Business from technology

Finnish Trial Program Activities

Seminar on Cognitive Radio Systems and
the use of White Spaces, ITU-R, Geneva, 18.11.2013

Dr. Marja Matinmikko on behalf of Finnish Trial Program
VTT Technical Research Centre of Finland

Outline

- Introduction to Finnish Trial program
- Overview of key projects in Trial program
- Licensed Shared Access (LSA)/Authorised Shared Access (ASA) trials

Introducing the Finnish TRIAL Program: Trial Environment for Cognitive Radio and Networks

Tekes

Trial

http://www.tekes.fi/en/programmes-and-services/tekes-programmes/trial/

Key Partners in Trial Program

- Trial programme offers international partners an opportunity to cooperate with the key players in Finland: 51 projects, ten companies and 7 research institutes with a total volume of 35 M€.
- Research partners: Aalto University, Centria University of Applied Sciences, University of Oulu (CWC), Tampere University of Technology, Turku University of Applied Sciences, University of Turku, and VTT Technical Research Centre of Finland.
- Industrial partners: Anite, Fairspectrum, Elektrobit, EXFO, Digita, Nokia, Nokia Solutions and Networks, PPO/Elisa, PehuTec, and Renesas/Broadcom.
- Public sector partners: the Finnish Defence Forces, Finnish Communications Regulatory Authority (FICORA) and Tekes.

Tekes

Trial Program's Focus Areas

- Trial environments
- Efficient and flexible usage of radio spectrum
- Spectrum sharing
- Spectrum access and sensing technologies
- Cognitive radio geolocation database
- Smart antennas
- Interference management
- TV white space systems and applications
- Techno-economic framework for CRS
- New applications and business models
- Test methodologies and test equipment technologies
- Regulation and standardisation

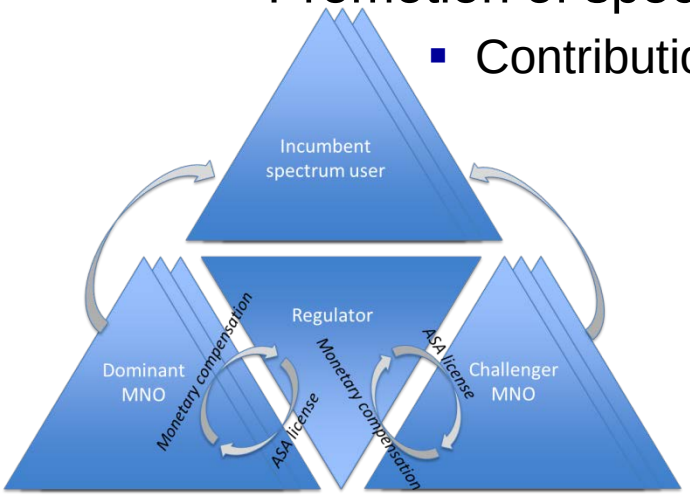
Tekes

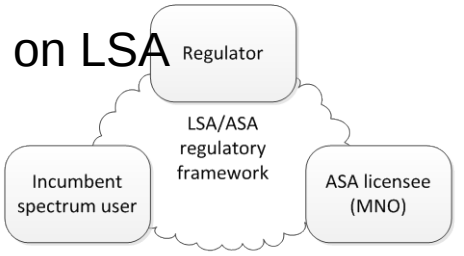
Trial

TRIAL PROJECTS

CORE and CORE+ Projects 2011-2014

- Development of Trial environment and trials on key concepts in spectrum sharing and related CRS technology
  - Licensed Shared Access (LSA)/Authorised Shared Access (ASA), Active Antenna Systems (AAS), device-to-device (D2D) communications
- Development of cognitive decision making techniques for mobile communication networks to support trials
- Scenarios and business models for key stakeholders in spectrum sharing
- Promotion of spectrums sharing in regulation
  - Contributions to e.g. ITU-R on CRS and CEPT on LSA





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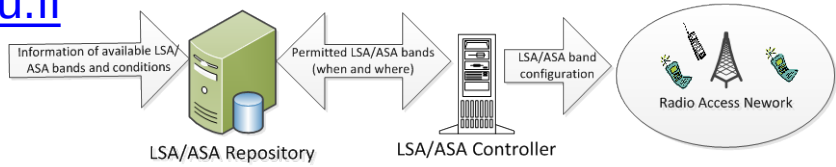

WISE and WISE2 Projects 2011-2014

- Operational live Turku TV white space testbed for 470-790 MHz band complemented by radio lab, geolocation database and simulation environment
- Incumbent protection, interference measurements, testing of white space radios, technical pilots and service pilots with devices utilizing TV white spaces
- Incumbent protection for LSA/ASA (Licensed Shared Access/Authorized Shared Access)

- LSA/ASA repository for 2.3-2.4 GHz band including incumbent manager software
- Interference measurements

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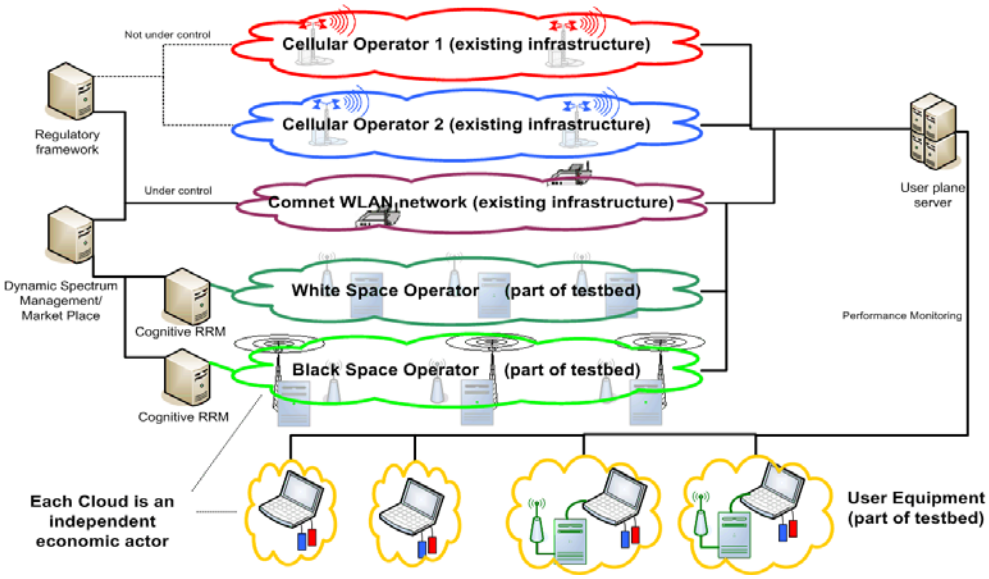
TURKU UNIVERSITY OF APPLIED SCIENCES

EECRT and EECRT2 Projects 2011-2014

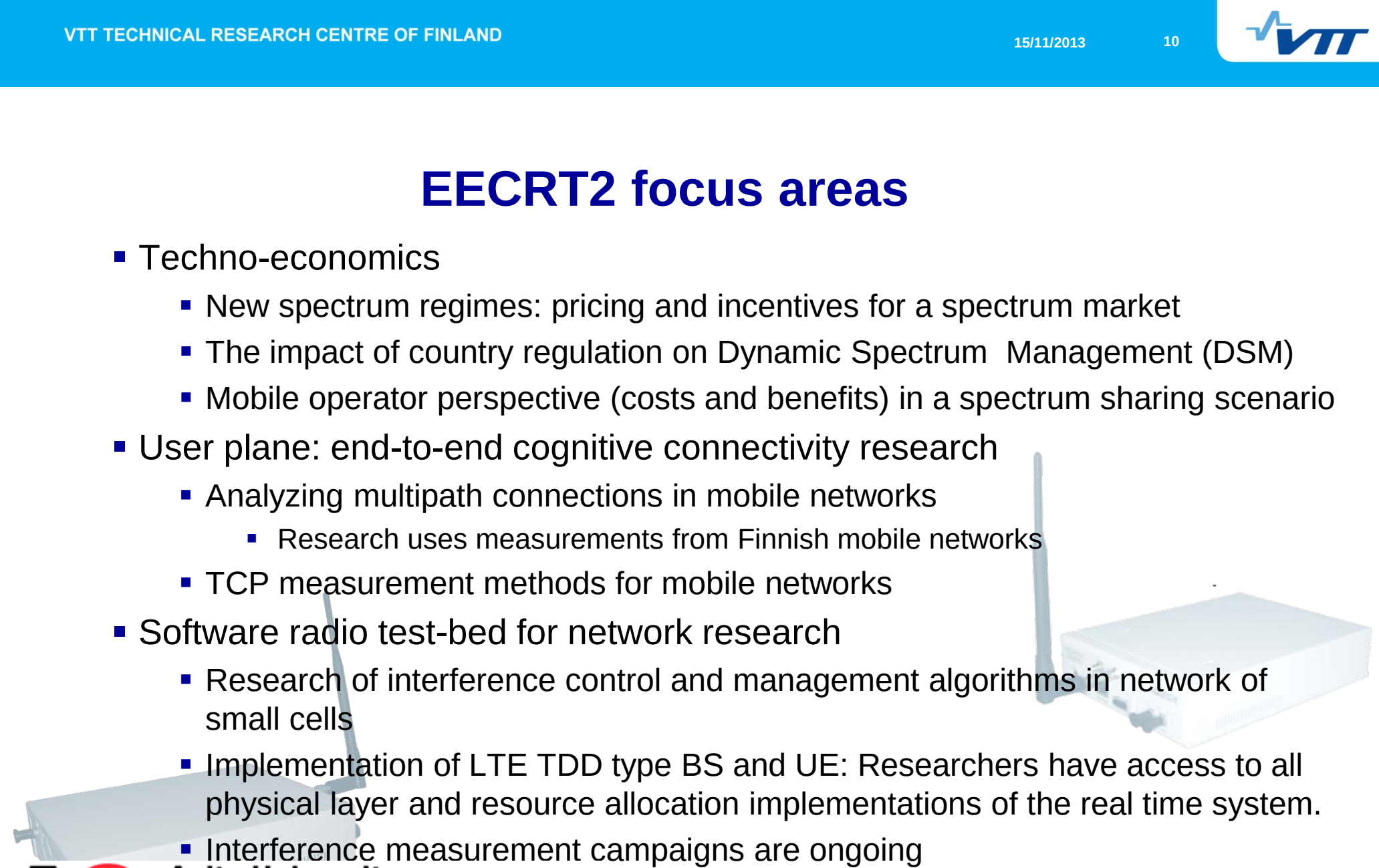
- Creation of a living lab cognitive radio test-bed for developing solutions that utilize cognitive radio capabilities.
- Three subtasks
  - Study of the technical and economical control interfaces between players
  - User plane: end-to-end cognitive connectivity
    - Cognitive radio access
    - Cognitive transport
  - Control plane: network of cognitive radios
    - Radio resource control in a network of cognitive radios
    - Interference management



Aalto University

EECRT2 focus areas

- Techno-economics
  - New spectrum regimes: pricing and incentives for a spectrum market
  - The impact of country regulation on Dynamic Spectrum Management (DSM)
  - Mobile operator perspective (costs and benefits) in a spectrum sharing scenario
- User plane: end-to-end cognitive connectivity research
  - Analyzing multipath connections in mobile networks
    - Research uses measurements from Finnish mobile networks
  - TCP measurement methods for mobile networks
- Software radio test-bed for network research
  - Research of interference control and management algorithms in network of small cells
  - Implementation of LTE TDD type BS and UE: Researchers have access to all physical layer and resource allocation implementations of the real time system.
  - Interference measurement campaigns are ongoing



Aalto University

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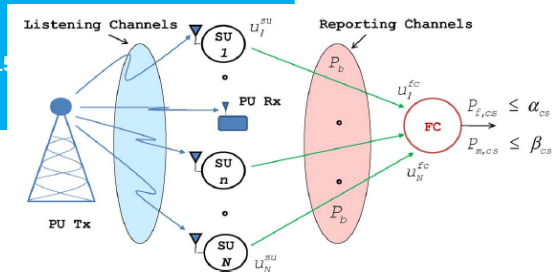
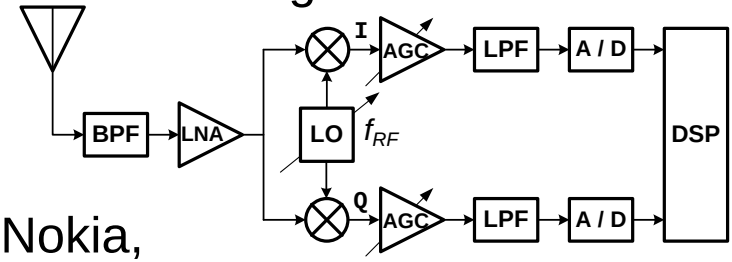
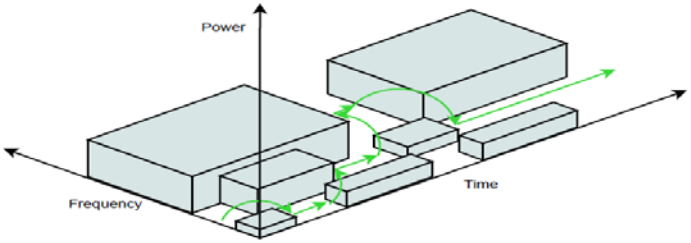


ENCOR and ENCOR2 Projects 2011-2014

- Aalto University and Tampere University of Technology
- Focus on concept design, signal processing methods and radio circuits in dynamic spectrum access and cognitive radio networks with strong demonstration emphasis.
- The goal of the project is to develop new HW and algorithm solutions for cognitive radios and verify their functionality with test platform initiated by Nokia, and developed further in this project, in real radio environment.



- More detailed focus areas:
  - Spectrum exploration and exploitation methods, focus on decentralized and collaborative methods as well as wideband sensing techniques
  - Power efficient hardware implementations
  - Modeling and mitigation of hardware originated interference and RF nonidealities
  - Increasing the efficiency of spectrum sensor implementations with combined detectors
  - Reconfigurable building blocks for receiver chain, including wideband multiband A/D interface (TUT) and sensor linearization.



Example: Cooperative spectrum sensing and field measurements

- Mobile sensors with cyclostationary-based feature detectors
- Sensor collaboration (sensor fusion) for reliable spectrum sensing
- Experimentation and demonstrations with field measurements on DVB channels in Helsinki area; sensor fusion with hard and soft processing
- Demonstrating clearly that reliable sensing and radio environment mapping can be obtained through collaborative techniques
- Contacts: Mikko Valkama, mikko.e.valkama@tut.fi, Visa Koivunen, visa.koivunen@aalto.fi, Jussi Ryynänen, jussi.ryynanen@aalto.fi

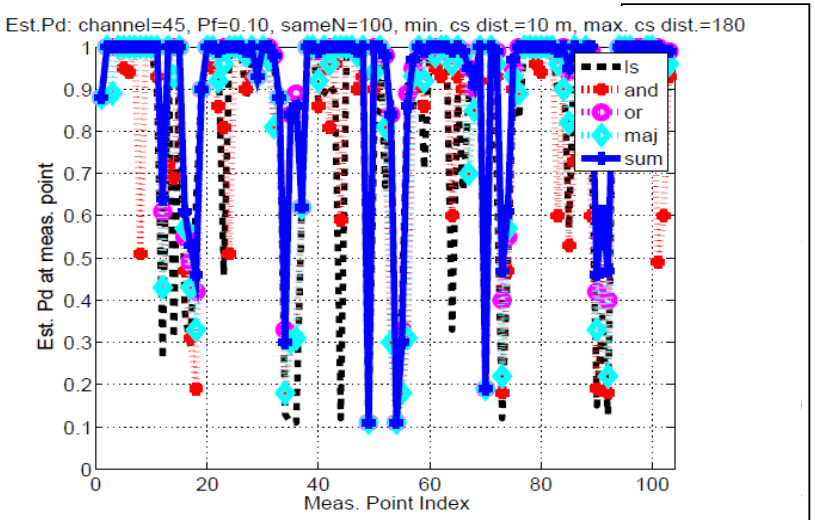
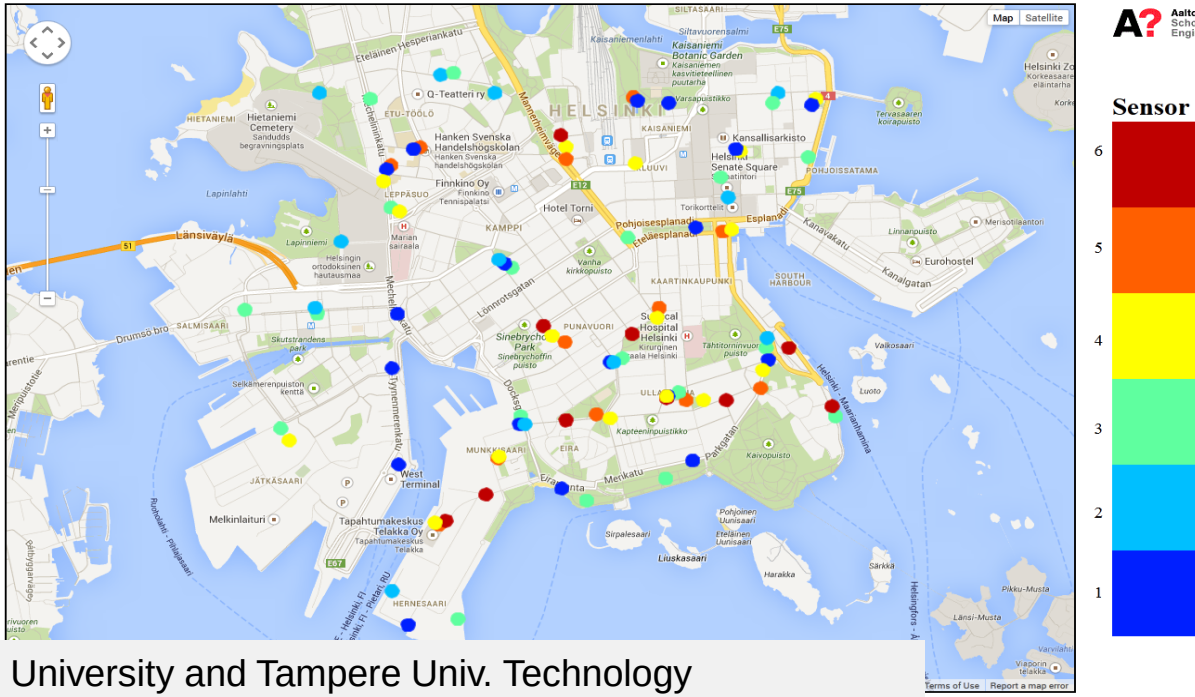


Fig. 12. Average probability of detection at different locations for channel 45. This channel is clearly visible in some locations and not in others. Local sensing fails in reliably detecting this channel while cooperative sensing does.



FINNISH LSA/ASA TRIALS

CORE+ and WISE2 projects

Research organizations:

VTT

Centria
RESEARCH AND DEVELOPMENT

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Industry:

nsn

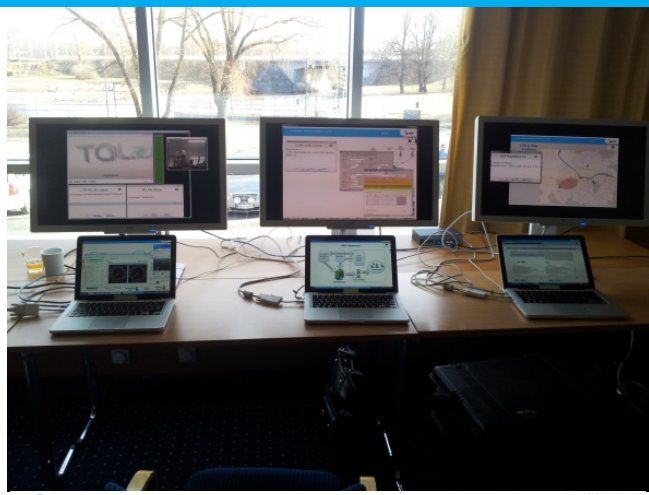
Fairspectrum

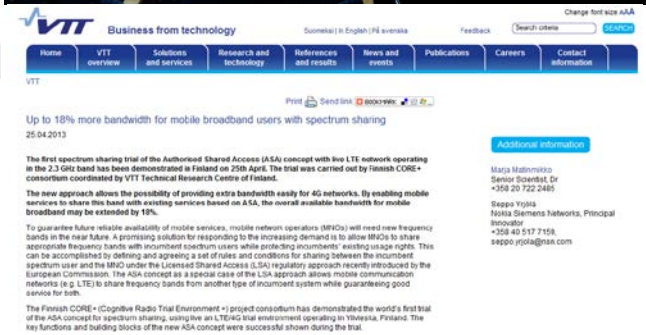
PPO

Regulator:

Viestintävirasto
Finnish Communications
Regulatory Authority

LSA/ASA trials

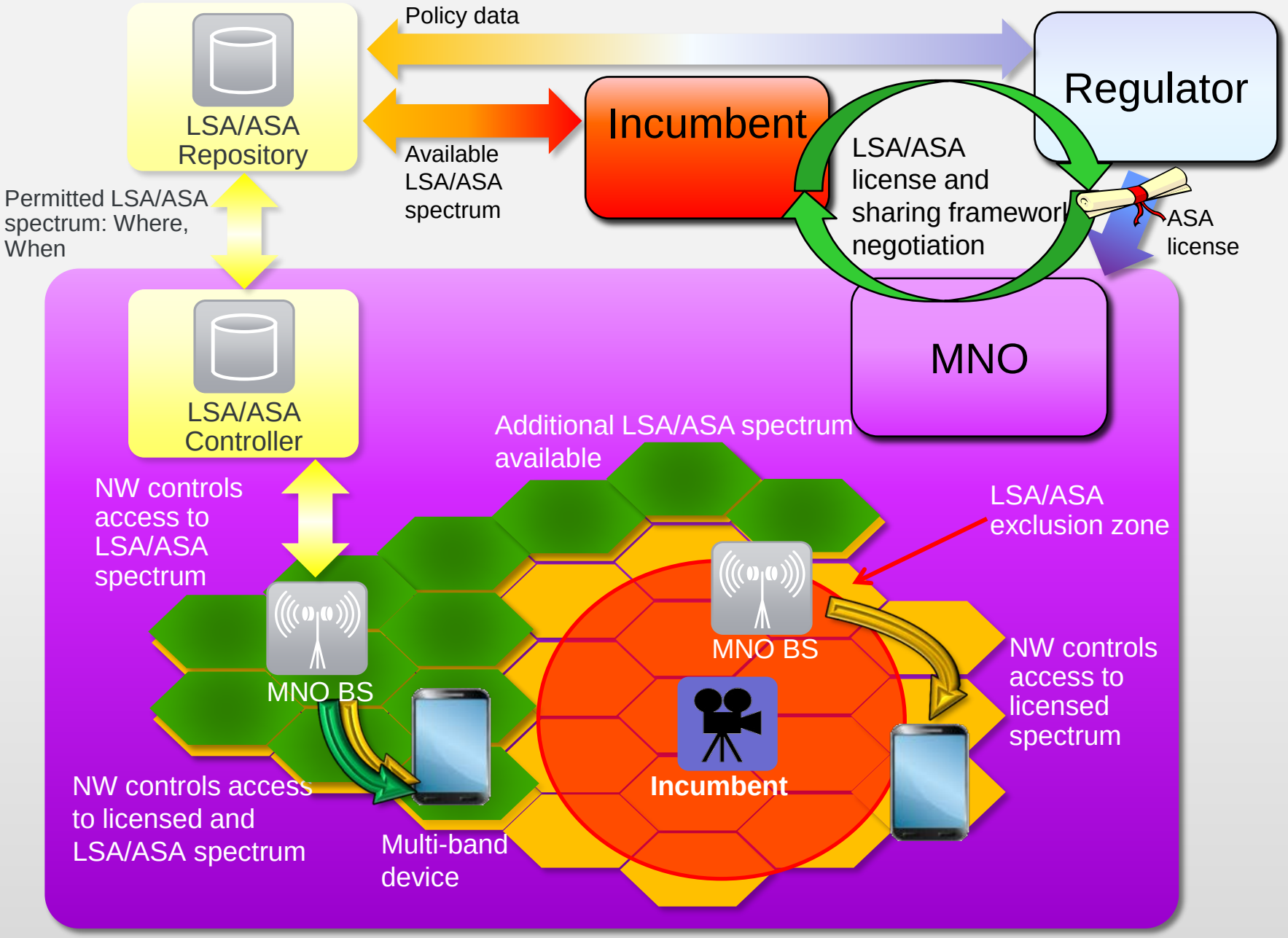




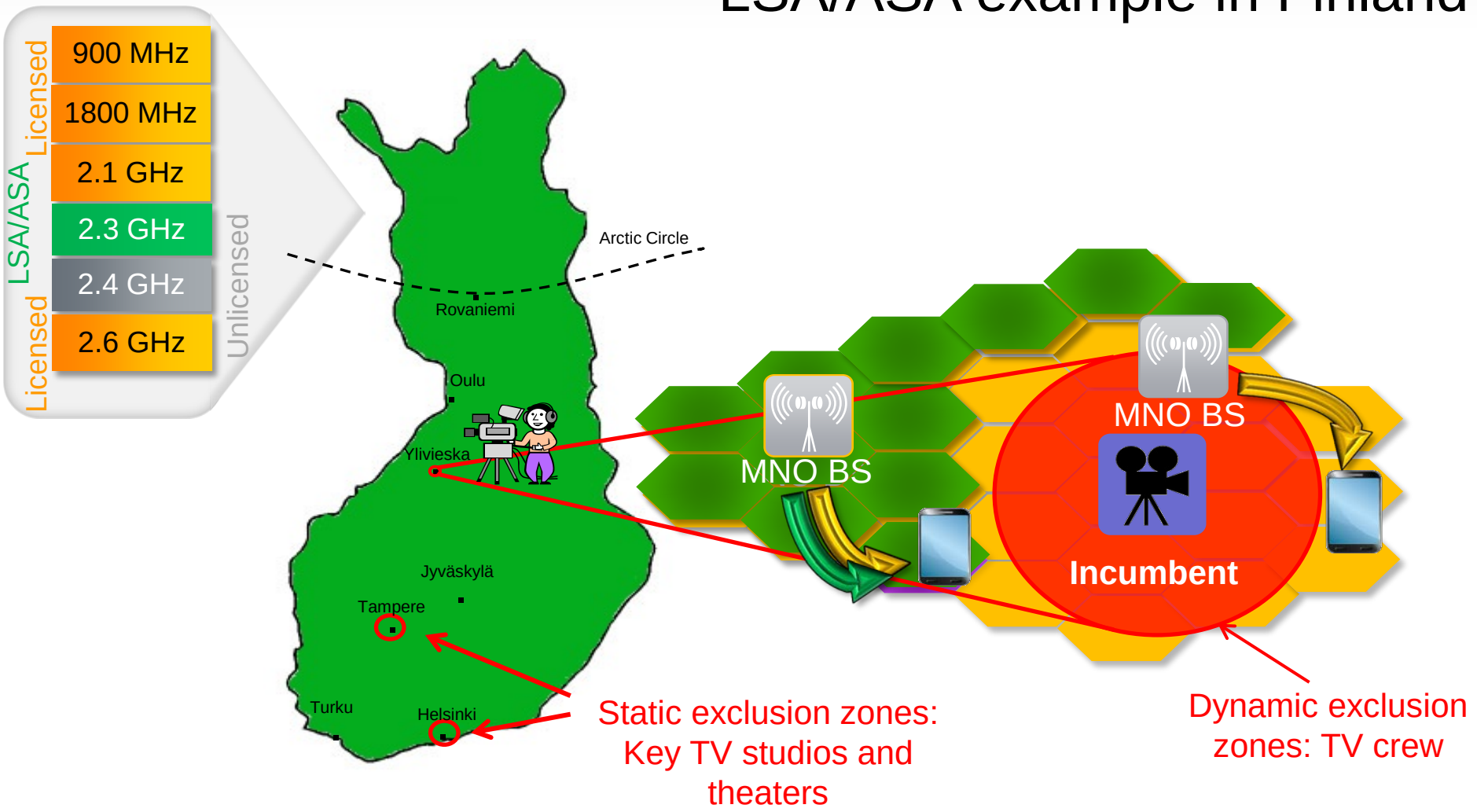
- World's first live LSA/ASA trial of TD-LTE in 2.3 GHz band was presented at WWRF meeting in Oulu, Finland, in April 2013.
  - Published in: M. Matinmikko, et al. "Cognitive radio trial environment: First live authorized shared access-based spectrum-sharing demonstration," *IEEE Veh. Technol. Magazine*, vol. 8, pp. 30–37, September 2013.
  - http://www.vtt.fi/news/2013/25042013_ASA.jsp
- New enhanced LSA/ASA trial was shown at Trial LSA Workshop arranged by Tekes and COST TERRA in Helsinki, Finland, in September 2013.

http://www.wwrf30.ch/
https://tapahtumat.tekes.fi/event/triallsaworkshop

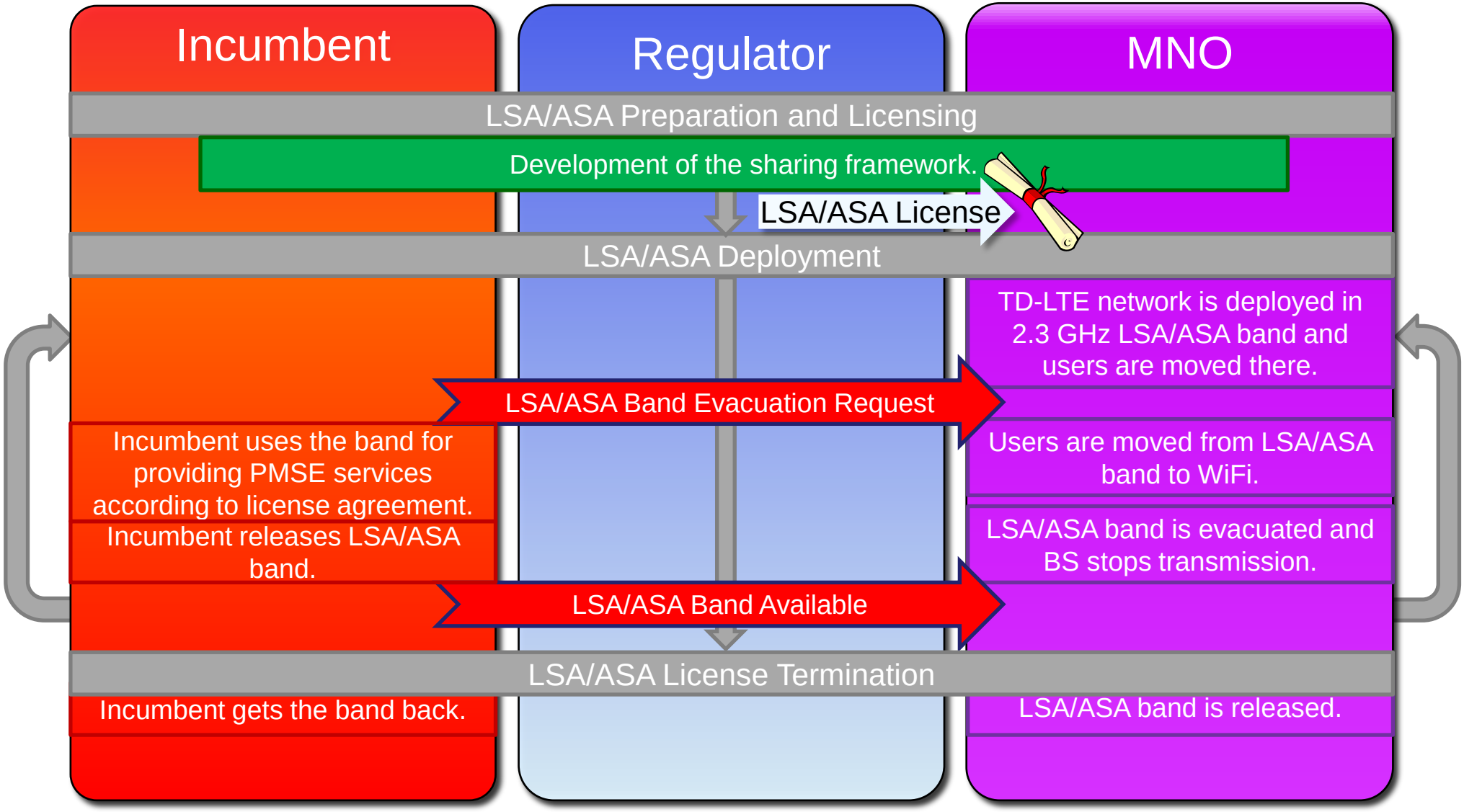
LSA/ASA Concept



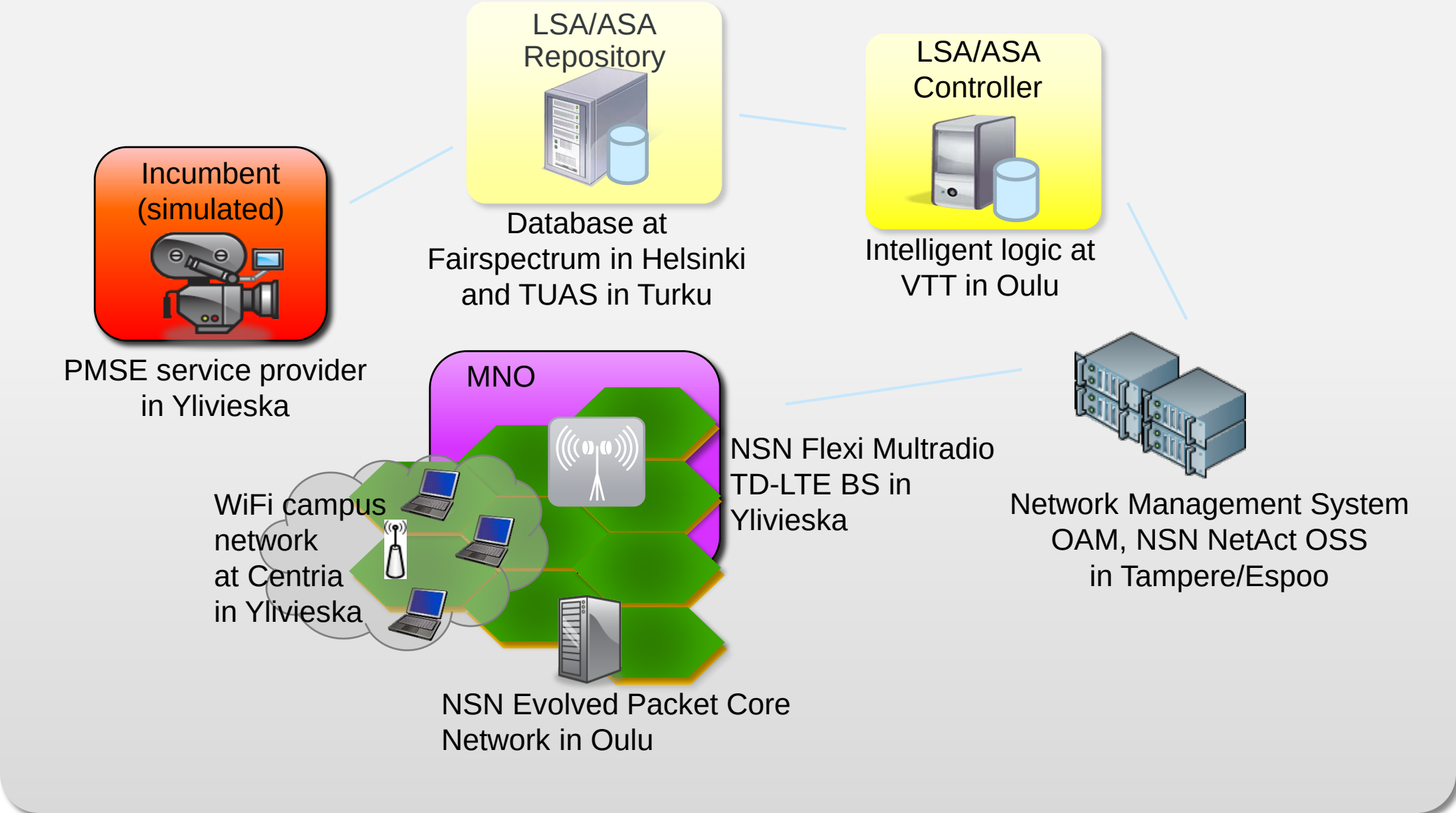
LSA/ASA example in Finland



Finnish LSA/ASA Trial Flow



Finnish LSA/ASA Trial Setup



Conclusions

- CRS research is mature to start showcasing the CRS techniques for specific systems and frequency bands.
- Finnish Trial program has developed trial environments and related CRS technology and demonstrated new spectrum sharing concepts
  - TV White space work in live test environment and sensing studies
  - World's first live LSA/ASA trial with real TD-LTE base stations in 2.3 GHz LSA/ASA band in April 2013 and an enhanced trial in September 2013.
- Trial story will continue in 2014 with new enhanced trial setups and demonstrations on LSA/ASA and other concepts in more realistic scenarios.
- CROWNCOM 2014 (9th International Conference on Cognitive Radio Oriented Wireless Networks) will take place in Oulu, Finland, June 2-4, 2014, and show the Finnish Trial environments.
  - http://crowncom.org/2014/show/home

Questions?

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