Restudy of 5GHz band radar detection requirement and market outlook

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Outline

- 5 GHz band status in WLAN
- Radar detection (DFS) requirement in 5 GHz bands
- Some typical examples that show DFS band difficulty
- Challenges for using DFS bands and their some approaches
- Conclusions

5 GHz band status in WLAN

2.4 GHz band

Good points

- Very Popular
  - Most of WLAN products in the world have 11b/g interface

Limitation

- limited throughput by limited channel band width
  - 40MHz not recommend
  - 80 MHz and over are not available
- Unstable throughput performance due to congestion
  - Limited # of channels
    - ✓ There are 13+1 channels, but only 3 independent channels are available
  - Congestion by using ISM band
    - ✓ There are many kinds of another wireless systems such as BT, MW oven, ZigBee etc..

5 GHz band

Good points

- Much more channels (19 ch total)
  - W52: 20 MHz x 4 chs (5.15-5.25)
  - W53: 20 MHz x 4 chs (5.25-5.35)
  - W56: 20 MHz x 11chs (5.470-5.725)
  - 160 MHz (with 11ac) is available

Limitation

- Location restriction
  - W52 and W53 are for indoor use only
- Additional mandatory mechanism
  - The interference avoidance mechanism for radar should be implemented for W53 and W56 bands (5.25-5.35GHz, 5.470-5.725GHz)

5GHz Channel availability in the world

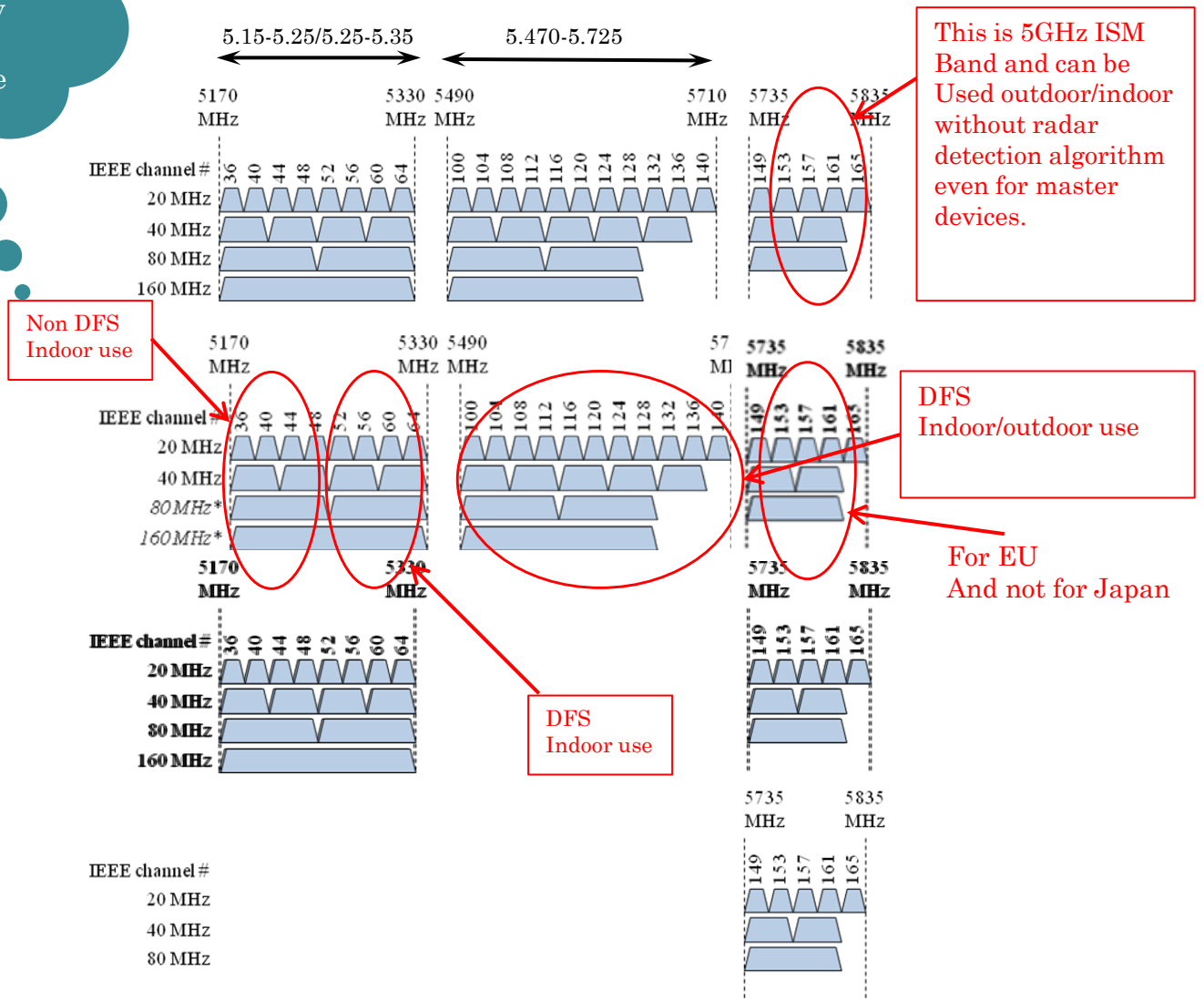
It can't be used with mobile device because it is only for indoor use. Large TV may be able to use.

US

Europe & Japan

India

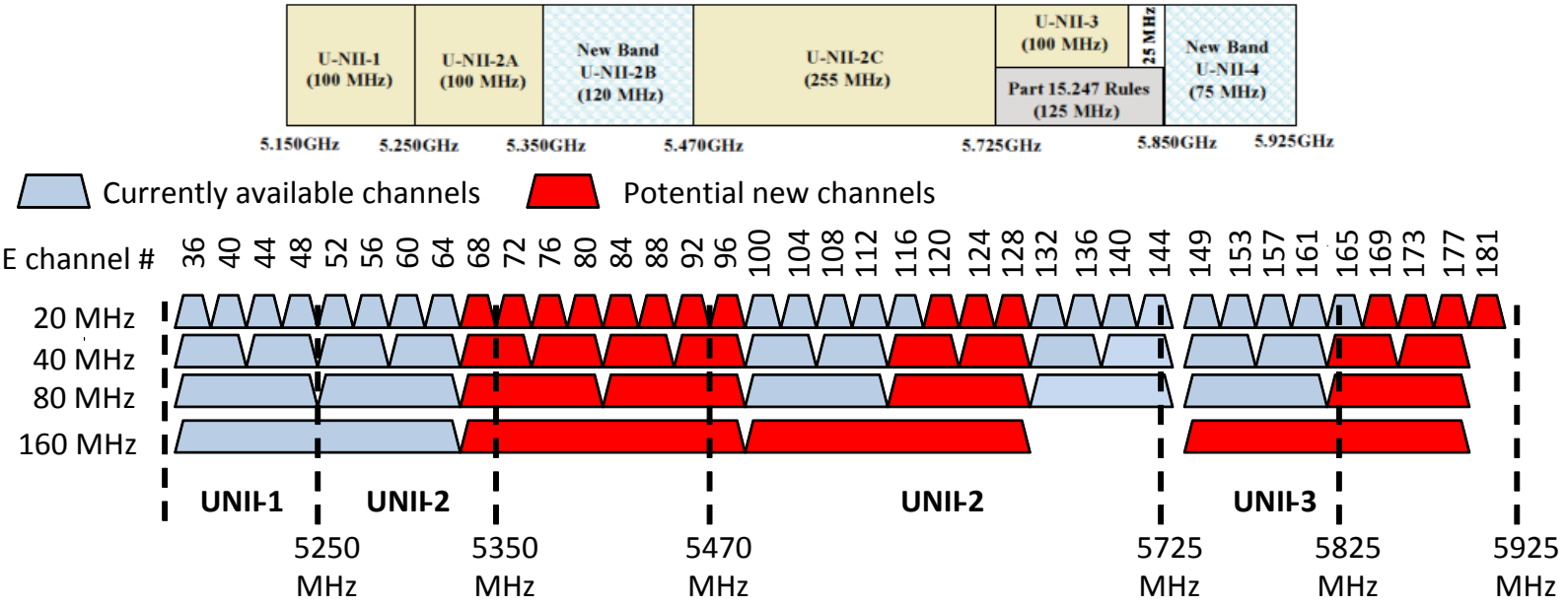
China



US 5GHz regulatory status

he FCC released a Notice of Proposed Rulemaking outlining proposals to amend Part 15 of its Rules governing the operation of Unlicensed National Information Infrastructure (U-NII) devices in the 5 GHz band./ The *NPRM* covers potential changes to the rules governing the existing spectrum allocated for U-NII devices as well as the addition of 195 megahertz of spectrum to the 5 GHz U-NII bands. Below is a brief summary of the FCC's proposals. Comments are due 45 days, and reply comments 75 days, respectively, after Federal Register publication of the *NPRM*, which has not yet occurred.

/ *Revision of Part 15 of the Commission's Rules to Permit Unlicensed National Information Infrastructure (U-NII) Devices in the 5 GHz Band*, Notice of Proposed Rulemaking, ET Docket No. 13-49 (rel. Feb. 20, 2013) ("*NPRM*").

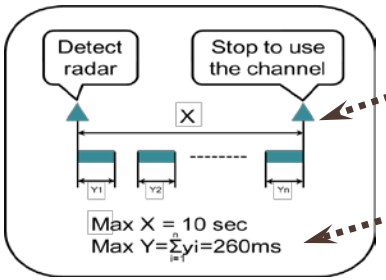


Radar detection (DFS) requirement in 5 GHz bands

For DFS Function:

Parameter	Value
Non-occupancy Period	≥ 30 minutes
Channel Availability Check Time	≥ 60 seconds
Channel Move Time	≤ 10 seconds
Channel Closing Transmission Time	≤ 260 milliseconds

Table 1: DFS Response Requirement Value



Once radar was detected in a channel, you can't come back to the channel next 30min.

You need monitor channels for a minute before starting a service.

Once radar was detected in a channel, you need to stop a service in 10 seconds.

Once radar was detected in a channel, you need to stop a service before aggregated packet duration reached to 260 ms.

Master Equipments need to **monitor 60 sec before sending a packet.** Radar shall be monitored during service period and when radar is detected, you need to **stop sending packets within 260 ms**. Before restarting sending packet on another DFS channel, you shall **monitor radar for 60 sec again**.

Radar Type	Pulse Repetition Frequency (Hz)	Pulse Width (usec.)	Number of Pulses	Radar Detection Probability
DFS-J1-1	700	1	18	60% or more
DFS-J1-2	260	2.5	18	60% or more

*1. The Channel Loading is 50 % of Maximum Transmission Data Rate.

*2. The receiving threshold level is the following. (This is the average power while receiving radar with an absolute gain 0 dBi antenna.)

The case of Po ≥ 200mW; ≥-64dBm (avg.) / The case of Po < 200mW;Po ≥-62dBm (avg.) (Po; Max. Transmit Power (EIRP) of EUT)

Table 2: Parameters of DFS Test Signals (appended table 1).

USA/EU/JPN DFS test radar parameters

USA

FCC 0696

Signal types	1, 2, 3, 4, 5, 6 simulated hopping

FCC 1322

Signal types	0, 1, 2, 3, 4

Europe

ETSI EN 301893 V1.7.1

Signal types	1, 2, 3, 4, 5, 6

ETSI EN 302502 V1.2.1(5.8GHz)

Signal types	1, 2, 3, 4, 5, 6, simulated hopping 1, 2

Japan

Signal types	W53 1,2 W56 1, 2, 3, 4, 5, 6 W56 chirped waveform

US/JPN Parameters of DFS test radar signals

Radar Test Signal	PRI(usec.)	Pulse Width (usec.)	Number of pulse	DFS (%)	Trial/ US	Testing Period	Append 1	Append2
Radar 1-1	1428(700Hz)	1	18	60	20	15sec	5.3GHz	-
Radar 1-2	3846(260Hz)	2.5	18	60	20	15sec	5.3GHz	-
Radar 1	1389(720Hz)	0.5	18	60	20	15sec	5.6GHz	Aggregated DFS though 1-6, over than 80%
Radar 2(US1)	1428(700Hz)	1	18	60	20	15sec	5.6GHz	
Radar 3	4000(250Hz)	2	18	60	20	15sec	5.6GHz	
Radar 4(US2)	150-230(4348-6667Hz)	1-5	23-29	60	20	15sec	5.6GHz	
Radar 5(US3)	200-500(2k-5kHz)	6-10	16-18	60	20	15sec	5.6GHz	
Radar 6(US4)	200-500(2k-5kHz)	11-20	12-16	60	20	15sec	5.6GHz	
Radar 7(US5)	1000-2000(500-1000Hz)	50-100	1-3 /Burst	80	20	12sec (8-20 even Intervals)	8-20 Burst /Test Period	5-20MHz Chirp width
Radar 8(US6)	333(3kHz)	1	9/Hop	70	20	300 msec	0.333kHz (Hopping Rate)	-

EU Parameters of DFS test radar signals

Table D.4: Parameters of radar test signals

Radar test signal # (see note 1 to note 3)	Pulse width W [µs]		Pulse repetition frequency PRF (PPS)		Number of different PRFs	Pulses per burst for each PRF (PPB) (see note 5)
	Min	Max	Min	Max		
1	0,5	5	200	1 000	1	10 (see note 6)
2	0,5	15	200	1 600	1	15 (see note 6)
3	0,5	15	2 300	4 000	1	25
4	20	30	2 000	4 000	1	20
5	0,5	2	300	400	2/3	10 (see note 6)
6	0,5	2	400	1 200	2/3	15 (see note 6)

Table D.3.1: DFS Test Signals simulating fixed frequency radars

Radar test signal (see note 2)	Pulse width W [µs] (see note 5) choose one value	Pulse repetition frequency PRF [pps] choose one value	Pulses per burst (see notes 1 and 3)	Detection probability with 30 % channel load (see note 4)
1 - Fixed	1	750	15	P_d > 60 %
2 - Variable	1, 2, 5	200, 300, 500, 800, 1 000	10	P_d > 60 %
3 - Variable	10, 15	200, 300, 500, 800, 1 000	15	P_d > 60 %
4 - Variable	1, 2, 5, 10, 15	1 200, 1 500, 1 600	15	P_d > 60 %
5 - Variable	1, 2, 5, 10, 15	2 300, 3 000, 3 500, 4 000	25	P_d > 60 %
6 - Variable modulated (see note 6)	20, 30	2 000, 3 000, 4 000	20	P_d > 60 %

Table D.3.2: DFS Test Signals simulating Frequency Hopping radars

Radar test signal	Pulse width W [µs]	Pulse repetition frequency PRF [pps]	Pulses per burst	Burst length [ms]	Bursts per Trial (see note 4)	Pulse modulation (see note 1)	Detection probability Pd with 30 % channel load (see note 2)
1	1	3 000	9	3	8	none	(see note 3)
2	20	4 500	9	2	2	chirp	(see note 3)

In Europe there are 175 radars in the 5 GHz frequency band. You may find this information on Internet : http://www.eumetnet.eu/radar-network (select Band C only).

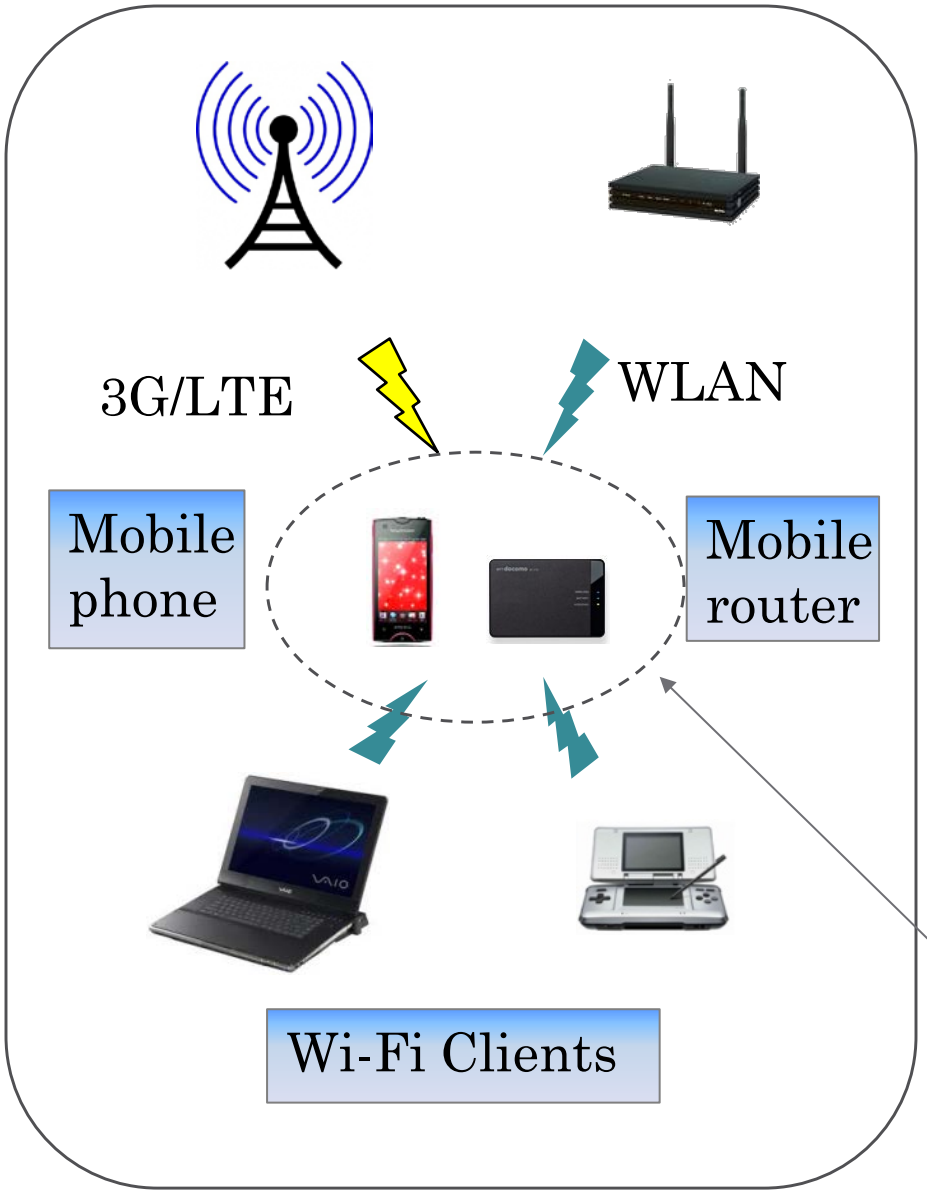
Potential problems using DFS bands

- Needs to wait for a minute to start application
  - It might not a problem with home router but may affect Wi-Fi direct (Miracast etc.) applications.
- One minute silence will occur if system detect radar while people enjoy application
  - Sudden stop may occur when people enjoy a movie over Wi-Fi
- When Wi-Fi traffics are congested, the system may false detects congested signal as radar and stop sending packets frequently.

Some typical examples that show DFS band difficulty

- Wi-Fi Tethering
  - Mobile clients now need to have radar detection algorithm
- Public Wi-Fi
  - Congested environment
- Video transmission & P-P communications
  - QoS application, Miracast (Wi-Fi direct)
- Automotive
  - Automotive is not categorized as indoor

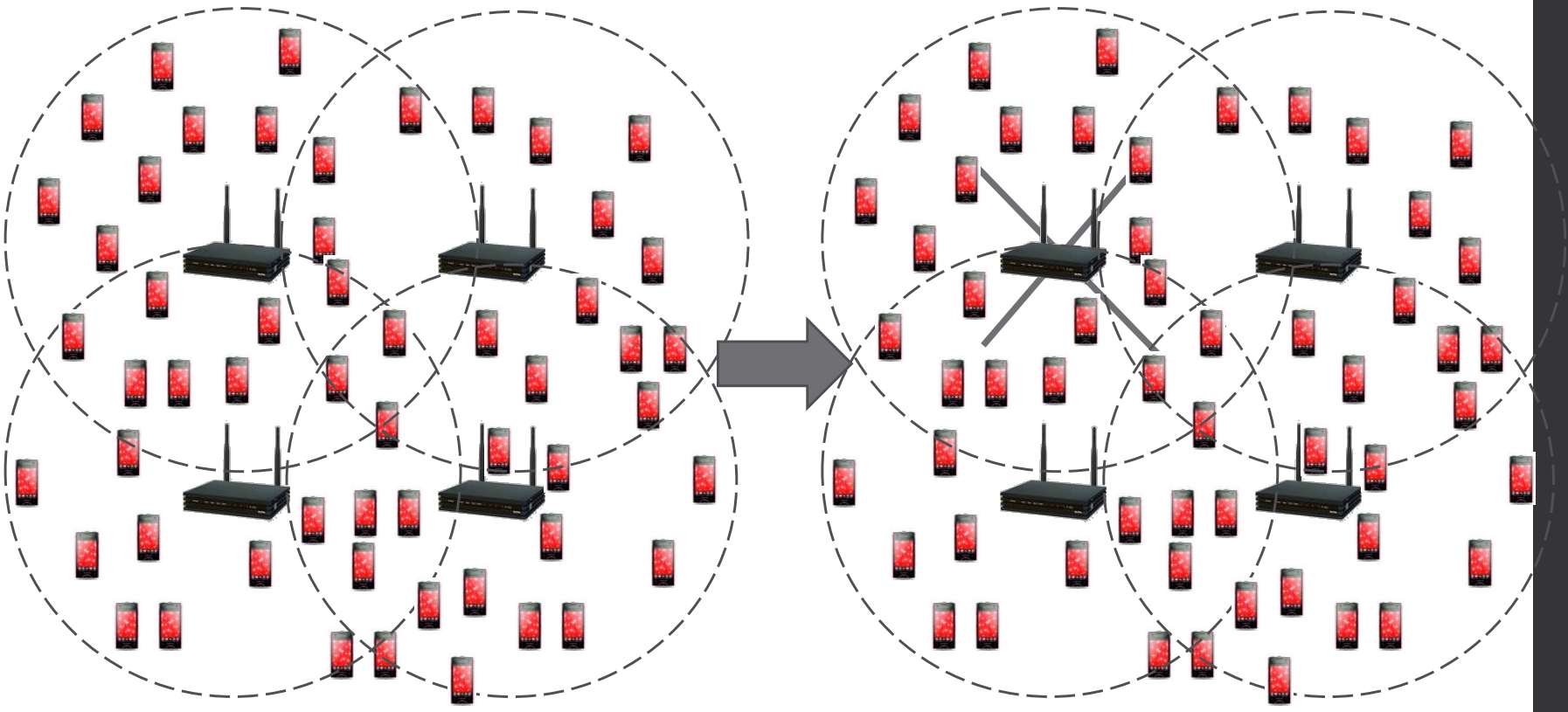
Wi-Fi Tethering



- **Early stage:**
  - Mobile phone just acted as Wi-Fi clients which connected to Wi-Fi master devices (no needs to implement radar detection algorithm).
- **Now:**
  - Wi-Fi tethering is becoming popular, where mobile phone acts as Wi-Fi master device.

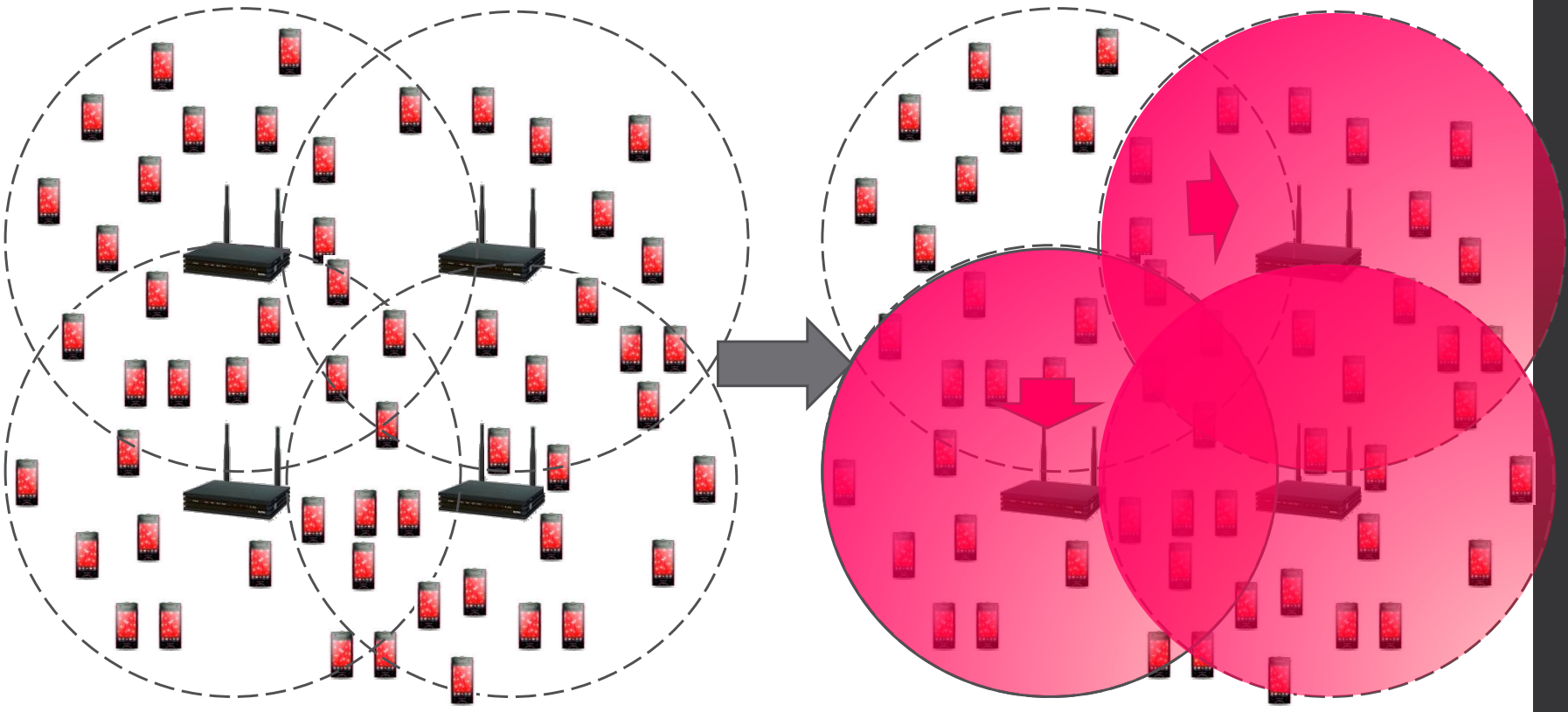
Mobile devices can choose a channel for Wi-Fi connection and hence needs to have radar detection algorithm
W52 (non DFS band) is only indoor use and then not ideal to mobile devices.

Public Wi-Fi



- When an access point (AP) stops service triggered by false detection, clients associated to the APs try to associates to adjacent APs and then the APs also increase the possibility to stop service due to the congestion.

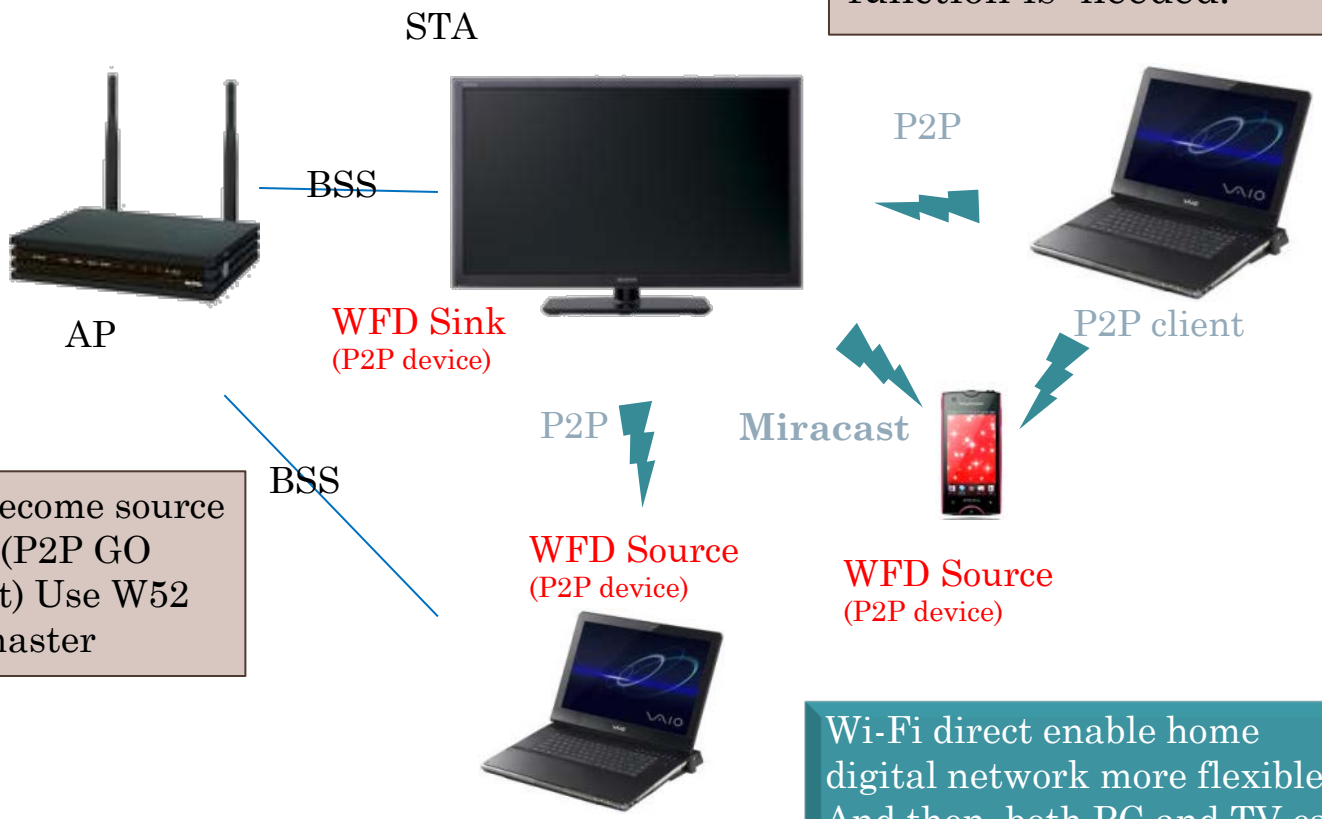
Public Wi-Fi



- When an access point (AP) stops service triggered by false detection, clients associated to the APs try to associates to adjacent APs and then the APs also increase the possibility to stop service due to the congestion.

Video transmission & P-P communications

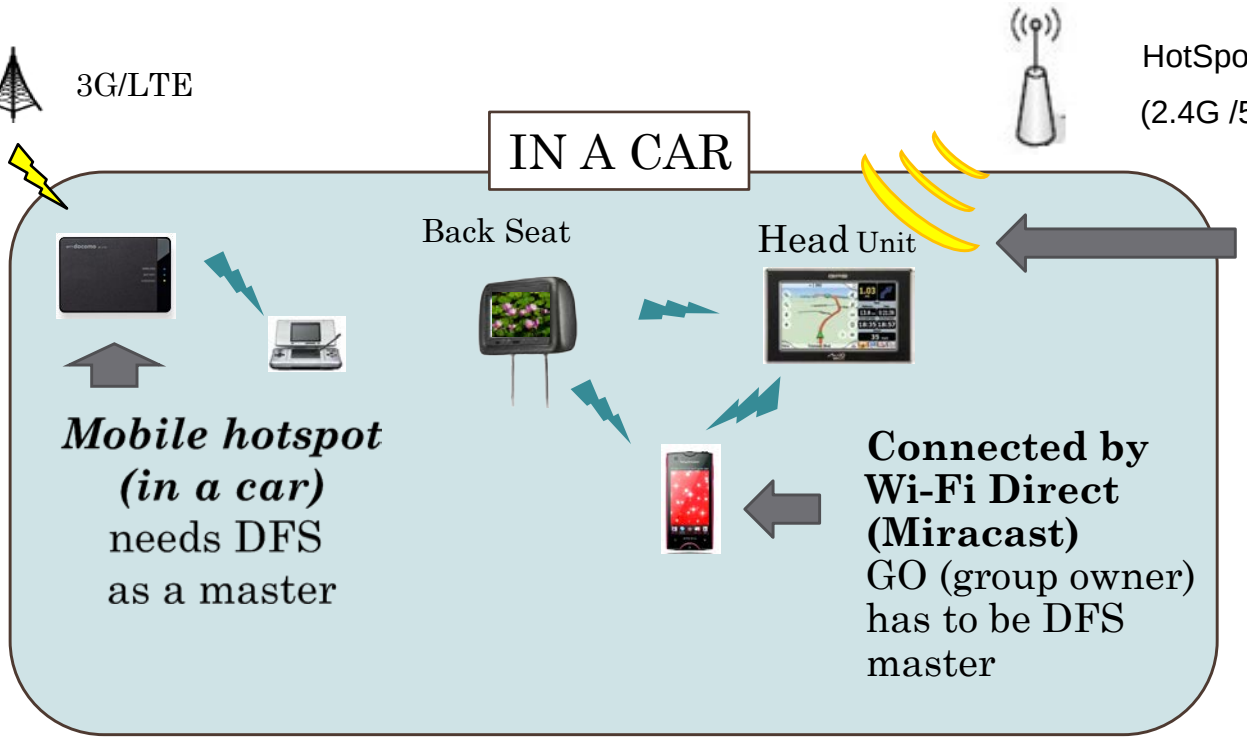
TV becomes source and sink (P2P GO and client)
Use W52 or DFS master function is needed.



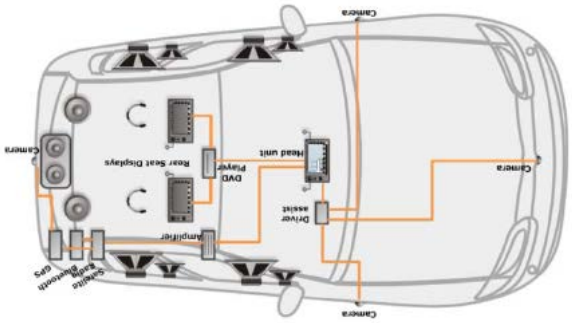
PC will become source and sink (P2P GO and client) Use W52 or DFS master needed

Wi-Fi direct enable home digital network more flexible. And then, both PC and TV can be both master/client. We need to support DFS as master

Automotive



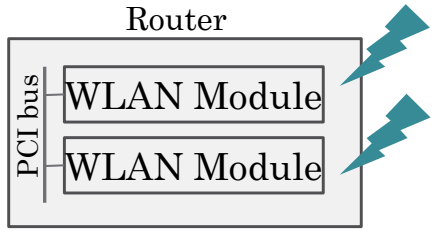
Client devices which connect to Wi-Fi infrastructure, does not need to have DFS master functionality.



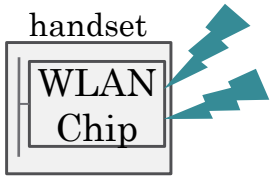
As automotive can't be categorized as indoor, only W56 (and 2.4GHz) is available. Then master device has to have radar detection algorithm.

Challenges for using DFS bands and some approaches

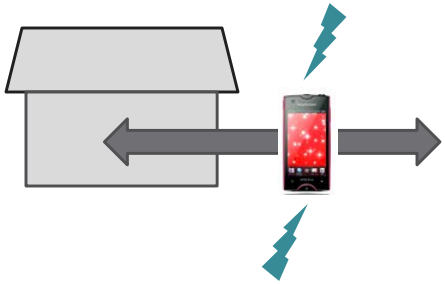
- One minute silence issue
  - Two WLAN modules in a router
    - ✓Some high end routers have two WLAN modules in them. One module is used for WLAN communication and the other is for radar monitoring.



  - Two RF chains in a chip
    - ✓It can be the solution for mobile (small form factor) devices



- Location limitation
  - Relaxation of regulations
    - ✓Indoor limitation is expected to be relaxed with some condition



- Frequent stops by false radar detection
  - Implementation algorithm improvement

Conclusions

- 5GHz is promising frequency bands for WLAN
- One hurdle to restrict 5GHz band usability is radar detection treatment
- DFS treatment is becoming important as;
  - Mobile devices as Wi-Fi master is becoming popular.
  - QoS (video) application is becoming popular.
  - Traffic congestion increase the probability of radar false detect
- Chip vendors and WLAN equip vendors are challenging to alleviate this problem and also worldwide harmonization is on going to expand the band and for improving usability step further