Device-to-Device for Public Safety (DDPS)

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http://www.openairinterface.org/
Problem Space & Stakeholders

Key Stakeholders:
• Law enforcement
• Firefighters
• Medical personnel
• Military organizations
• Volunteer groups

Key CONOPS for Public Safety:
• Fall back in the event of complete LTE network failure, e.g. natural disasters
• UE-UE communication within coverage
• UE-UE communication outside coverage
• Mixture of UE communication within and outside coverage

Key Services:
✓ Mission-Critical Voice
✓ 3GPP Proximity Service (ProSe)
✓ 1:1 and 1:many Group Communication
✓ Service Continuity

EPC
ProSe Function
S1
PC3
Cell tower
Relay
Partial-in-network
In-network
Off-network
New sidelink channel
Existing LTE channel

Uu
In-network
Off-network
DDPS Objectives

• Build complete ProSe stack by extending current OpenAirInterface™ implementation to include ProSe services based on 3GPP Rel-14 specifications
• Solve open issues related to resource allocation, time synchronization, and service continuity
  – Develop new scheduling algorithms for autonomous resource allocation to minimize collision probability.
  – Develop novel multi-antenna-based synchronization techniques to achieve significant improvement in UE autonomous synchronization
  – Solve complex service continuity challenges for on-, off-, and partial-on-network operations
• Demonstrate ProSe solution on software defined radio platform
• Help create an ecosystem that can be provided to interested vendors for commercialization on a system-on-a-chip platform
**DDPS Scenarios**

- **Scenario 1: Off-Network D2D**
  - Two UEs are off-network but communicate directly via a sidelink channel

- **Scenario 2: On-Network D2D**
  - Two UEs are located close to their eNodeB but communicate directly via a sidelink channel

- **Scenario 3: UE-to-Network Relay**
  - UE A is close to its eNodeB while a second UE B is out-of-coverage but within coverage of UE A. UE A acts as a relay to remote UE B and relay its traffic (e.g., to a FTP server, or another on-network UE C)
LTE ProSe 3GPP Standardization Timeline

ProSe: Proximity Services
LTE Proximity Services (ProSe)

- LTE ProSe enables establishment of communication paths between two or more ProSe-enabled UEs.

- LTE ProSe enables communication functions
  1. **One-to-One** – Direct UE-to-UE Communication
  2. **One-to-Many** - Communication to a ProSe group

- LTE ProSe Functions:
  - Discovery
    * **Mode A** – ‘I am here’
    * **Mode B** – ‘how is there ?’
  - Direct Communication
    * **Mode 1** – Coordinated by eNB
    * **Mode 2** – Ad-Hoc mode

Restricted to Public Safety (rel.14)
LTE Prose Extended Architecture

New Architecture Elements:

a) **ProSe Function** – management of D2D communication (authentication, discovery)
b) **PC5 interface** – UE to UE
c) **PC3 interface** – Prose Function to UE

Source: 3GPP
LTE ProSe – New Slidelink (SL) Channels

a) Sidelink Channels

b) Slidelink Pool

Source: Dr. Gallo, EURECOM
Discovery & One-to-One Communication

- **Announcing UE**
  - PC3
  - Service provisioning
- **ProSe Function**
  - PC5-C
  - Synchronization via PC5-C
- **Monitoring UE**
  - PC5-D
  - Announce over PC5
  - Direct Communication Request
  - IP address allocation
  - Direct Communication Accept
  - PC5-U
  - One-to-one Direct communication
Relay Discovery, Selection & Direct Communication

1. E-UTRAN Initial Attach and/or UE requested PDN connectivity

2. Discovery Procedure

3. Establishment of connection
   For one-to-one Communication

4. IP address/prefix allocation

3. Relay UE may establish a new PDN connection for Relay

5. Remote UE Report (Remote User ID, IP info)


Relayed traffic
OAI Architecture for ProSe Interfaces

User Interface (Vencore)

ProSe Controller (Vencore)

Remote UE

Configuration files

PC5-C

PC5-S

PC3

PC5-U

PC5-D

RRC eNodeB

Control socket

drb-config, logical channel config

UEip ko kernel module

UE (in/out EUTRAN)

L1
OAI Emulation Extensions for DDPS

- eNB L2
- UEs
  - SL PHY Stub UE
  - SL PHY Stub UE
- UE Sidelink MAC
  - receive SCI
  - receive SL_sdu
- UE Sidelink PHY
  - New interface
  - SL_Tx_request
  - SCI_Config
- D2D coordination procedures (NFAP)

Sidelink PHY-to-PHY scope
D2D for Public Safety on OAI – RoadMap

- **Phase 1 Stage 1 - Emulation**
  - Redesign of emulation mode – new PHY STUB

- **Phase 1 Stage 2 - Implementation**
  - Part A – Implementation of the ProSe Function/RRC/PDCP/RLC/MAC
  - Part B – Implementation of the PHY

- **Phase 1 Stage 3: Performance Evaluation**
  - Emulation-based Proof-of-Concept and Performance Evaluation

- **Phase 2 – Real-Time Lab**
  - Real-time UE PHY and Field Deployment

- **OpenAir Code:**
  - [https://gitlab.eurecom.fr/matzakos/LTE-D2D](https://gitlab.eurecom.fr/matzakos/LTE-D2D)
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