Cognitive Radio based Spectrum Sharing in the Television Broadcast Bands

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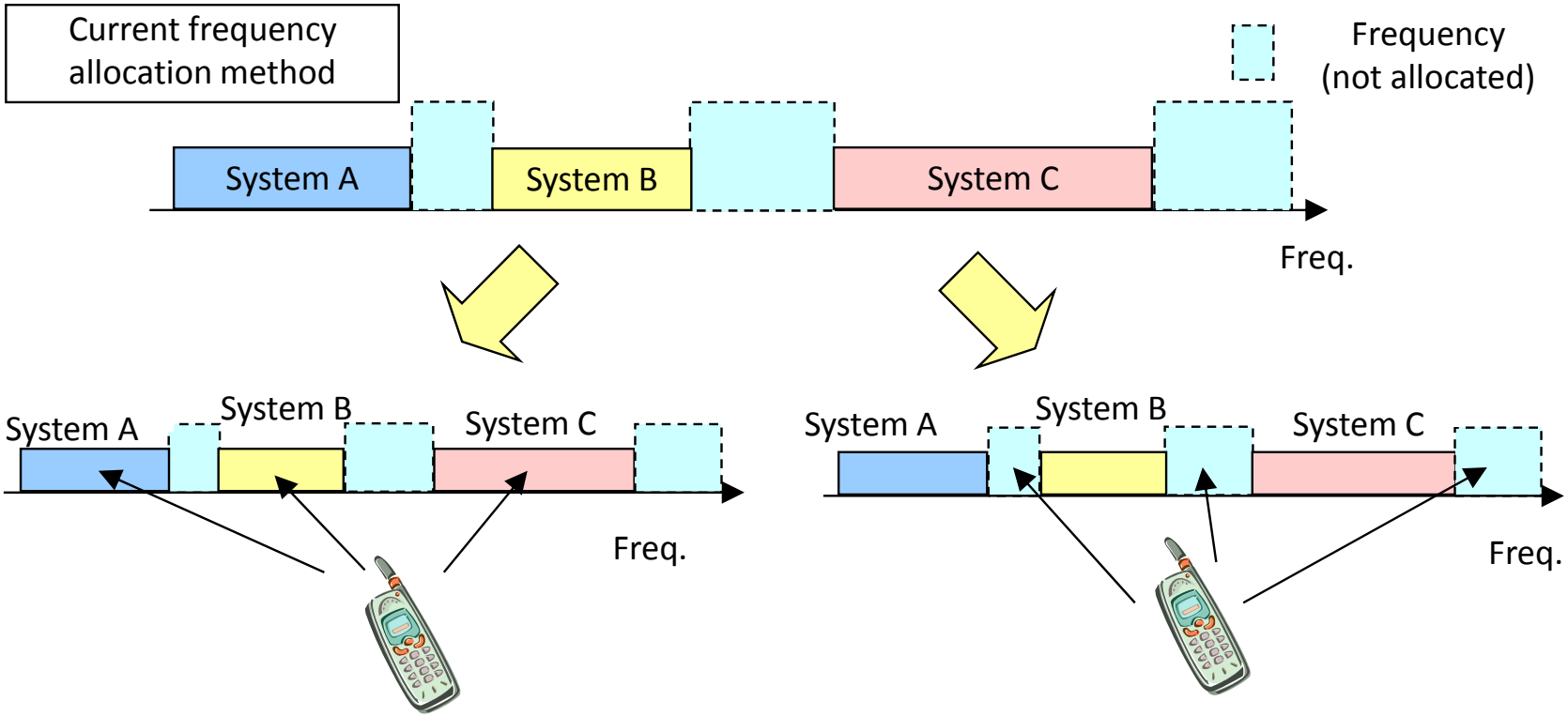
Cognitive radio

Cognitive radio is a radio or system that senses, and is aware of, its operational environment and can dynamically and autonomously adjust its radio operating parameters accordingly by collaborating wireless and wired networks



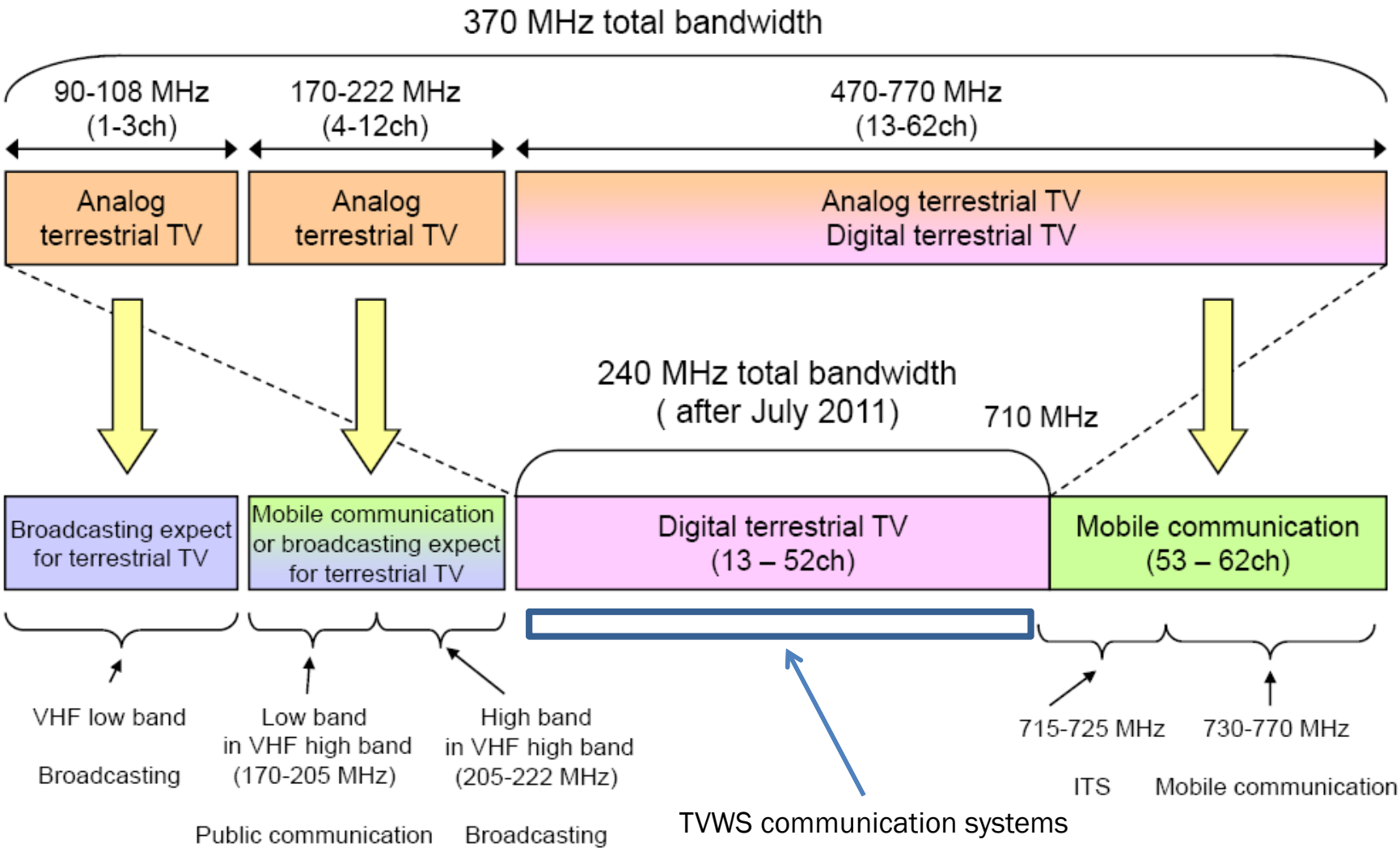
(a) Heterogeneous type cognitive radio

(b) Spectrum sharing type cognitive radio

By sensing frequency bands that systems have been allocated on and time slots, users secure adequate bandwidth by selectingexisting systems.

By sensing vacant frequency band and time slot, users secure adequate bandwidth by bundling vacant freq. bands.

Frequency allocation chart (VHF,UHF)

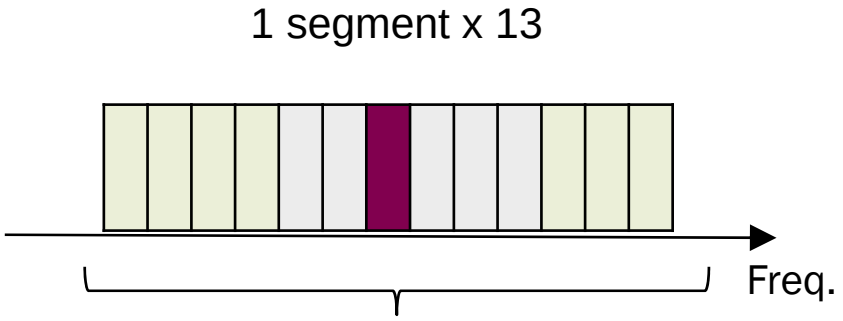


History of regulation deployment

Month/Year	Document
Nov. 2009	Investigation team concerning ideas for the use of new radio waves launched.
Dec. 2009	Call for proposal for the usage of white space, more than 100 proposals are submitted.
Jul. 2010	Investigation team selected 10 proposals as preceding model. **All propose dedicated area broadcasting service based on one segment type ISDB-T broad casting** (Area broadcasting service).
Aug. 2010	Investigation team report summarized. “Promote new frequency utilization such as white space and find possibilities for local revitalization, business opportunities, and engineering innovation.”
Sept. 2010	Council for White Space Promotion launched.
Sept. 2010	MIC called for the proposal on special white space areas and its usage. 44 proposals were submitted.
Oct. 2010	Broadcasting system committee, Information and Communications Council launched a working group for white space utilized broadcasting system.
Apr. 2011	25 proposals (white space areas) were accepted; 23 area broadcasting services, 1 wireless broadband, and 1 sensor network.
Sept. 2011	WG for coexistence in white space applications launched.
Mar. 2012	White space utilized broadcasting system WG first report issued.
Apr. 2012	Commercial services of area broadcasting started
Sept. 2012	WG for coexistence issued a report on summary of discussion on coexistence mechanism.

Oneseg broadcasting service

- ISDB-T
  - 6 MHz/ channel
  - Divided13 segment (13 OFDM segment) in a channel
  - Can divide maximum three parts
  - OFDM transmission scheme based
- Standardized in ARIB STD-B31 and TR-B14 (operational rules)
- Oneseg broadcasting is mainly used for mobile broadcasting



ISDB-T one channel (6 MHz)

	Oneseg specification		
Bandwidth	428.57 kHz		
	Mode 1	Mode 2	Mode3
Subcarrier spacing (kHz)	5.968	1.984	0.992
Num of subcarrier	108	216	432
Symbol duration (us)	252	504	1008
Guard interval	¼,1/8,1/16,1/32		
FEC(inncer code)	Convolutional (1/2,2/3,3/4,5/6,7/8)		
Outer code	RS(204,188)		

Current status

- Five main applications are under discussion in the Council for White Space Promotion in MIC
  - Wireless microphone
  - Ubiquitous broadcasting (Area-one-segment broadcasting service, Area oneseg)
  - Wireless access systems for emergency situation (disaster)
  - Sensor network
  - Wireless broadband

- Area oneseg services have been permitted to do actual services in TV white space with conditions summarized by White space utilized broadcasting system WG, Broadcasting system committee, Information and Communications Council in MIC
  - Not license-exempt
  - Actual services can be started **(Japan is second country that allows commercial frequency sharing service of TV white space)**

- Coexistence between needs to be considered
  - Between Primary system (TV) and secondary systems
  - Between secondary systems

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Working group for coexistence in white space applications

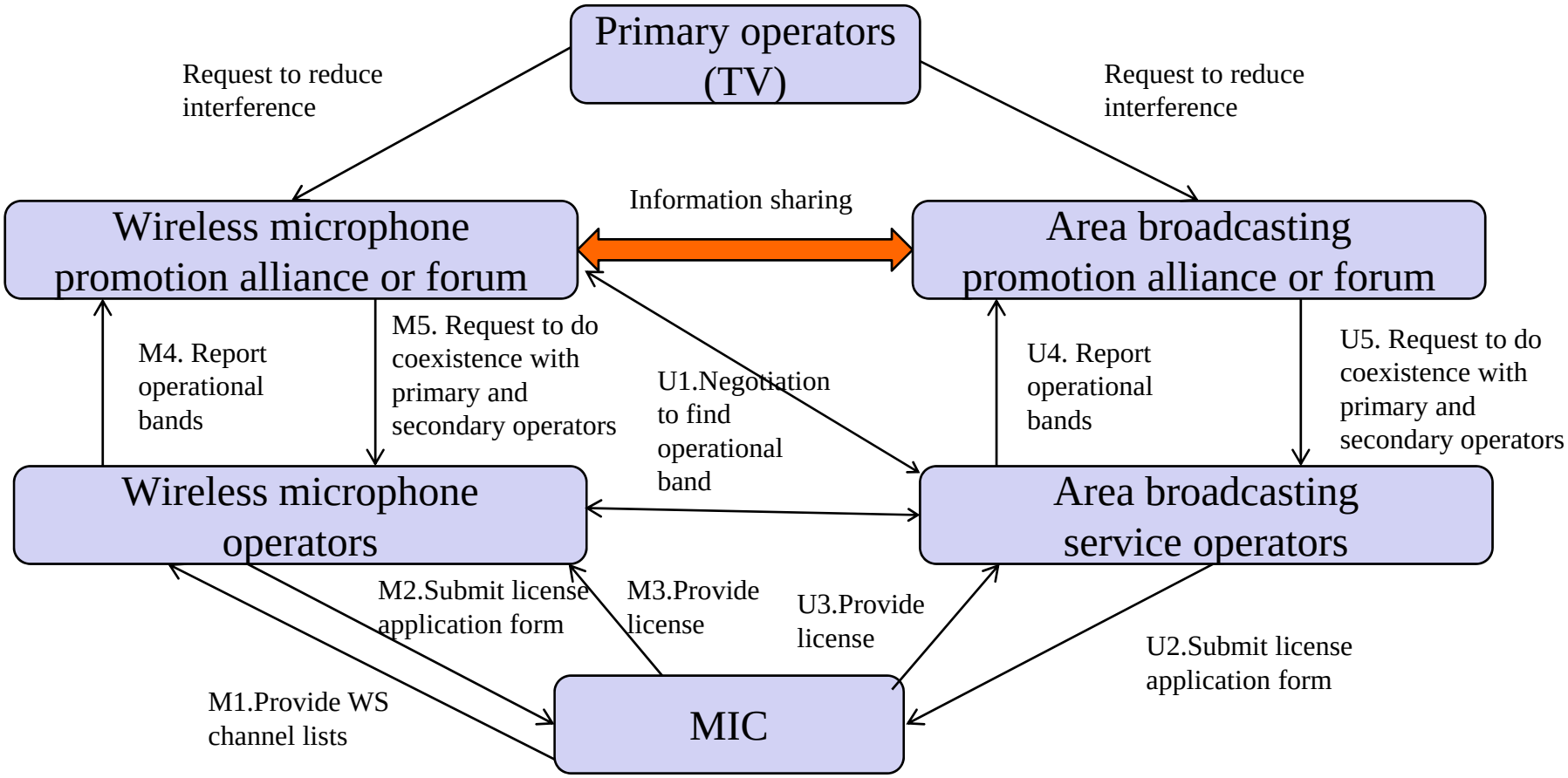
- Objectives and mission
  - Study coexisting mechanism in white space applications from the viewpoint of technical, institutional, and operation aspects
  - Report the conclusions to the meeting Meeting for White Space Promotion

- Status
  - September 2011: Working group launched
  - March 2012: First report issued

Current status

- Coexistence mechanism between white space systems is being discussed in the committee for white space promotion, MIC
  - Points to be discussed
    - Who provide available channel map on white space: MIC (but for wireless microphone operator)
    - Who permit to use white space: MIC
    - Will use WSDB ?: No, MIC will check the availability for regulation and provide license
    - Who will manage coexistence between WS systems: Continue to discuss
  - Provided a report on summary of discussion and future plan and opened it on September, and public comment was done.
  - The report mainly summarized how to coexist between WS systems.
    - Mainly for coexistence between wireless microphone and ubiquitous broadcasting
    - Coexistence including WS communication systems will be discussed after deciding coexistence mechanism between wireless microphone and ubiquitous broadcasting. R&D is encouraged for the topics
    - WSDB is NOT considered but the study and R&D of the WSDB is encouraged

Coexistence mechanism proposed in the report



- Provide channel list
- Update channel list
- Evaluate application of license
- Provide license

Standardization and development of TVWS devices

(Mainly contributed by NICT)

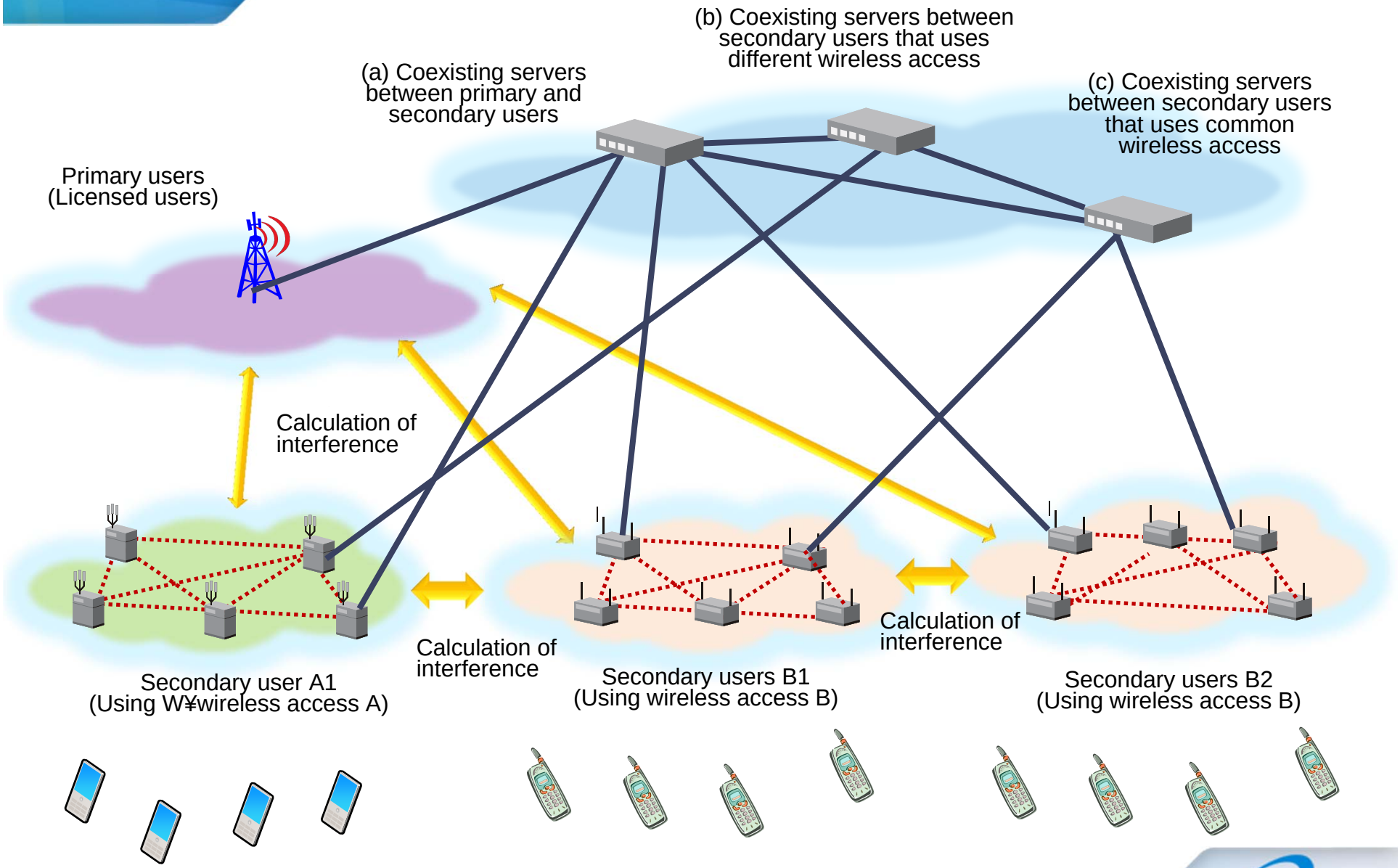
NICT's experts on white space communications

- Contributed to IEEE 802/1900 standards and alliances and trials
  - Taking leadership in WS communications standards
    - Chair: IEEE 1900, IEEE802.22b, IEEE802.19.1 (ex)
    - Vice Chair : IEEE802.11af, IEEE 802.22, IEEE802.15.4m
    - Board od Directors: Wireless Innovation forum, whitespace alliance
  - From 2006, NICT provided more than 1200 contributions to IEEE802
  - Done several WS trials in Japan and Singapore (member of Singapore White Space Pilot Group)
- Developed WS databases supporting US and Japan
  - Support multiple contour calculation algorithms (Japan, US FCC)
- Developed world's standards IEEE802 based WS products
  - World's first IEEE802.22 BS and CPE (Demonstrated in Supper WI-FI summit and NAB show)
  - World's first IEEE802.11af BS and MT
  - World's first IEEE802.15.4m (NB-OFDM) products
  - World's first tablet terminal based on IEEE802.11

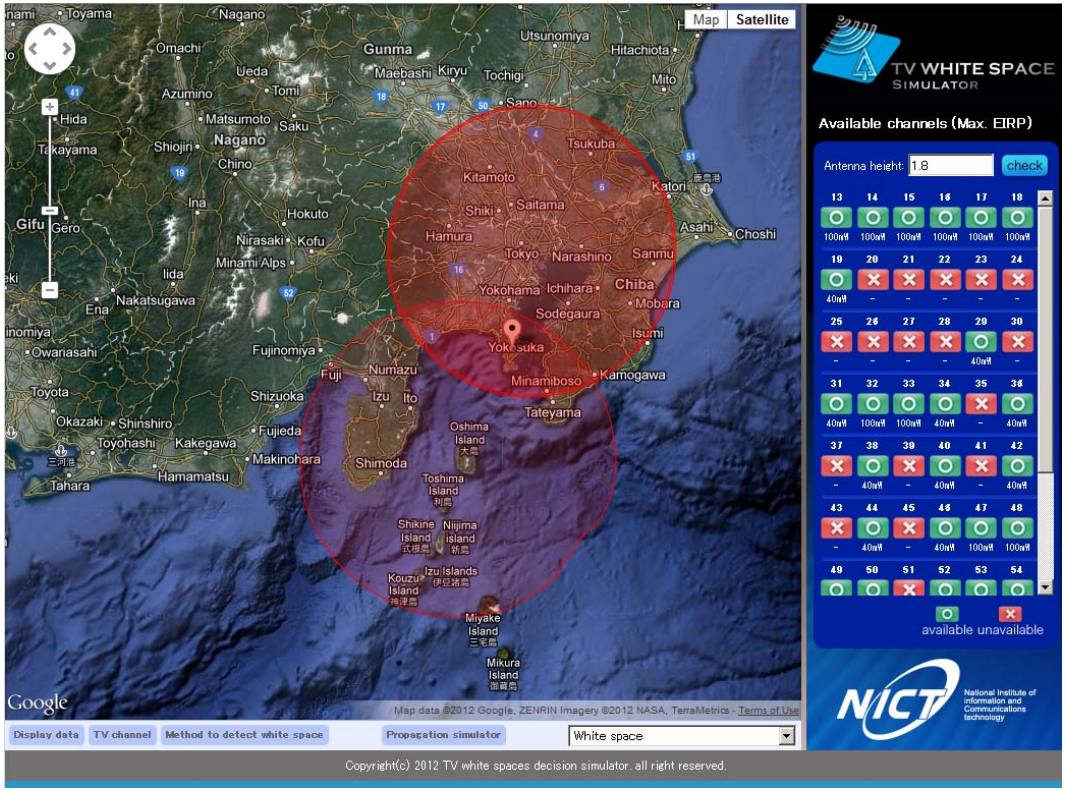
NICT's contribution to world standards

Standardization body	Working group (WG)	Title of project	**Leadership by NICT**
IEEE 802	802.22	Standard for cognitive wireless regional area network medium access control (MAC) and physical layer (PHY) specification: policies and procedures for operation in TV bands	Vice Chair, Secretary
	802.22b	Standard for enhancement for broadband services and monitoring applications	Chair, Secretary
	802.11af	Standard for wireless local area network medium access control (MAC) and physical layer (PHY) specifications: TV white spaces operation	Vice Chair, Secretary
	802.15.4m	Standard for low rate wireless personal area network: TV white space between 54 MHz and 862 MHz physical layer	Vice Chair, Technical Editor, Secretary
	802.19.1	Standard for TV white space coexistence methods	Chair, Technical Ediitor
IEEE Dyspan Standards Committee	1900.7	Standard for radio interface for white space dynamic spectrum access radio systems supporting fixed and mobile operation	Chair
	1900.4a	Standard for architecture and Interfaces for Dynamic Spectrum Access Networks in White Space Frequency Bands	Vice Chair
	1900.4.1	Standard for interfaces and protocols enabling distributed decision making for optimized radio resource usage in heterogeneous wireless networks	Vice Chair

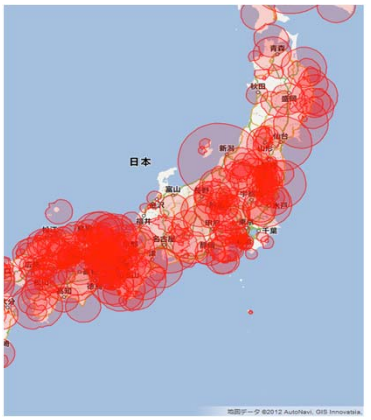
A fundamental configuration of WS communication systems



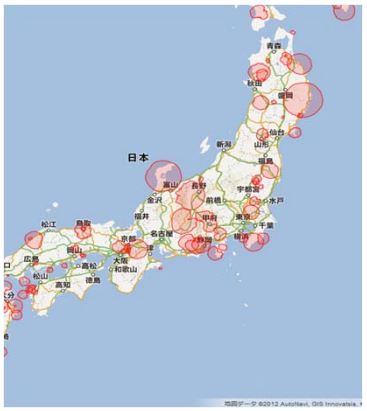
NICT's world's first WSDB supporting Japan and US primary systems' protection



NICT'S TVWS database
(Technically transferred to ISB corporation)



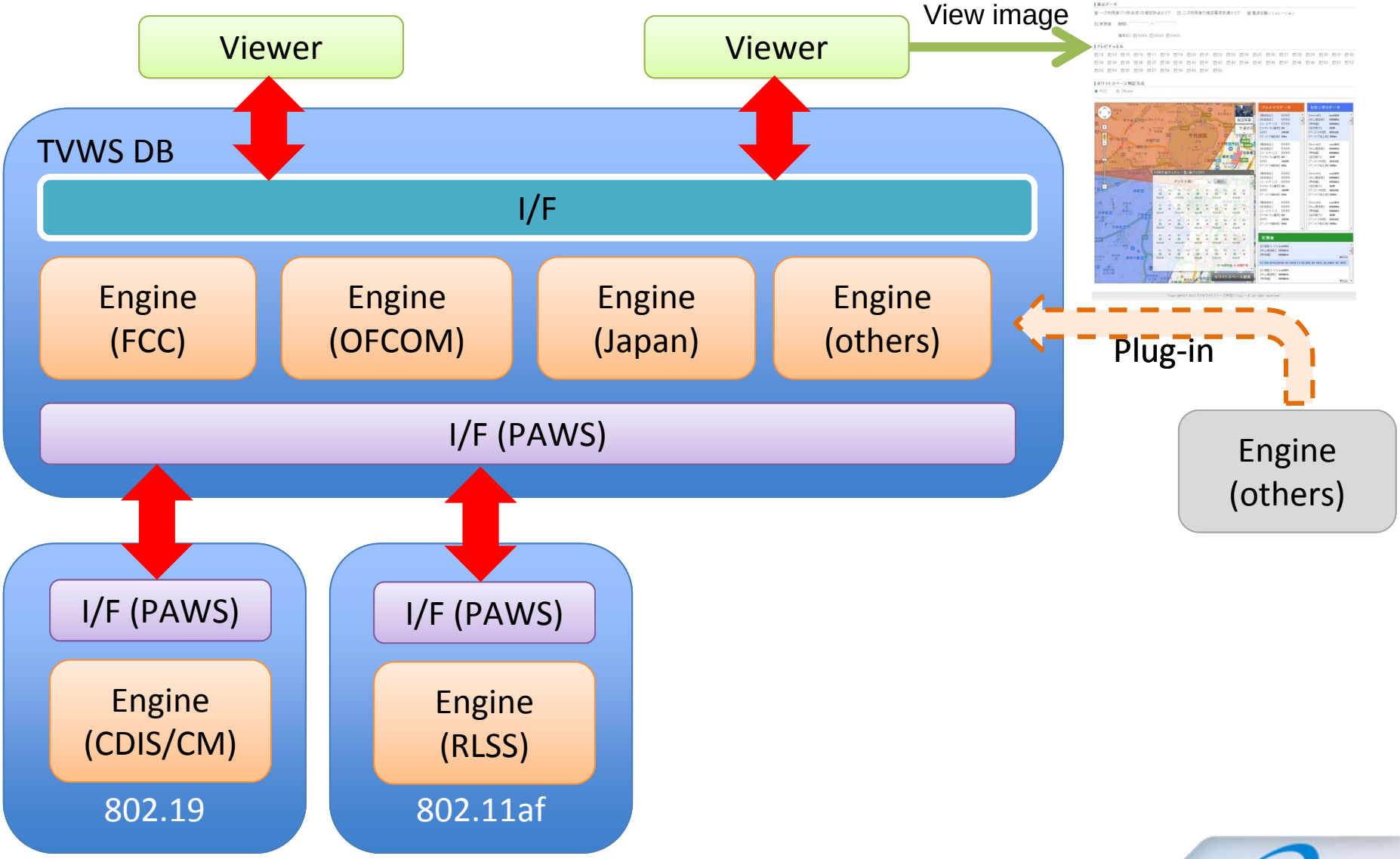
Contour calculation (13 ch) based on FCC algorithm



Contour calculation (52 ch) based on FCC algorithm

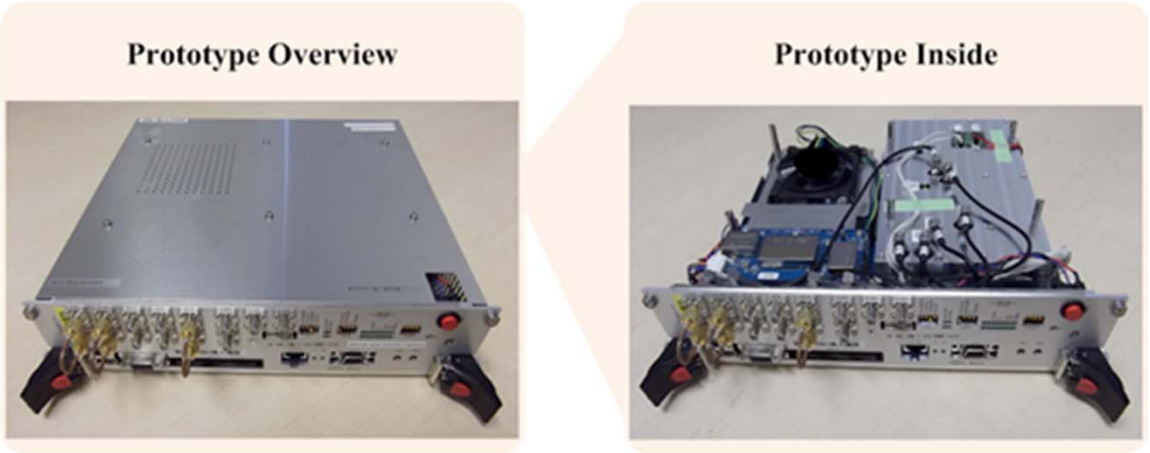
Contour calculation based on NICT original calculation algorithm

Configuration of developed database



NICT's world's first products

IEEE 802.11af/a based TVWS/2.4G access point
and
IEEE 802.11 based TVWS/2.4 G tablet terminal

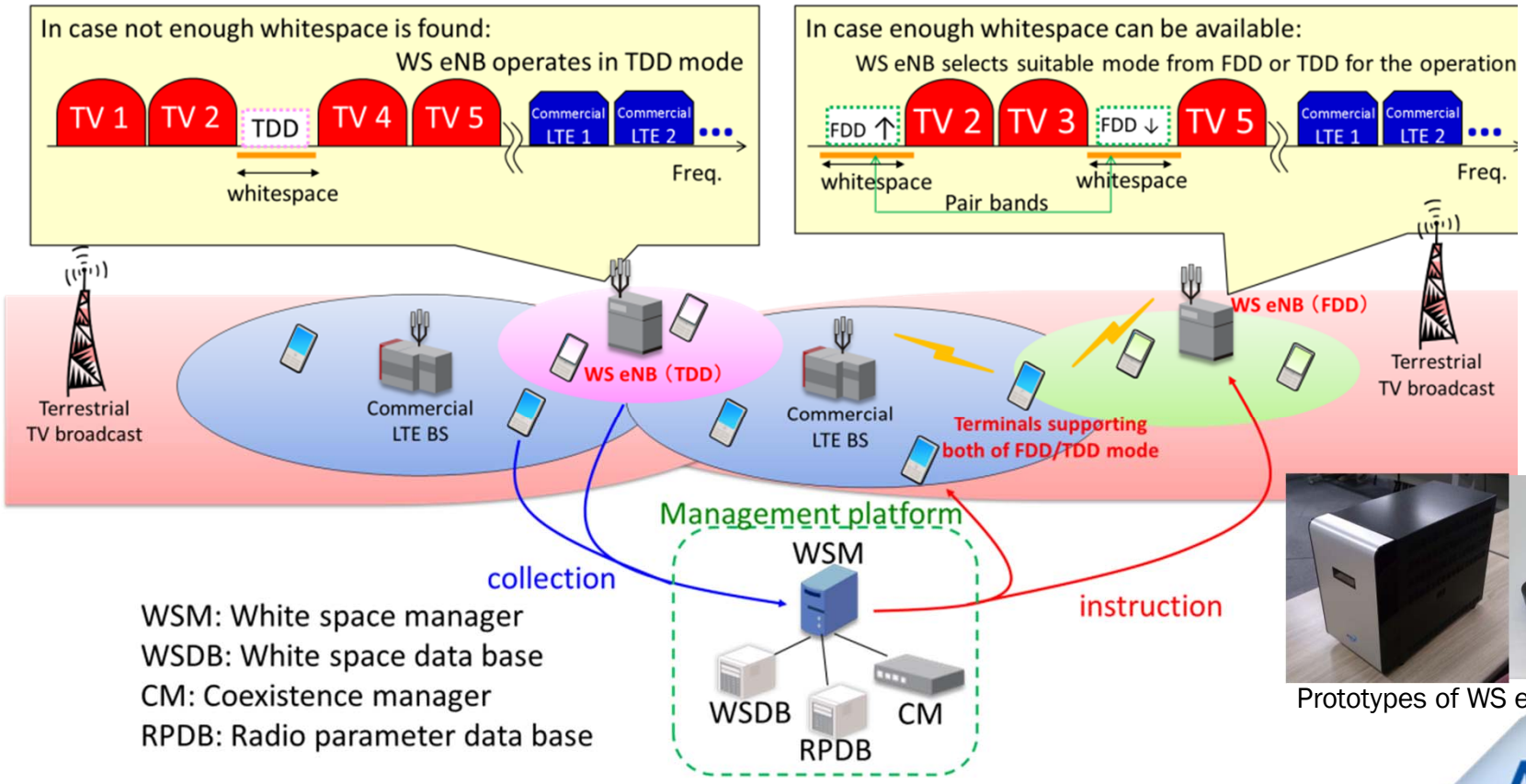


IEEE 802.22 radio for regional area network (Demonstrated Super WiFi Summit and NAB show)

IEEE 802.15.4m NB-OFDM radio for sensor networks

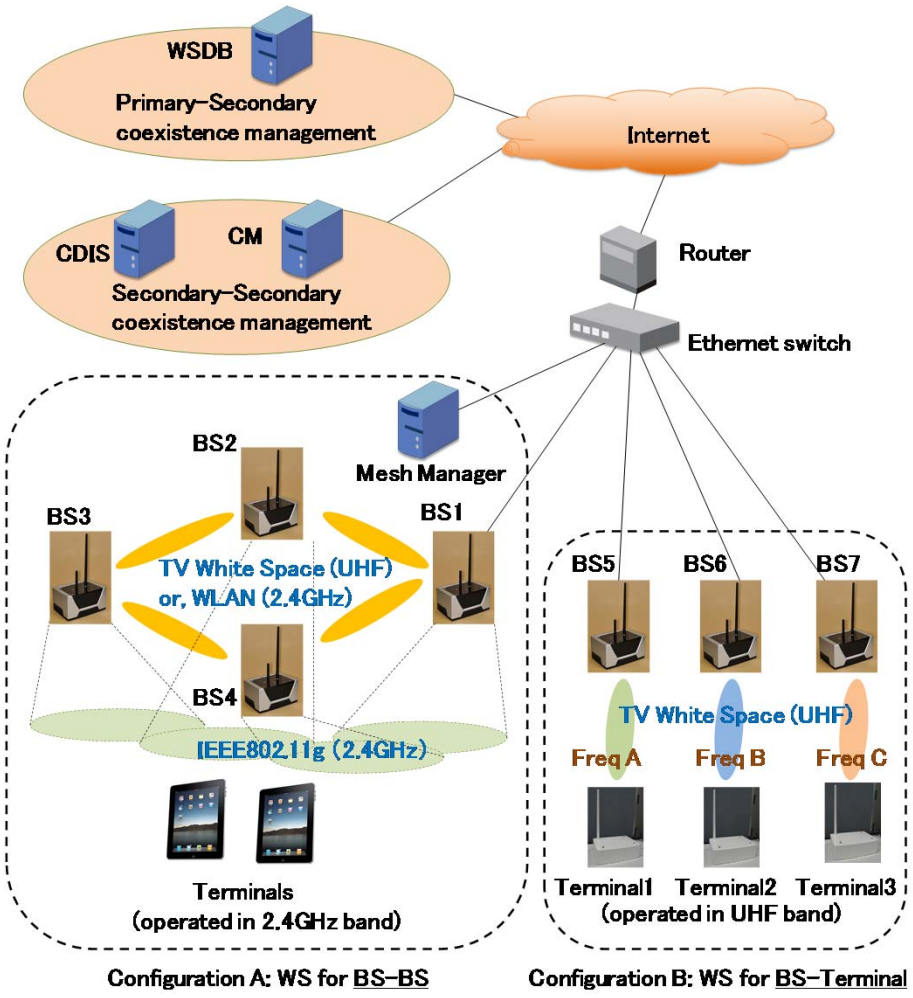
LTE system on white space

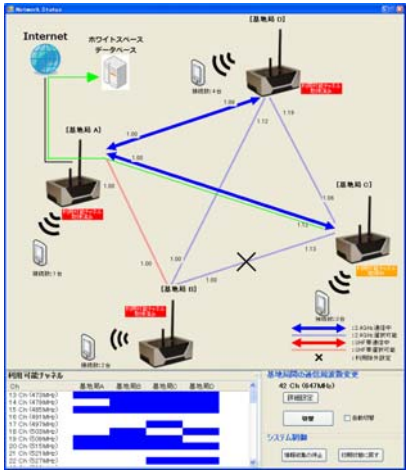
- Long Term Evolution (LTE) base stations (eNode B, eNB) and terminals on UHF TV white space bands
  - Contribute to reduce the load on commercial LTE bands
  - Can be implemented to commercial LTE devices with low cost
- Study of management framework and device technologies is on going



Prototypes of WS eNB and termianl

White space mesh network (TVWS,2.4G)





Configuration of mesh manager

Conclusion

- Since Nov. 2009, white space operation has been discussed in Ministry of Internal Affairs and Communications (MIC) in order to secure bandwidth
- Five main applications are under discussion in the Meeting (Council) for White Space Promotion in MIC
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  - Not license-exempt
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- Coexistence WG is launched under council for white space promotion and has reported about coexistence mechanism. Usage of white space data base is under consideration
- Regarding wireless broadband and sensor network, IEEE 802 based prototype has been developed by NICT
- White space database has been developed, and several contour prediction and interference prediction algorithm are being studied