs need to respect to before requesting tx relay discovery resources and if a differentiation of behavior between Model A and Model B.

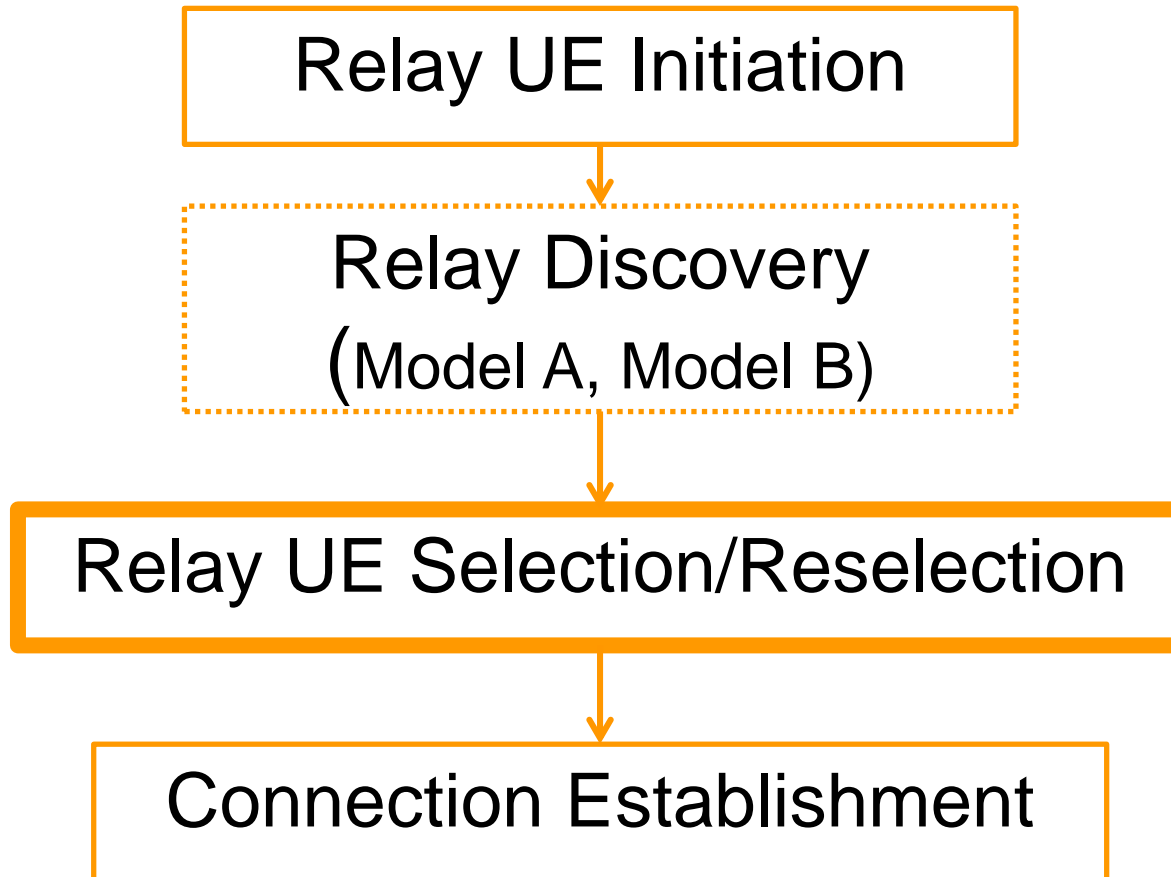
Initiate Relay UEs

- If Relay UEs are **initiated by broadcast signaling**, they can also **perform relay discovery** when **in idle**.
 - Similar to type 1 discovery
- If Relay UEs are **initiated by dedicated signaling**, they can **perform relay discovery** as long as they are **in connected mode**.
 - Similar to type 2 discovery

In-coverage Remote UE

- UEs can transmit relay discovery solicitation messages while in RRC Connected and RRC idle (if network configured)
- A remote UE may only transmit discovery solicitation messages if the Uu link quality at the UE is below an optional network configured threshold.

Steps



Relay Selection/re-selection for in-coverage remote UE

- An in-coverage remote UE performs relay selection (using the same selection criteria as out-of-coverage)
- In connected mode, after selecting a relay, the remote UE informs the eNB using the *UESidelinkInformation* similar to Rel-12. The remote UE indicates in the message that the request is for relay one-to-one communication purposes. The eNB similar to rel-12 can choose to provide or not provide resources for relay communication.

Relay selection/reselection for all remote UEs

- ❑ No other RAN2-specified criteria, except **radio link quality**, shall be considered for relay UE selection/re-selection.
- ❑ A relay UE is considered as suitable **if the PC5 link quality exceeds a configured signal strength threshold**.
- ❑ The detailed criteria to select a new relay and the ranking of relays is FFS.
- ❑ The remote UE can also trigger a selection of a new relay when it **receives a release message from the relay UE** (as defined by SA2).

Connection Establishment

- ❑ **Authorization** of remote UEs is done by higher layers
- ❑ A **relay UE** performing relay communication has to **be in RRC connected mode**.
- ❑ After receiving **a layer-2 link establishment request** from a remote UE, the relay UE informs the eNB using ***UESidelinkInformation***. The relay UE indicates in the message that the request is for relay one-to-one communication purposes. The eNB similar to rel-12 can chose to provide or not provide resources for relay communication.
- ❑ RAN2 will not define any layer-2 link establishment messages.

ProSe discovery for inter-carrier and inter-PLMN

Discovery TX Resource

- Serving eNB is not mandated to provide **discovery transmission resources** for all carriers signalled in its SIB19.
 - Serving eNB might choose to provide discovery tx resource information
- The UE is not expected to connect to the other PLMN to perform discovery transmission. The UE should remain connected to **the serving PLMN**.
 - Use your own PLMN's discovery tx resources

Case : eNB doesn't provide discovery TX resources in SIB19

- If SIB19 doesn't provide discovery transmission resources for the allowed carriers listed in the SIB19, **the network can signal whether the UE should autonomously read the SIB19 of the signaled carrier or**
 - If the UE autonomously reads SIB19 of the other carrier to acquire tx resources and that carrier doesn't provide discovery transmission resources in SIB19, the UE is not allowed to transmit on that carrier.
- if the UE is expected to request resources from the serving cell for that carrier.

Gap Configuration

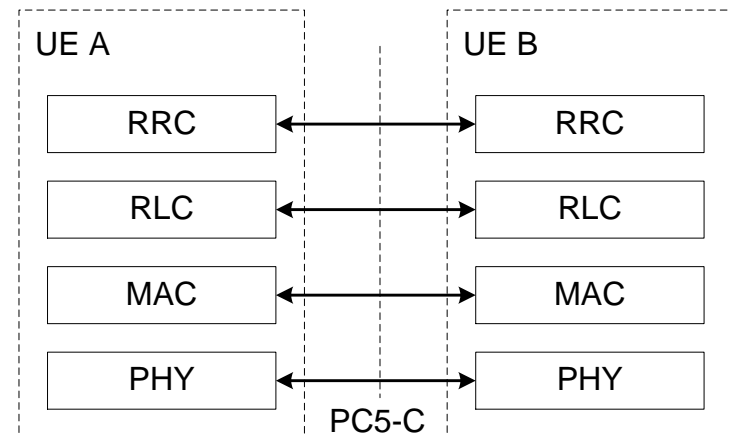
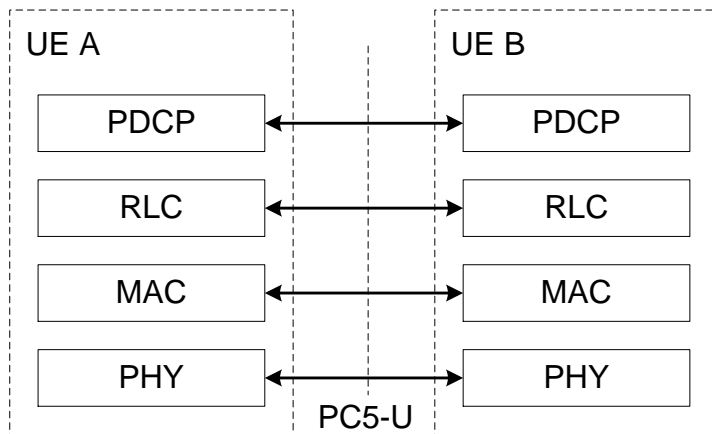
- Gaps introduced for discovery transmitter and reception should apply to both **inter-frequency** and **intra-frequency** cases for **connected mode** UEs
- **eNodeB controls** the gap configuration on a **per UE** basis

Gap overhead

- The gap created for discovery should take into account **additional overhead** (for synchronization and subframe offset) and interruption time for retuning. The actual overhead and interruption time depends on RAN4 discussion.

Gap request

- The UE can **request gaps** for discovery reception and/or transmissions. In the request the UE can **inform the eNB** of the subframes (corresponding of the timing of the serving cell) on which the UE needs gaps for transmission and/or reception.
 - FFS on what the transmissions subframes correspond to (all allowed transmission subframes or the subframes in which the UE intends to transmit). FFS when the request is triggered.



Group priorities for ProSe communications

PPP and the Interface

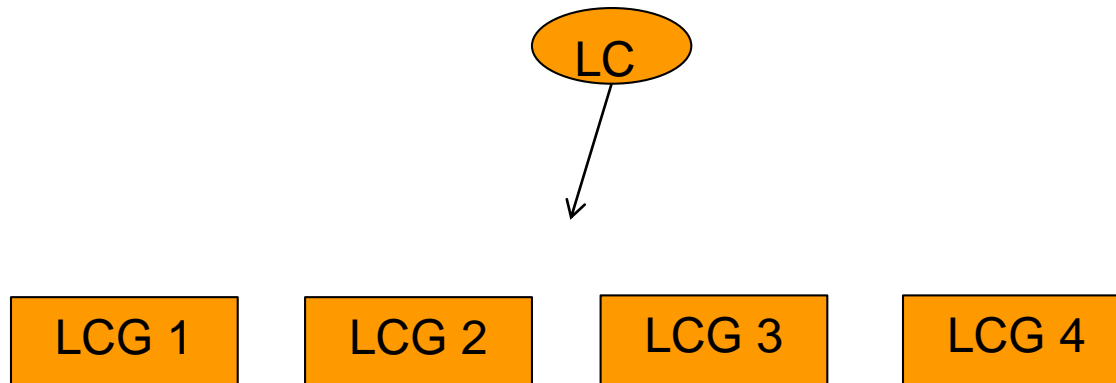
- To implement PPP only changes to the **PC5 interface** are necessary
 - **Priority per packet** (per application)
 - **Uu interface** doesn't change
- If a packet is prioritized on the PC5 interface, it should also be treated with some priority on the Uu interface (if a **ProSe UE-to-Network relay** is used).
- If a packet is prioritized on the Uu interface, it should also be treated with some priority on the PC5 interface (if a ProSe UE-to-Network relay is used).

Put PPP info in PDCP

- From RAN2 point of view **a static mapping between LCID and PPP is not a feasible solution.** The need to **provide PPP information from the transmitter to the receiver is only for the relay case** (if there is one at all). From a RAN2 point of view, the preferred solution is to provide PPP information is by **including the information in the PDCP of the sidelink.**

LCG per ProSe Destination

- Define **LCG per ProSe destination**, and within one ProSe destination, each sidelink logical channel is mapped to one of four LCGs depending on the PPP of the sidelink logical channel.
 - FFS how the mapping between LCGID and priority is determined.



Buffer Status

- The same Rel-12 sidelink BSR format will be used as a baseline. When sending a SL BSR, the UE includes BS (Buffer status) of all LCGs having SL data among all ProSe destinations as many as it can (relying on the truncation mechanism of Rel-12).
 - FFS how the ProSe BSR is constructed (the order in which BS is provided for each LCGID)

Select a ProSe Group

- When the UE receives a SL grant, the UE selects the ProSe destination group having the sidelink logical channel with the highest PPP among the sidelink logical channels having SL data, and then serves all sidelink logical channels belonging the selected ProSe destination group in a decreasing priority order.

LTE-based V2X Services

--- Vehicle to Everything

Introduction

- *China* shows great interest in vehicular communications.
 - In 2014, CCSA has finished the feasible study for vehicle safety application based on **TD-LTE**
 - The series of industrial standard of communication based on LTE for vehicle application began
 - In 2015, the **frequency study** of V2X also started
 - National Regulatory Authority in China will allocate the frequency of connected vehicles
- *Vehicle manufacturers and cellular network operators* also show strong interests in vehicle wireless communications for proximity safety services as well as commercial applications
- 3GPP's goal is to **realize “connected car” via LTE**

Definition

□ Road Side Unit

- an entity supporting V2I Service that can transmit to, and receive from a UE using V2I application. RSU is implemented in an eNodeB or a stationary UE.

□ V2I Service (Vehicular-to-Infrastructure/Network)

- a type of V2X Service, where one party is a UE and the other party is an RSU both using V2I application.

□ V2P Service (Vehicular-to-Pedestrian)

- a type of V2X Service, where both parties of the communication are UEs using V2P application.

□ V2V Service (Vehicular-to-Vehicular)

- a type of V2X Service, where both parties of the communication are UEs using V2V application.

V2X in RAN1

- **RAN1 Rel-13 FS_LTE_V2X: Study on LTE-based V2X Services**

Objective in RAN1

- Evaluation methodology
 - Deployment scenarios
 - Modeling of vehicle density and mobility
 - Traffic models and performance metric
- PC5 transport for V2V services
 - Enhancement for resource allocation mechanism
 - Enhancement for high Doppler case
- Uu transport for V2V, and PC5/Uu transport for V2I/N and V2P services
 - latency, network coordination, resource efficiency, and energy efficiency of UE
 - Support each of eNB type and UE type RSU
 - multi-cell multicast/broadcast for reduced latency and improved efficiency

V2X in SA1

- **SA1** Rel-14 FS_V2XLTE: LTE support for V2X services

- Use cases and requirements

V2X Use Cases



List of Use Cases: Safety

- V2V Use case for emergency vehicle warning
- V2X Road safety service via infrastructure
- Road safety services
- Vulnerable Road User (VRU) Safety
- V2V Emergency Stop Use Case
- V2I Emergency Stop Use Case

List of Use Cases: Warning

- Forward Collision Warning
- Control Loss Warning
- Queue Warning
- Pre-crash Sensing Warning
- Wrong way driving warning
- Curve Speed Warning
- Warning to Pedestrian against Pedestrian Collision

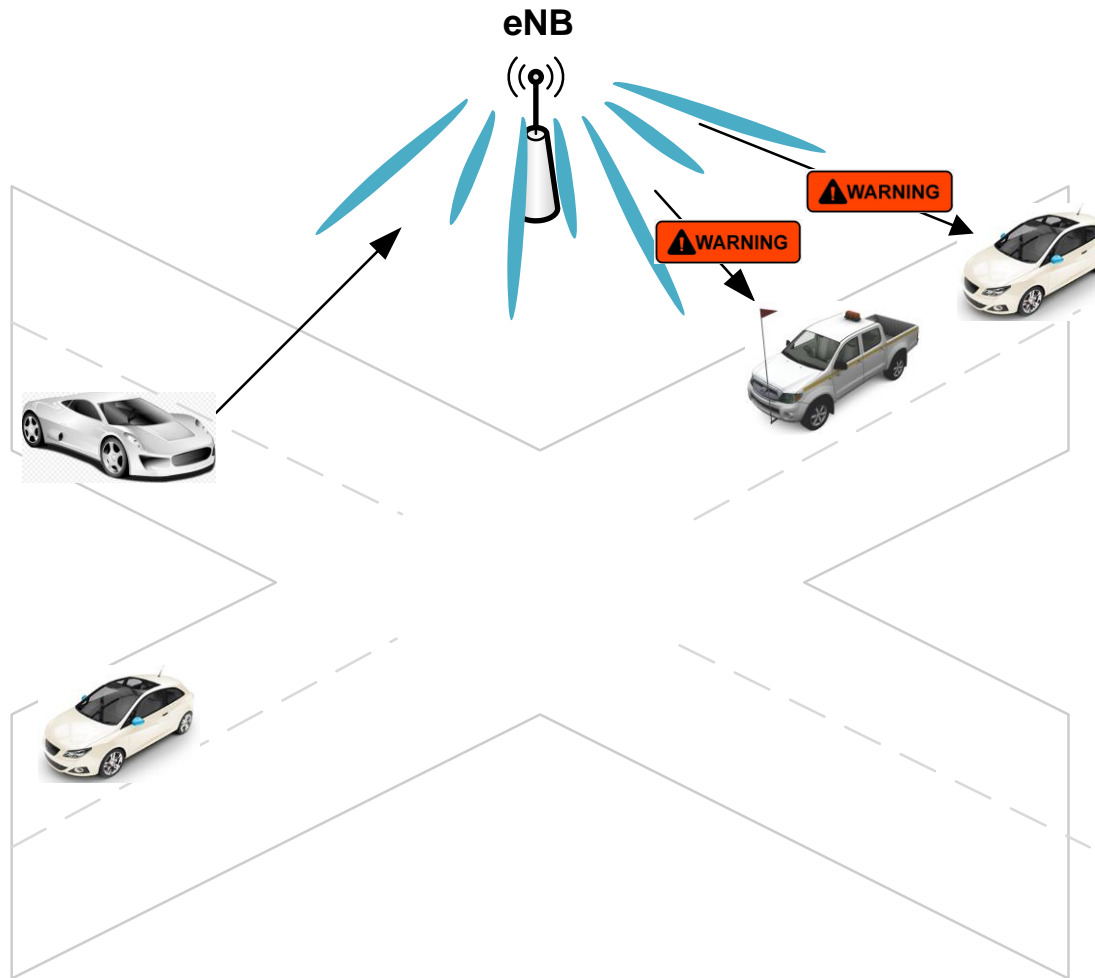
List of Use Cases: Network

- V2X in areas outside network coverage
- V2I / V2N Traffic Flow Optimisation
- V2V message transfer under operator Mobile Network Operator (MNO) control

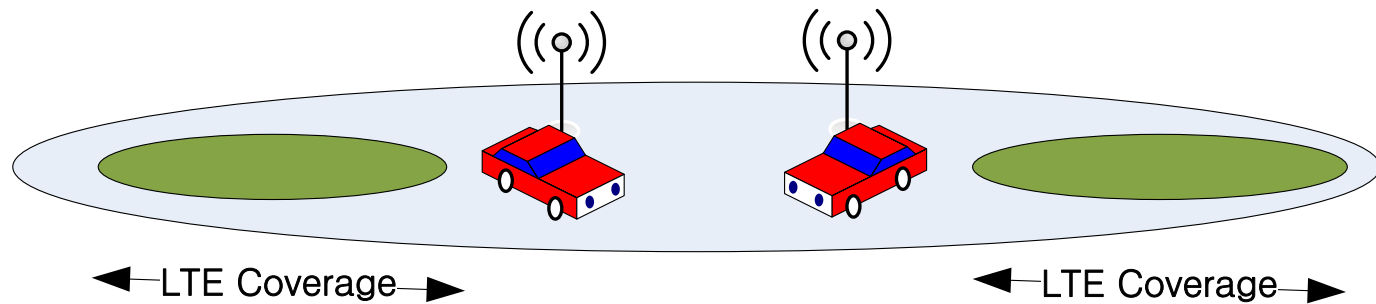
List of Use Cases: Applications

- Cooperative Adaptive Cruise Control
- Automated Parking System

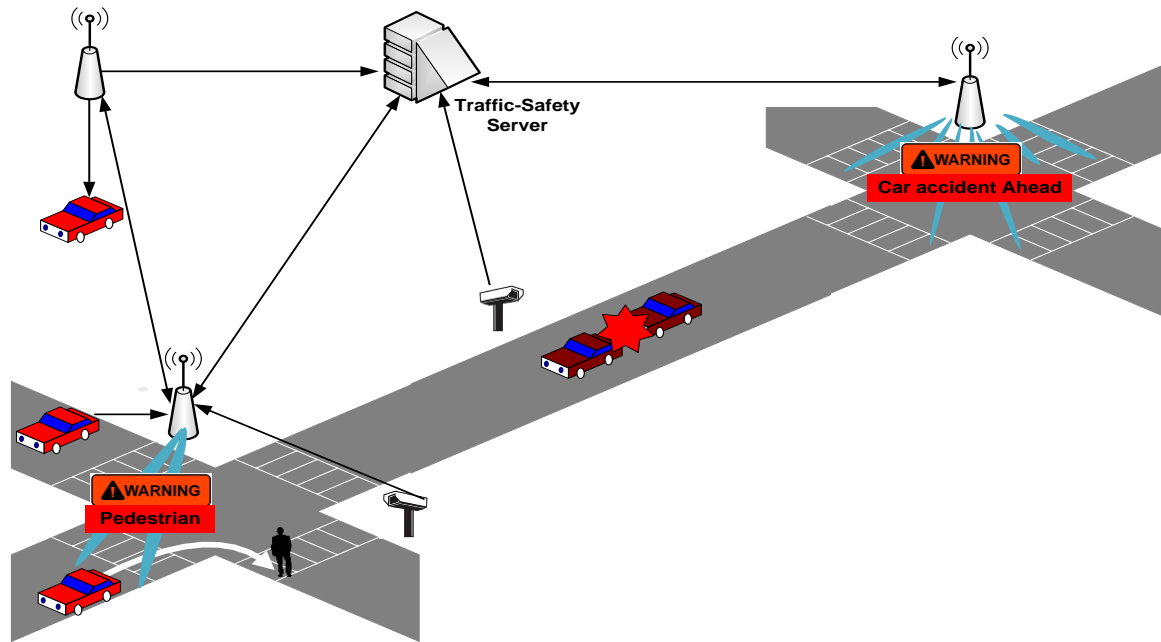
Example: Road safety service



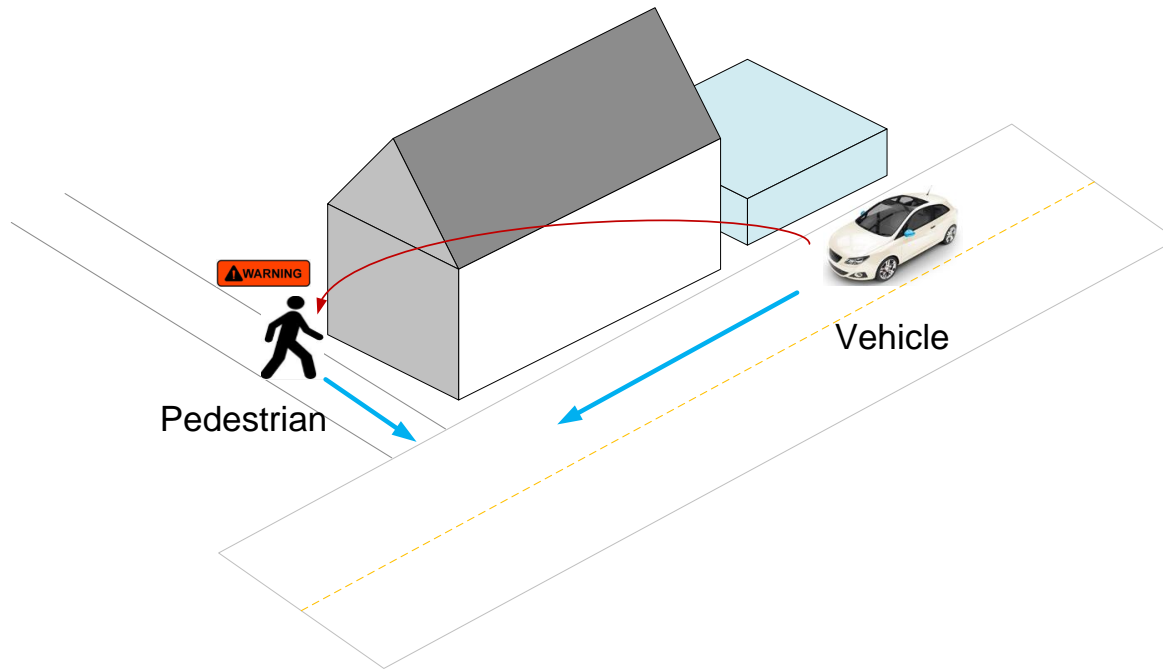
Example: Vehicle outside network coverage



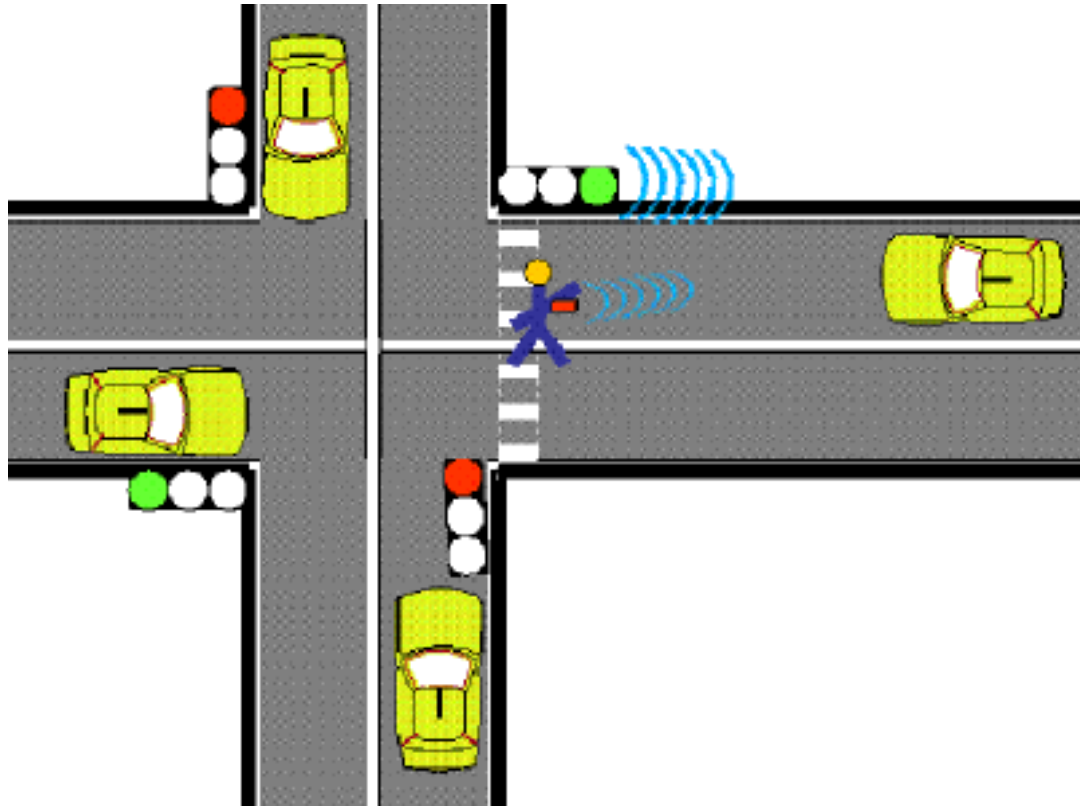
Example: V2X Road safety service via infrastructure



Example: Warning to pedestrian against pedestrian collision



Example: Vulnerable road user warning



Reference

- ❑ 3GPP TSG RAN WG2 #91 Chairman Notes, Aug. 2015
- ❑ 3GPP RP-151109, “New SI proposal: Feasibility Study on LTE-based V2X Services”, Aug. 2015
- ❑ 3GPP S1-152587, “Use Case sections – editorial change proposals”, Aug. 2015
- ❑ 3GPP S1-150284, “Proposed study on LTE-based V2X”, Feb. 2015

Questions ?

