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Development of Measurement based Spectrum Database for Efficient Spectrum Sharing

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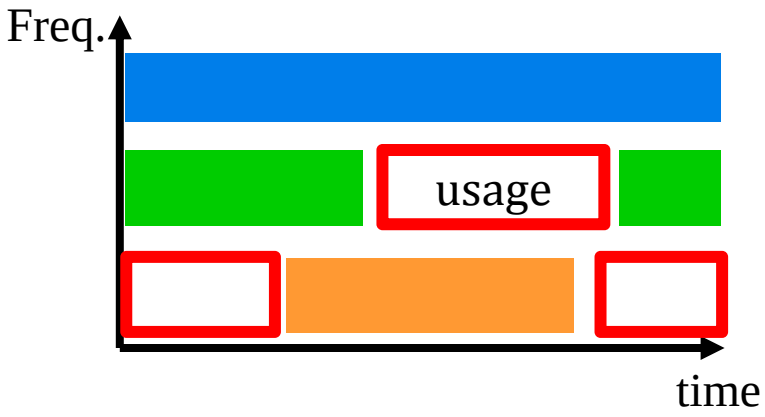
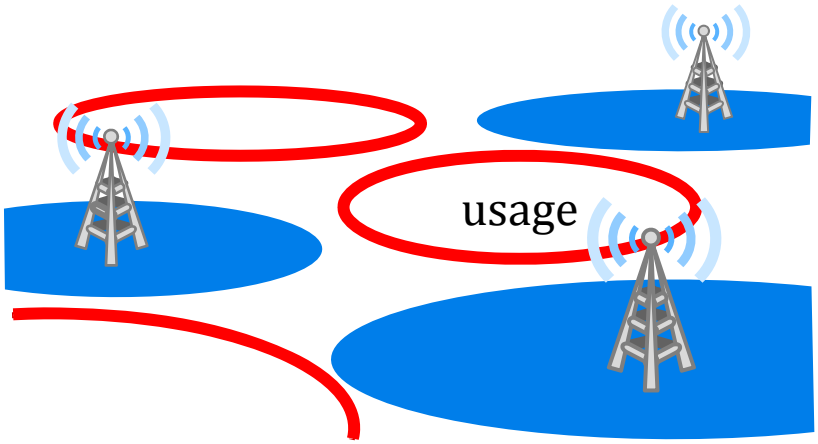
Background

- Increased demand for frequency by increasing wireless devices
  - » Radio frequency is already allocated → Difficult for new system entry
- Around 85 % frequency is unused at time and special domain in existing system





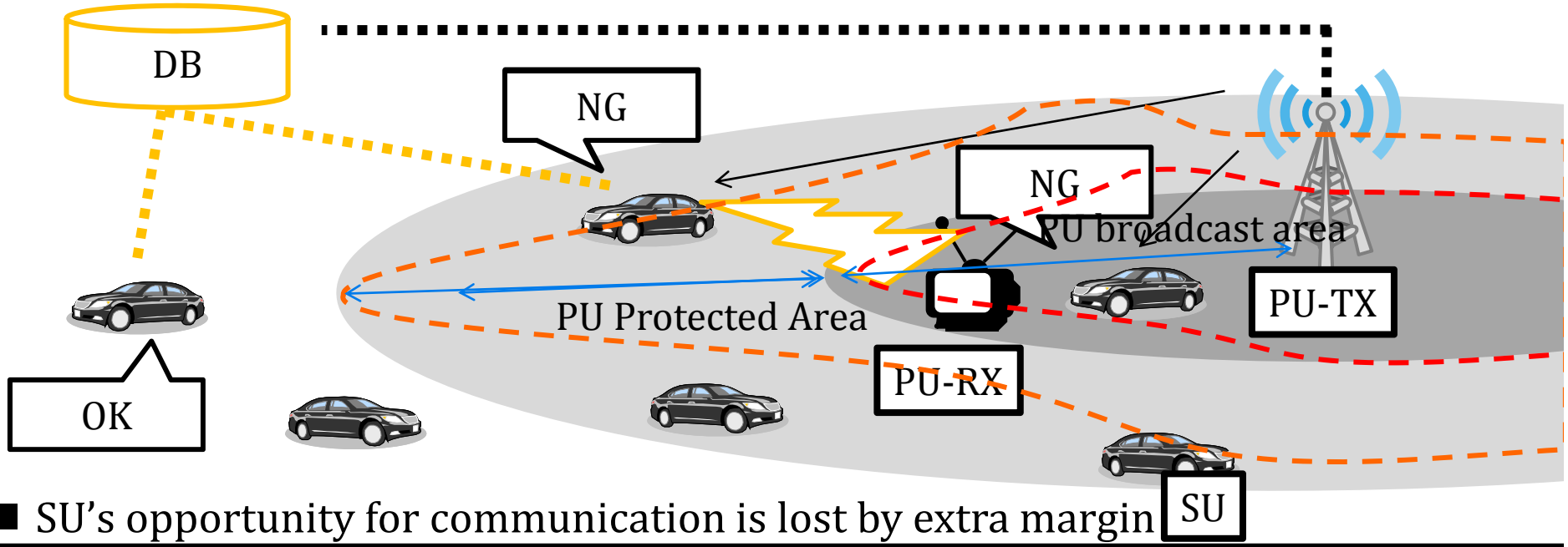
- By effective utilization of White Space (WS), new system can be entered

Cognitive Radio Technology

- » Devices recognize surrounding radio environment and change parameters by itself
- » Applied CR devices are called Secondary User (SU) by using frequency secondary
- » SU is not allowed to interfere toward Primary User (PU) communication

Background

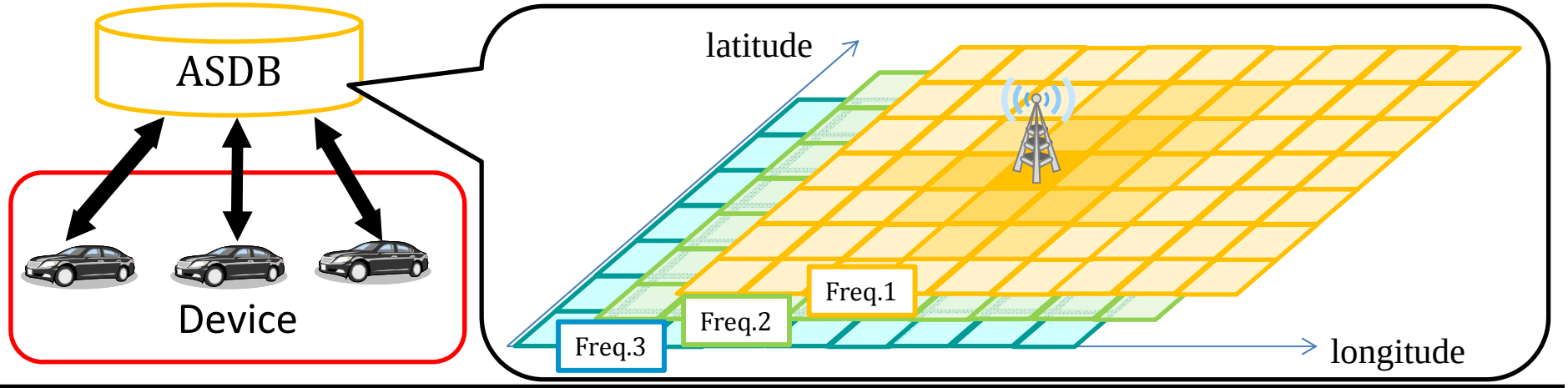
- PU protected method: Spectrum Sensing
  - » SU senses surrounding radio environment and determines PU transmission state
  - » SU cannot detect receiver →Interference toward PU receiver
- PU protected method：Database Cooperation
  - » PU broadcast and protected area configured by Radio environment model→Avoid interference
  - » FCC defined DB：Use F-curve



- SU's opportunity for communication is lost by extra margin

Proposed method：Advanced Spectrum Database

- Develop the database based on real environment and provide PU information
  - » Need to consider Measurement device and Database
- **SU Measurement Device**:
  - » Measure PU state and report information with measurement position
  - » Measure Info.：latitude, longitude, altitude, date, time, frequency, power and so on
- **Advanced Spectrum DataBase** (ASDB):
  - » Obtain and Store information from SU measurement devices
  - » convert measurement info. to statistical info.
  - » Statistical Info.: Average Power, Power Variance, PU Occupancy



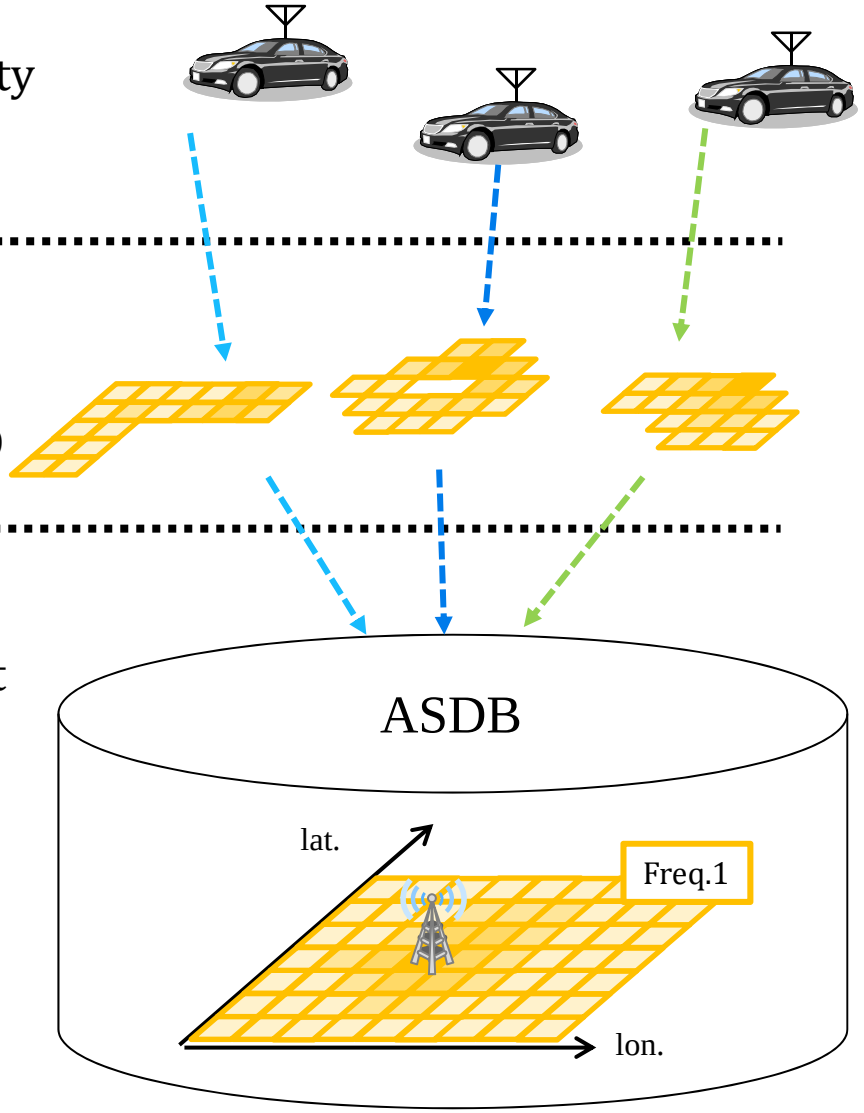
Development of Advanced Spectrum Database

1. **Measurement**（SU）
   - » Device collects PU information with mobility
   - » Measurement device：idle state SU
   - » We assume prove car

2. **Registration**（SU→DB）
   - » SU uploads stored information to database
   - » In this experiment, data is changed by HDD

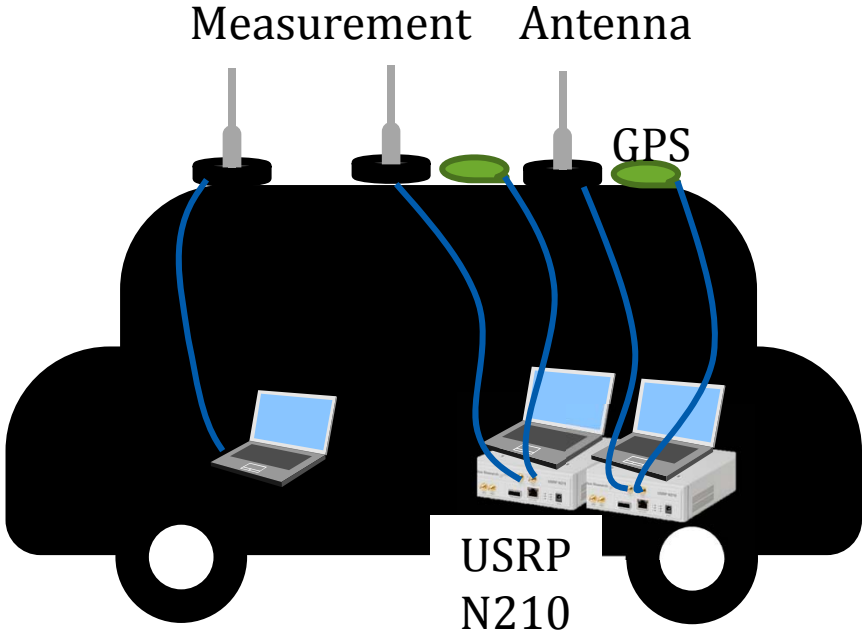
3. **Statistical process**（DB）
   - » DB maintains statistics from measurement information
   - » Need to convert information as available to SU

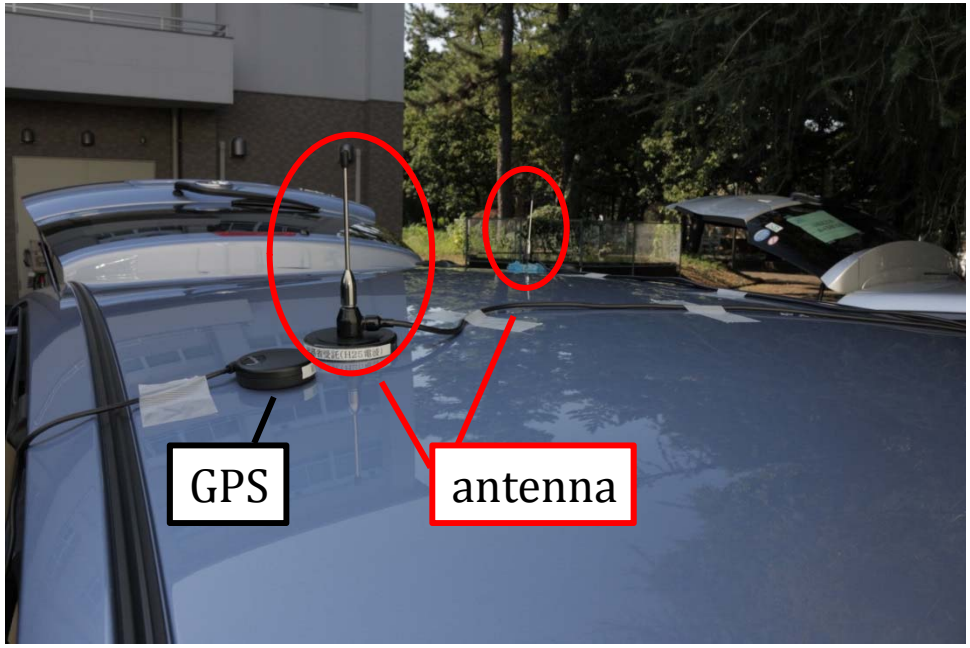
■ Finally, Database is developed



Measurement Devices

- Use USRP N210(※) as radio environment measured devices
  - » Mount WBX (50-2200MHz) which applies TV broadcasting as daughter board
  - » Implement function of recording several frequency power and location in the same time
  - » Set measurement antenna and GPS antenna on roof of vehicle
- For checking view state, One-Seg device is also prepared



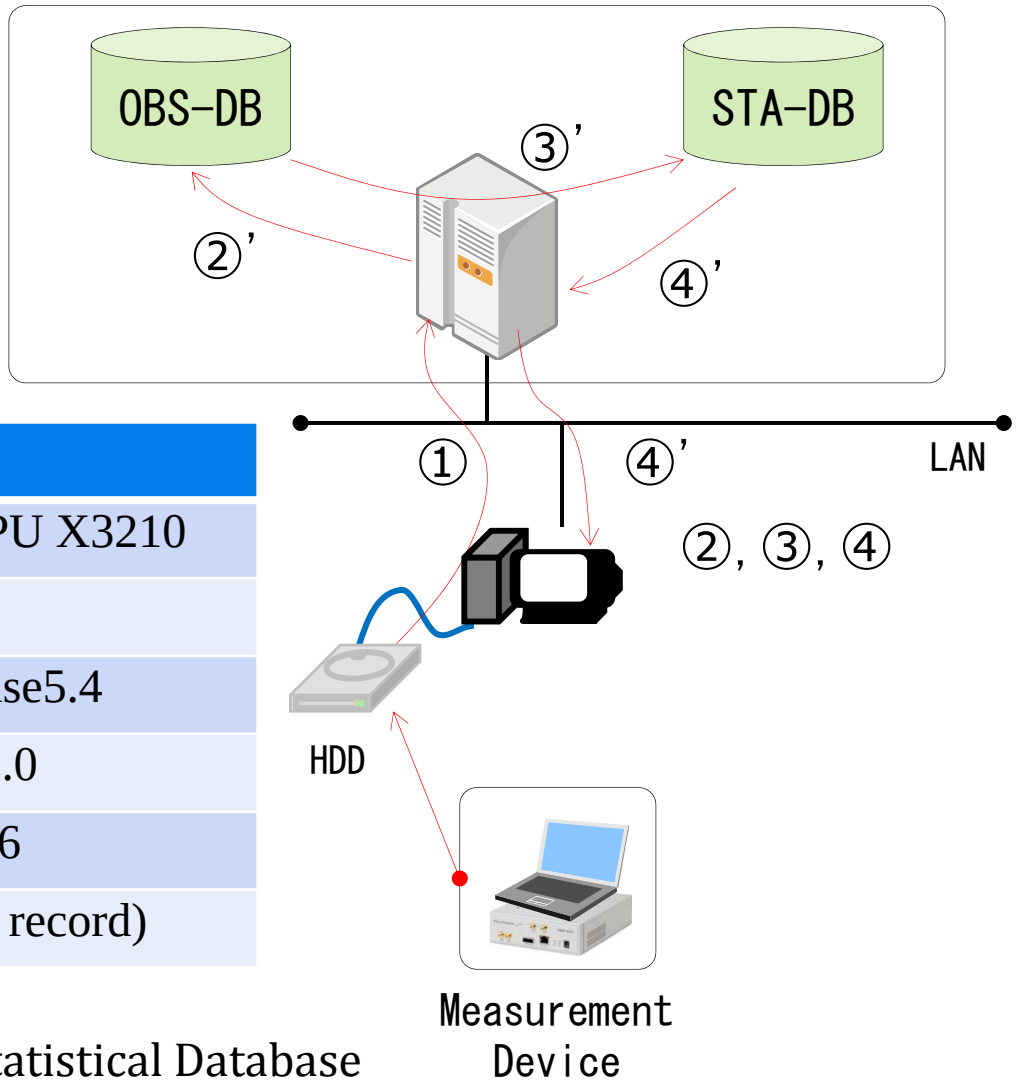


※Universal Software Radio Peripheral Network series 210

Registration：Database Server

■ Data flow in the system

① Upload
② Execute register process
③ Execute statistical process
④ Download to device



名称	設定
CPU	Intel® Xeon® CPU X3210
Memory	16.0GB
OS	CentOS release5.4
Database	MySQL 5.0
PHP	PHP 5.1.6
Registration speed	7m33s(/million record)

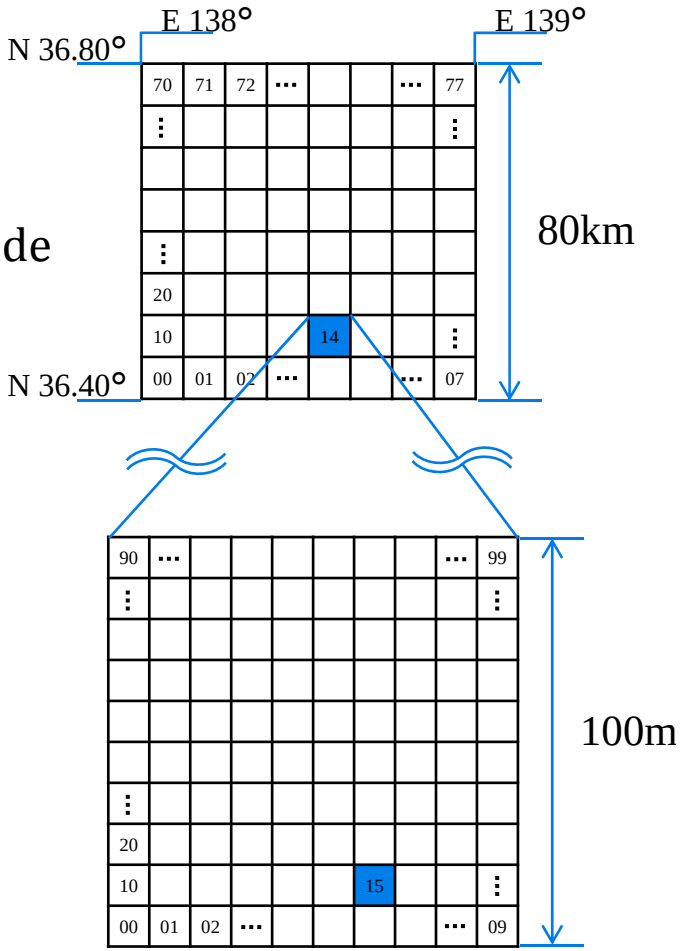
OBS-DB: Observation Database, STA-DB: Statistical Database

Statistical process：Convert position to Mesh code

- GPS can read position information with an accuracy of 0.09m
  - » Large storage is required in the case of raw position data are used

- Divide into 10 m mesh with position information
  - » 80km Mesh：
    - Calculate 80km square area by latitude and longitude
  - » 10km Mesh：
    - Divide 80km mesh to 8×8 area
  - » 10m Mesh：
    - Divide 100m mesh to 10×10 area

- By using mesh code, SU becomes to easily refer to database



Measurement Environment

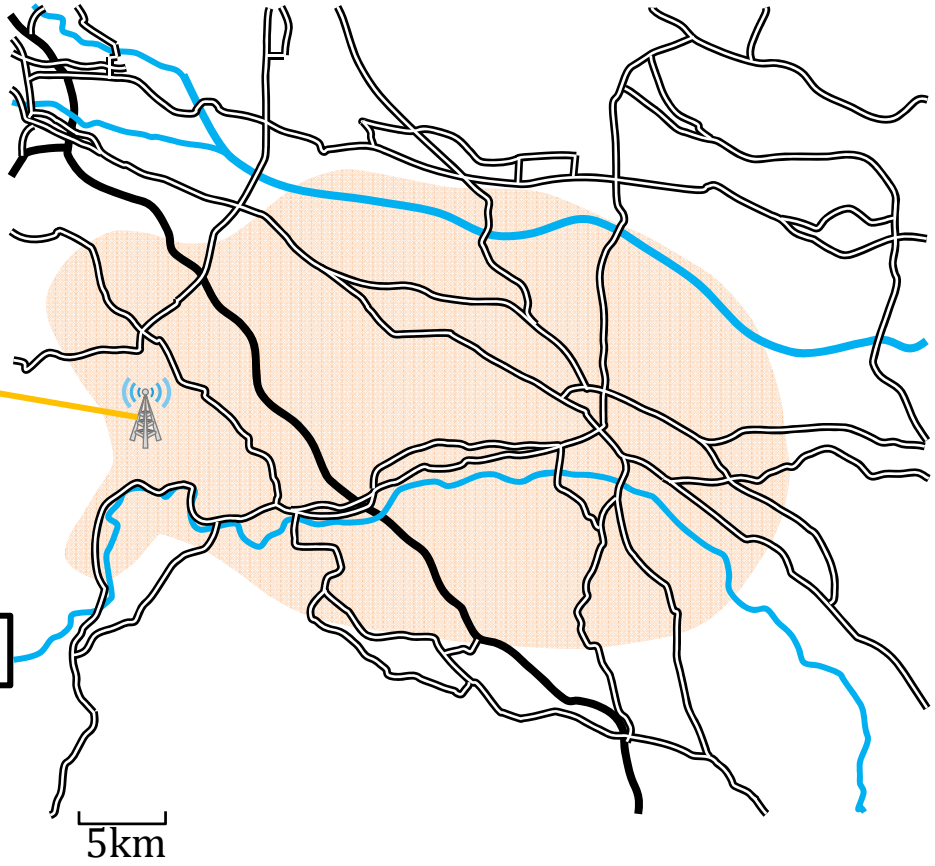
- Area：KUMAGAYA-HUKAYA-GYOUDA, SAITAMA, Japan
- Term：10 days(1st experiment : 28, Oct. – 1,Nov. , 2nd experiment : 10-14, Feb.)
- Target：KUMAGAYA Relay station (KODAMA Relay Station)
- Object：1% of Area

KUMAGAYA Relay Station

- Polarized Wave：
  - » Vertical polarization
- Transmitted Power：
  - » 3W（10W)
- Transmitted Channel
  - » 13,21,22,23,24,25,26ch,(32ch)

Unique

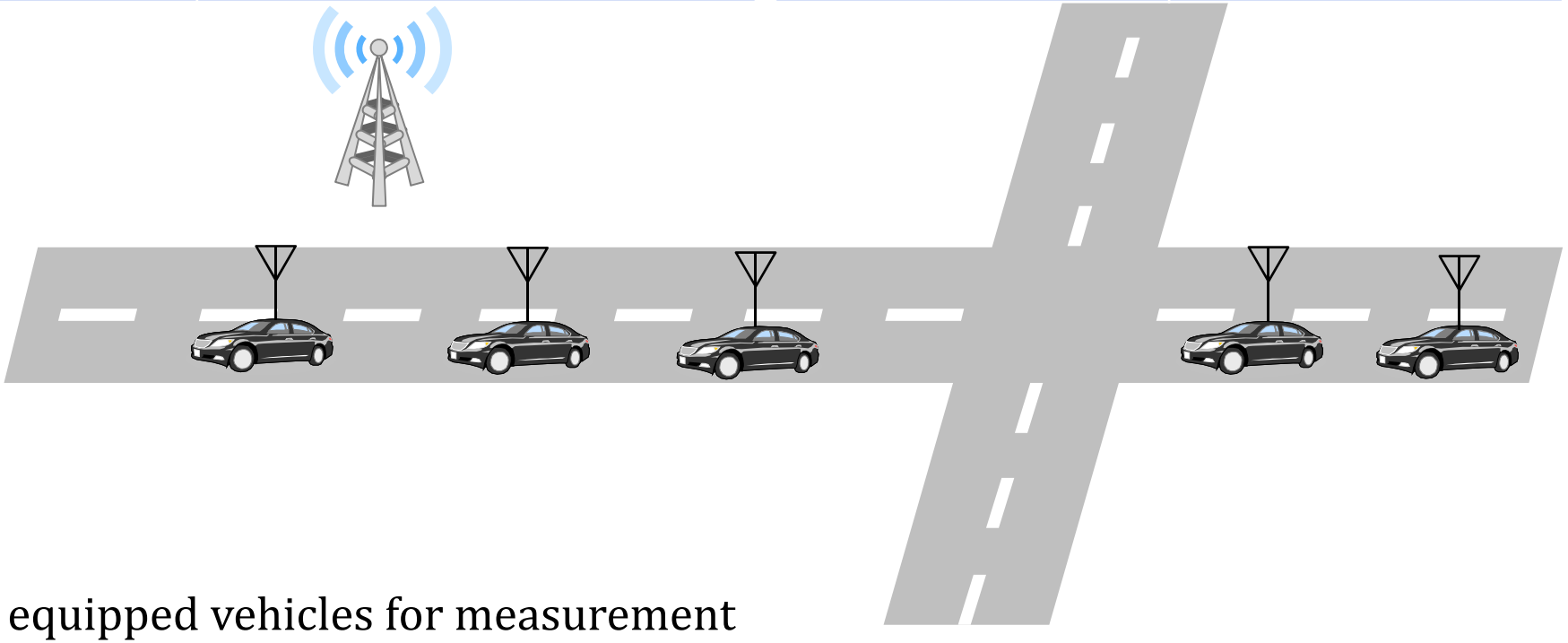
Conjunction with SKY TREE



Parameters

object	value
Channel	13,12,22,23,24,25,26,32 ch
FFT size	2048
Sample rate	200 kHz

object	GPS Specification
GPS device	GarminGPS 18x
Accuracy	<15m,95% typical
Update rate	1record per second



- 5 equipped vehicles for measurement
- Random driving in measurement area

Experimental Result

	Number of Point	Number of Mesh	Driving Area	Rate	Point/Mesh
1st	23,118,609	107,156	33×47km^2	0.69%	215
2nd	23,128,600	82,970	33×47km^2	0.53%	279

- Center of broadcast area

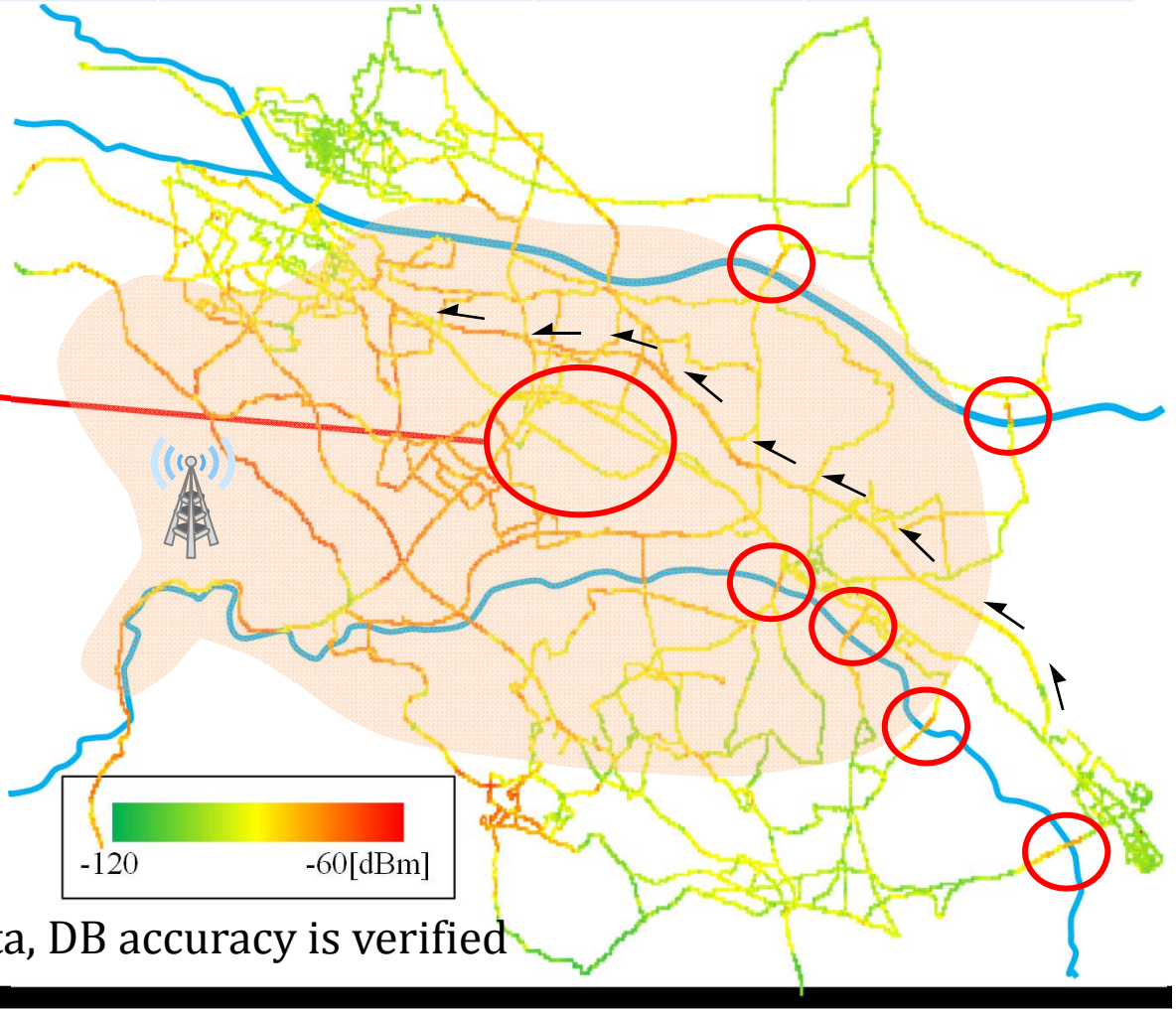
  →Built-up areas

  » received power: low

- River side

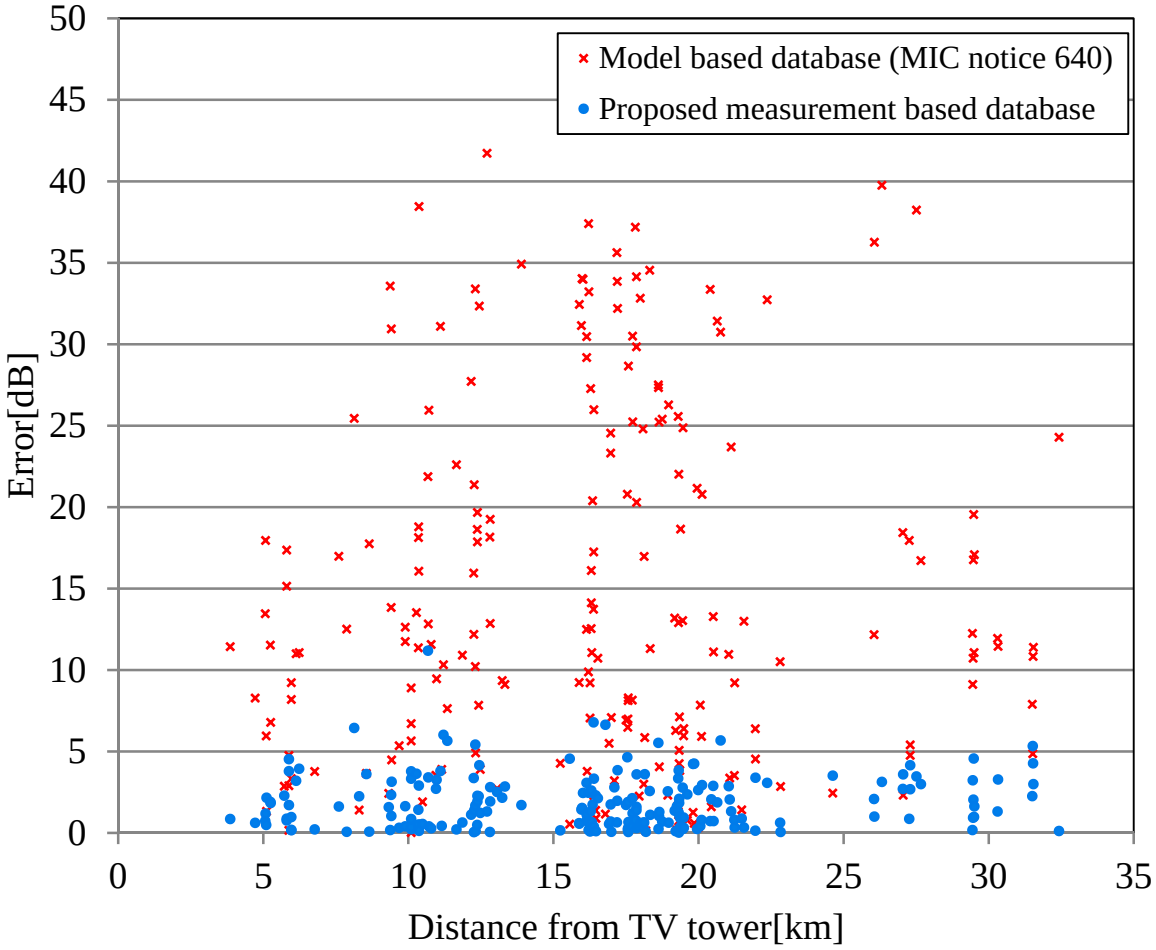
  →in line of sight

  » received power: high



By using arrayed road(root 17) data, DB accuracy is verified

Compare with Accuracy of MIC and ASDB

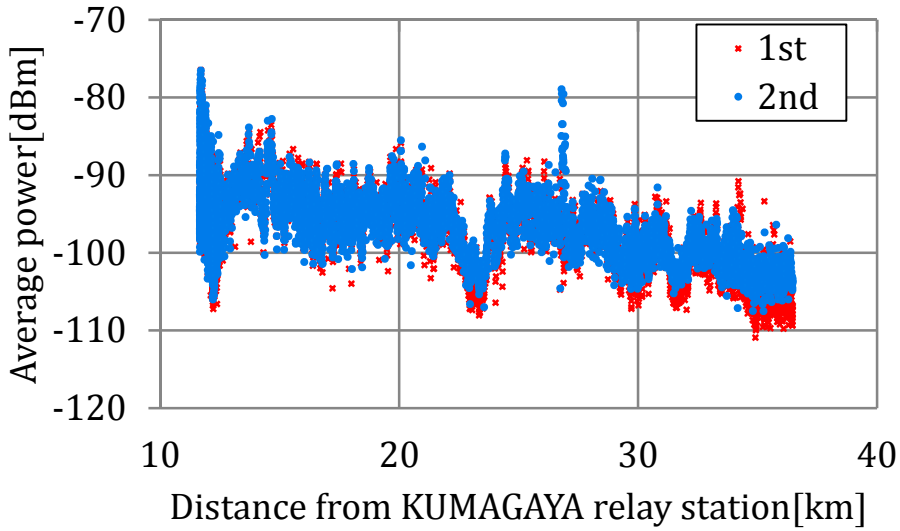


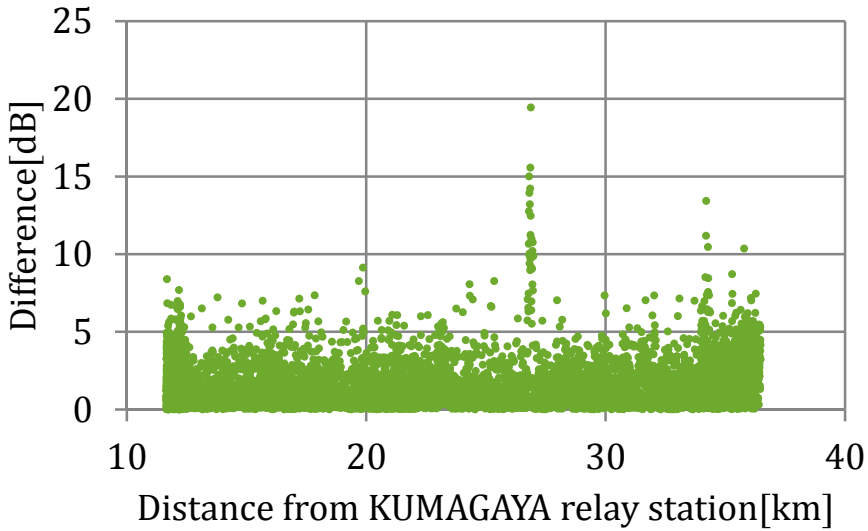
- **Item**
  - » MIC value：
    - The MIC notice 640 is a propagation model for terrestrial TV broadcast
  - » ASDB value：
    - Average value calculated by received power
- **Error**
  - » MIC value：
    - MAX 41.7dB
    - Average 14.3dB
  - » ASDB value：
    - MAX 11.2dB
    - Average 1.8dB

- ASDB can provide high accuracy information to SU

Compare with Experiment Result in 1st and 2nd

- Compare the experimental result of the 1st and 2nd
- Average Received Power
  - » Difference: see nothing
  - » In the same mesh, power is near same
- Difference between 1st and 2nd
  - » Max: 19.4 dB
  - » Average: 1.65 dB
- Found large difference in local, but most of mesh has small value





Effect of Altitude

- Altitude information is not included as a part of ASDB

- Line-of-Sight(LOS) road
  - » Relay station is located in the East side
  - » On the elevated road:
    - There is low wall side of the road
  - » Under the elevated road:
    - There is no wall or shield

- No Line-of-Sight(NLOS) road
  - » Relay station is located in the East side
  - » On the elevated road:
    - There is no wall side of the road
  - » Under the elevated road:
    - Road is covered with wall

Effect of Altitude

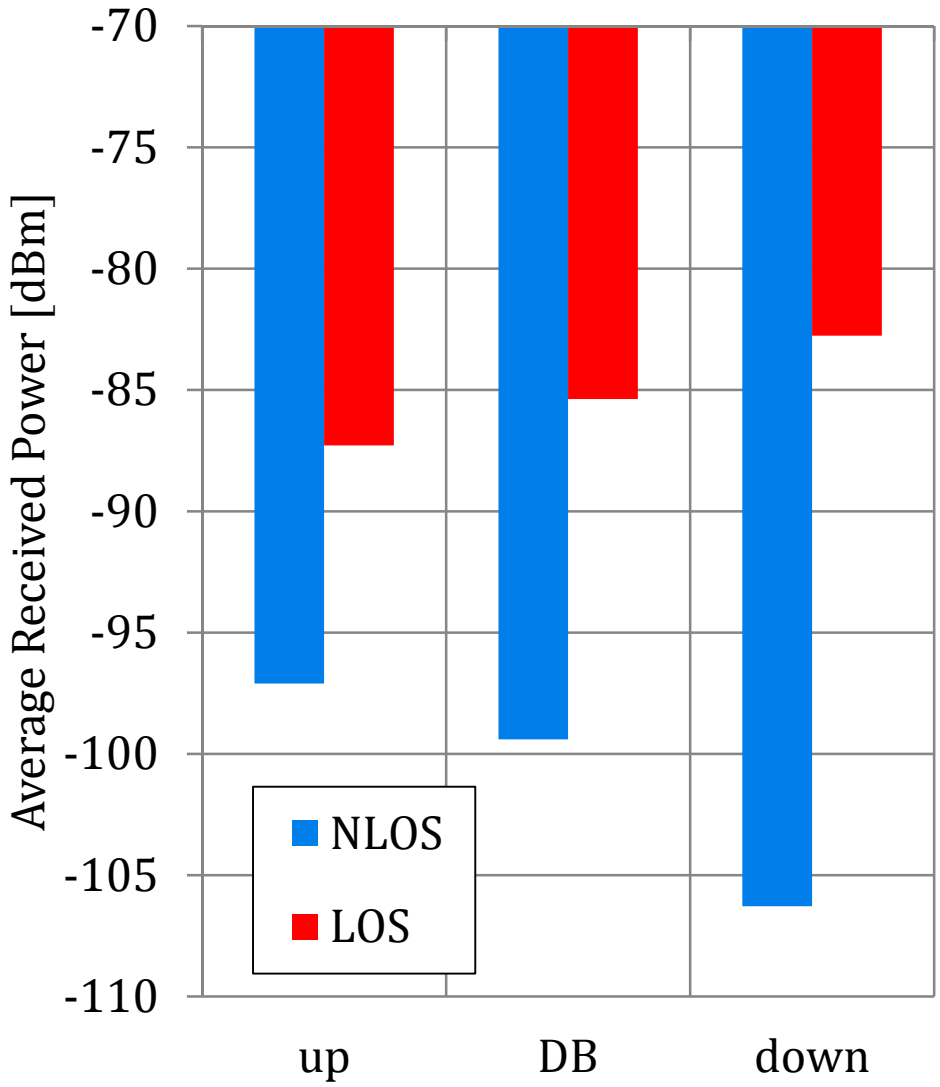
- LOS road
  - » Difference: 4.5 dB

Altitude	low → high
Power	high ← low

  - » Power decreases as it goes to a high place
- NLOS road
  - » Difference: 9.1 dB

Altitude	low → high
Power	low → high

  - » Power increases as it goes to a high place
- Need to consider the altitude



Conclusion

- For PU protection, Cognitive device requires cooperation with database
  - » Database advocated by FCC is defined as PU communication area by calculation based on propagation model
  - » Propagation model cannot present real environment
  - » SU communication opportunity is reduced

- Advanced Spectrum Database
  - » Database provides high accuracy information by development based on measurement
  - » Database gathers information from SU
  - » Divide location into 10m square mesh and all information is stored in each mesh

- Development of Advanced Spectrum Database advantages SU

Thank you for listening