SONY
make.believe

SE43_11_44
SE43_11_46
SE43_11_63

2011/09/26

Sony

Background

- In response to item G3 of ECC REPORT159, this document introduces the WSD network capacity comparison and analysis between the location specific WSD output power level calculation method for database approach in ECC REPORT159 and its extension methods which consider the number of active master WSDs in each available channel in WSD master-slave operation

Summary of submissions

- **SE43_11_44**
  - WSD network capacity comparison and analysis between the location specific WSD output power level calculation method based on **different *IM (multiple Interference margin)* calculation methods** for database approach in ECC REPORT159 and its extension methods which consider the number of active master WSDs in each available channel in WSD master-slave operation. This result shows that the consideration of the number of active master WSDs in each available channel will have a large impact for the WSD network capacity while satisfying the incumbent service protection.
- **SE43_11_63**
  - Proposed update of **equation (A.7.2-2)** of ECC REPORT 159 which specifies the *IM* calculation methods
- **SE43_11_46**
  - Proposed update of **equation (4.3-1)** of ECC REPORT 159 which specifies the *IM* calculation methods

Proposal

- **SE43_11_44**
  - To insert this contribution as a Annex part of the SE43 working document in response to item G3 of ECC REPORT159.

- **SE43_11_63**
  - To insert this contribution as a new subsection of the SE43 working document in response to item G3 of ECC REPORT159.

- **SE43_11_46**
  - To insert this contribution as a new subsection of the SE43 working document in response to item G3 of ECC REPORT159.

IM calculation methods

Revisiting maximum permitted WSD e.i.r.p

Equation (A.7.2-2) of ECC REPORT159

$$P_{\mathrm{IB}\ (\mathrm{dBm})}^{WSD} \le m_{Z\ (\mathrm{dBm})} - m_{G\ (\mathrm{dB})} - r(\Delta f)_{(\mathrm{dB})} - \mu(q_2)\sqrt{\sigma_{Z\ (\mathrm{dB})}^2 + \sigma_{G\ (\mathrm{dB})}^2} + \mathrm{IM}_{(\mathrm{dB})},$$

$$P_{\mathrm{OOB}}^{WSD}(\Delta f) \le P_{\mathrm{IB}}^{WSD} - \mathrm{ACLR}_{\mathrm{CR}}(\Delta f),$$

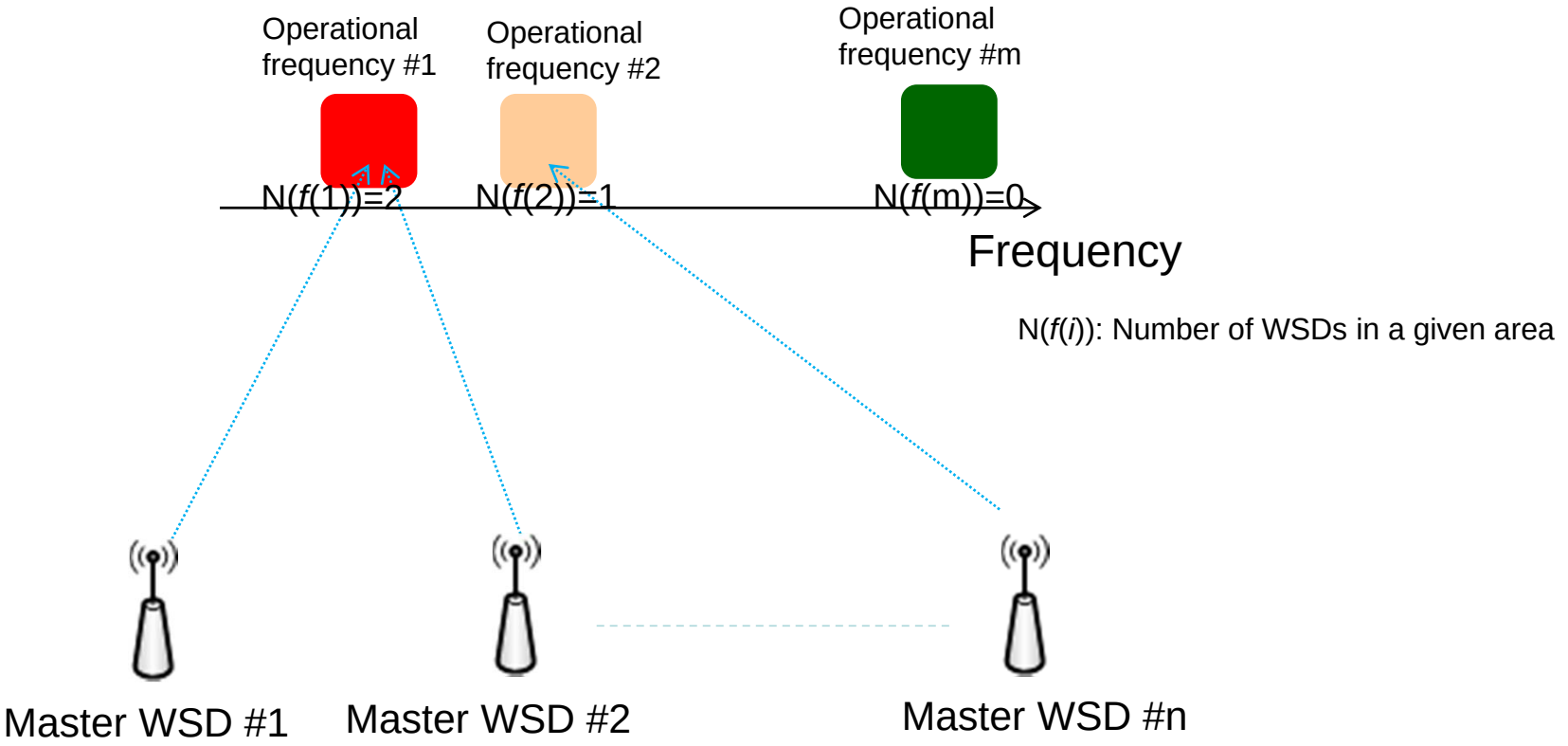
In ECC REPORT159 (Page 136), “The term is a *safety margin* which can be judiciously set by the database to provide an additional margin of protection to DTT services. The value of this margin might, for example, be increased in response to a proliferation of WSDs and an increase in the potential for aggregate interference to DTT services”.

How can we define *IM* (multiple interference margin)?

Candidate calculation methods of *IM*

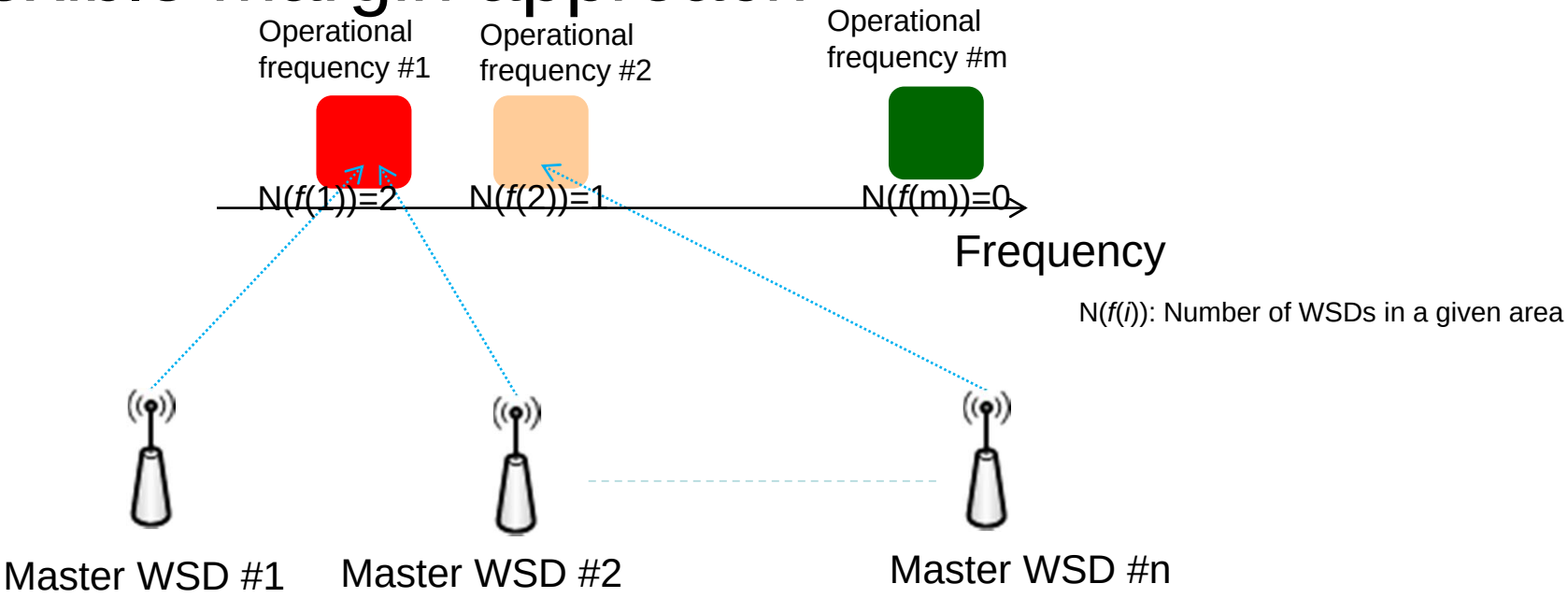
- Fixed margin approach
  - ✓ As pre-determined value, a potential maximum number of interferes in *IM* without considering the number of active-WSDs/actual-interferers in each operational frequency at a given area as *IM is* adopted
- Flexible margin approach
  - ✓ Calculation engine knows the number of active-WSDs in each operational frequency at a given area, and flexible margin is selected according to the condition
- Minimized margin approach
  - Calculation engine knows the number of active-WSDs in each operational frequency at a given area, and a minimized *IM* according to the consideration of intrinsic calculation parameters of each WSD, like path loss and ACLR et. al, is adopted

Fixed margin approach



- In fixed margin setting approach, geo-location database does not know the number (N(*f*(*i*))) of active WSDs in each operational frequency at a given area
  - ✓ Therefore, the *IM* can be defined as follows:
    - ✓ ***IM* = 10*log10(Potential maximum number of interferers at a given area)**

Flexible margin approach



- In flexible margin setting approach, geo-location database knows the number (N(*f*(*i*))) of active WSDs in each operational frequency at a given area
  - ✓ If the *IM* based on equation (A.7.2-2) of ECC REPORT 159 can be defined as follows:
    - ✓ ***I M* = 10*log10(Maximum number of active interferers in each operational frequency at a given area)**
      - ✓ if maximum number of active WSDs/actual interferers in each operational frequency is not chosen as the input parameter in calculating *IM*, the equation (A.7.2-2) cannot differentiate an intrinsic feature, so harmful interference to incumbent user might occur

Minimized margin approach #1

$$IM_{(dB)} = (10 \cdot \log_{10}(N_{\text{potential maximum number of interferes}}) \text{ or } 10 \cdot \log_{10}(\max(N_{\text{number of active interferes}}(f_{WSD})))) - \alpha_{(dB)}$$

Fixed/flexible margin

Redundancy will occur when the number of active-WSDs in each operational frequency at a given area is different each other.

Fine adjustment value (for WSD output power increase while satisfying incumbent protection) which can ensure fairness among all the WSDs. Same value is adopted for each WSD.

Minimized margin approach #2

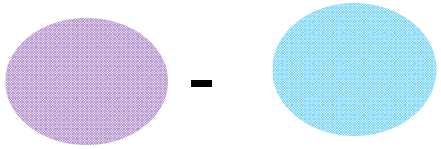
$$\alpha_{(dB)} = m_{Z(dBm)} - r(0)_{(dB)} - \mu(q_2)\sqrt{\sigma^2_{Z(dB)} + \sigma^2_{G(dB)}}$$

$$-10\log_{10}\left[\sum_{j\in O_{f_{WSD\_all}}}\sum_{k\in Q_{f_{WSD\_all(j)}}} 10^{\frac{P'^{WSD}_{IB}\left(f_{WSD\_all(j),k}\right)_{(dBm)} + r\left(f_{WSD\_all(j)} - f_{BS}\right)_{(dB)} - r(0)_{(dB)} + m_G\left(d_{WSD(k)-BS(i')}\right)_{(dB)}}{10}}\right]$$

Protection threshold of target operational frequency

Each WSD output power level calculated based on fixed/flexible margin and equation (A.7.2-2) of ECC REPORT159.

Total aggregated interference power level in a most severe interferer victim reference point i' which means a reference point where the difference between each aggregated interference power level and its protection threshold is smallest in all the target interfere-victim reference points for all the target WSDs.



Upper limit of the adjustment value for fixed/flexible margin

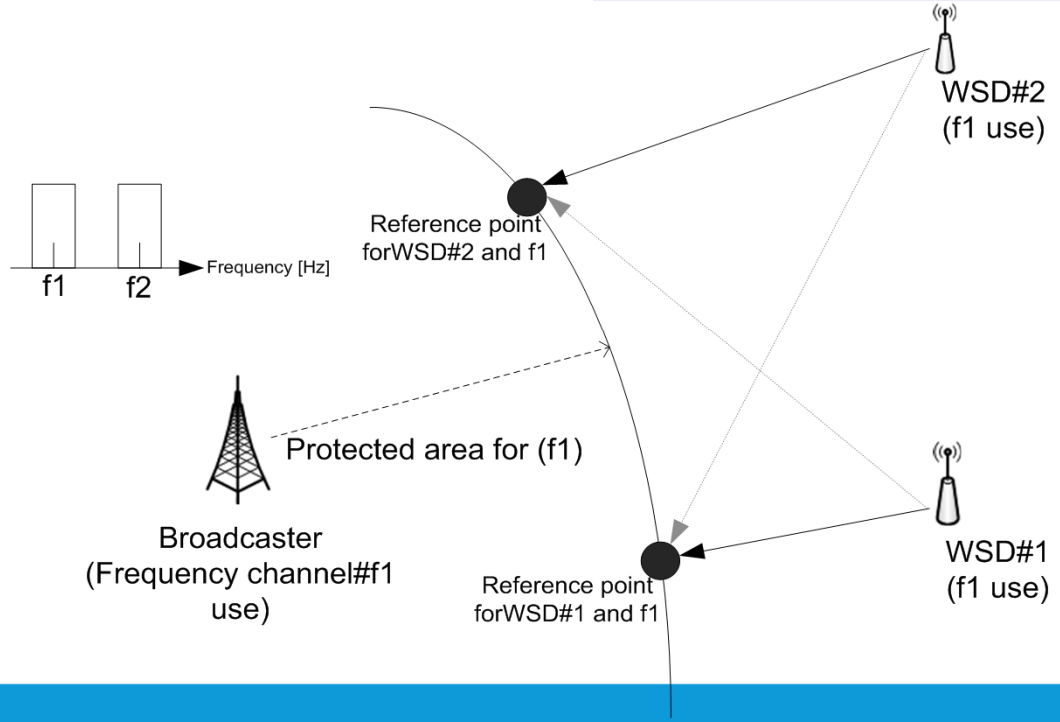
Interfere-victim reference point selection

Equation (A.7.2-2) of ECC REPORT159

$$P_{\mathrm{IB}\ (\mathrm{dBm})}^{\mathrm{CR}} \le m_{Z\ (\mathrm{dBm})} - m_{G\ (\mathrm{dB})} - r(\Delta f)_{(\mathrm{dB})} - \mu(q_2)\sqrt{\sigma_{Z\ (\mathrm{dB})}^2 + \sigma_{G\ (\mathrm{dB})}^2} + \mathrm{IM}_{(\mathrm{dB})},$$

$$P_{\mathrm{OOB}}^{\mathrm{CR}}(\Delta f) \le P_{\mathrm{IB}}^{\mathrm{CR}} - \mathrm{ACLR}_{\mathrm{CR}}(\Delta f),$$

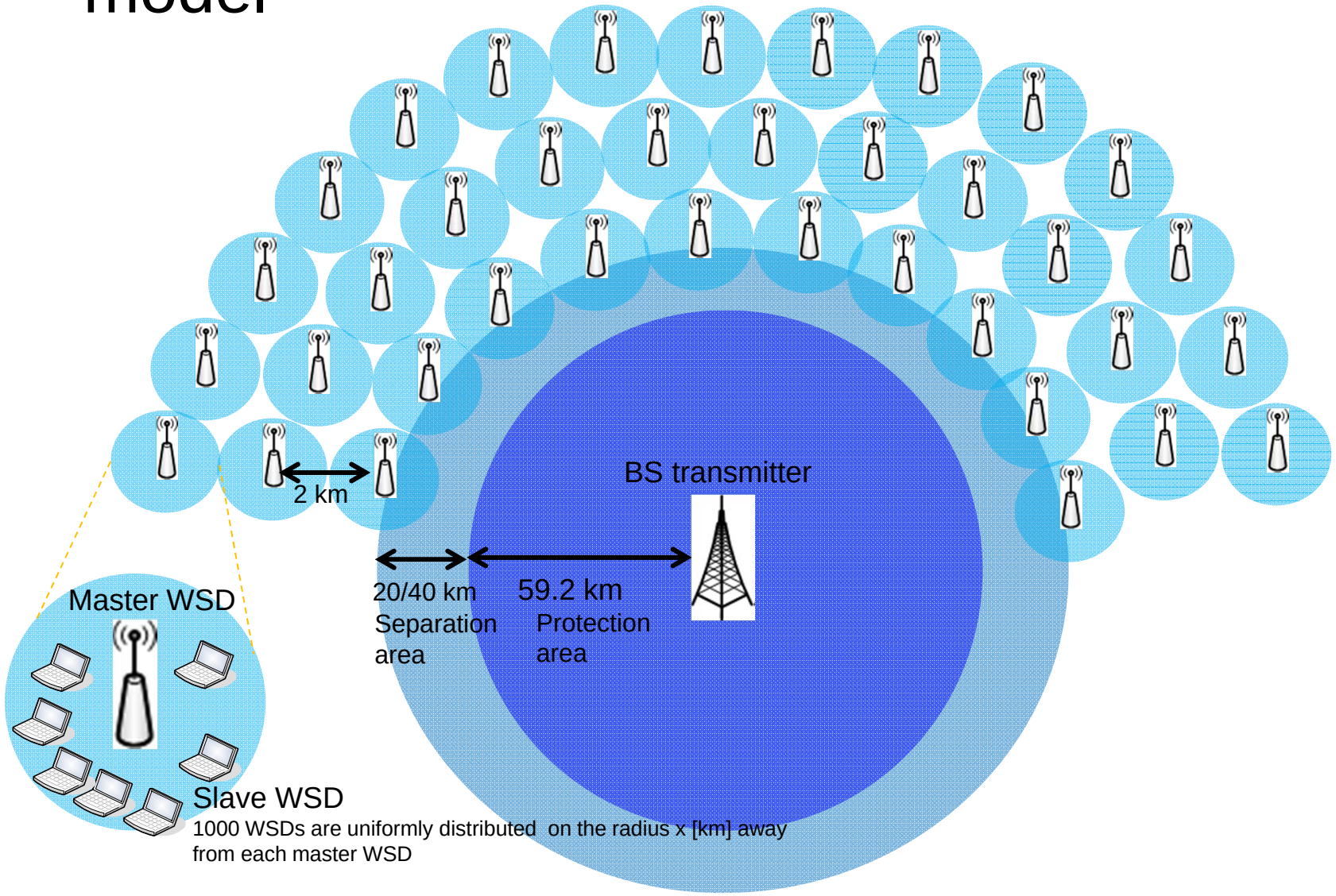
In determining the geo-location of the protection point of operational frequency of BS transmitter at a given area, the protection point (interfere-victim reference point) shall be defined as the closest geo-location point to the calculation target WSD in the protection contour of BS service in equation (A.7.2-2).



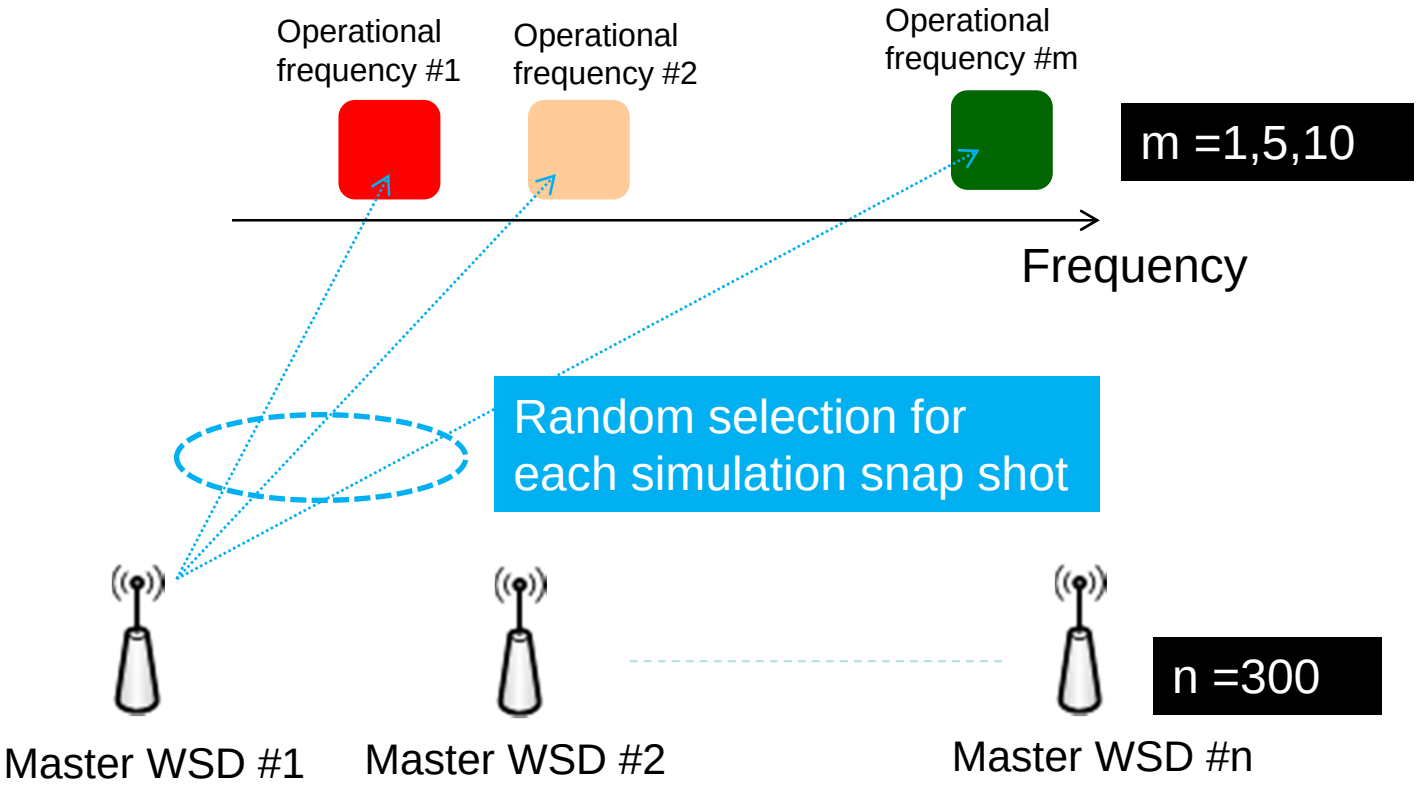
SONY
make.believe

Simulation model and its results

Network geometry image of simulation model

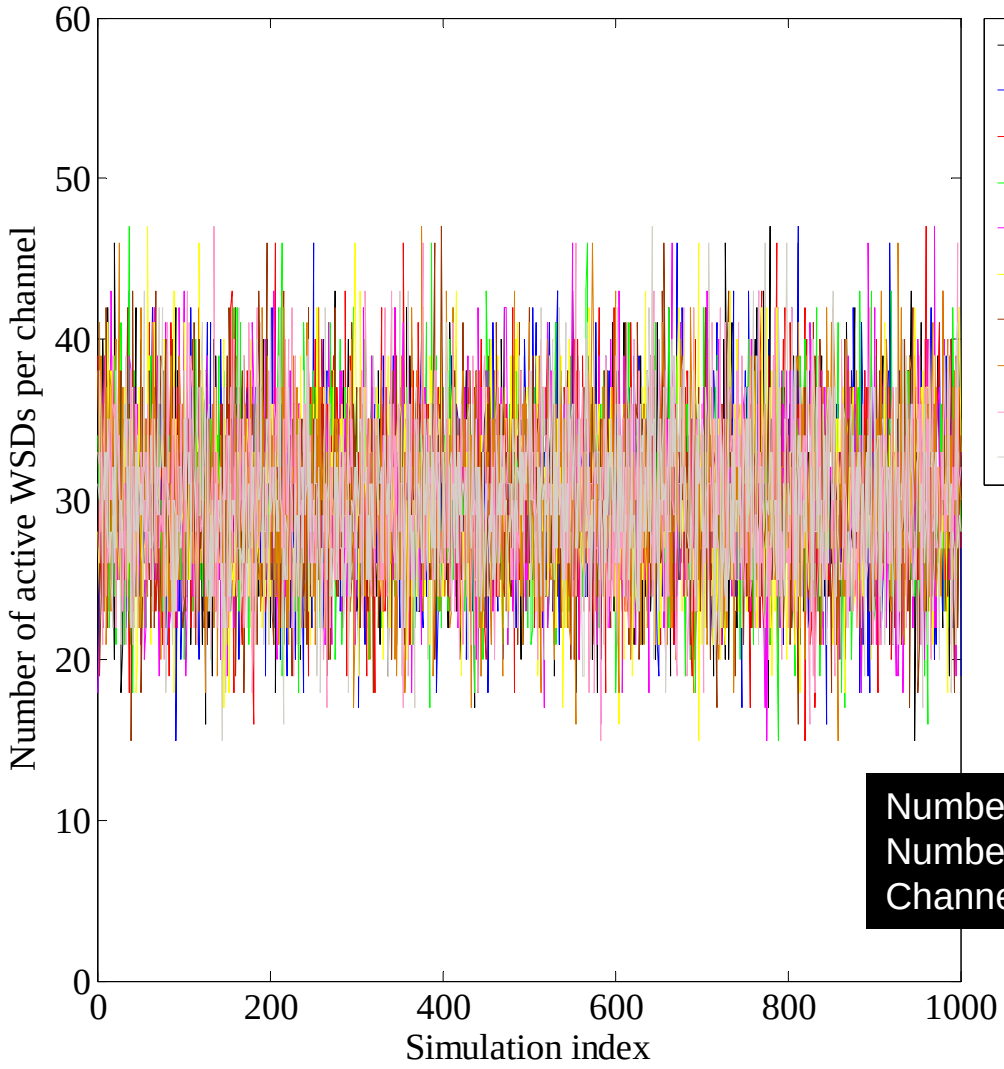


Random selection of WSDs in channel selection



Channel selection probability

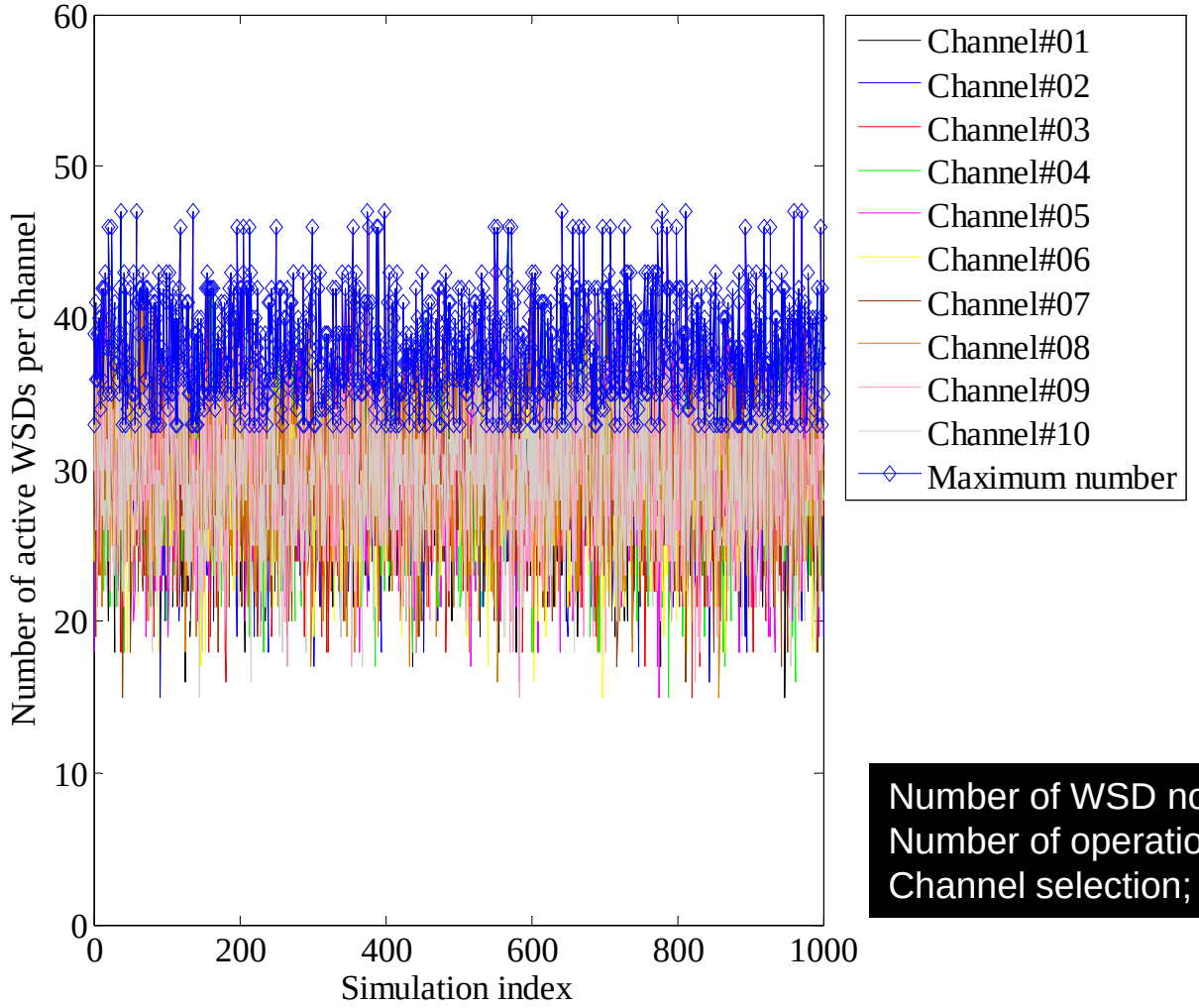
Simulation index vs. Number of active WSD per operational frequency



Number of WSD nodes: 300
Number of operational frequencies: 10
Channel selection; random

Channel selection probability

Simulation index vs. Number of active WSD per operational frequency



Number of WSD nodes: 300
Number of operational frequencies: 10
Channel selection; random

Simulation parameters

SONY
make.believe

Parameter	Value
Frequency-related parameters	
Frequency	600 MHz
Number of channels	1, 5 or 10
Channel bandwidth	7.6 MHz
Channel separation	8 MHz
ACLR	**Scenario #1** ACLR: 33 dB for the first adjacent channel, 36 dB for the second and later adjacent channels ACS (33 dB) **Scenario #2** ACLR (36 dB for all adjacent channels), ACS: (61 dB)
ACS	
Number of active master WSDs	300
Range of angle where master WSD are distributed	0 - 180 degrees
Number of slave WSDs which is located in an area of (D_2/2) [km] away from the geolocation point of each master WSD	10,000
Distribution of geolocation points of slave WSDs	Uniform distribution on the radius of 0.5, 1, or 3 [km] away from the geolocation point of master WSD
Propagation-related parameters	
Propagation model	ITU-R P.1546 (Rural, Time percentage = 1%)
BS broadcaster antenna height	200 m
BS receiver antenna height	10 m
Master WSD antenna height	20 m
Slave WSD antenna height	10 m
BS receiver antenna directivity discrimination with respect to WSD D_{dir}	16 dB
TV receiver antenna gain (=)	12 dB
TV receiver feeder loss (=)	3 dB
BS receiver polarization discrimination with respect to the WSD signal	0 dB
Output power-related parameters	
Limit of WSD output power	36 dBm
WSD safety margin SM (including fading margin -)	19 dB (from Annex 6 of CEPT SE43 Report 159)
TV broadcaster transmission power	79.15 dBm/channel
Noise-related parameters	
Noise density	-174 dBm/Hz
Noise figure	7 dB for all nodes
Incumbent service operation parameters	
Minimum incumbent service (BS) power @ receiver	77.1 dBm
Protection ratio	23.1 dB

Simulation results on WSD output power level

Comparison of output power level of WSD (Number of TVWS channels = 1)

Number of master WSDs		300					
Number of channels		1					
Protection distance [km]		20			40		
Output power calculation method		Fixed	Flexible	Maximized	Fixed	Flexible	Maximized
Output power level of WSD [dBm]	5% CDF	11.5	11.5	20.4	24.2	24.2	31.2
	50% CDF	13.3	13.3	22.3	25.0	25.0	32.0

Comparison of output power level of WSD (Number of TVWS channels = 5)

Number of master WSDs		300					
Number of channels		5					
Protection distance [km]		20			40		
Output power calculation method		Fixed	Flexible	Maximized	Fixed	Flexible	Maximized
Output power level of WSD [dBm]	5% CDF	11.5	19.4	25.1 (23.5)	24.2	32.2	36.0
	50% CDF	13.3	21.6	27.2 (25.5)	25.0	33.0	36.0

Scenario 1 Scenario 2

Comparison of output power level of WSD (Number of TVWS channels = 10)

Number of master WSDs		300					
Number of channels		10					
Protection distance [km]		20			40		
Output power calculation method		Fixed	Flexible	Maximized	Fixed	Flexible	Maximized
Output power level of WSD [dBm]	5% CDF	11.5	22.0	26.8 (25.5)	24.2	36.0	36.0
	50% CDF	13.3	23.9	29.0 (27.5)	25.0	36.0	36.0

Calculation assumption of WSD network capacity

SONY
make.believe

Network capacity calculation related parameters	
Definition of the network coverage in calculating network capacity of each master WSD	Calculating the down link network capacity between each master WSD and its slave WSDs which are distributed on the radius of 0.5, 1, or 3 [km] away from the geolocation point of master WSD itself
Resource allocation method for each slave WSD in an area of (D_3/2) [km] away from the geolocation point of master WSD itself	Centric resource allocation method via TDD-TDMA (No access collision is considered)
Network coexistence protocol (i.e. coexistence beacon mechanism of IEEE 802.22) among neighbour networks managed by each master WSD	N/A
Channel selection method of each master WSD	Random selection
Reference node of potential interferes for incumbent service receiver in each WSD network	Each master WSD
Interference among WSD networks	Considered
Transmission power level of slave WSDs	N/A (Because the downlink transmission is only simulated here)

Simulation results on WSD network cap.

SONY
make.believe

Comparison of network capacity of WSD (Number of TVWS channels = 1, Distance between master and slave WSDs = 0.5 km)

Number of master WSDs		300					
Number of channels		1					
Master-Slave WSD distance [km]		3					
Protection distance [km]		20			40		
Output power calculation method		Fixed	Flexible	Maximized	Fixed	Flexible	Maximized
SINR of WSD [dB]	5% CDF	-26.2	-26.2	-17.2	-10.3	-10.3	-5.5
	50% CDF	-8.4	-8.4	-1.3	1.0	1.0	3.0
Network capacity of WSD [bps/Hz]	5% CDF	0.0	0.0	0.0	0.1	0.1	0.4
	50% CDF	0.2	0.2	0.8	1.2	1.2	1.6

Only scenario 1

Comparison of network capacity of WSD (Number of TVWS channels = 1, Distance between master and slave WSDs = 1 km)

Number of master WSDs		300					
Number of channels		1					
Master-Slave WSD distance [km]		1					
Protection distance [km]		20			40		
Output power calculation method		Fixed	Flexible	Maximized	Fixed	Flexible	Maximized
SINR of WSD [dB]	5% CDF	-15.3	-15.3	-8.2	-2.4	-2.4	-1.3
	50% CDF	-3.3	-3.3	2.5	6.7	6.7	7.6
Network capacity of WSD [bps/Hz]	5% CDF	0.0	0.0	0.2	0.7	0.7	0.8
	50% CDF	0.6	0.6	1.5	2.5	2.5	2.8

Comparison of network capacity of WSD (Number of TVWS channels = 1, Distance between master and slave WSDs = 3 km)

Number of master WSDs		300					
Number of channels		1					
Master-Slave WSD distance [km]		0.5					
Protection distance [km]		20			40		
Output power calculation method		Fixed	Flexible	Maximized	Fixed	Flexible	Maximized
SINR of WSD [dB]	5% CDF	-1.2	-1.2	5.2	11.2	11.2	12.1
	50% CDF	7.9	7.9	13.6	18.4	18.4	19.4
Network capacity of WSD [bps/Hz]	5% CDF	0.8	0.8	2.1	3.8	3.8	4.1
	50% CDF	2.9	2.9	4.6	6.2	6.2	

Simulation results on WSD network cap.

SONY make.believe

Comparison of network capacity of WSD (Number of TVWS channels = 5, Distance between master and slave WSDs = 0.5 km)

Number of master WSDs		300					
Number of channels		5					
Master-Slave WSD distance [km]		0.5					
Protection distance [km]		20			40		
Output power calculation method		Fixed	Flexible	Maximized	Fixed	Flexible	Maximized
SINR of WSD [dB]	5% CDF	-1.1	5.2	10.6	14.6	17.4	17.9
	50% CDF	8.3	14.4	19.5	23.1	26.8	28.1
Network capacity of WSD [bps/Hz]	5% CDF	0.8	2.1	3.6	4.9	5.8	6.0
	50% CDF	3.0	4.9	6.5	7.7	8.9	9.3

Only scenario 1

Comparison of network capacity of WSD (Number of TVWS channels = 5, Distance between master and slave WSDs = 1 km)

Number of master WSDs		300					
Number of channels		5					
Master-Slave WSD distance [km]		1					
Protection distance [km]		20			40		
Output power calculation method		Fixed	Flexible	Maximized	Fixed	Flexible	Maximized
SINR of WSD [dB]	5% CDF	-15.2	-8.2	-2.9	0.4	3.3	3.8
	50% CDF	-2.9	3.8	8.6	11.8	16.0	17.0
Network capacity of WSD [bps/Hz]	5% CDF	0.0	0.2	0.6	1.1	1.7	1.8
	50% CDF	0.6	1.8	3.0	4.0	5.3	5.7

Comparison of network capacity of WSD (Number of TVWS channels = 5, Distance between master and slave WSDs = 3 km)

Number of master WSDs		300					
Number of channels		5					
Master-Slave WSD distance [km]		3					
Protection distance [km]		20			40		
Output power calculation method		Fixed	Flexible	Maximized	Fixed	Flexible	Maximized
SINR of WSD [dB]	5% CDF	-26.2	-17.7	-12.2	-9.9	-2.2	-1.6
	50% CDF	-8.1	-0.2	4.7	5.0	11.1	11.6
Network capacity of WSD [bps/Hz]	5% CDF	0.0	0.0	0.1	0.1	0.7	0.8
	50% CDF	0.2	1.0	2.0	2.1	3.8	

Simulation results on WSD network cap.

SONY
make.believe

Comparison of network capacity of WSD (Number of TVWS channels = 10, Distance between master and slave WSDs = 0.5 km)

Number of master WSDs		300					
Number of channels		10					
Master-Slave WSD distance [km]		3					
Protection distance [km]		20			40		
Output power calculation method		Fixed	Flexible	Maximized	Fixed	Flexible	Maximized
SINR of WSD [dB]	5% CDF	-26.1	-15.2	-10.4	-9.7	-0.9	-0.9
	50% CDF	-8.1	2.3	6.9	5.5	13.6	13.6
Network capacity of WSD [bps/Hz]	5% CDF	0.0	0.0	0.1	0.2	0.9	0.9
	50% CDF	0.2	1.4	2.6	2.2	4.6	4.6

Only scenario 1

Comparison of network capacity of WSD (Number of TVWS channels = 10, Distance between master and slave WSDs = 1 km)

Number of master WSDs		300					
Number of channels		10					
Master-Slave WSD distance [km]		0.5					
Protection distance [km]		20			40		
Output power calculation method		Fixed	Flexible	Maximized	Fixed	Flexible	Maximized
SINR of WSD [dB]	5% CDF	-1.1	7.7	12.8	15.4	20.2	20.2
	50% CDF	8.4	17.0	21.8	24.1	30.5	30.5
Network capacity of WSD [bps/Hz]	5% CDF	0.8	2.8	4.3	5.2	6.7	6.7
	50% CDF	3.0	5.7	7.3	8.0	10.2	10.2

Comparison of network capacity of WSD (Number of TVWS channels = 10, Distance between master and slave WSDs = 3 km)

Number of master WSDs		300					
Number of channels		10					
Master-Slave WSD distance [km]		1					
Protection distance [km]		20			40		
Output power calculation method		Fixed	Flexible	Maximized	Fixed	Flexible	Maximized
SINR of WSD [dB]	5% CDF	-15.2	-5.8	-0.9	1.0	6.1	6.1
	50% CDF	-2.8	6.6	11.0	12.8	19.6	19.6
Network capacity of WSD [bps/Hz]	5% CDF	0.0	0.3	0.9	1.2	2.4	
	50% CDF	0.6	2.4	3.8	4.3	6.5	

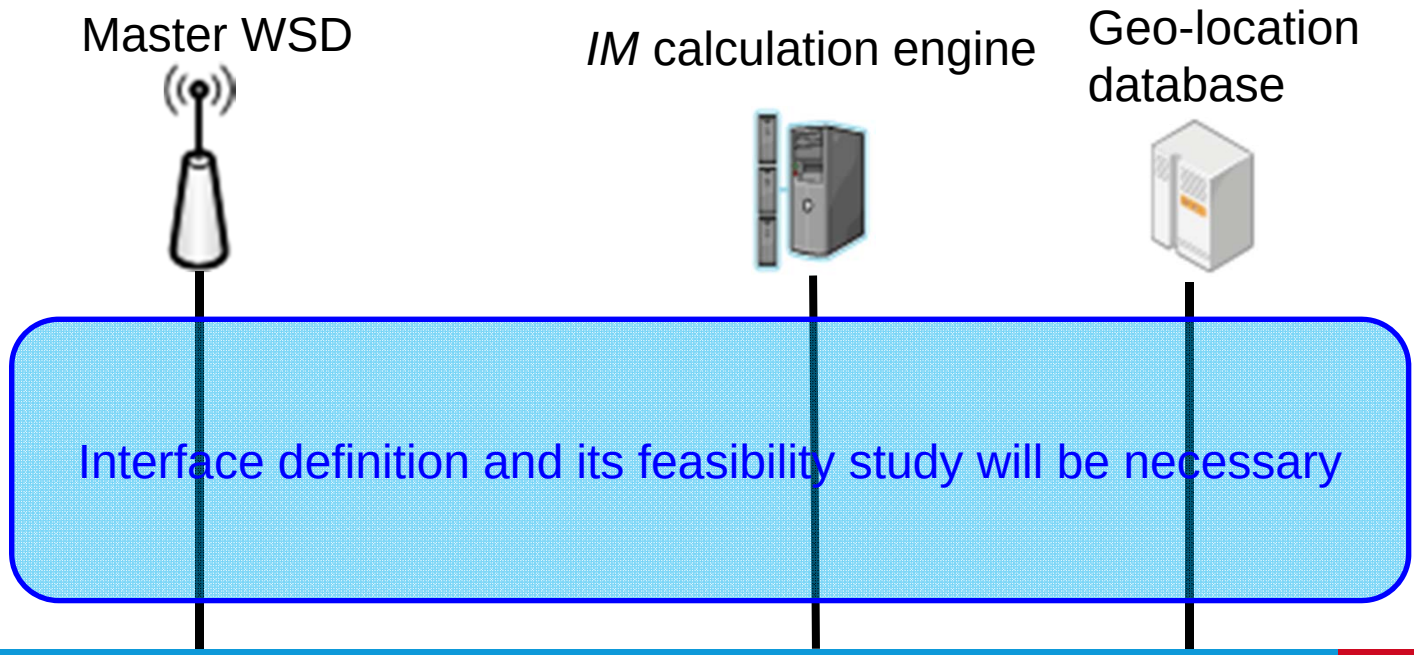
Conclusions

- The studies specifies *IM* calculation methods
  - Three kinds of methods, which are based on fixed margin, flexible margin and minimized margin, were introduced

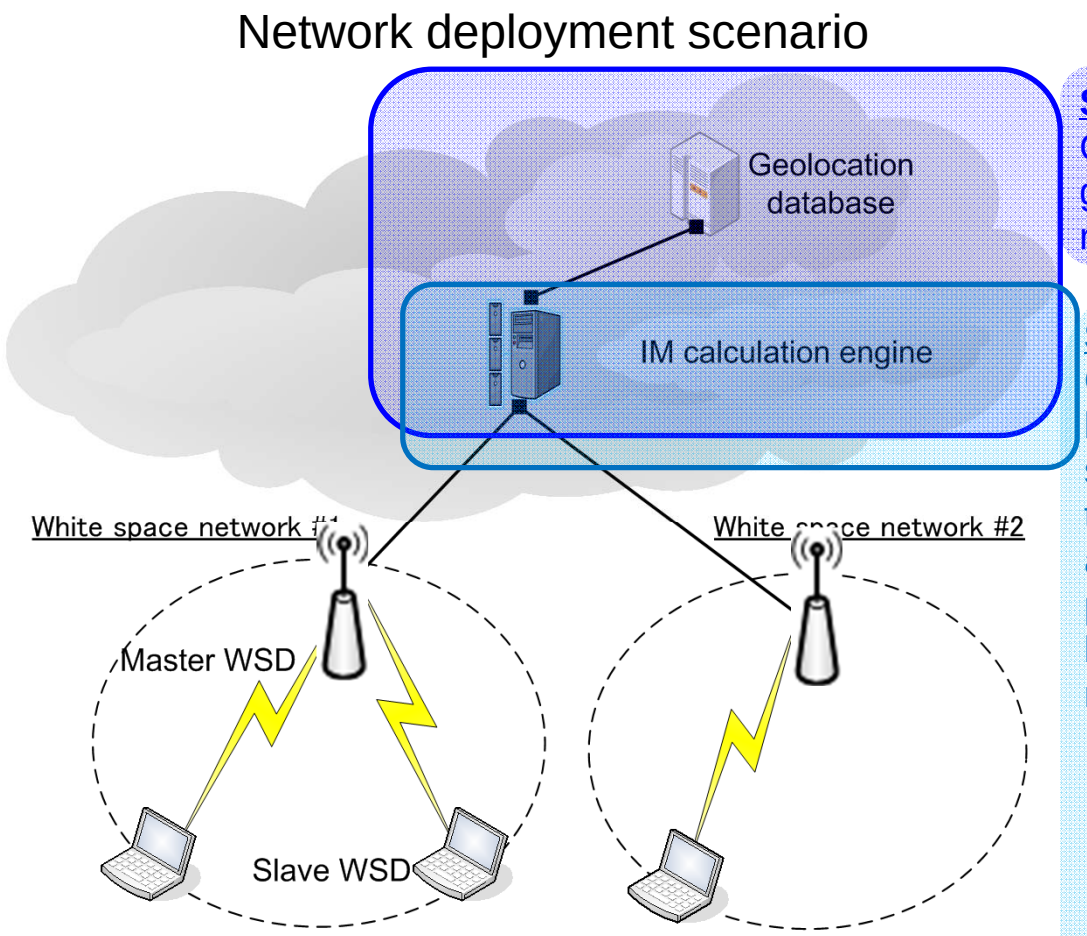
- The **WSD network capacity comparison and analysis between** the location specific WSD output power level calculation method based on **different *IM* calculation methods** for database approach in ECC REPORT159 has been conducted.
  - This result shows that the consideration of the number of active master WSDs of each available channel in calculating *IM* value will have large impact for the network capacity of WSDs while satisfying the incumbent service protection

Future work

- Further study may be necessary in SE43 and/or ETSI, specifically for the feasibility of the interface between the geo-location database, IM calculation engine and WSDs allowing for the number of active master WSDs to calculate the location specific WSD output power level in a geo-location database.



Network deployment scenario



Scenario#1:
Geo-location database and advanced geo-location engine are managed by regulatory body

Scenario#2:
Geo-location database is managed by regulatory body. But a third party should take a responsibility to protect the incumbent service receivers from an aggregated interference problems, and the operation should be kept under surveillance by regulatory body

The merit will be to enable the processing load of the geo-location database managed by regulatory body to offload to the third party engine.

SONY

make.believe