Study of Protection Criterion and Signal Detections based on Cognitive Radio Techniques for IEEE 802.22 Wireless Regional Area Network (Rural FWA) in Japan

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Outline

- Background
- Cognitive Radio
- IEEE 802.22 WRAN System
- Research Directions
- Interference Protection of ISDB-T System
- Summary and Conclusion

Background (1)

- Currently, the radio spectrum is scarce because of using the static spectrum access techniques.
- In many radio bands, the use of radio spectrum is very low.
- Especially, in the TV band, many channels are unused over large geographical location.

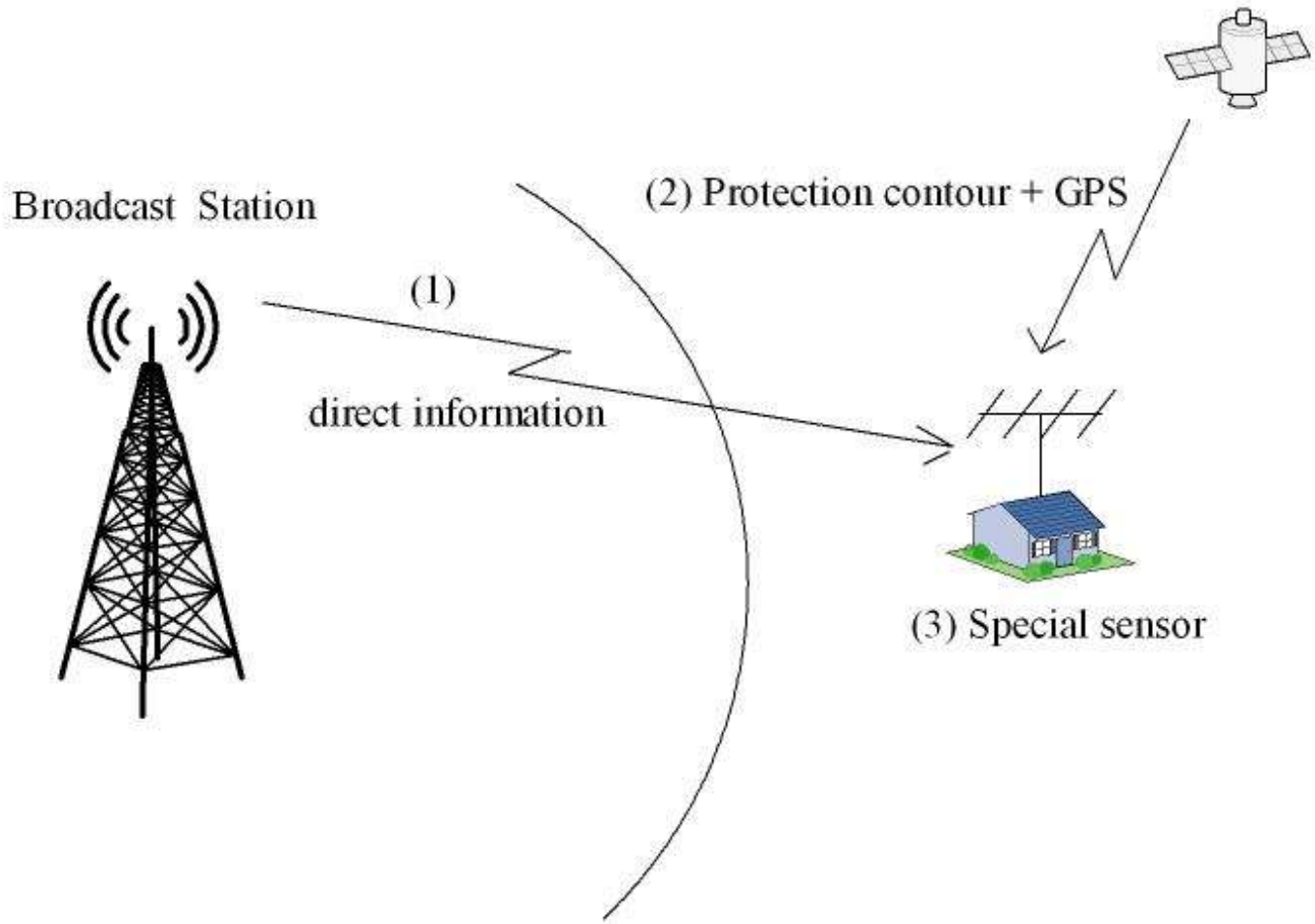
Background (2)

- To overcome this issue, in May 2004, the FCC proposed new rules permitting unlicensed devices based on Cognitive Radio (CR) to operate in the TV broadcasting at locations where the spectrum is not in use.

Background (3)

- Based on FCC rule, there are at least three methods that could be used to determine whether a TV channel is unused at a specific time and/or location.

Background (4)



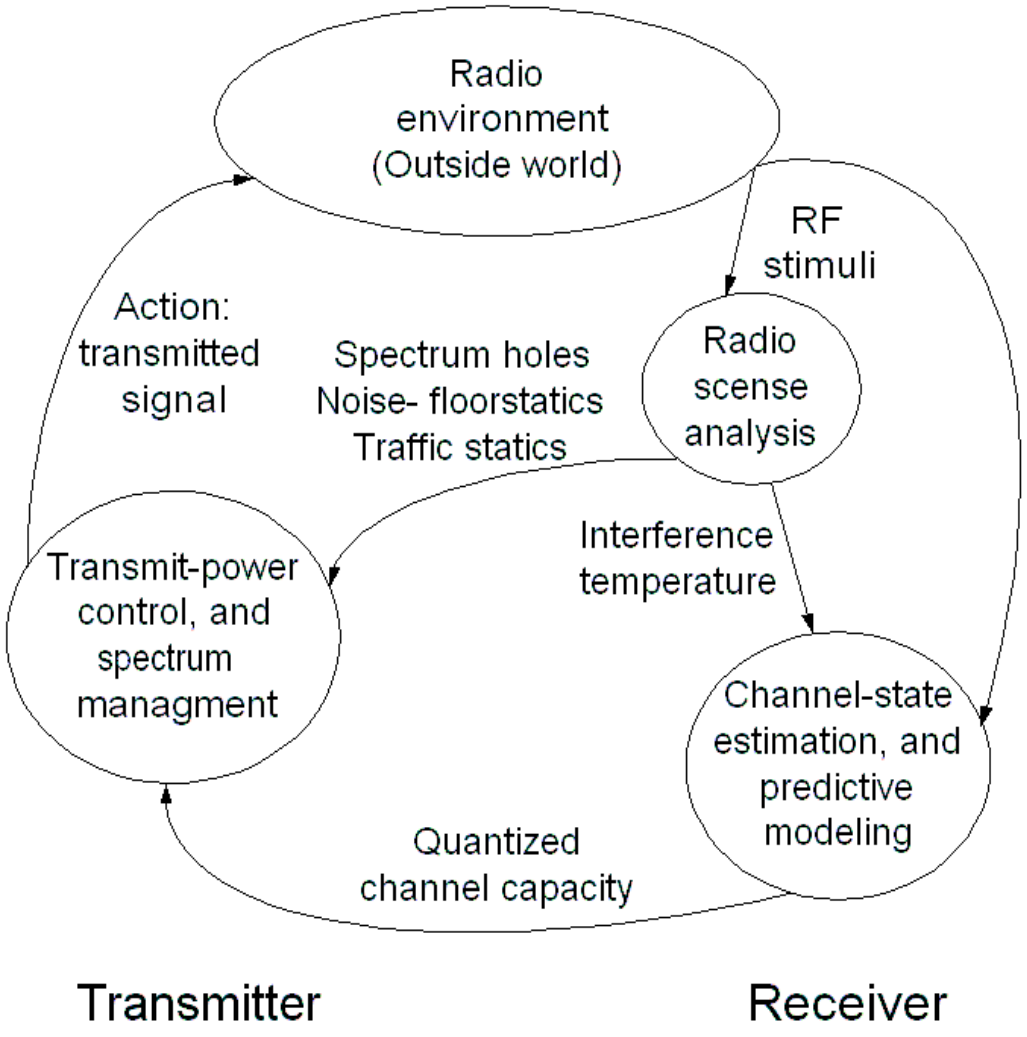
Background (5)

- In rural, the need for broadband is not being met yet.
- In November 2004, the IEEE 802.22 Wireless Regional Area Network (WRAN) has been proposed to operate in TV bands at rural area.

CR(1)

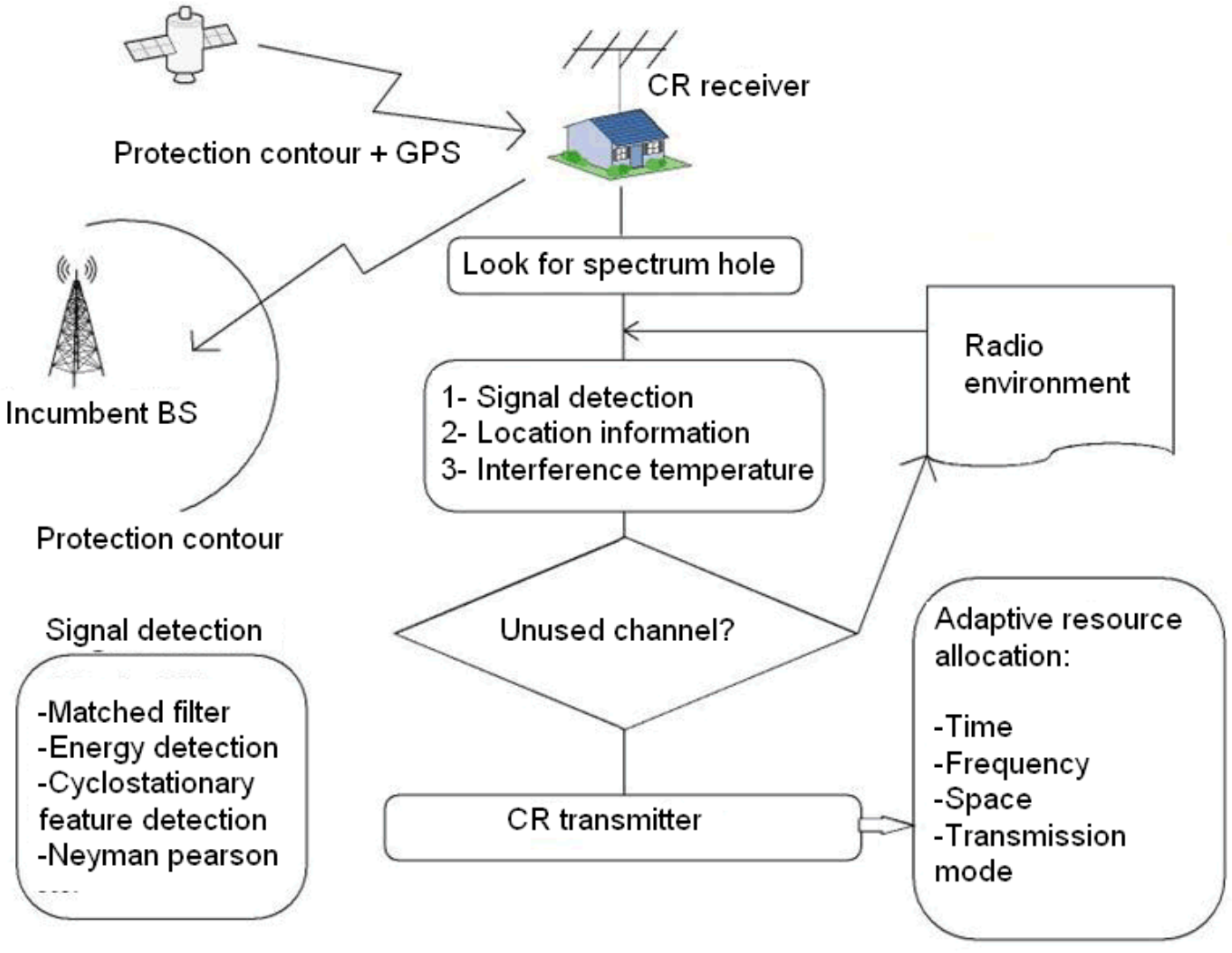
- Cognitive Radio is a smart radio that is aware of its surrounding environments by which, the CR transmitter/receiver can detect whether a particular segment of the radio spectrum is being in use and jump into the temporarily unused spectrum very rapidly, without interfering with the transmission of incumbent services.

CR(2)



S. Haykin, "Cognitive Radio: Brain-Empowered Wireless Communication" IEEE JSAC 2005

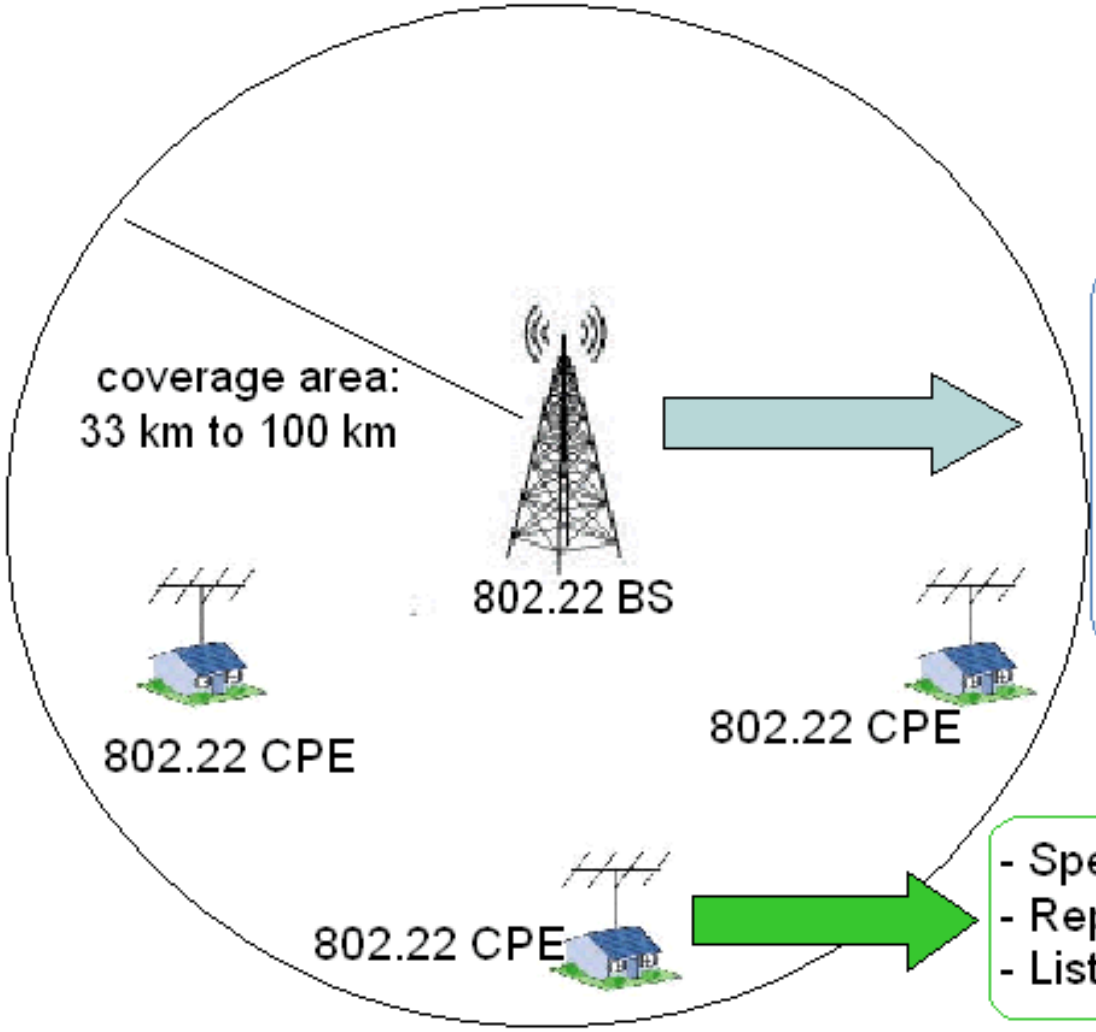
CR(3)


Protection contour + GPS
CR receiver
Look for spectrum hole
Incumbent BS
Protection contour
1- Signal detection
2- Location information
3- Interference temperature
Radio environment
Unused channel?
Signal detection
-Matched filter
-Energy detection
-Cyclostationary feature detection
-Neyman pearson
CR transmitter
Adaptive resource allocation:
-Time
-Frequency
-Space
-Transmission mode

IEEE 802.22 WRAN (1)

- IEEE 802.22 WRAN is the first worldwide wireless standard based on CR.
- A fixed point-to-multipoint (P-MP) wireless air interface.
- It operates in the TV bands
- Aim at providing the wireless broadband access to rural and remote areas.

IEEE 802.22 WRAN (2)



- Control medium access
- Transmit data to CPEs in the cell
- Control all the RF characteristics of CPE
- Spectrum management
- Power control

- Spectrum measurement
- Report the results to BS
- Listen to the BS

IEEE 802.22 WRAN (3)

Frequency operation	54-862 MHz (41-910 MHz)
Bandwidth	6 MHz (7 MHz or 8 MHz)
Data rate	1.5 Mbp (downstream) 384 Kbps (upstream)
BS transmit EIRP	100 W
CPE transmit EIRP	4 W

Issue

- Most of the requirements for standardization of IEEE 802.22 system are coming from US.
- 802.22 WRAN must not interfere with the TV services.
- IEEE 802.22 WRAN must use only the unused TV channel. How to detect vacant TV channel?

Research Direction (1)

- Our study starts from the investigation of the applicability of IEEE 802.22 WRAN to Japan.

K. Po and J. Takada, "Study of Applicability of IEEE 802.22 in Japan" IEICE Technical Report, SR2006-40, July 2006

Research Direction (2)

- In our study, the protection criteria for ISDB-T system from the IEEE 802.22 WRAN system are investigated.
- In our study, the separation distance between the IEEE 802.22 transmitter and ISDB-T receiver is computed.

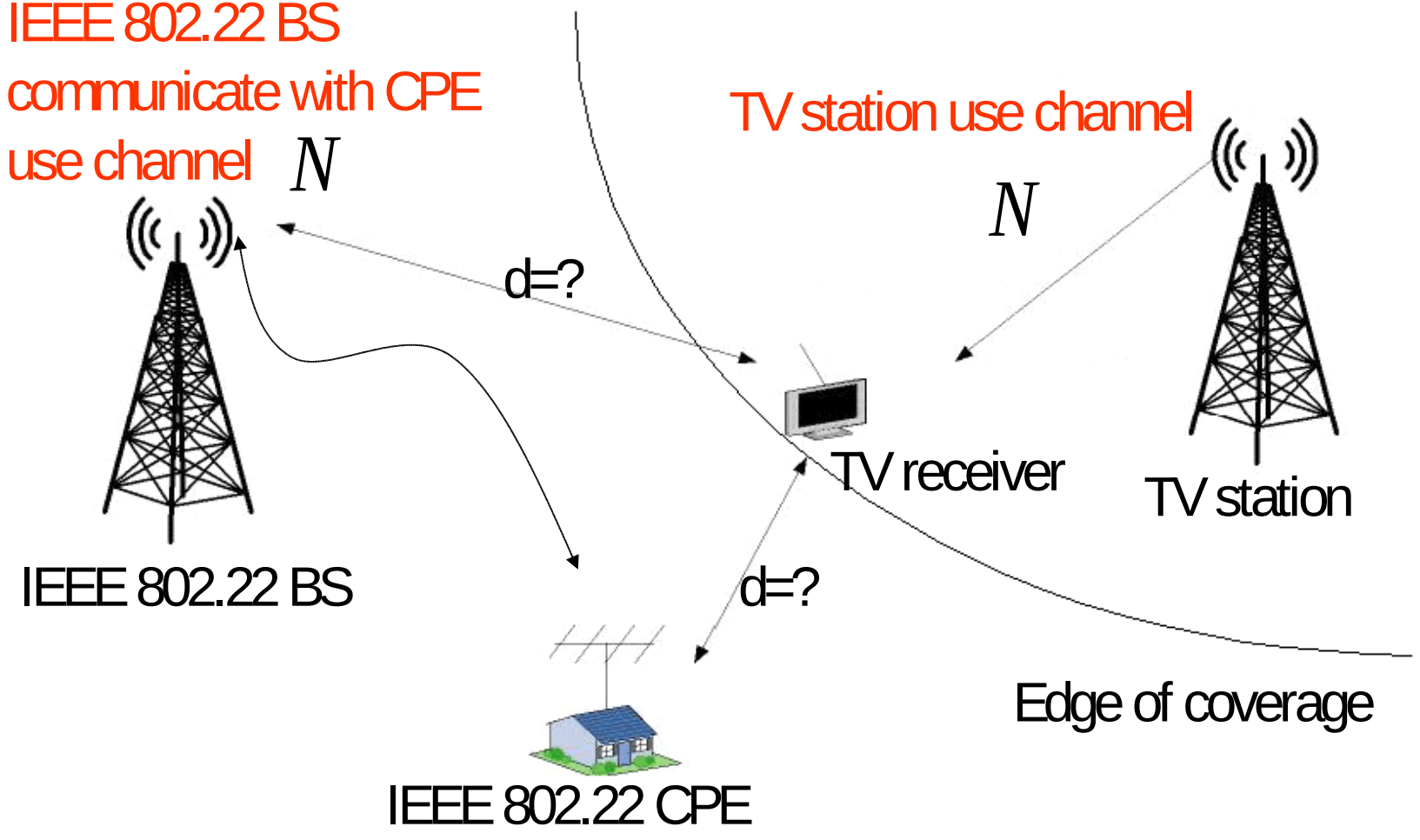
K. Po and J. Takada, "Protection Criteria for ISDB-T system from IEEE 802.22 System" IEICE Society Conference, B-17-13, September 2006.

Research Direction (3)

- To study various signal detection mechanisms that can detect the unused TV channel for use by IEEE 802.22 WRAN system.

- Our initial study about detection methods are Monte Carlo simulation and Neyman-Pearson approach.

Protection Criteria for ISDB-T system from IEEE 802.22 (1)



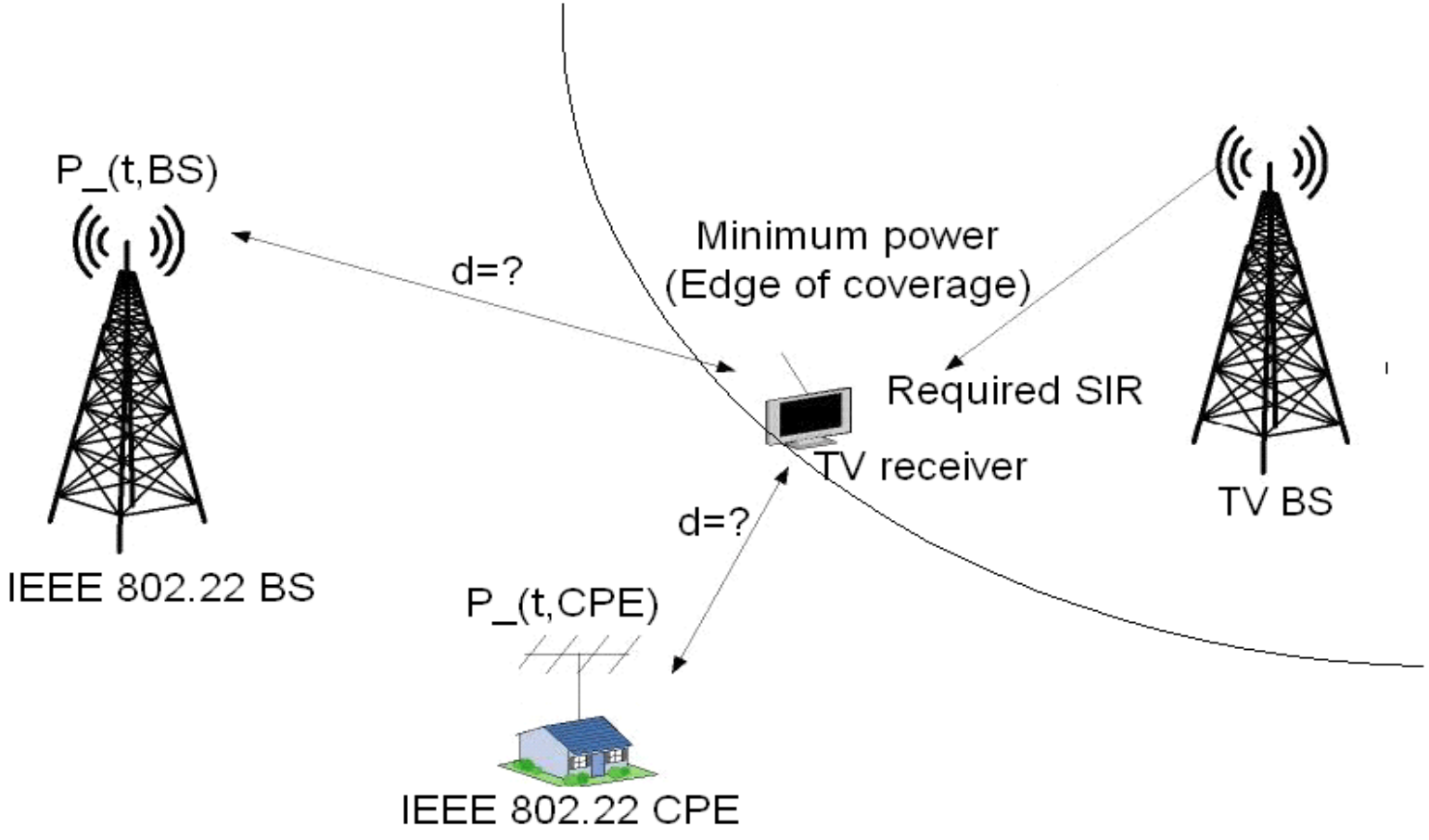
Protection Criteria for ISDB-T system from IEEE 802.22 (2)

- We compute a separation distance between IEEE 802.22 Tx and ISDB-T Rx
- The separation distance is computed based on two approach:
  - Protection criterion from unknown interference (like UWB)
  - Protection criterion from ISDB-T system

Protection Criteria for ISDB-T system from IEEE 802.22 (3)

- We are also considering two propagation models:
  - Free space propagation model
  - Spherical earth diffraction model (ITU-R P.526)

Protection Criteria for ISDB-T system from IEEE 802.22 (4)



Protection Criteria for ISDB-T system from IEEE 802.22 (5)

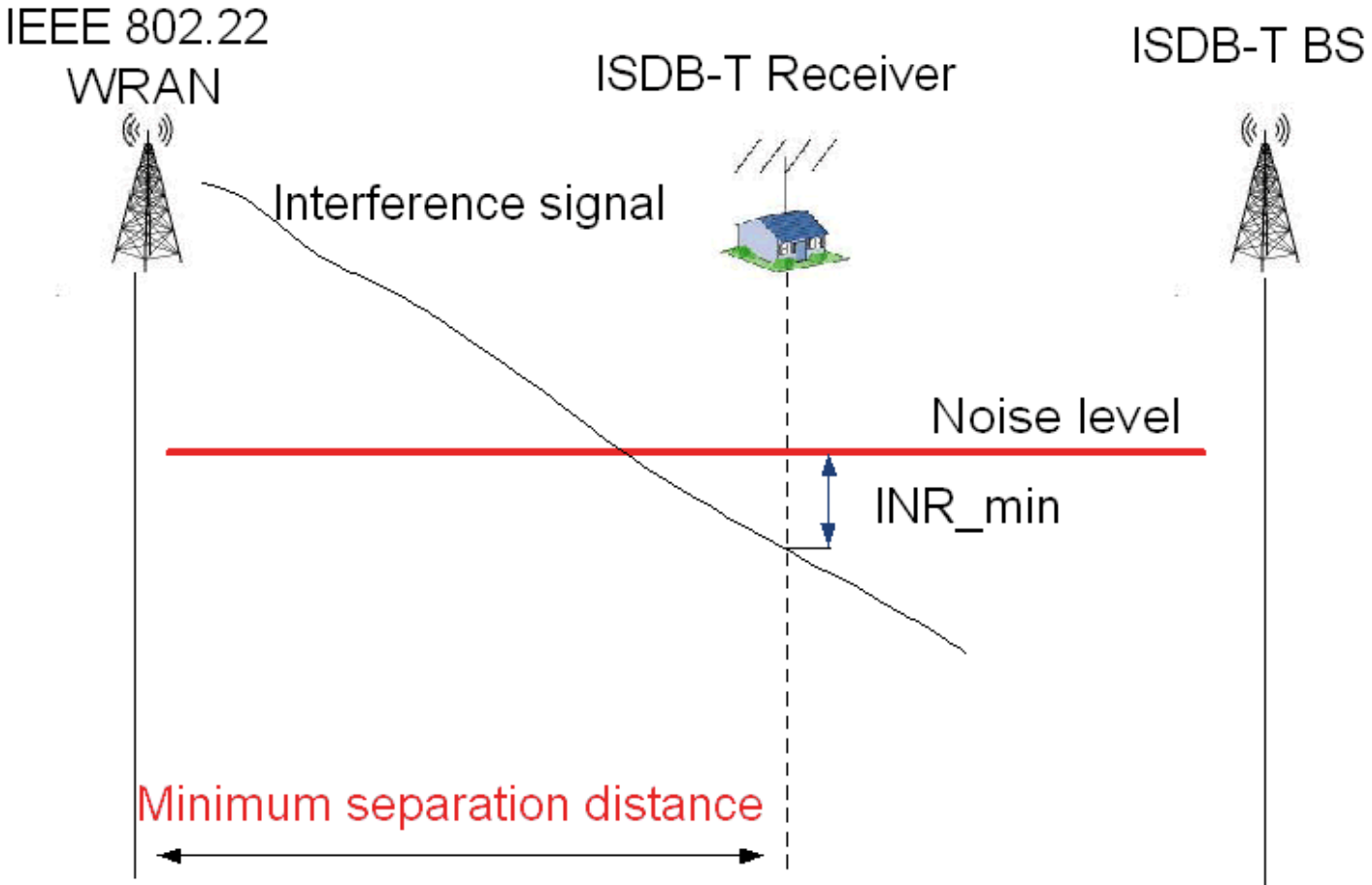
Criterion I: protection from unknown system	INR = -20 dB
Criterion II: protection from other TV station	INR = 0 dB

Protection Criteria for ISDB-T system from IEEE 802.22 (6)

- Common Condition

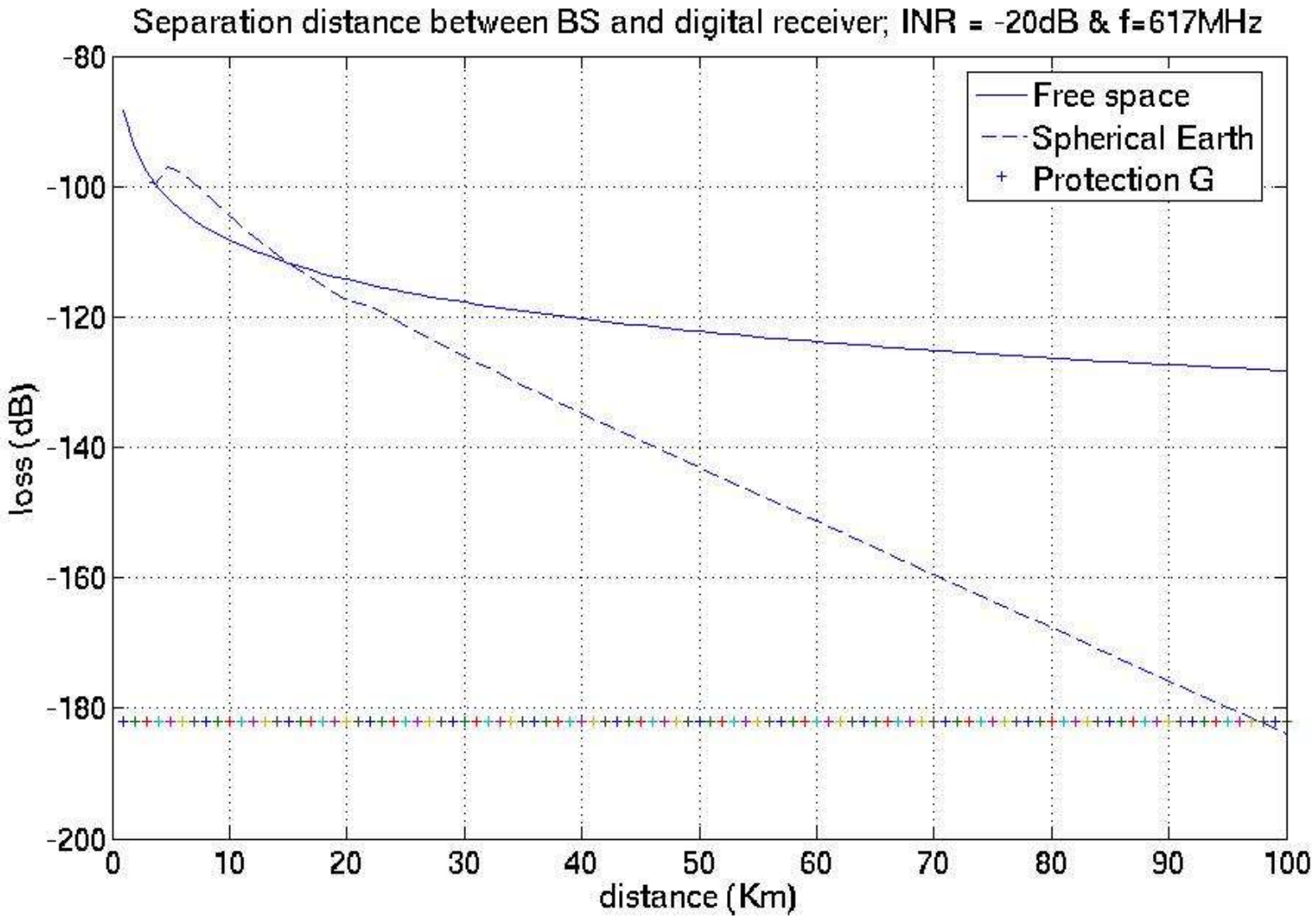
Frequency	617/99/195 MHz
Temperature	290 K
Receiver noise figure	3 dB
Bandwidth	6 Mhz
Directive gain	12 dB
Feeder loss	3 dB

Protection Gain

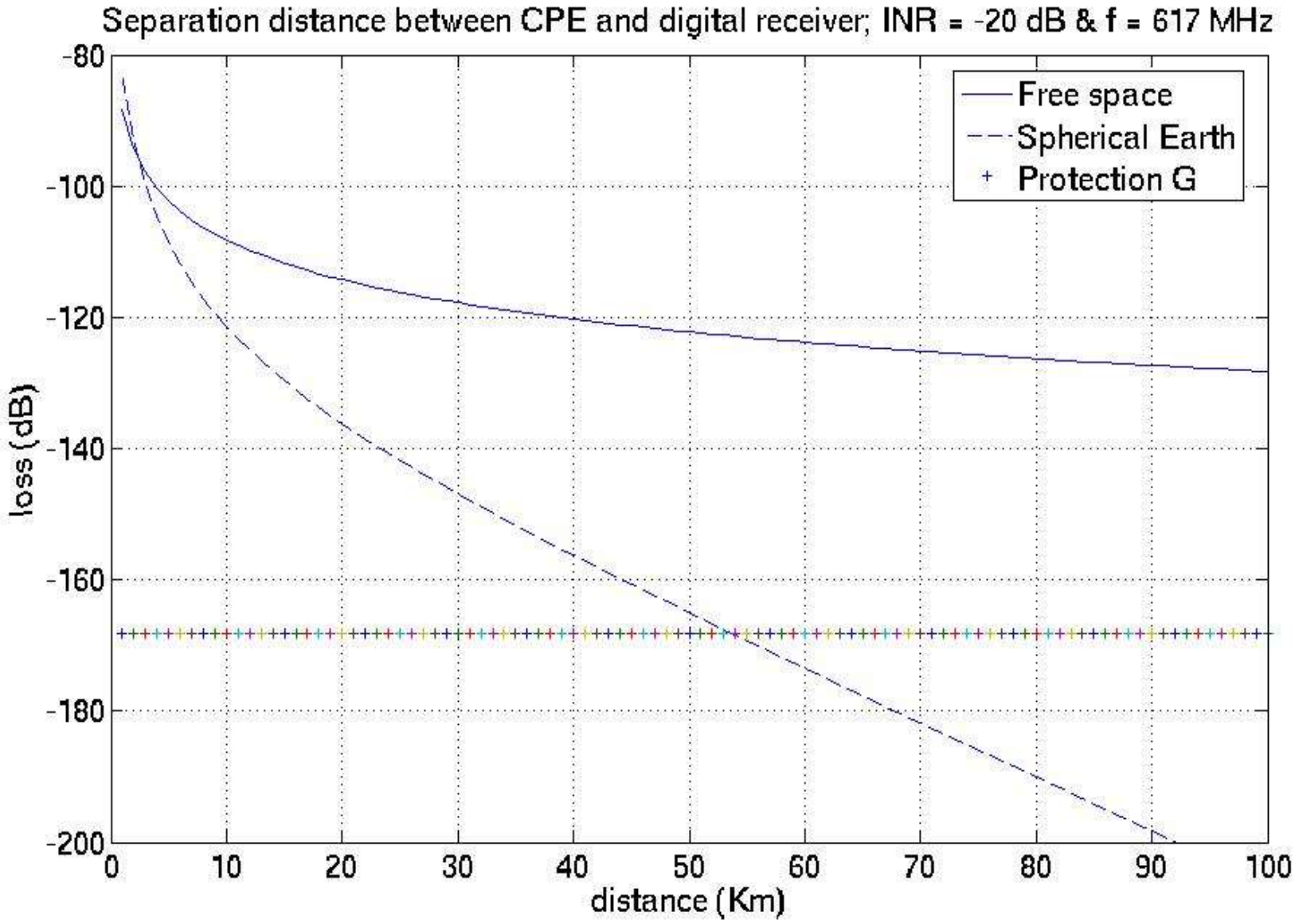


Based on the minimum INR, we can compute the maximum power permissible at the receiver and the protection gain

Separation Distance between IEEE



Separation Distance between IEEE



Minimum Separation between IEEE 802.22 Tx/CPE and ISDB-T Rx (F=617MHz)

[km]	Free Space		Spherical earth model	
	BS	CPE	BS	CPE
Criterion II: INR=0 dB	4,900	1,000	73	31
Criterion I: INR=-20 dB	49,000	10,000	98	54
LoS clearance	49	26		

Minimum Separation between IEEE 802.22 Tx/CPE and ISDB-T Rx (F =195MHz)

[km]	Free Space		Spherical earth model	
	BS	CPE	BS	CPE
Criterion I: INR=0 dB	16,000	3,200	90	38
Criterion II: INR=-20 dB	156,000	32,000	126	68
LoS clearance	49	26		

Minimum Separation between IEEE 802.22 Tx/CPE and ISDB-T Rx (F =99MHz)

[km]	Free Space		Spherical earth model	
	BS	CPE	BS	CPE
Criterion I: INR=0 dB	31,000	6,300	102	38
Criterion II: INR=-20 dB	310,000	60,000	144	76

Summary and Conclusion

- To avoid interference, the protection distance between ISDB-T receiver and IEEE 802.22 system have been computed.
- With spherical earth model, reasonable separation distance is obtained

Summary and Conclusion

- To use the same channel as ISDB-T system may not feasible. However, further study is needed for the use of the adjacent channel of ISDB-T.
- Detector is very important for the IEEE 802.22 system, to detect its unused channel.

- Thank you for your attention

Q&A