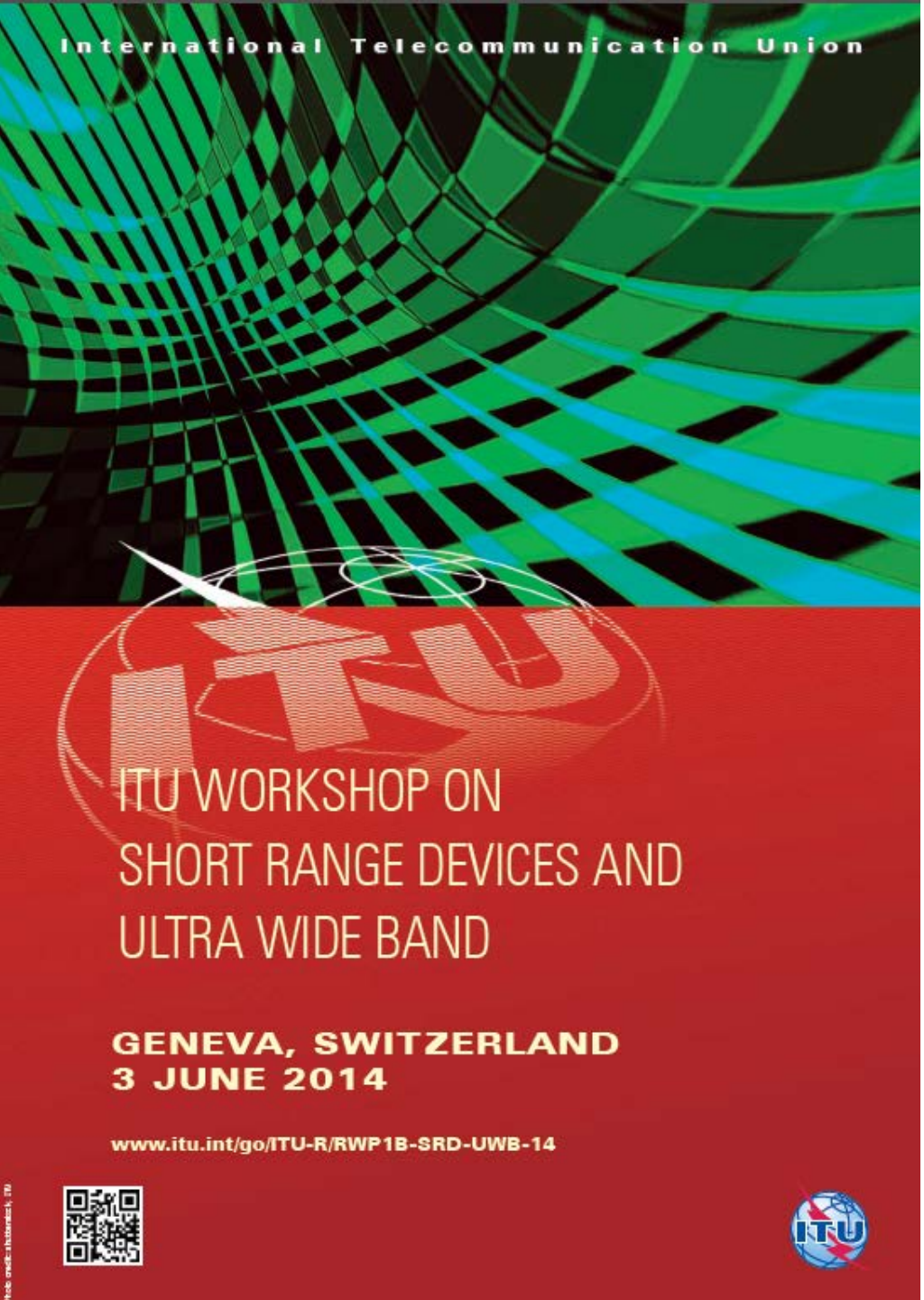


ITU WORKSHOP on
SHORT RANGE DEVICES (SRDs)
AND ULTRA WIDE BAND (UWB)
(Geneva, 3 June 2014*)

APT Activities on SRD Frequency Usage Harmonisation

Dr Masayuki Ariyoshi
Chairman of the APT/AWG TG-SRD

** in conjunction with the June 2014 block of meetings of ITU-R Study Group 1*

Outline

- SRD related status in Asia-Pacific
  - SRD implementations
  - SRD operations
  - Introduction of SRD applications and services
- Towards harmonised use of SRDs
  - Regulatory aspects: frequency band and output power
  - Technical aspects: related R&D activities for advanced technology on SRD

Definitions of SRD

- Report ITU-R SM.2153-4:
  - Short-range Radiocommunication Devices (SRDs) are intended to cover radio transmitters which provide either unidirectional or bidirectional communication and which have low capability of causing interference to other radio equipment.
  - Such devices are permitted to operate on a non-interference and non-protected basis.

Recent Activities in APT/AWG

- Survey on SRD operations
  - SRD type approval process, Mutual Recognition Arrangement (MRA), licensing requirements, etc
  - APT/AWG/REP-07 (rev 2): adopted in August 2008, revised in Sept 2008 and in Sept 2012
- Survey on SRD introduction, applications, issues and technologies
  - Rather focusing on SRD services and applications in operation, especially in ISM band
  - APT/AWG/REP-31: adopted in Sept 2012, currently being revised
- Frequency bands for harmonised use of SRDs
  - Summary of implementation status and directions for harmonised use of SRDs including possible frequency bands for harmonisation
  - APT/AWG/REP-35: adopted in March 2013

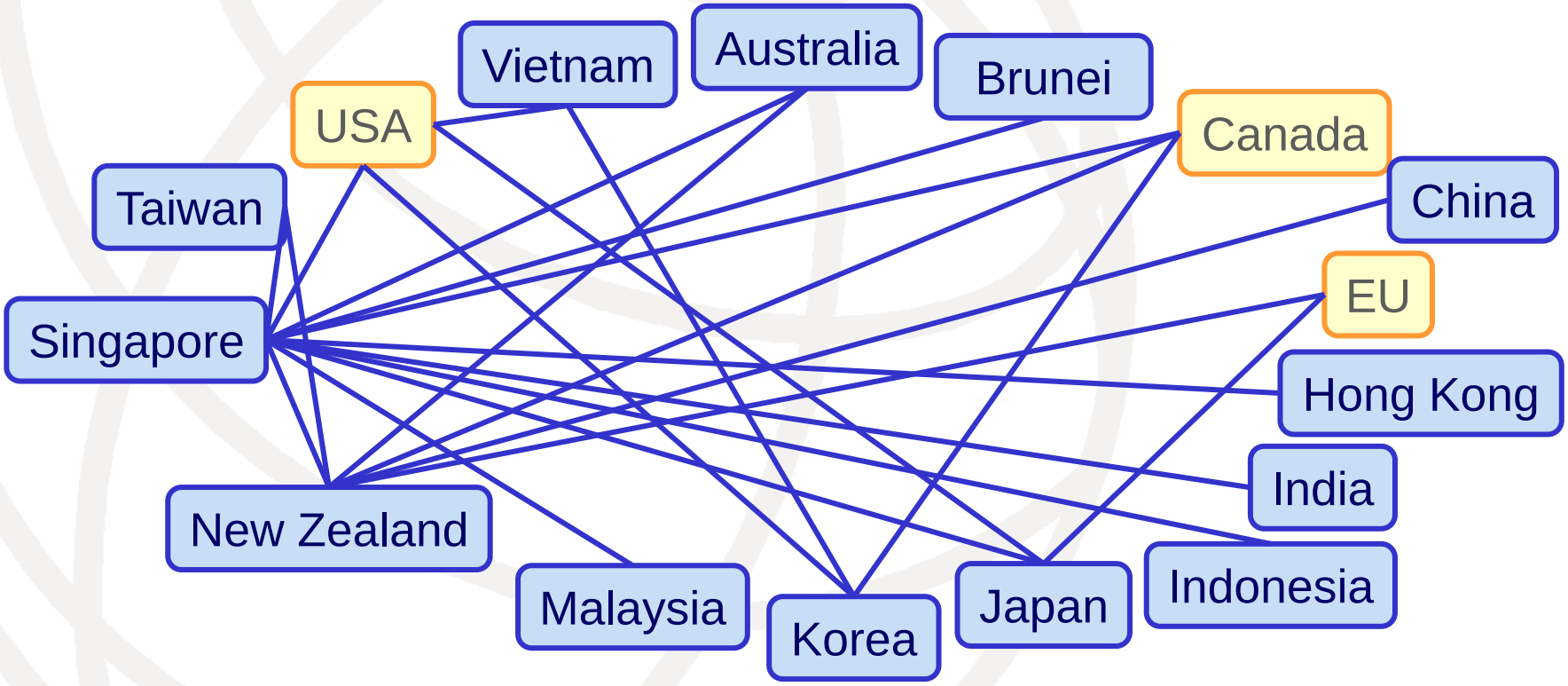
Status of SRDs Implementation

Frequency band	Remarks	AUS	BRU	CTN	CHN	J	KOR	LAO	MLA	MYN	Macao	PNG	RMI	SNG	THA	VTN
9-148.5 kHz		Y	P	Y	Y	N	Y	Y	Y	N	Y	N	N	Y	P	P
148.5-315 kHz		N	N	U	P	N	P	N	Y	N	N	U	N	N	N	N
3 155-3 400 kHz	RR No.5.116	Y	Y	U	Y	P	Y	Y	Y	N	N	U	N	N	N	N
6 765-6 795 kHz	RR No.5.138	U	Y	Y	Y	Y	U	U	Y	N	N	U	N	N	N	N
7 400-8 800 kHz		Y	Y	Y	P	N	P	N	U	N	N	U	N	N	N	N
13.553-13.567 MHz	RR No.5.150	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	U	N	Y	Y	Y
26.957-27.283 MHz	RR No.5.150	Y	Y	Y	Y	Y	P	Y	Y	Y	Y	U	N	Y	P	Y
40.66-40.7 MHz	RR No.5.150	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	U	N	Y	P	Y
312-315 MHz		Y	Y	N	P	Y	N	N	Y	Y	N	U	N	Y	Y	Y
433.05-434.79 MHz		Y	Y	Y	Y	P	P	Y	Y	N	N	U	[P]	Y	Y	Y
401-402 MHz		Y	N	U	N	N	U	Y	U	N	N	U	N	Y	Y	Y
402-405 MHz		Y	N	U	N	Y	Y	Y	Y	N	N	U	N	N	Y	[P]
405-406 MHz		Y	N	U	N	N	U	Y	Y	N	N	U	N	N	Y	Y
862-875 MHz		N	P	P	N	N	N	Y	Y	N	N	U	U	P	N	P
875-960 MHz		N	P	P	P	P	P	N	Y	N	N	N	[P]	P	P	P
2 400-2 483.5 MHz	RR No.5.150	P	Y	Y	Y	Y	Y	Y	Y	Y	Y	U	N	Y	Y	Y
5 150-5 350 MHz		Y	P	Y	N	Y	Y	Y	N	Y	N	U	[P]	Y	Y	Y
5 470-5 725 MHz		Y	P	Y	N	Y	P	Y	N	Y	N	U	[P]	Y	Y	Y
5 725-5 875 MHz	RR No.5.150	Y	Y	Y	Y	Y	P	Y	Y	Y	P	U	[P]	Y	P	P
24.00-24.25 GHz	RR No.5.150	Y	Y	Y	Y	Y	P	Y	Y	N	N	U	[P]	Y	P	Y
61.0-61.5 GHz	RR No.5.138	Y	N	Y	N	Y	Y	Y	Y	N	N	U	N	Y	U	N
76-77 GHz		Y	Y	Y	Y	Y	Y	N	Y	Y	N	U	N	Y	Y	N
122-123 GHz	RR No.5.138	U	U	Y	N	Y	U	Y	Y	N	N	U	N	N	N	N
244-246 GHz	RR No.5.138	U	U	Y	N	Y	U	Y	Y	N	N	U	N	N	N	N

Y: Yes, implemented already P: Partially implemented U: Under implementation N: Not [available or undecided]

Status of SRD Operation

- Radio equipment type approval process and related
  - In the most of the APT countries
- Mutual Recognition Arrangement with other countries/regions (as of Sept 2012)



Status of SRD Introduction

- It has been seen that SRD connectivity in ISM bands is getting widely introduced in APT countries
- Introduced in:
  - PCs, tablets, mobile phones
  - Digital devices (camera, recorder, etc), games, portable audios
  - Wireless AP, mobile routers
  - medical equipment, wireless microphones, etc
- Deployed in:
  - Airports, train stations, café, shopping mall, public offices, schools, museums, …

Towards Frequency Harmonisation

- There are differences in implementation status, power limits and other technical parameters for SRDs in Asia-Pacific region
- However, regionally harmonised frequency bands and technical rules for SRDs would be desirable
- It is also noted that even when the same band is allowed for SRD operation, the type of application designated for SRDs may not be the same; resulting in different categories of SRDs operating under various output power levels
- What to be harmonised?
  - Frequency bands and typical applications
  - RF output power levels

Benefits of Global/Regional Harmonisation

- Harmonised use for SRDs provides benefits for SRD end users, manufacturers, and regulators:
  - greater user confidence in the reliable functioning of devices when travelling abroad;
  - a broader manufacturing base and increased volume of equipment (globalisation of markets) resulting in economies of scale and expanded equipment availability;
  - improved spectrum utilisation;
  - potential reduction in the influx of illegal or non-conforming SRDs into the marketplace of some countries

Frequency Bands Already Harmonised

- Some frequency bands have been harmonised for typical applications in Asia-Pacific
  - across Brunei, Hong Kong, Japan, Korea, Malaysia, Philippines, New Zealand, and Singapore

Typical Applications	Frequencies / Frequency band (MHz)	Range of the maximum power level
Cordless Phones / Telemetry	315	25uW to 10mW e.r.p
Medical Implant	402-405	25uW e.r.p
RFID	433.92	1mW to 25m W e.r.p
WLAN	2400-2483.5	10mW to 1000mW e.i.r.p
Vehicle Radar	76000-77000	10mW to 100W e.i.r.p

  - across Hong Kong, Korea, Philippines, New Zealand, and Singapore

Typical Applications	Frequencies / Frequency band (MHz)	Range of maximum power level
RFID	13.553-13.567	100 mW (e.i.r.p) / 42 dBµA/m at 10m
	26.96-27.28	0.5W to 3W e.r.p / 42 dBµA/m at 10m
Model Control	40.66-40.70	100 mW to 1000mW e.r.p
	72-72.25	10 mW to 750 mW e.r.p
Cordless Phones	864.8-865	10 mW to 1000 mW e.r.p
WLAN	5725-5850	10 mW to 4W e.i.r.p

Frequency Bands for Further Harmonisation

- There are certain frequency bands for SRDs in all regions
  - Recommendation ITU-R SM.1896: frequency ranges for SRD global harmonisation
  - Most of these frequency bands are ISM bands and SRDs are allowed to operate within these bands under the condition accepting harmful interference which may be caused by these applications
- Possible frequency bands for harmonisation of SRDs in Asia-Pacific region

Frequency band	Typical Application	Remarks
402-405 MHz	Medical Implant	APT REC-05
433.05-434.79 MHz	RFID	APT REP-07
862-960 MHz	RFID	APT REC-03
5150-5350 MHz	WLAN	APT REC-06
5470-5725 MHz	WLAN	
76-77 GHz	Vehicle Radar	APT REP-07

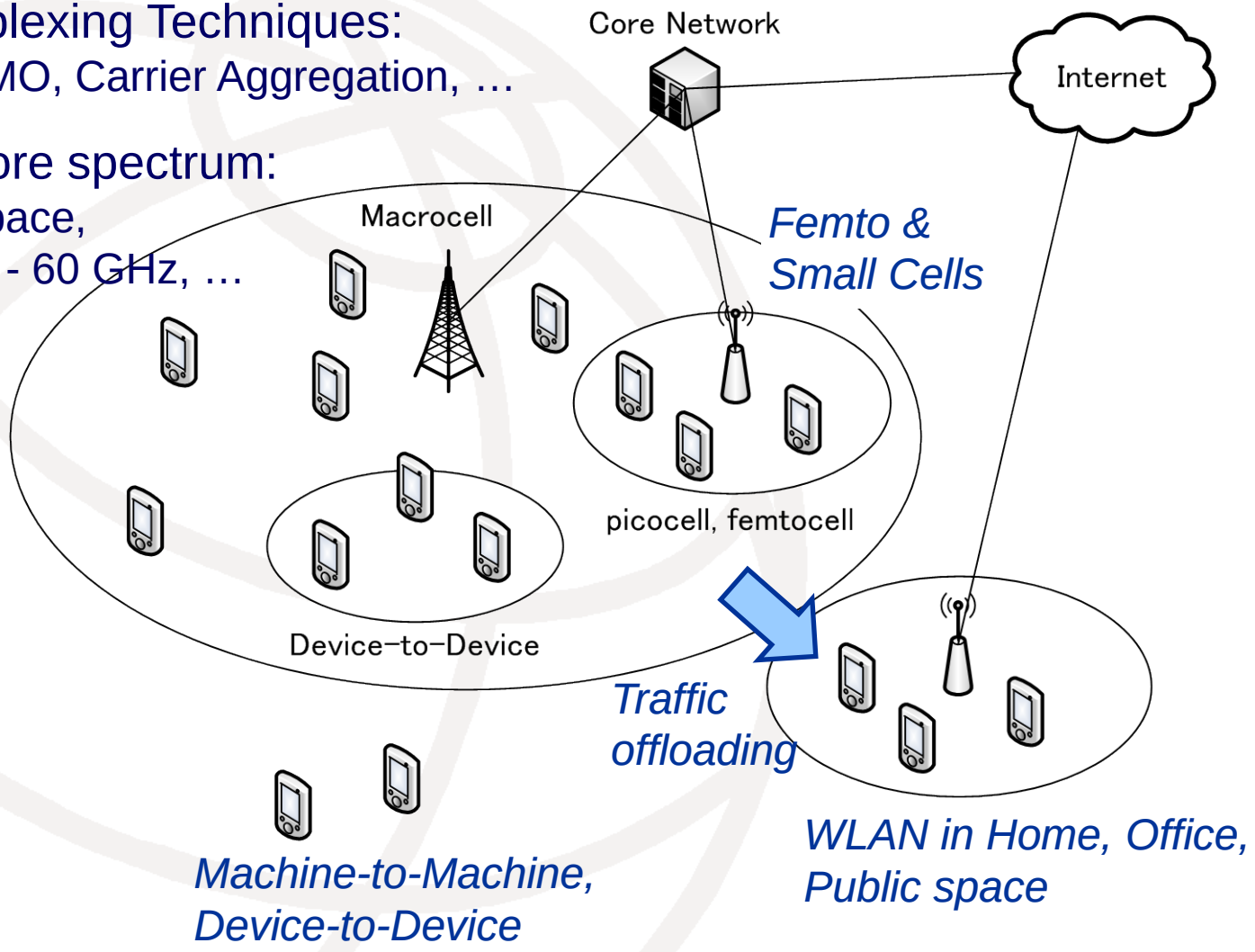
Exploring New Technologies for SRD

- R&D activities on SRD related technologies in APT countries (as of Sept 2012)

Country	Comments
Australia	National ICT Australia (NICTA) has been researching gigabit Wi-Fi. The low-power 60 GHz chip could be up to 10 times faster than current Wi-Fi chips, achieving speeds of up to 5 Gbps.
Brunei	A the moment there are R&D activities which are focused on the development of RFID applications e.g. Point-of-Sales (PoS),inventory management, vehicle ID tracking etc.
China	Some companies, research institution and universities carry out research on SRD related technologies in China.
Japan	- Millimetre-wave and Terahertz related technologies (There are several projects related to system and semiconductor device). - Dynamic Spectrum Access for WPAN (radio resource enhancement technologies, organised by the Ministry of Internal Affairs and Communications, Japan).
Korea	IEEE802.11ac(5GHz band), WiGig (57 -64GHz band), UWB, Picocast, NFC (Near Field Communication).
Malaysia	Institutions of higher learning in Malaysia have been actively doing R&D activities with regards to SRD, such as Wireless Sensor Networks (WSN) and Ultra Wideband (UWB) technology.
Singapore	No e.g. Multi-Gigabit technologies for last inch research by various Research & Development Institutions and local Universities.

Evolution of Wireless Networks

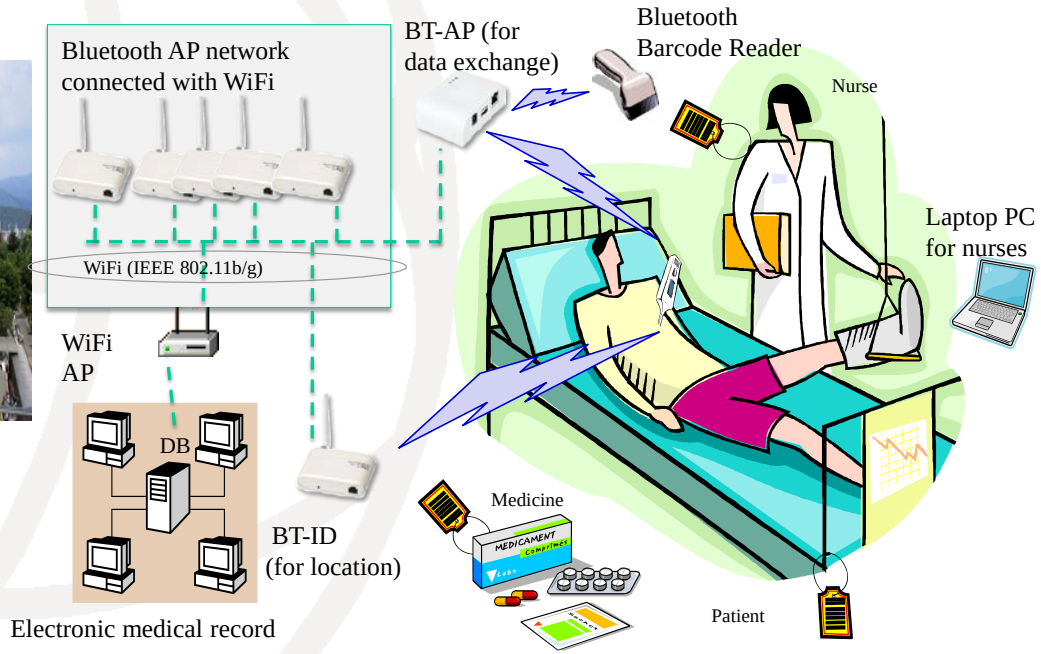
- Space Multiplexing Techniques:
  Massive MIMO, Carrier Aggregation, …
- Exploring more spectrum:
  TV White Space,
  3.4 GHz, 10 - 60 GHz, …



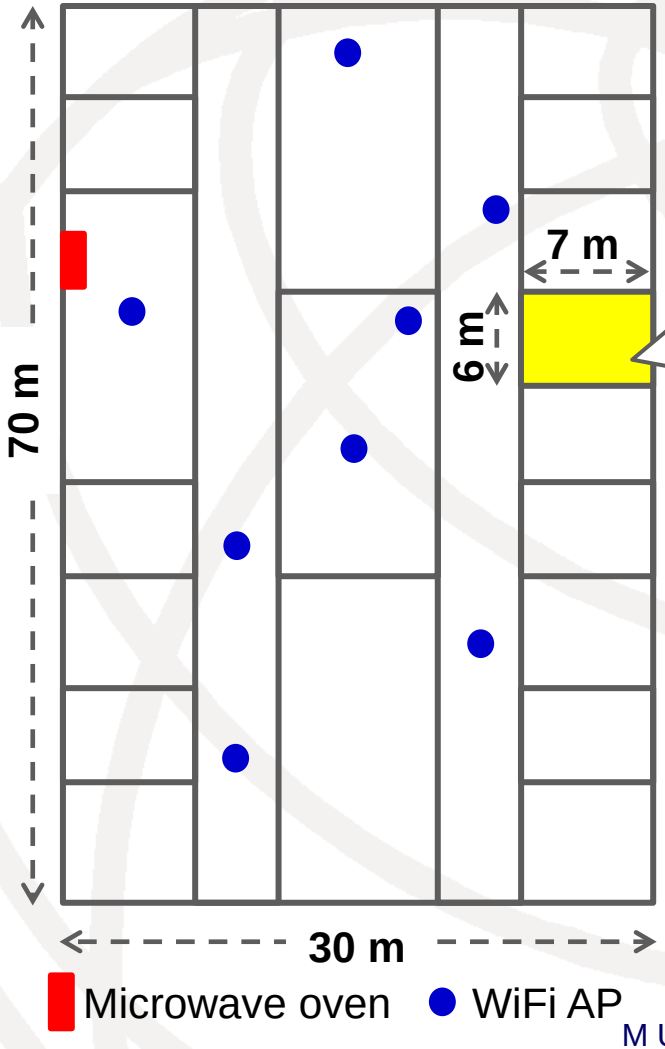
Growing M2M Applications Using SRDs

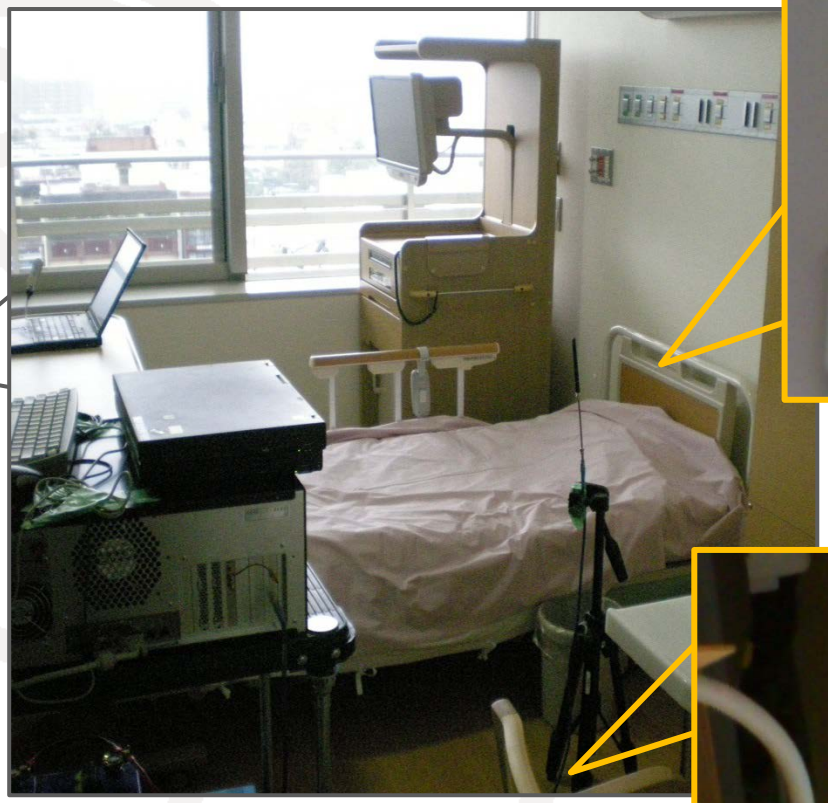
- Various M2M applications are in operation using WLAN, Bluetooth, ZigBee, etc in ISM band
  - Medical information systems: medical sensors, handheld devices, …
  - Emergency situations: disaster recovery, rescue operations, …

Kyoto University Hospital



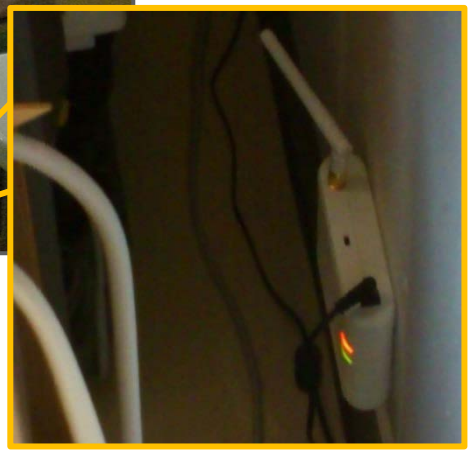
A Measurement in Hospital





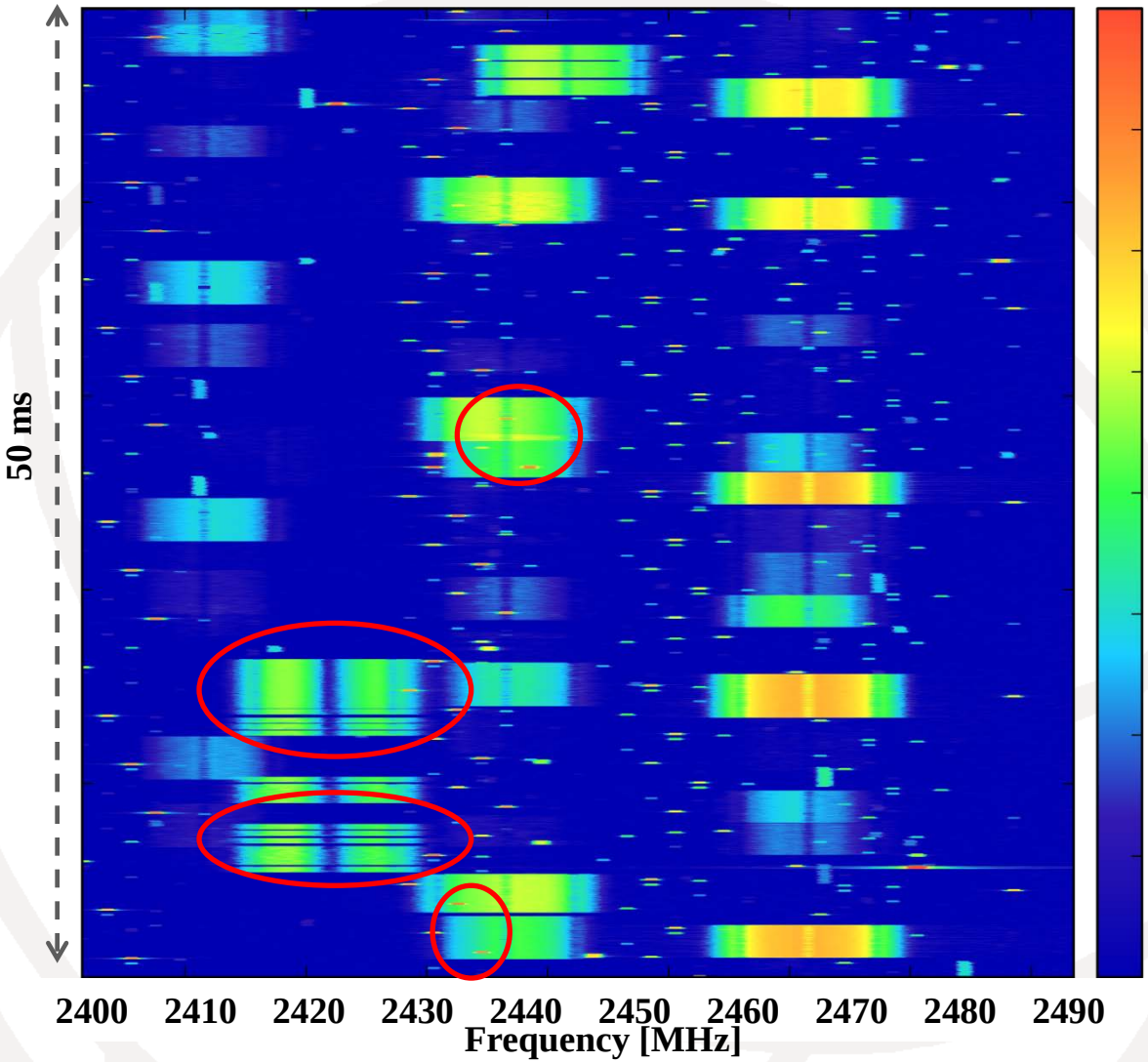
Bluetooth AP

Bluetooth ID



M Uno, et al, "A proposal of QoE based self-organised wireless system considering the measurement results in a major hospital," Proc of WinMee 2013, May 2013

An Example of Measurement Results

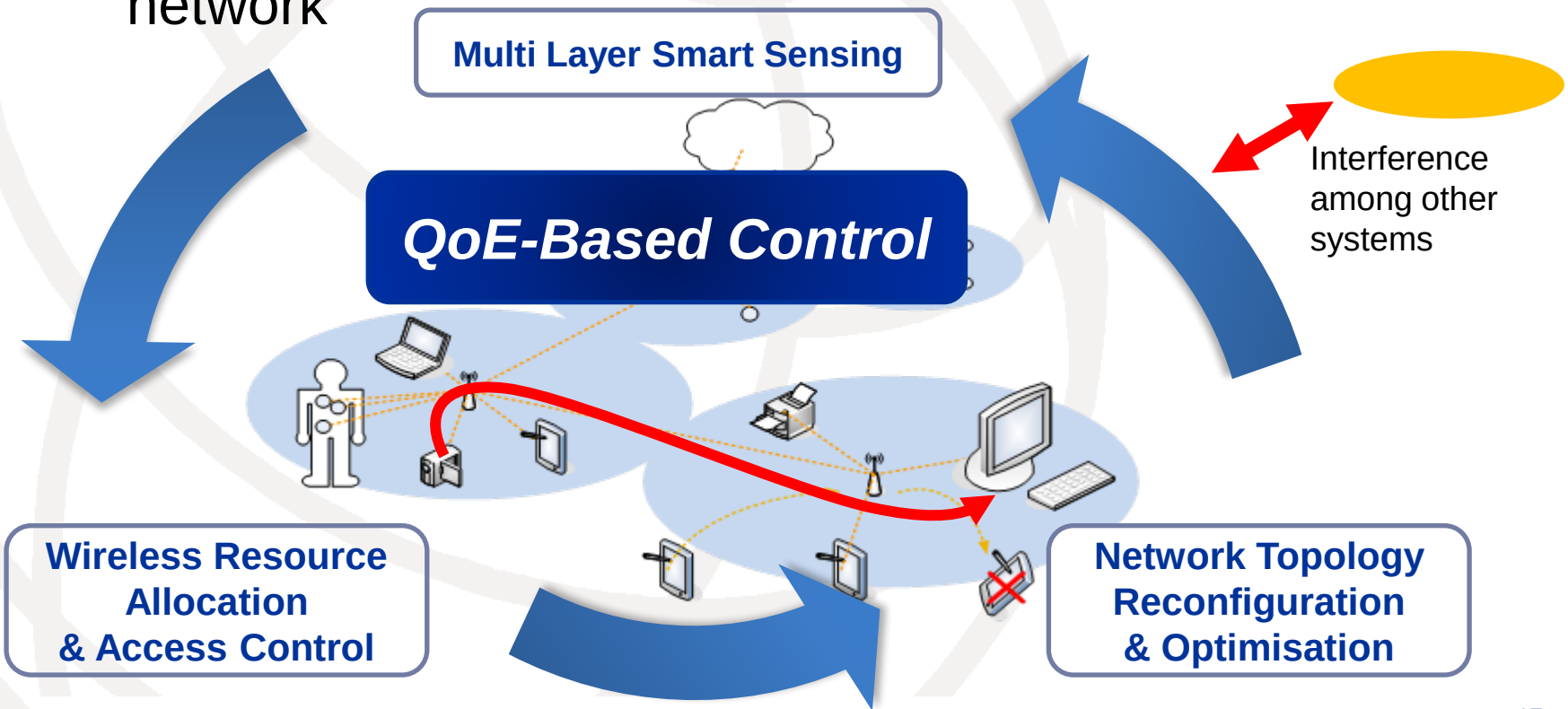


- ✓ Hospital WLAN service is provided on channels 1, 6, and 11
- ✓ Other private devices operated on other channels would cause interference to existing WLAN devices
- ✓ WLAN and Bluetooth packets would cause collisions
- ✓ Noise from microwave oven is also measured

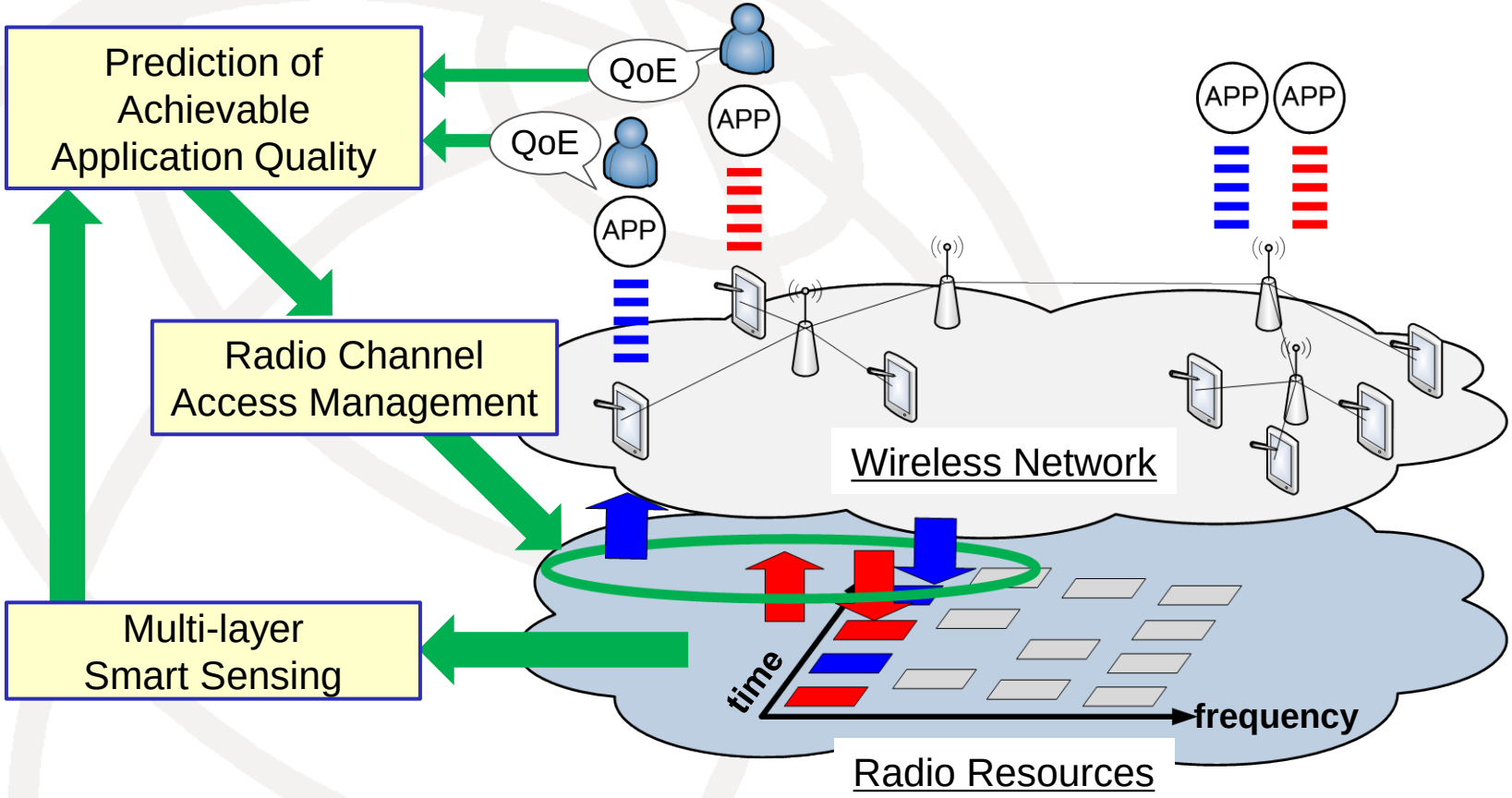
M Uno, et al, "A proposal of QoE based self-organised wireless system considering the measurement results in a major hospital," Proc of WinMee 2013, May 2013

Proposed Dynamic & Reconfigurable Wireless Network

- A new self-organising wireless network on which applications on many terminals can run with high quality even in congested shared frequency bands
- QoE as a key metric for designing / managing the network



General Concept of the Proposed System

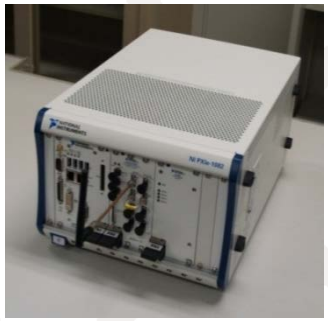


M Ariyoshi, et al, “Design of a self-organising wireless network improving application QoE in shared frequency band,“ Proc of SDR-WInnComm 2014, March 2014

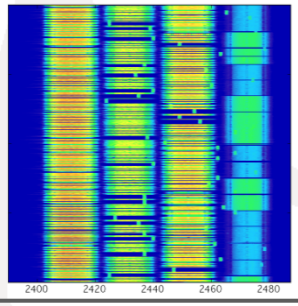
Multiple Layer Smart Sensing

Measurement → Signal Separation → RAT Identi-fication → QoS Estimation

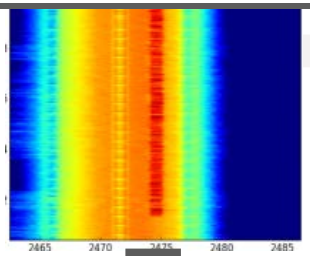
Logging 80MHz Wideband Data



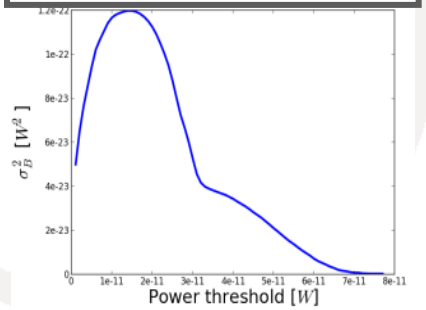
Spectrogram Acquisition



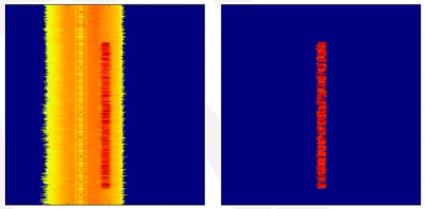
Deriving threshold by *discriminant analysis* on power variance



Deriving maximum variance among classes

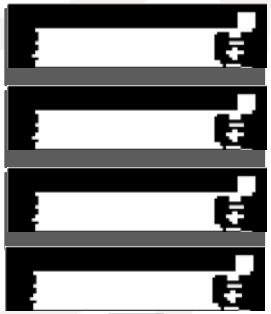


Identifying RATs by pattern detection after signal separation

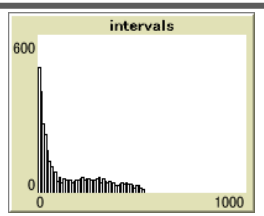


WLAN Bluetooth

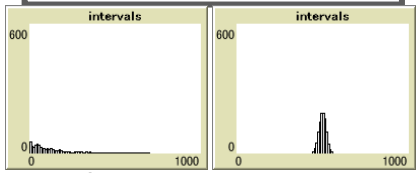
Packet Identification



Deriving distribution of packet duration



Separating applications by *Non-negative Matrix Factorisation*



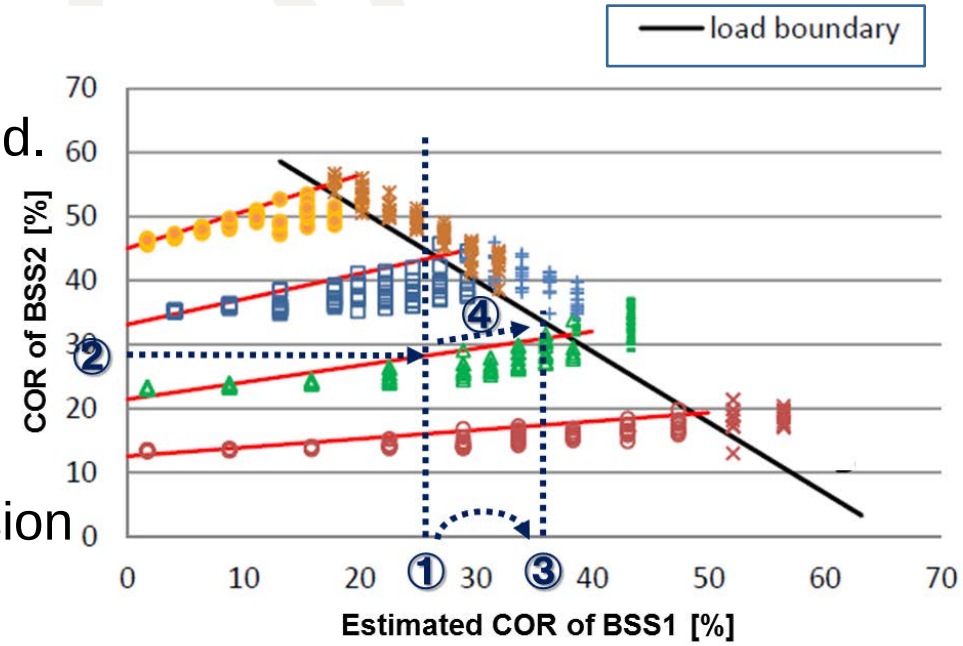
random Tx CBR

QoS estimation by statistical processing

T Miyasaka, et al, "Brind separation of multiple radio signals based on statistical approach," Proc of the 2013 IEICE General Conference, B-17-7, March 2013

Prediction of Achievable Application Quality

1. Calculate the estimated Channel Occupancy Rate (COR) of own wireless network from current information about offered load, average packet size, and data rate of each STA.
2. Get information about COR of other network from multi-layer smart sensing function.
3. Update the estimated COR of the own network considering additional offered load.
4. Prediction of COR change of other network is obtained. According to the predicted point, one can judge whether or not the traffic of own network would achieve their QoS requirement at the next transmission period.



M Sekiguchi, et al, "WLAN QoS prediction for improving application QoE in shared spectrum band," IEICE Technical Report, SR2013-36, July 2013

QoE-Based Wireless Resource Allocation & Access Control

- Proposing an enhanced access control upon IEEE 802.11e Enhanced Distributed Channel Access (EDCA)
  - Random back-off parameter set for each access category
  - Exclusively grant transmission opportunity (TXOP)
  - Support of achieved QoS
  - Handling of cases when there is some traffic in a same access category
  - Traffic with excessive required QoE will be restricted; and such the surplus resources will be allocated to other traffic
- Integrated wireless resource allocation mechanisms based on:
  - Dynamic Frequency Selection (DFS) with bandwidth control, or
  - Dynamic Spectrum Access (DSA)

An Example Evaluation of QoE-Based Wireless Resource Allocation & Access Control

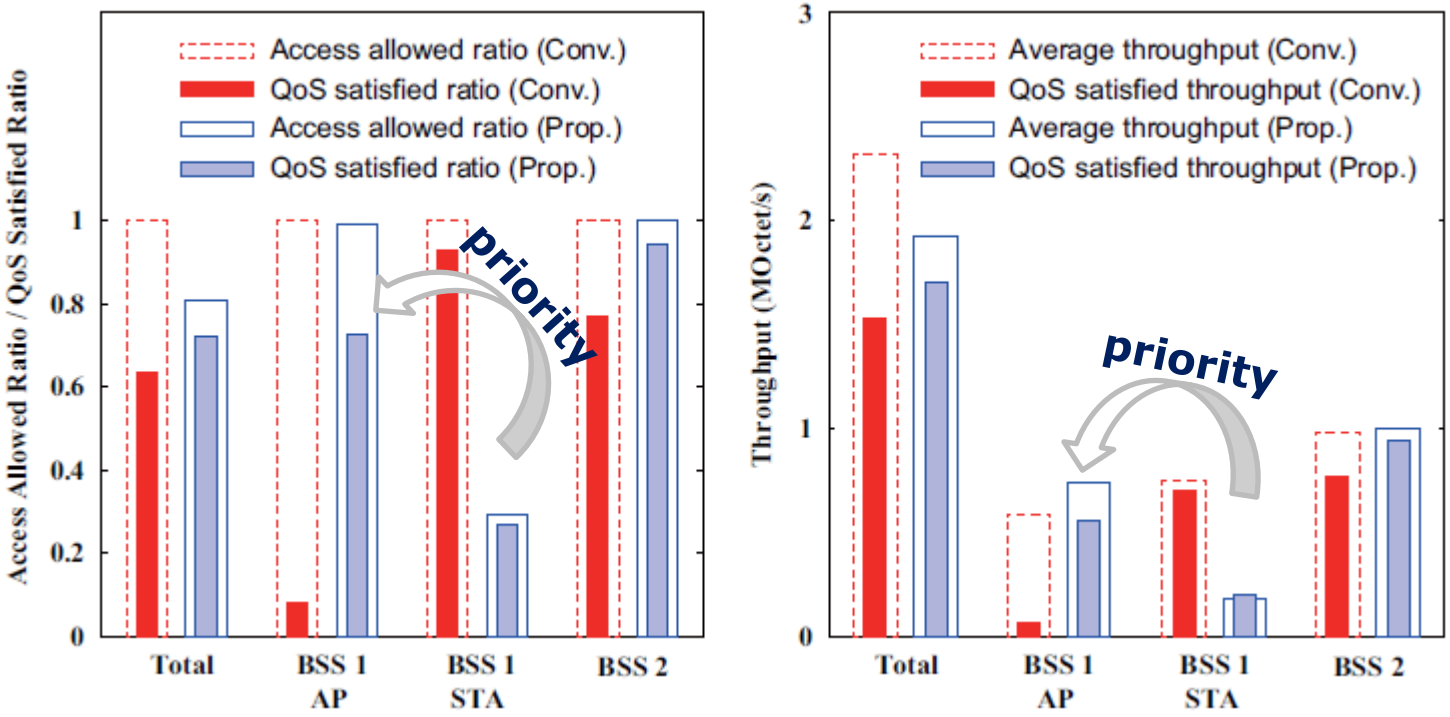
- System Simulation Parameters

System	IEEE 802.11g ERP-OFDM [5]
Simulation runs	3 s × 20 runs
Control slot duration	500 ms
Sampling rate, FFT size	120 MHz, 6.4 μs (768 points)
Spectrum sensing threshold	-89 dBm/MHz
Simulation area	20 m × 20 m
Number of BSSs and STAs	2 (BSS), 5 / BSS (STA)
Transmission power	16 dBm (AP), 12 dBm (STA)
Propagation model	Free space loss
Center frequency	2.442 GHz
Antenna directivity	Omni-diractional (2.15 dBi)
Number of antennas	2 (AP, 0.5λ spacing), 1 (STA)
Transmitted frame	DATA, ACK
Transmission rate	24 Mb/s
Payload length	1500 Octet
Offered load	150 kOctet/s/link (BSS 1) 100 kOctet/s/link (BSS 2)
Noise parameters	NF = 10 dB, 300 K

K Yano, et al, "On the effect of load capacity prediction and priority-based access control for multiple-system coexistence," Proc of the 2013 IEICE Society Conference, B-17-4, Sept 2013

An Example Evaluation Result

- Conditions:
  - Two sets of BSS
  - Priority of BSS1 traffic: AP > STA
- Improvement in QoS satisfaction ratio / throughput owing to access limitation for BSS1 STA



K Yano, et al, "On the effect of load capacity prediction and priority-based access control for multiple-system coexistence," Proc of the 2013 IEICE Society Conference, B-17-4, Sept 2013

Prototyping for Field Trials

- Wireless transceivers and sensing nodes have been developed for field trials
- Wireless TRx prototype:
  - Proposed functions are implemented by modifying driver software on commercial WLAN module
- Sensing node:
  - Capable of sensing of 80MHz bandwidth in 2.4GHz band

This work (pp 13-24) is supported by the Ministry of Internal Affairs and Communications, Japan under a grant entitled "Research and development of dynamic and reconfigurable M2M wireless network technology."

Concluding Remarks

- Needs for future work:
  - to work towards harmonised spectrum bands for SRDs
  - to provide regulatory certainty for manufactures and end-users
  - to catalyst the developments of new SRD applications
- The possible approaches:
  - to simplify the conditions on the use of SRDs
  - to the largest extent possible
  - to adopt frequency bands that are already established in Europe or US: e.g., Recommendation CEPT/ERC/REC 70-03, the Recommendation ITU-R SM. 1896
- This however should take into account potential interference from SRDs and ensuring that existing services remain protected.

References

- APT/AWG/REP-07 (Rev 2): Operation of Short-Range Devices (SRDs)
- APT/AWG/REP-35: The Frequency Bands for Harmonised Use of Short-Range Devices (SRDs)
- APT/AWG/REP-31: Introduction, Application, Issues and Technologies for Short Range Devices (SRDs)