White Space Communication Enabled by IEEE Standard 1900.4

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Summary

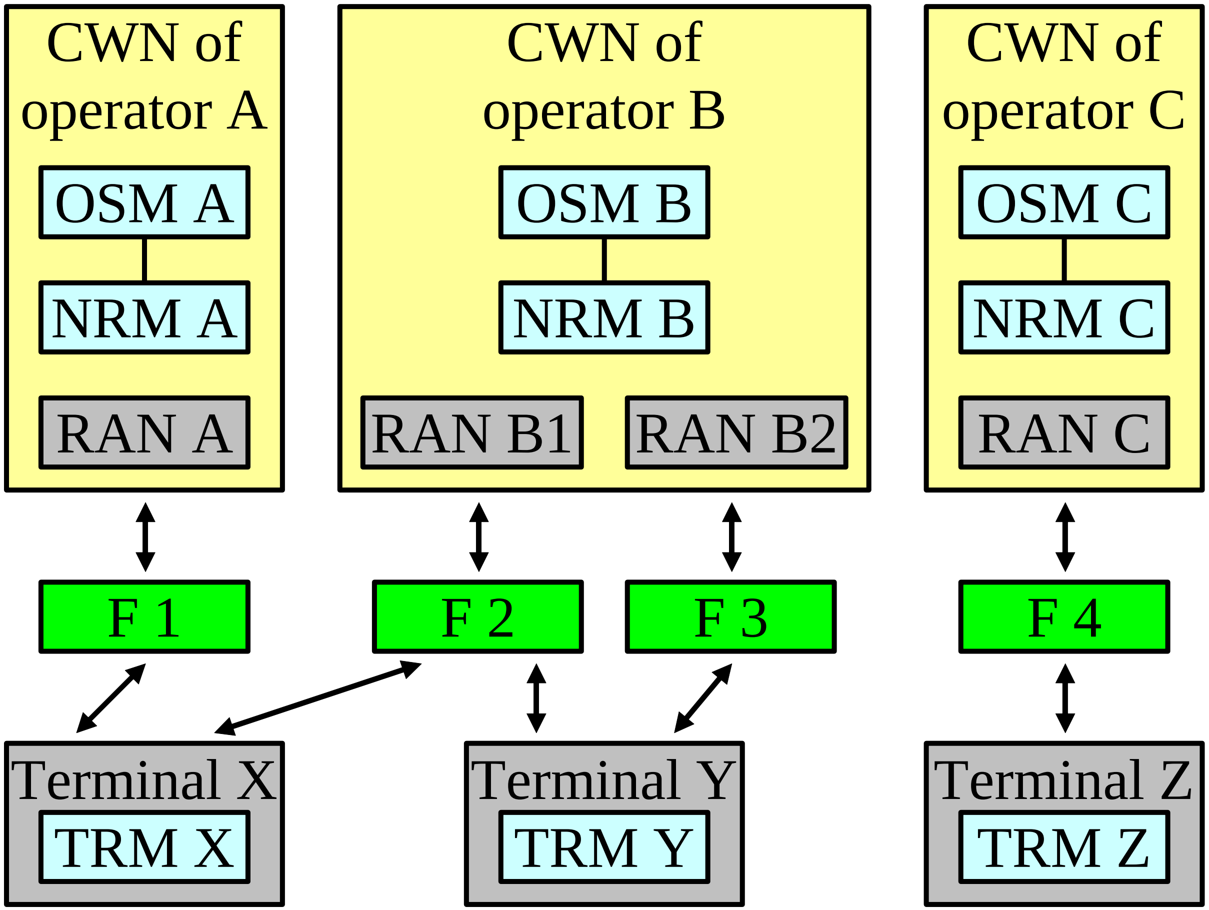
- This contribution gives brief overview of the IEEE standard 1900.4 on “Architectural building blocks enabling network-device distributed decision making for optimized radio resource usage in heterogeneous wireless access networks” and describes how white space communication can be enabled by 1900.4 system

Outline

- 1900.4 overview
  - Context
  - System architecture
- White space communications enabled by 1900.4 system
  - Use case
  - Coexistence mechanisms
- Conclusions
- For further information

1900.4 Overview

1900.4 Context (1/3)



CWN – Composite Wireless Network

OSM – Operator Spectrum Manager

NRM – Network Reconfiguration Manager

TRM – Terminal Reconfiguration Manager

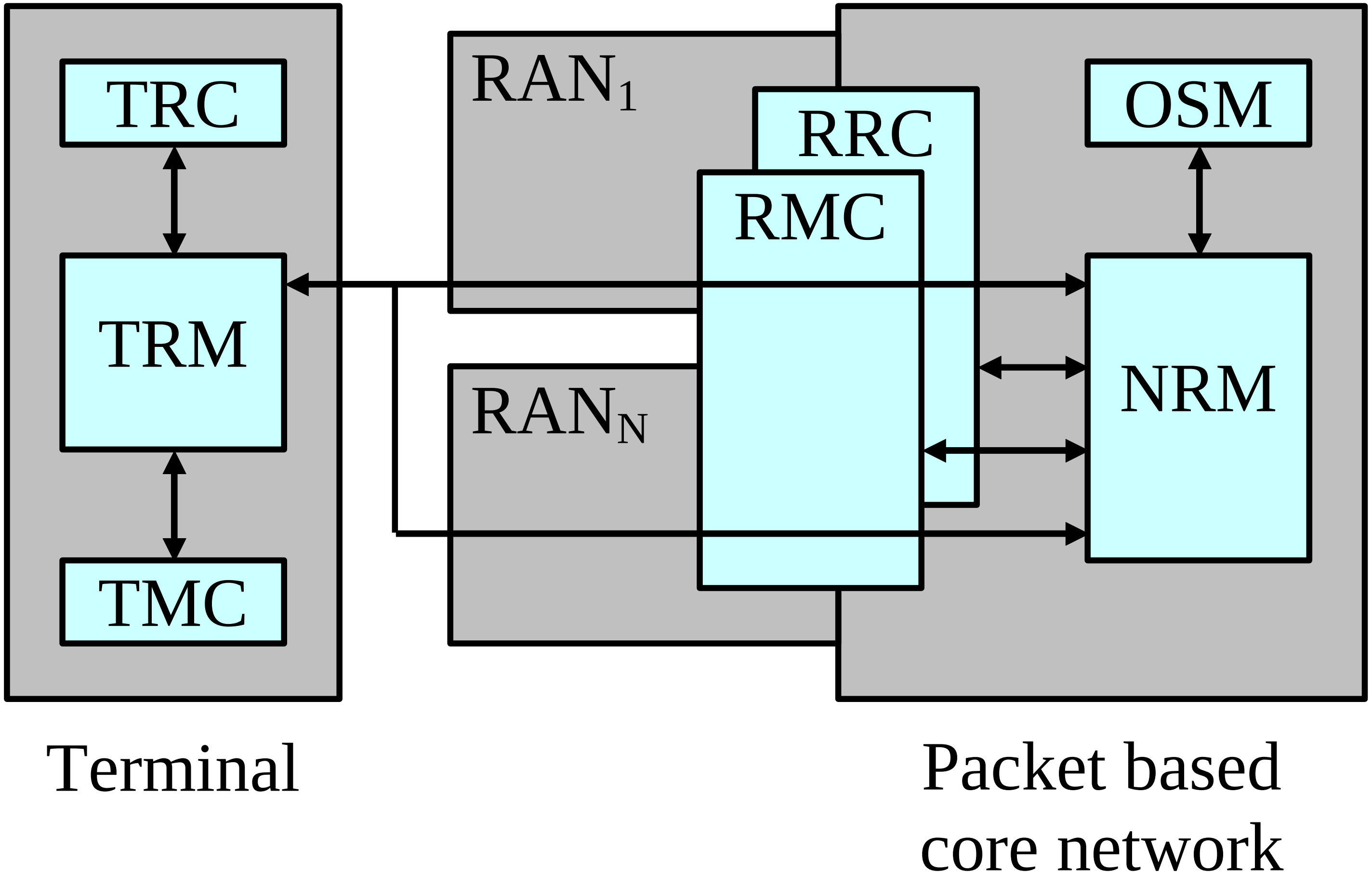
1900.4 Context (2/3)

- Heterogeneous environment
  - Multiple operators
  - Multiple RANs
  - Multiple radio interfaces (RATs)
- Reconfigurable equipment
  - Legacy and reconfigurable RANs/BSs
  - Legacy and reconfigurable terminals
- Dynamic spectrum access
  - Dynamic spectrum assignment
  - Dynamic spectrum sharing

1900.4 Context (3/3)

- IEEE Standard 1900.4 enables advanced spectrum management and radio resource usage optimization in heterogeneous wireless environment
  - by defining management system
    - comprising management entities and interfaces
  - to be deployed on top of this heterogeneous wireless environment

1900.4 System Architecture (1/11)



1900.4 System Architecture (2/11)

- Network side entities
  - **Operator Spectrum Manager** (OSM) is the entity that enables operator to control dynamic spectrum assignment decisions of NRM
  - **RAN Measurement Collector** (RMC) is the entity that collects RAN context information and provides it to NRM
  - **Network Reconfiguration Manager** (NRM) is the entity that manages CWN and terminals for network-terminal distributed optimization of radio resource usage and improvement of QoS
  - **RAN Reconfiguration Controller** (RRC) is the entity that controls reconfiguration of RANs based on requests from NRM

1900.4 System Architecture (3/11)

- Terminal side entities
  - **Terminal Measurement Collector** (TMC) is the entity that collects terminal context information and provides it to TRM
  - **Terminal Reconfiguration Manager** (TRM) is the entity that manages the terminal for network-terminal distributed optimization of radio resource usage and improvement of QoS within the framework defined by the NRM and in a manner consistent with user preferences and available context information
  - **Terminal Reconfiguration Controller** (TRC) is the entity that controls reconfiguration of terminal based on requests from TRM

1900.4 System Architecture (4/11)

- Interfaces
  - TMC ⇔ TRM
  - TRM ⇔ TRC
  - OSM ⇔ NRM
  - RMC ⇔ NRM
  - NRM ⇔ RRC
  - NRM ⇔ TRM
  - NRM ⇔ NRM (of different operators)

1900.4 System Architecture (5/11)

- TMC ⇔ TRM interface
  - From TRM to TMC
    - Terminal context information requests
  - From TMC to TRM
    - Terminal context information
  - Terminal context information may include
    - User preferences
    - Required QoS levels
    - Terminal capabilities
    - Terminal measurements
    - Terminal geo-location information

1900.4 System Architecture (6/11)

- TRM ⇔ TRC
  - From TRM to TRC
    - Terminal reconfiguration requests
  - From TRC to TRM
    - Terminal reconfiguration responses

1900.4 System Architecture (7/11)

- OSM ⇔ NRM
  - From OSM to NRM
    - Spectrum assignment policies
  - From NRM to OSM
    - Information on spectrum assignment decisions
  - Spectrum assignment policies express
    - regulatory framework and
    - operator objectives in radio resource usage optimization related to dynamic spectrum assignment

1900.4 System Architecture (8/11)

- RMC ⇔ NRM
  - From NRM to RMC
    - RAN context information requests
  - From RMC to NRM
    - RAN context information
  - RAN context information may include
    - RAN radio resource optimization objectives
    - RAN radio capabilities
    - RAN measurements
    - RAN transport capabilities

1900.4 System Architecture (9/11)

- NRM ⇔ RRC
  - From NRM to RRC
    - RAN reconfiguration requests
  - From RRC to NRM
    - RAN reconfiguration responses

1900.4 System Architecture (10/11)

- NRM ⇔ TRM
  - From NRM to TRM
    - Radio resource selection policies
    - RAN context information
    - Terminal context information related to other terminals
  - From TRM to NRM
    - Terminal context information related to terminal of this TRM

  - Radio resource selection policies create the framework within which TRMs will make terminal reconfiguration decisions

1900.4 System Architecture (11/11)

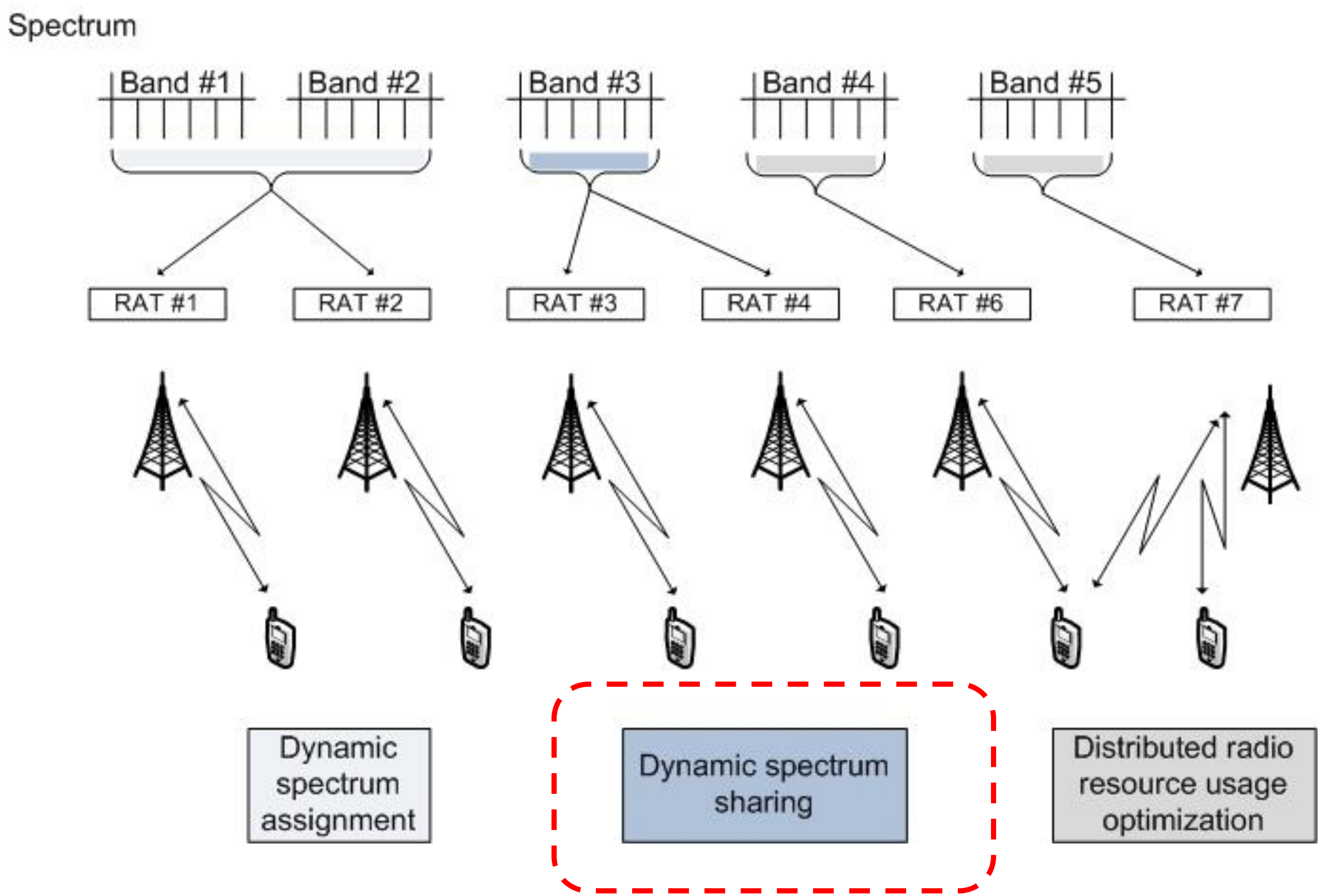
- NRM ⇔ NRM (of different operators)
  - Spectrum assignment policies
  - RAN reconfiguration decisions
  - RAN context information
  - Terminal context information
  - Radio resource selection policies

White Space Communication Enabled by 1900.4 System

Use Case (1/9)

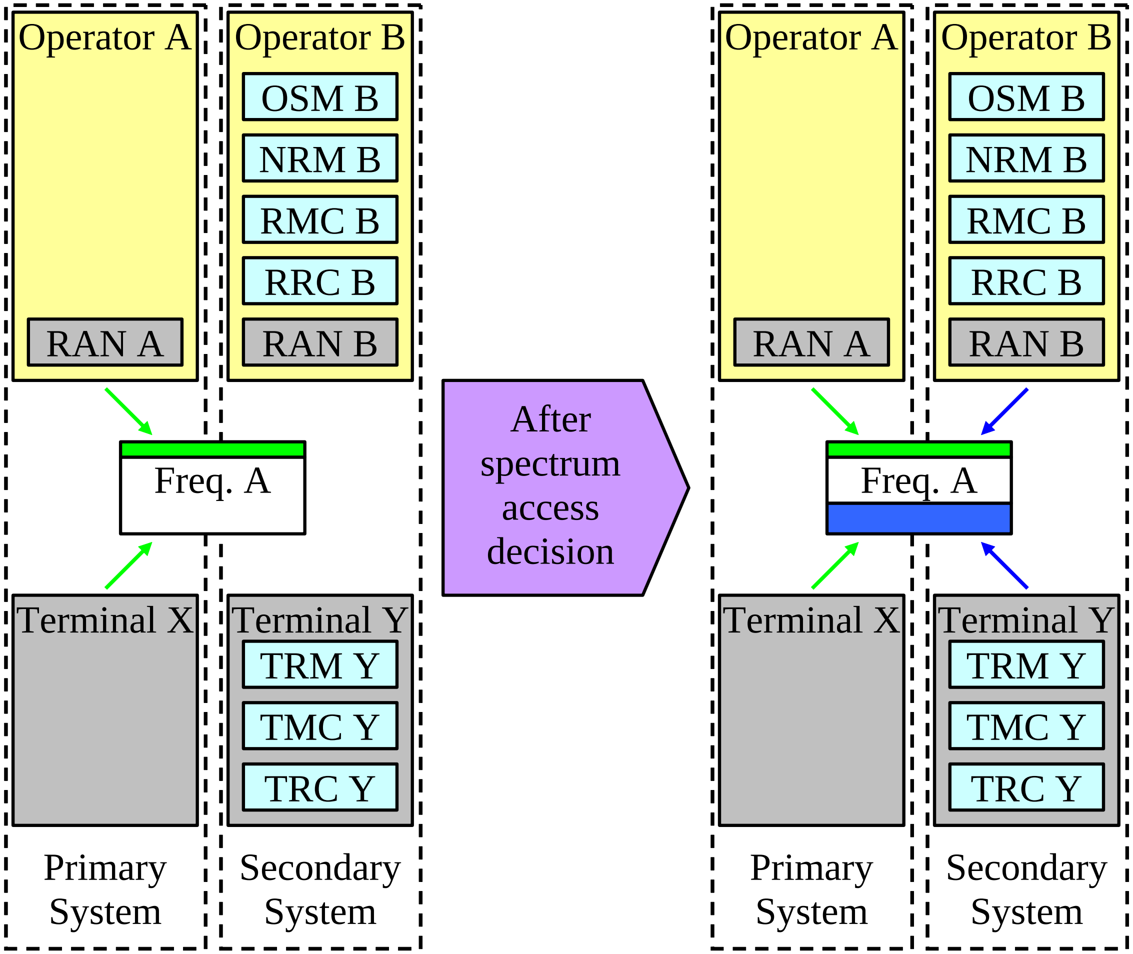
- IEEE 1900.4 has three use cases
  - Dynamic spectrum assignment
  - Dynamic spectrum sharing
  - Distributed radio resource usage optimization
- Among these use cases, dynamic spectrum sharing use case includes white space communication (secondary spectrum usage)
- Two examples of dynamic spectrum sharing use case are given here
  - In example 1, primary wireless system does not have 1900.4 entities inside, while secondary wireless system has
  - In example 2, both primary and secondary wireless systems have 1900.4 entities inside

1900.4 Use Cases (2/9)



Use Case (3/9)

- Example 1



Use Case (4/9)

- Example 1
  - OSM B sends spectrum assignment policies to NRM B
    - These spectrum assignment policies indicate frequency bands allowed for secondary usage
  - NRM B and its TRMs (for example, TRM Y) receive context information
    - RMC B obtains RAN context information from RAN B and sends it to NRM B
    - TMC Y obtains terminal context information from terminal Y and sends it to TRM Y
    - NRM B and TRM Y exchange context information
    - RAN context information and terminal context information contain spectrum sensing information

Use Case (5/9)

- Example 1
  - Based on received spectrum assignment policies and available context information NRM B detects that frequency band A used by primary RAN A has white space and is allowed for secondary use
  - NRM B selects frequency band A for secondary usage by RAN B
  - NRM B reconfigures RAN B correspondingly
    - NRM B selects RAT to be used by RAN B
    - NRM B requests RRC B to reconfigure RAN B
    - RRC B controls reconfiguration of RAN B
  - NRM B generates radio resource selection policies and sends them to its TRMs (for example TRM Y)
    - These radio resource selection policies indicate frequency band and RAT selected by NRM B
    - These radio resource selection policies will guide TRMs in their reconfiguration decisions

Use Case (6/9)

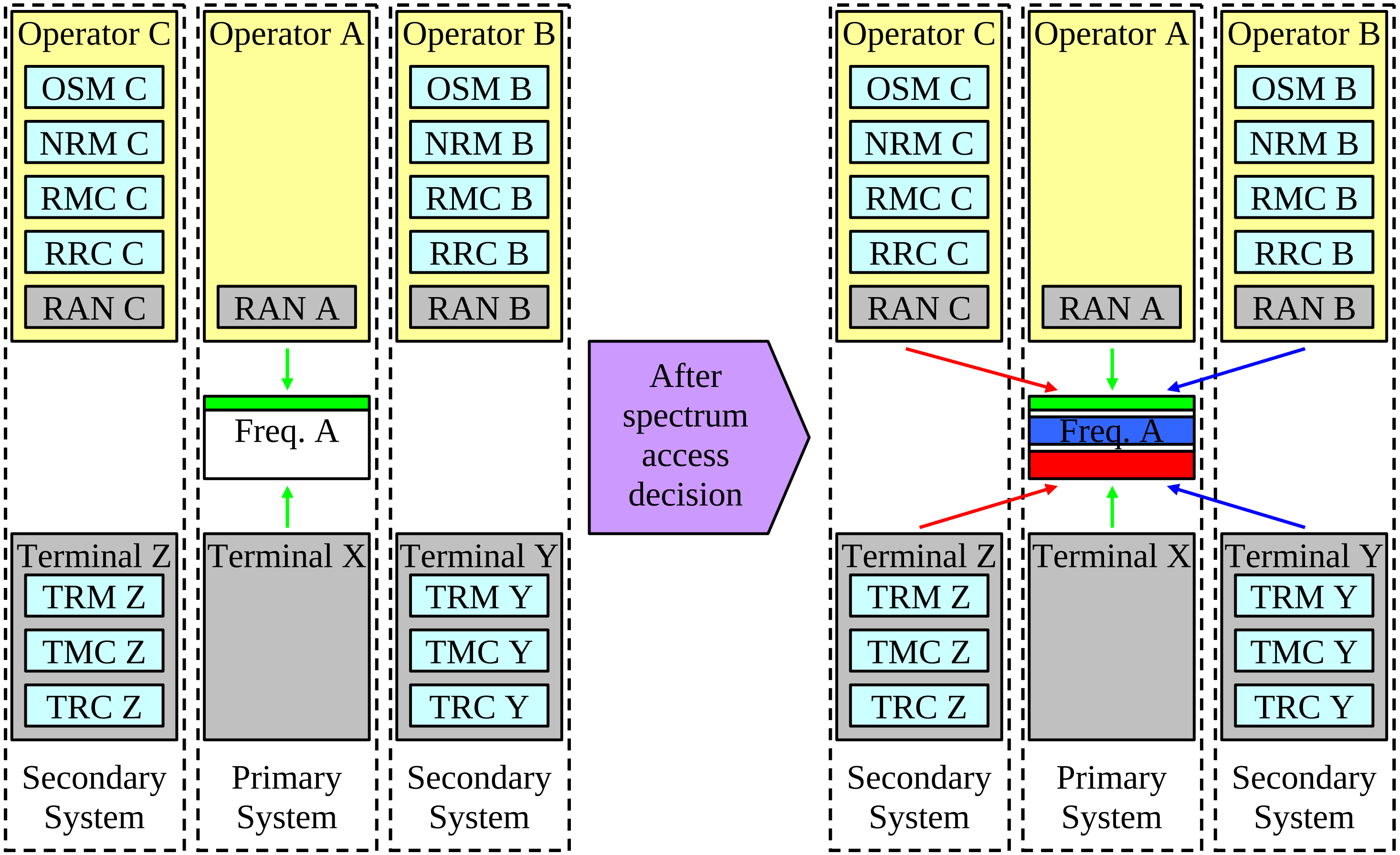
- Example 1
  - Based on received radio resource selection policies and available context information each TRM decides on its terminal reconfiguration
  - Each TRM (for example, TRM Y) reconfigures its terminal correspondingly
    - TRM Y selects RAT to be used
    - TRM Y requests TRC Y to reconfigure terminal Y
    - TRC Y controls reconfiguration of the terminal Y
  - After reconfiguration of RAN B and its terminals (for example, terminal Y), frequency band A is shared by two wireless systems
    - Primary RAN A and its terminals (for example, terminal X)
    - Secondary RAN B and its terminals (for example, terminal Y)

Use Case (7/9)

- Example 1
  - *NOTE 1*
    - Definition of RAN is quite wide in IEEE standard 1900.4
      - "3.1.1 base station: This term is used to refer to any radio node on the network side from radio interface, independently of its commonly used name in a particular standard. Examples of common name are Base Station in IEEE 802.16, Base Transceiver System in cdma2000, Node B in UMTS, Access Point in IEEE 802.11, broadcasting transmitter, etc."
    - This means that primary RAN A can be wireless system providing TV broadcast service
  - *NOTE 2*
    - IEEE standard 1900.4 does not specify or restrict radio access technology (RAT), for example, PHY and MAC layers, that primary RAN A and secondary RAN B use in frequency band A
    - Any appropriate RAT can be used
      - For example, RAT of primary RAN A can be wireless system providing TV broadcast service while RAT selected by secondary RAN B can be according to IEEE 802.22 standard

Use Case (8/9)

- Example 2



Use Case (9/9)

- Example 2
  - Compared to example 1, secondary system B and secondary system C can negotiate with each other before selecting frequency band A for secondary usage
    - This negotiation is done via NRM B ⇔ NRM C interface
  - This can allow better detection of white space in frequency band A
  - Also, this can allow efficient usage of white space in frequency band A, where RAN B and RAN C, for example, use different parts of white space in frequency band A

Coexistence Mechanisms (1/5)

- Spectrum assignment policies
  - OSM sends spectrum assignment policies to NRM
  - These spectrum assignment policies express regulatory framework
  - For example, for white space communication spectrum assignment policies can describe frequency bands allowed for secondary usage and specific constraints for using these frequency bands
  - Spectrum assignment policies are mandatory for NRM

Coexistence Mechanisms (2/5)

- Radio resource selection policies
  - NRM sends radio resource selection policies to its TRMs
  - These radio resource selection policies create framework for TRM reconfiguration decisions
  - For example, for white space communication radio resource selection policies can ensure that TRM will make reconfiguration decisions compliant with regulatory framework defined by spectrum assignment policies
  - Radio resource selection policies are mandatory for TRMs

Coexistence Mechanisms (3/5)

- Context information
  - TMC provides terminal context information to TRM
  - RMC provides RAN context information to NRM
  - TRM and NRM exchange context information
  - NRMs of different operators exchange context information
  - For example, for white space communication context information can contain spectrum sensing information for dynamic detection of white space
  - Context information serves as a basis for NRM and TRM reconfiguration decisions

Coexistence Mechanisms (4/5)

- Interactions of NRMs of different operators
  - NRMs of different operators can exchange
    - Spectrum assignment policies
    - RAN reconfiguration decisions
    - RAN context information
    - Terminal context information
    - Radio resource selection policies
  - For example, for white space communication such NRM ⇔ NRM interactions can allow better detection and usage of white space

Coexistence Mechanisms (5/5)

- Coexistence mechanisms summary for white space communication
  - Primary ⇔ secondary coexistence
    - Spectrum assignment policies
    - Radio resource selection policies
    - Context information
  - Secondary ⇔ secondary coexistence
    - Interactions of NRMs of different secondary operators

Conclusions

- White space communication (primary/secondary spectrum usage) is included into dynamic spectrum sharing use case of IEEE standard 1900.4
- Features of white space communication enabled by 1900.4 system
  - Fixed and/or mobile wireless access is supported
  - Frequency band and RAT (e.g. PHY and MAC) are not specified or restricted
    - Any appropriate frequency band and RAT can be used
  - Multiple coexistence mechanisms are defined
    - Primary ⇔ secondary coexistence
    - Secondary ⇔ secondary coexistence

For Further Information

- http://grouper.ieee.org/groups/scc41
- http://grouper.ieee.org/groups/scc41/4/index.htm
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