IP CREW

Cognitive Radio Experimentation World

A Cognitive Radio Experimentation on the Validation of Control Channels for the Management of D2D Constructs

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Seminar on Cognitive Radio Systems and the use of White Spaces

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Outline

- **IP CREW Overview**
  - IP CREW Identity
  - IP CREW Target
  - IP CREW Platform
  - The CREW offer

- **Cognitive Control Channels Experimentation**
  - Motivation
  - Rationale
  - Related topics
  - Data structures
  - Scenario
  - Architecture
  - Functionality
  - Experimentation environment
  - Indicative results

IP CREW Overview

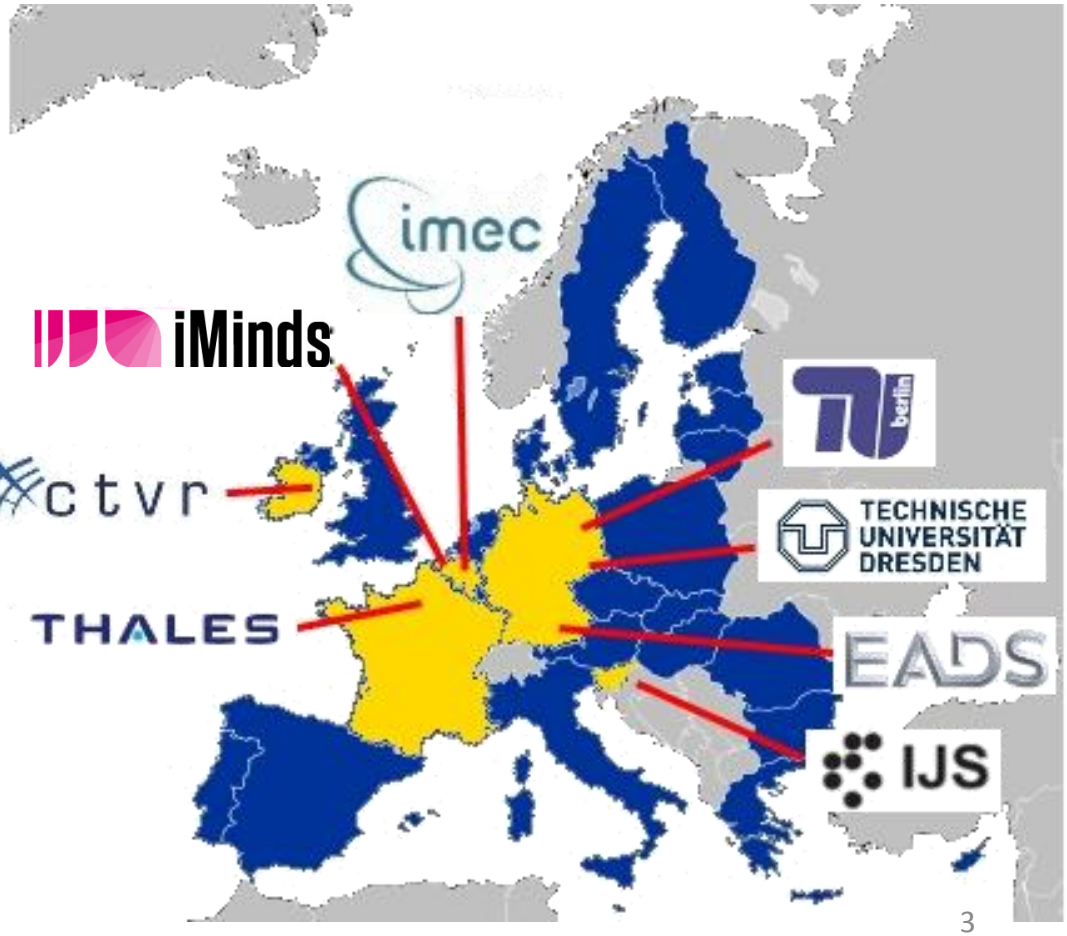
IP CREW: Identity

Cognitive Radio Experimentation World

- FP7 call 5 (FIRE - Future Internet Research and Experimentation Initiative)
- Project started October 2010
- 8 core partners
- 3+6 open call partners
  - UDUR (UK)
  - TUIL (DE)
  - TECNALIA (ES)

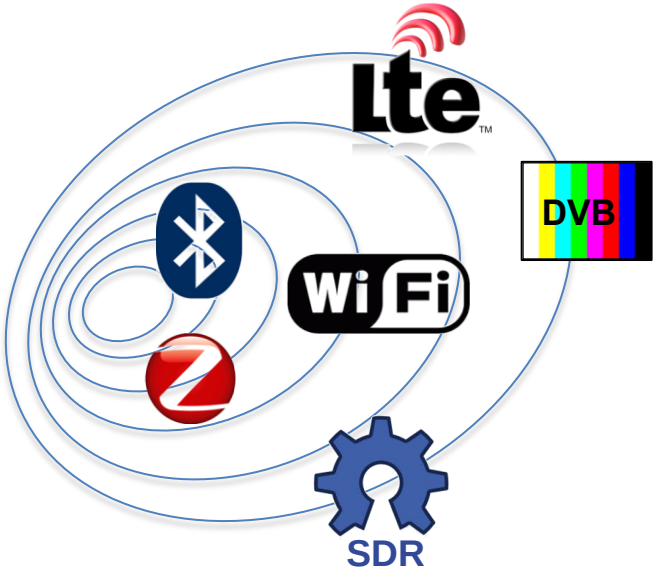
  OC1
  - IT (PT)
  - CMSF (PT)
  - CNIT (IT)
  - WINGS (GR)
  - UTH (GR)
  - NICTA (AU)

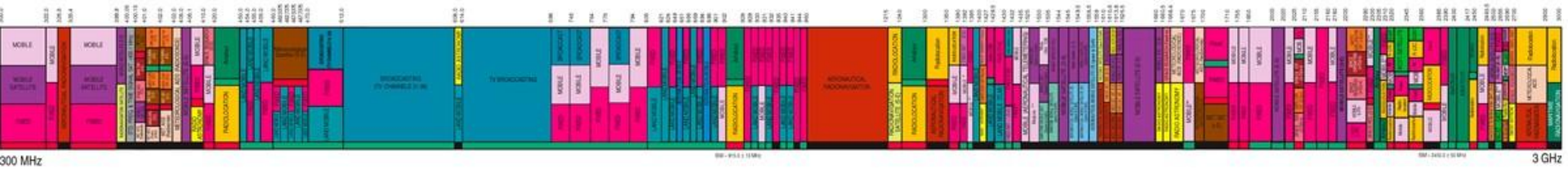
  OC2



IP CREW: Target

- **establish an open federated test platform, facilitating experimentally-driven research on**
  - advanced spectrum sensing
  - cognitive radio (CR)
  - cognitive networking (CN)
  - spectrum sharing
    in licensed and unlicensed bands





IP CREW: Platform

heterogeneous ISM
@ Ghent (iMinds)

WinnF Transceiver Facility (API)

wireless sensor
@ Berlin (TUB)

IMEC sensing agent

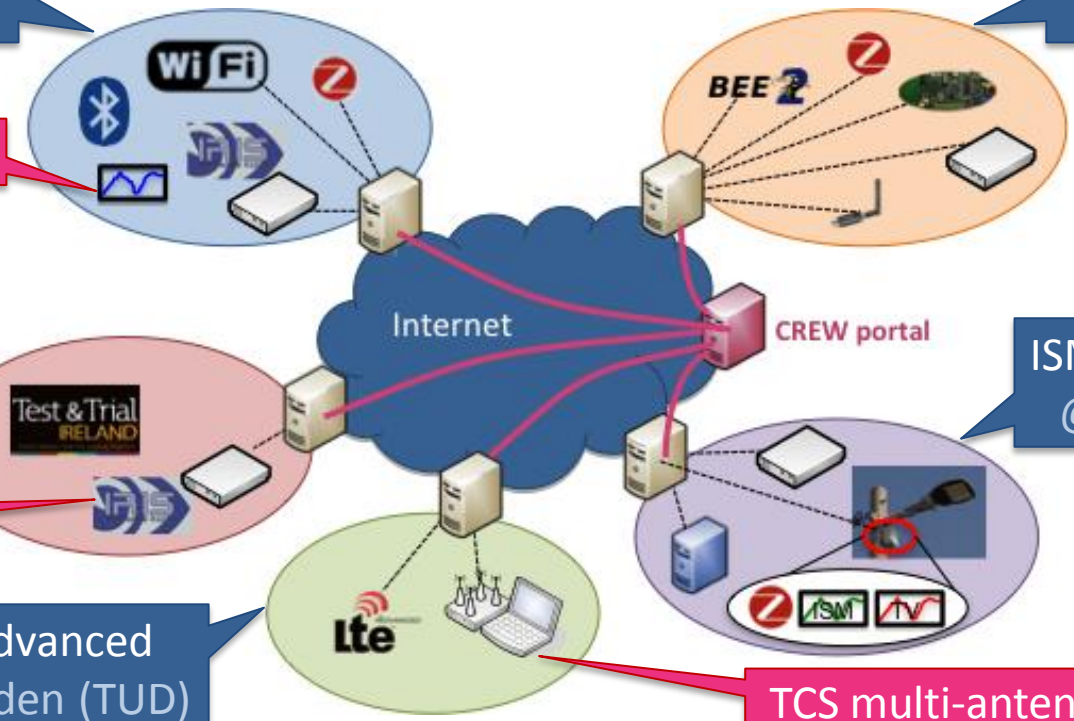
TV-bands
@ Dublin (TCD)

ISM/TVWS outdoor
@ Ljubljana (JSI)

IRIS SW radio

LTE-advanced
@ Dresden (TUD)

TCS multi-antenna LTE detection



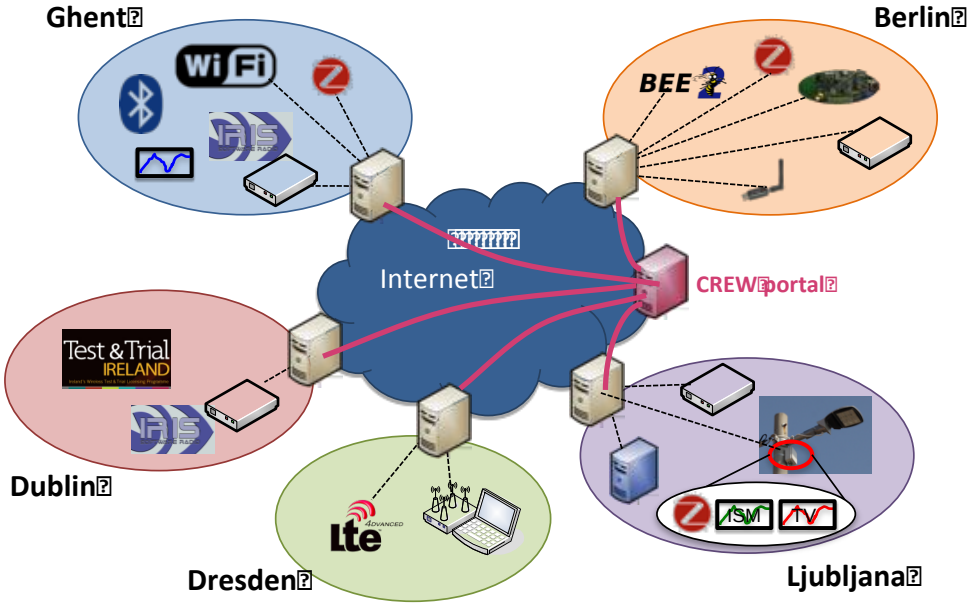
IEEE 802.11
IEEE 802.15.1
IEEE 802.15.4
LTE-advanced
EyesIFX nodes
CR database

IRIS 3GPP-based software radio platform
Comreg spectrum licenses
BEE2 FPGA platform
USRP software radio
VESNA platform on light pole

IMEC Sensing Agent
UHF/VHF TV sensing
ISM bands sensing
TCS Multi-antenna LTE detection
WiSpy Spectrum analyzer
Interconnection of portals
Interconn. between testbed elements

The CREW offer

- **Open access to 5 different testbed islands and advanced cognitive components**
  - different wireless technologies
  - different spectrum bands
  - mature testbeds
  - methodologies and tools for experimentation
  - reproducible test conditions
  - expertise from PHY layer to application layer



- **Portal with detailed information and guidelines on access and use of the facilities (www.crew-project.eu)**

- **Technical support & assistance to experimenters**
  - methodologies for experimentation

Cognitive Control Channels Experimentation

Some background

- Work was stimulated by research conducted in the context of the Wireless World Research Forum (WWRF)
- WWRF is the unique forum where the wireless community can tackle the key research challenges
- Elaboration on key aspects was conducted through our SME (WINGS ICT Solutions)
- Experiments are executed through the participation of WINGS in the CREW project, which provides the necessary experimentation facilities

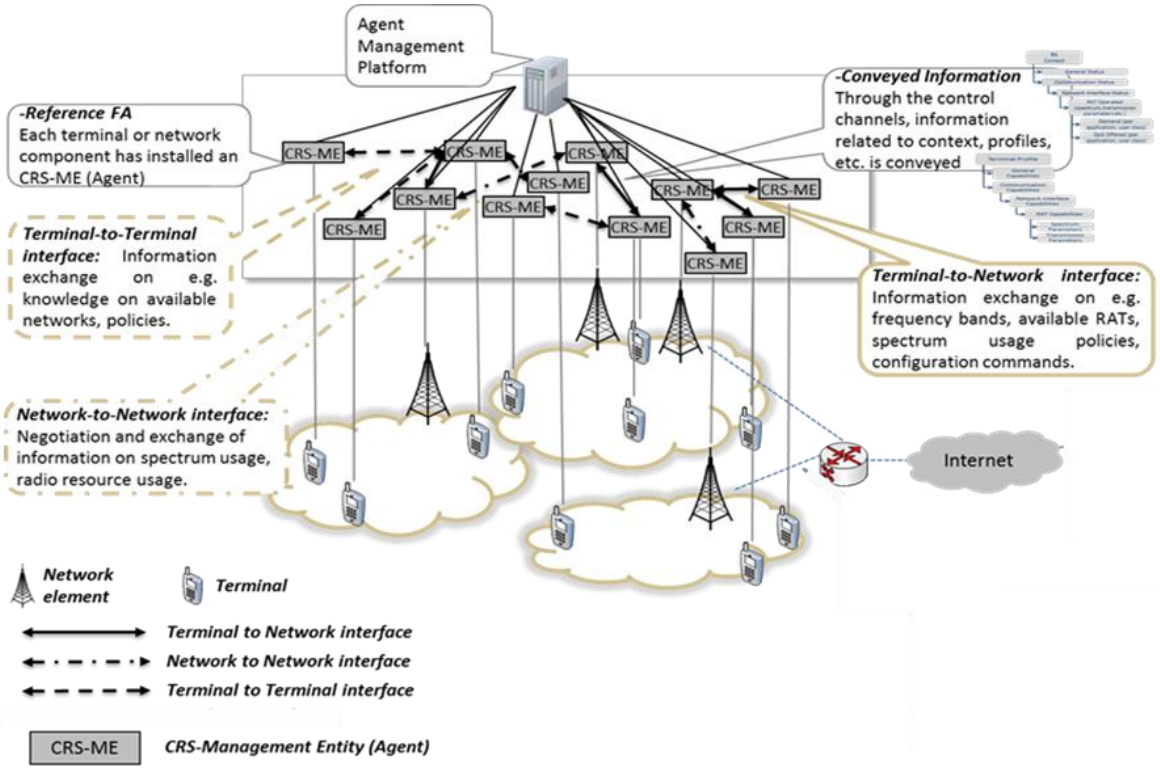
WINGS-ICT-Solutions profile

- **WINGS focuses on conducting R&D and providing consulting services in all areas related to telecommunication networks and services**
- **Wide expertise on:**

- **Comprises a team of selected, experienced engineers and computer scientists**

Experimentation: Motivation

- Mechanisms for management of wireless infrastructure
- Mechanisms for realizing infrastructure offloading scenarios
- Mechanisms for managing D2D networking solutions



Experimentation: Rationale

- **Control Channels for Cognitive Radio Systems (CC-CRSs)** have been identified as a key feature required for supporting CRSs in their operation, through conveying information and knowledge on the:
  - context of operation (traffic/mobility/interference conditions)
  - the involved profiles (of users/applications/devices)
  - and the valid policies (e.g., objectives to be pursued and constraints to be respected, designated by stakeholders, i.e., operators, regulators)

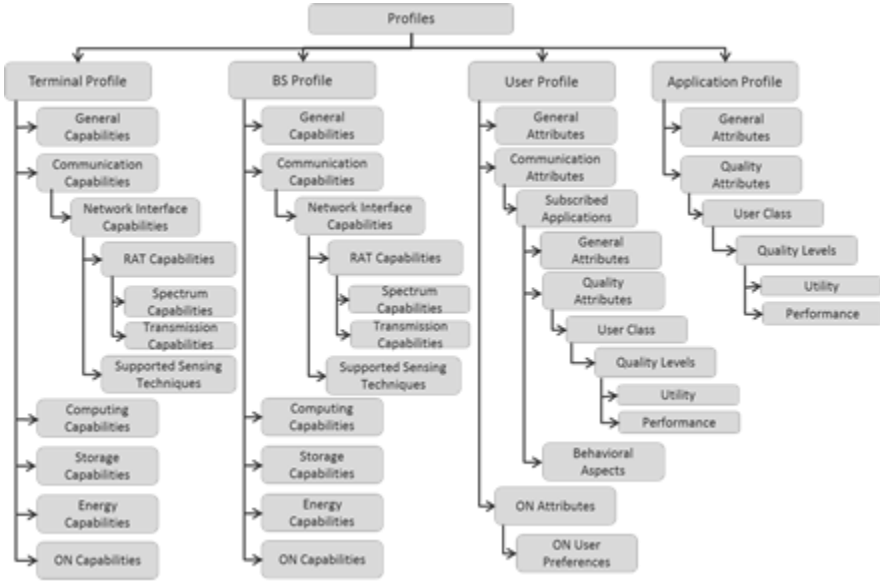
- ***The aim of this work is to perform experiment-based validation of control channels for Cognitive Radio Systems***

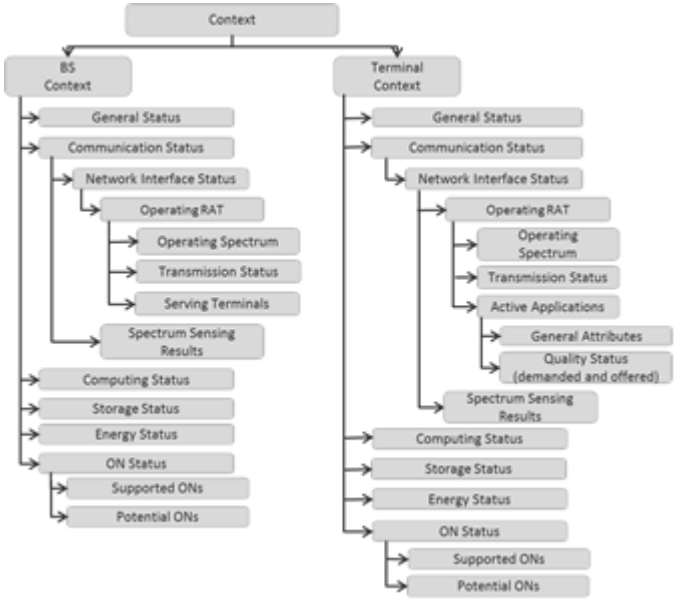
Experimentation: Related topics to cognitive control channels

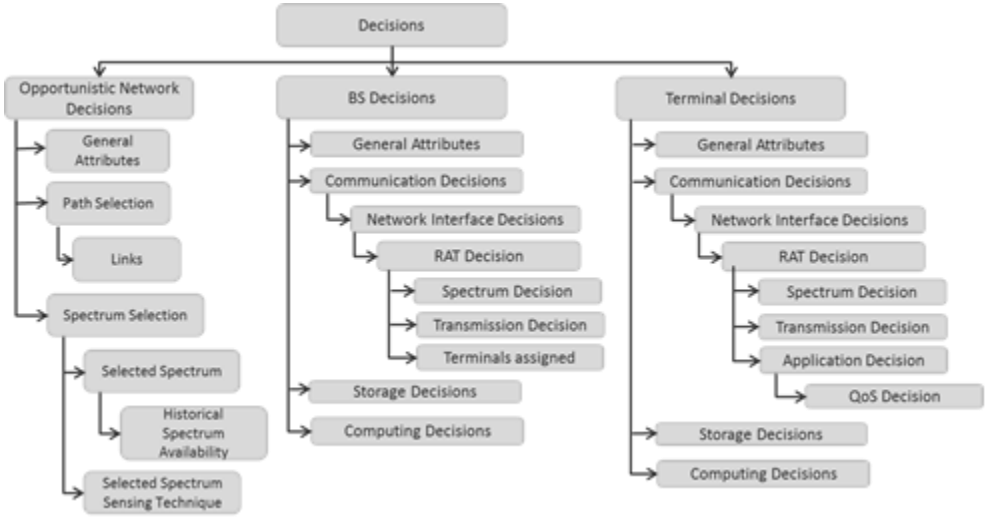
- **Related ETSI Technical Reports**
  - ETSI TR 102 682 V1.1.1, "Reconfigurable Radio Systems (RRS); Functional Architecture (FA) for the Management and Control of Reconfigurable Radio Systems", 2009
  - ETSI TR 102.683, v1.1.1, “Reconfigurable Radio Systems (RRS); Cognitive Pilot Channel (CPC)”, 2009
  - ETSI TR 102 684 V1.1.1, "Reconfigurable Radio Systems (RRS); Feasibility Study on Control Channels for Cognitive Radio Systems", 2012
- **Related publications**
  - S.Buljore, H.Harada, P.Houze, K.Tsagkaris, O.Holland, S.Filin, T.Farnham, K.Nolte, V.Ivanov, “Architecture and enablers for optimized radio resource usage in heterogeneous wireless access networks: The IEEE 1900.4 Working Group”, IEEE Commun. Mag., Vol. 47, no. 1, pp. 122-129, Jan. 2009
  - M.Mueck, A.Piipponen, G.Dimitrakopoulos, K.Tsagkaris et al., “ETSI Reconfigurable Radio Systems – Status and Future Directions on Software Defined Radio and Cognitive Radio Standards”, Communications Magazine, IEEE, vol.48, no.9, pp.78-86, Sep. 2010
  - V. Stavroulaki, K. Tsagkaris, P. Demestichas, J. Gebert, M. Mueck, A. Schmidt, R. Ferrus, O. Sallent, M. Filo, C. Mouton, L. Rakotoharison, "Cognitive control channels: from concept to identification of implementation options," Communications Magazine, IEEE , vol.50, no.7, pp.96-108, Jul. 2012
  - D. Karvounas, A. Georgakopoulos, V. Stavroulaki, K. Tsagkaris, P. Demestichas, "Evaluation of Signaling Load in Control Channels for the Cognitive Management of Opportunistic Networks", to appear to European Transactions on Telecommunications, Wiley, 2013
- **Related projects**
  - FP7/ICT project OneFIT (Opportunistic networks and Cognitive Management Systems for Efficient Application Provision in the Future InterneT), http://www.ict-onefit.eu
  - FP7/ICT project E3 (End-to-End Efficiency), https://ict-e3.eu/

Experimentation: Data structures

- **Specific data structures have been defined related to:**
  - Profiles
  - Context
  - Policies
  - Decisions
  - Knowledge

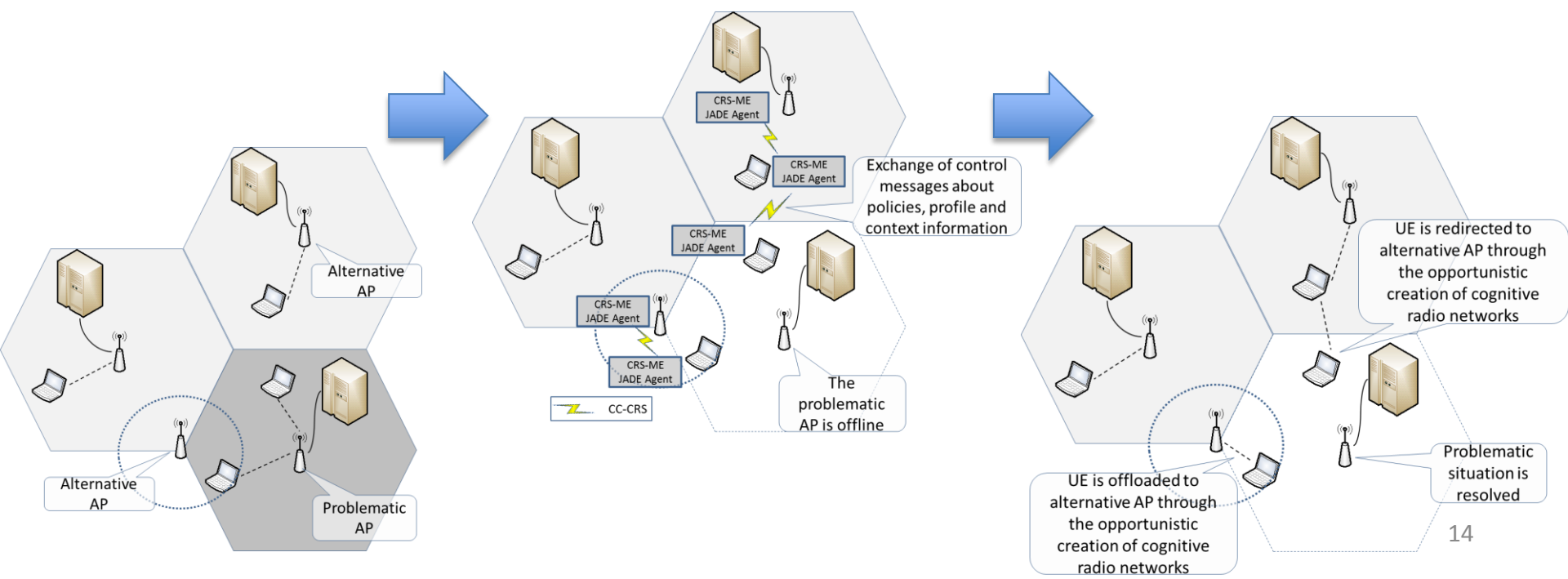




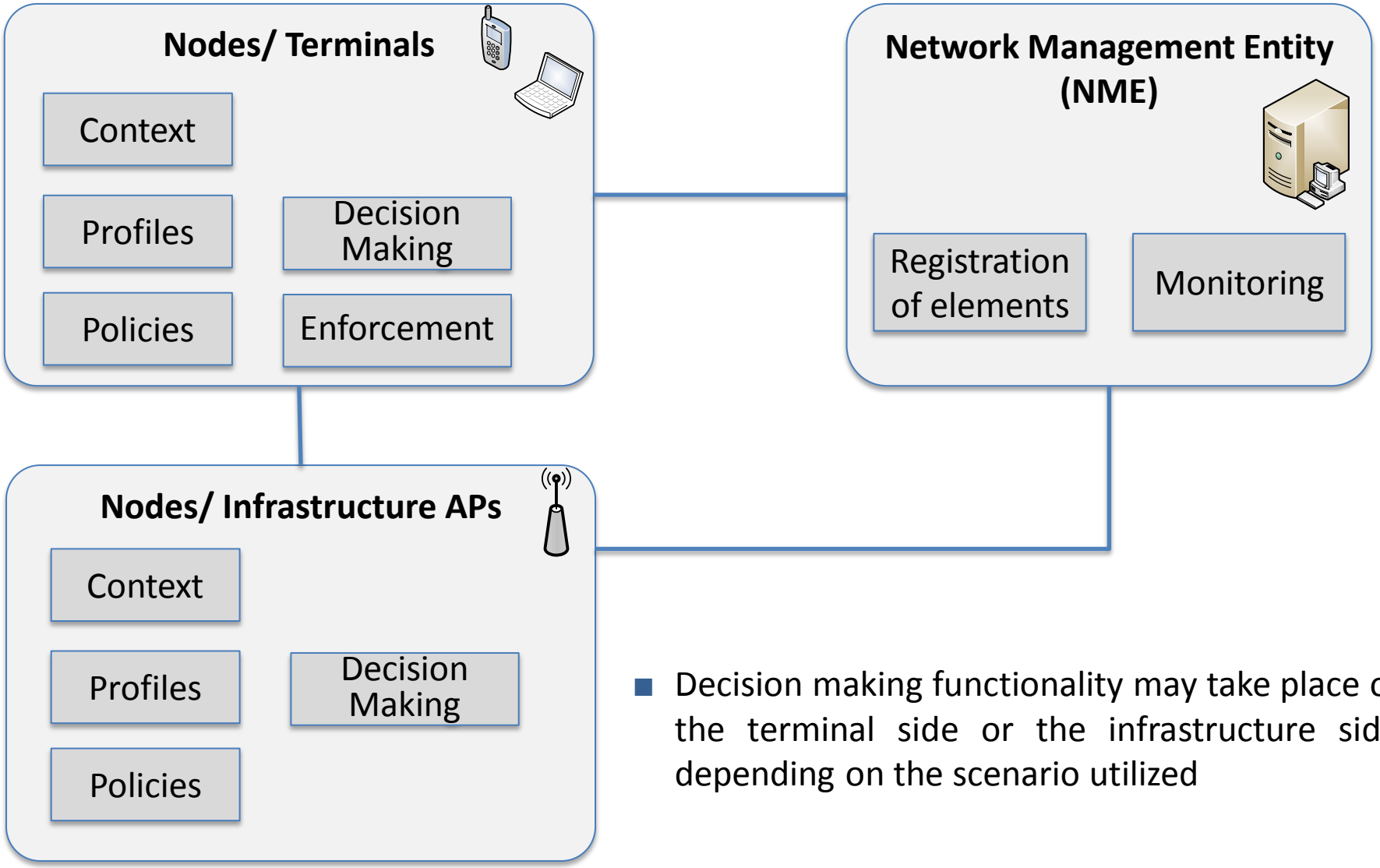


Experimentation: Indicative Scenario

- Coverage expansion of the infrastructure
- An AP unexpectedly transits to an offline mode
- Terminals that were served by the problematic AP shall identify neighboring terminals that are connected to alternative APs
- Opportunistic creation of (ad-hoc) cognitive radio network and redirection of traffic to alternative APs, also through the neighboring terminals



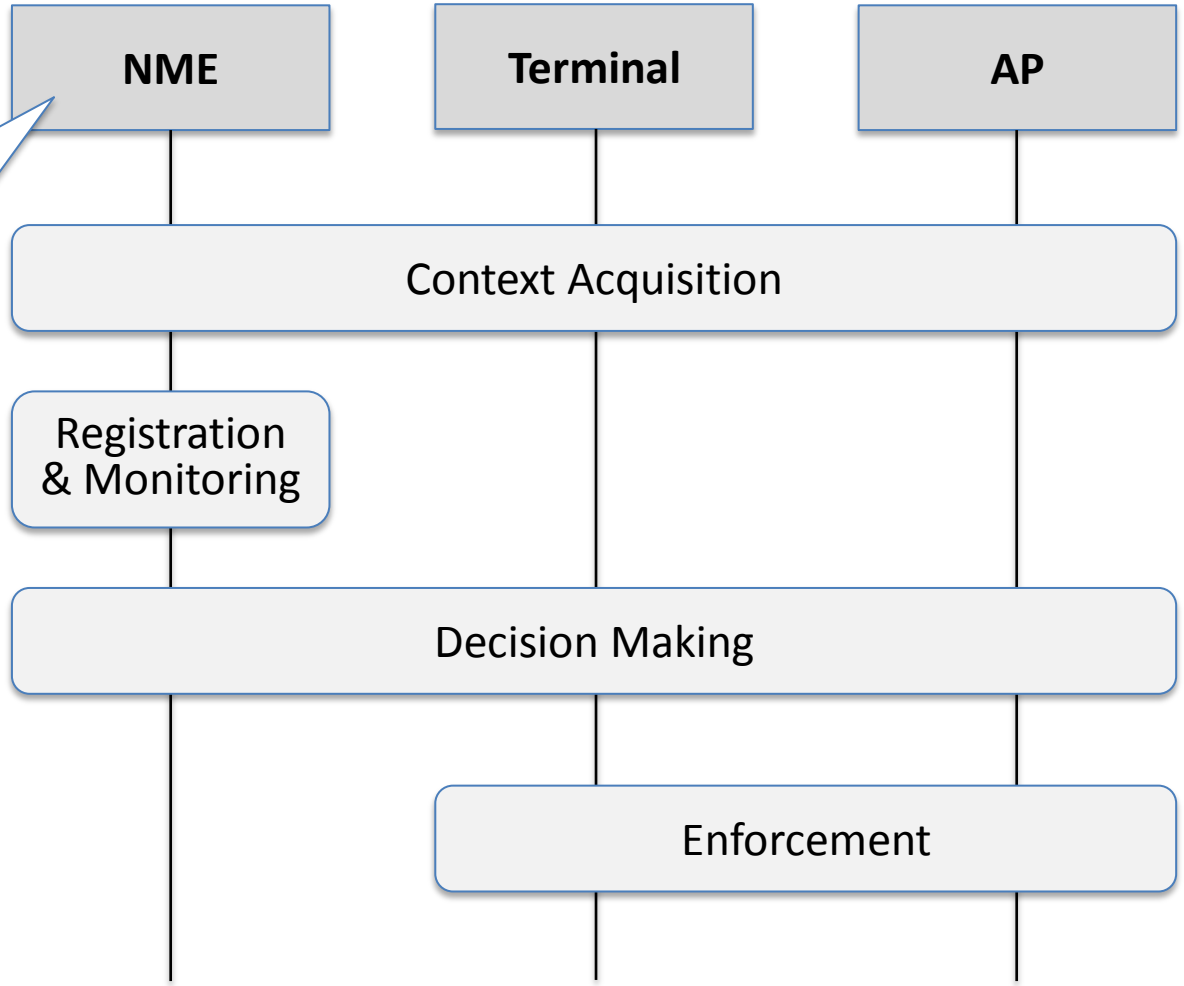
Experimentation: Architecture and Functionality



- Decision making functionality may take place on the terminal side or the infrastructure side, depending on the scenario utilized

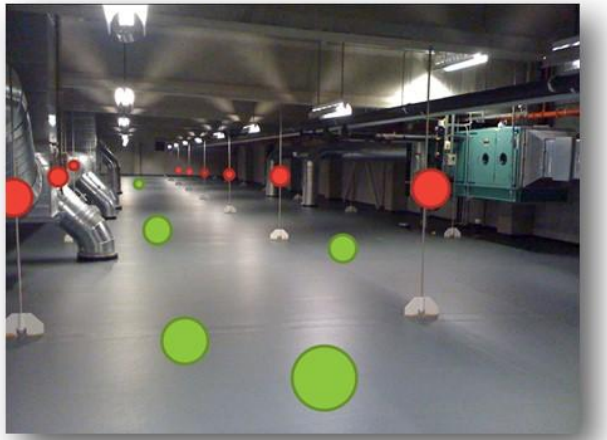
Experimentation: Functionality

- NME: Entity for registering network elements (e.g., infrastructure APs) and for monitoring the network

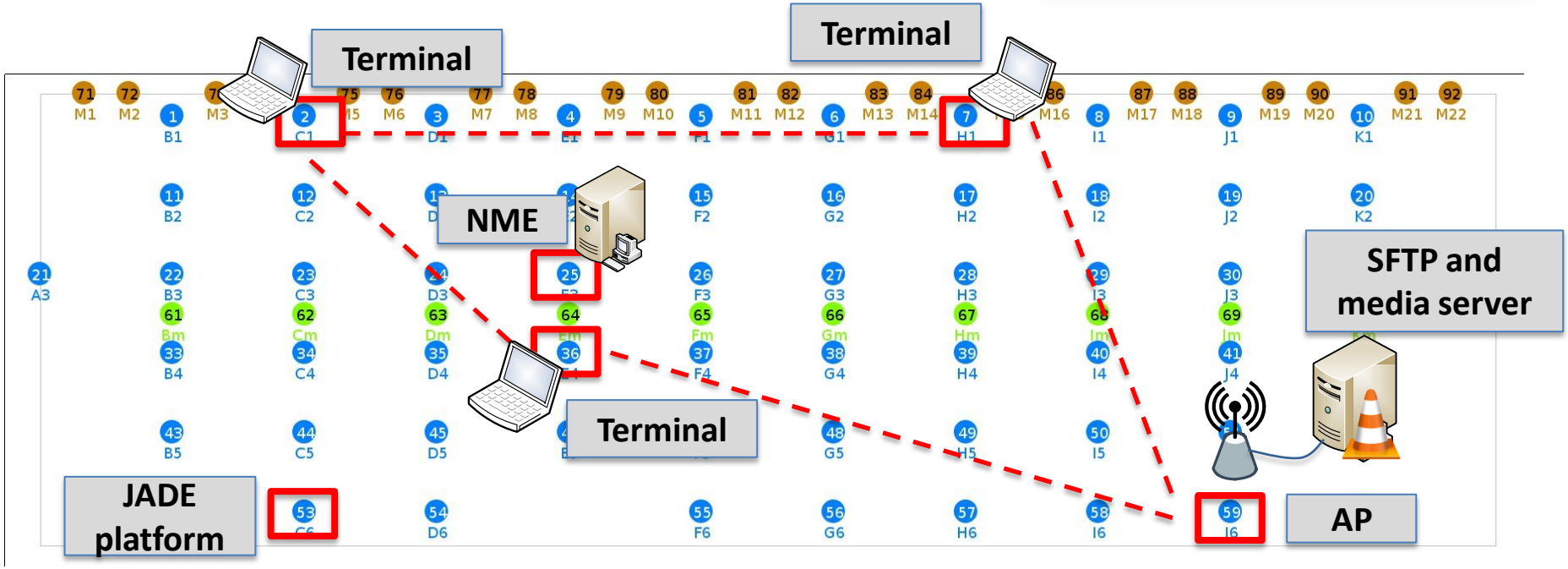


Experimentation: Environment

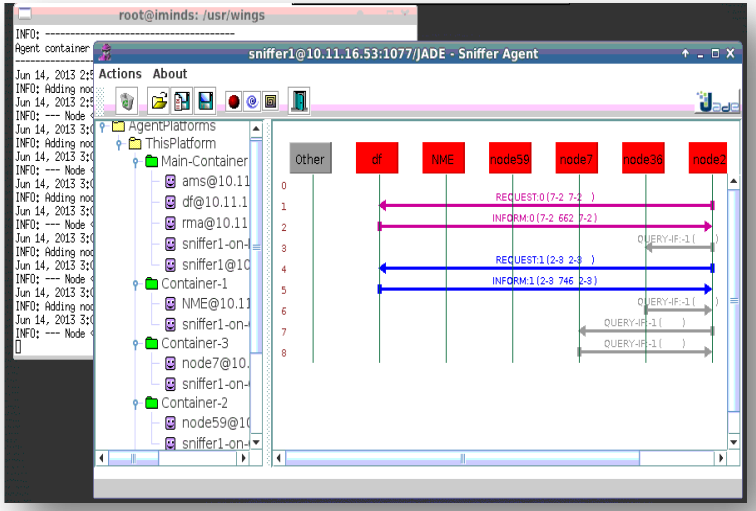
- CREW facilities in iMinds (Ghent) utilized



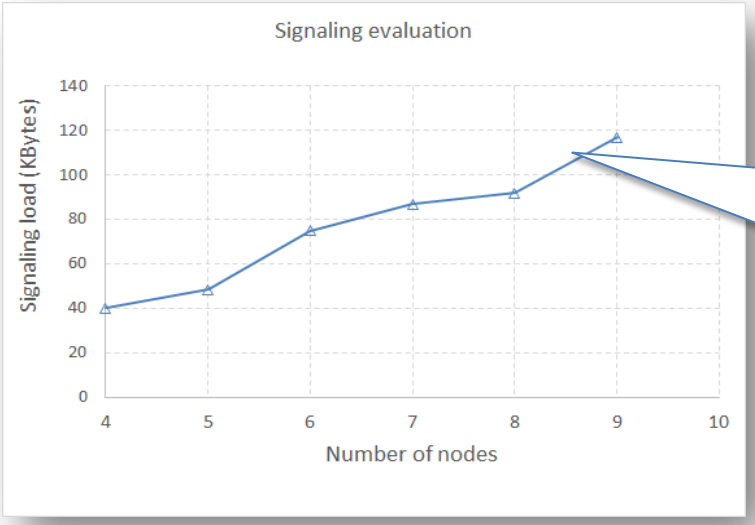
iMinds w-iLab.t testbed (Ghent)
Zwijnaarde environment



Experimentation: Indicative results



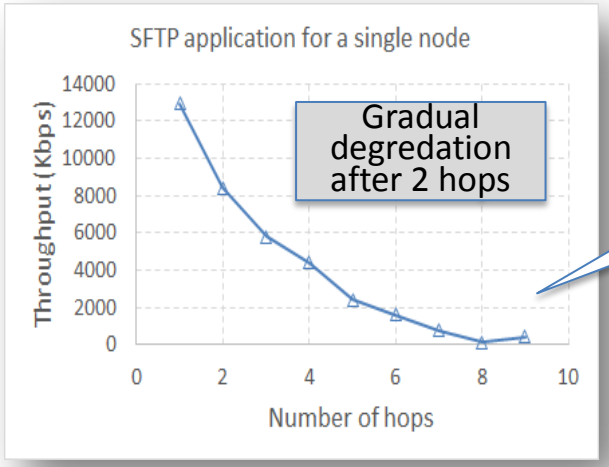
Visualization of exchanged messages



-Signaling load increasing as more hops are added to the D2D network

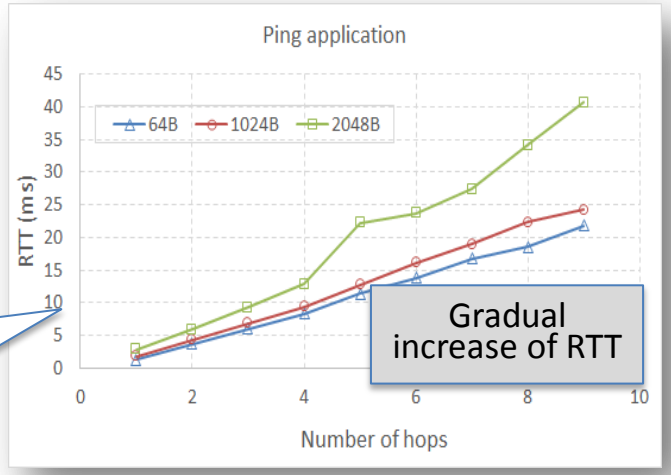
-This is due to more exchanged information between more elements

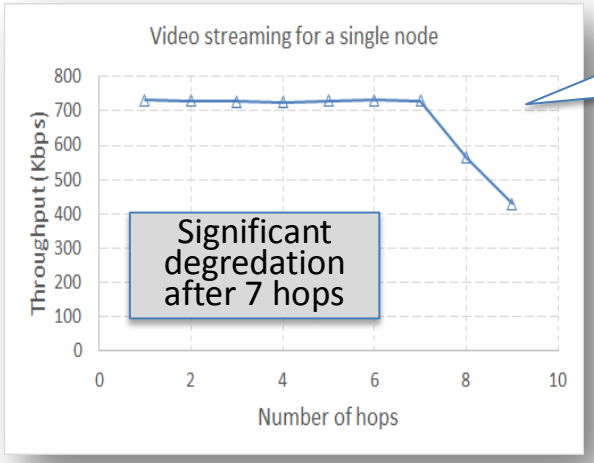
Experimentation: Indicative results



TCP application performance vs. # of hops

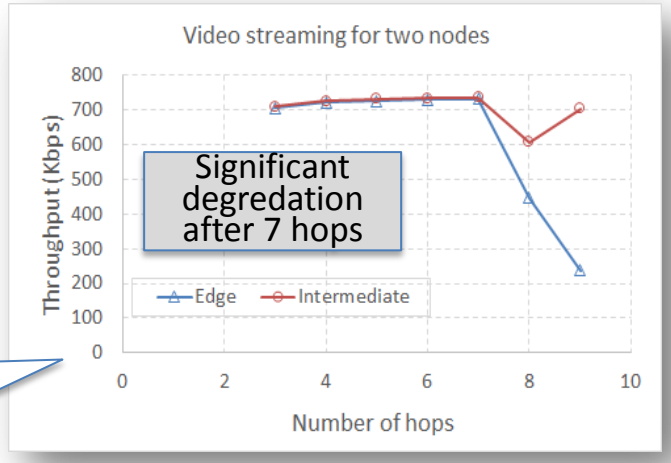
Ping performance vs. # of hops





UDP application performance vs. # of hops

Performance of edge vs. intermediate nodes



- **Performance tends to degrade as more nodes are added to the D2D network**
- **Degradation level differs depending on the applications used**

Conclusions

- Through control channels we are able to exchange contextual information of the environment
- By knowing the status of the environment, decision making on the creation of D2D connections can be triggered
- Performance of solutions enforced can be evaluated in order to assess the impact of the decision
- Quality of D2D communications is affected by the number of hops and the type of application (streaming, file transfer, ping)
- Quality of communication tends to degrade and higher amount of signaling information is being exchanged as more hops are added to a D2D network

Thank You!