Channel characterization and modeling for specific wireless communication systems

- Wideband directional propagation channel analysis inside an arched tunnel
- Influence of Fresnel zone in Ray-tracing simulation
- Comparison of directional channel measurement and Ray-tracing simulation in university campus
- Identification of relevant clusters at an Urban MIMO macro cell
- Propagation characteristics in outdoor environment for MIMO system
- Scatter identification and stochastic modeling of street micro cell
- Ultra wideband propagation channel measurement

Advanced radio instrumentation and measurement techniques

- Propagation measurement system for ETC gate
- Radio source localization using array antennas based on fingerprint techniques in outdoor environment

Other topics

- Performance Evaluation of Analog Adaptive Array Antennas for mobile applications
- Cognitive radio coexisting with TV broadcasting services
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- **Physical Phenomena**
  - In a street microcell, multiscattering is dominant compared to free space path loss.
  - Locus of multiscatterings are parallel lines symmetric to the middle line of the street.

  **Single-bounce Scattering Power Distributions**

  ![Power Delay Profile](image)

- **Proposed Model**
  - The scattering power diminishes fast in the building zone, along y axis. The attenuation across the x axis in the street zone has a slower rate.
  - The scattering distribution for 3 zones: street zone, building zones and LoS component are defined.

  $$P = e^{-\alpha x + \alpha y}$$

  ![Coefficient of the Model Obtained by Approximation to the Measurement Data](image)

  **Comparison of directional channel measurement and Ray-tracing simulation** (by Navarat Lertsirisopon)

- **Measurement Scenario and Equipment**
  - The microcell measurement was carried out in O-okayama campus of Tokyo Institute of Technology. The Medav RUSK Fujitsu channel sounder was employed to accomplish the measurements.

- **Channel Data Processing Reconstruction**
  - To simulate the measurement by using ray-tracing output, the array frequency response $h_{RT}$ is constructed as
    $$h_{RT} = \sum_{l=1}^{L} \gamma_{lV,l} \cdot (h_{l,T} \otimes (h_{BS,V,l} \otimes h_{BS,H,l})) + \gamma_{HH,l} \cdot (h_{l,T} \otimes (h_{BS,H,l} \otimes h_{BS,V,l}))$$
  - Beamforming is applied in every $6^\circ$ for the azimuth range (from 0° to 360°), and for the co-elevation range (from 30° to 150°) according to antenna limitations. The resultant spectrum $P(s)$
    $$P(s) = \frac{w^T(s) h_{RT}^T}{w^T(s) w(s)}$$
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**Identification of Relevant Clusters in an Urban MIMO Macrocell**
(by Materum Lawrence)

- The need to model the collection of multipaths that lie in the “same” angle-delay domain, or clusters, is also one of the things needed to approach the full performance advantage of Multiple-Input Multiple-Output (MIMO) systems for future cellular communications.
- Properly characterizing clusters (collection of multipaths that lie in the “same” angle-delay domain) is also started by correctly identifying them.
- A clustering method is being developed for identifying clusters in an urban macrocell, where wideband MIMO antennas were used.

The propagation environment is important for effect of MIMO. Many studies pertaining to MIMO systems in indoor environments were conducted. A studies pertaining to MIMO system in outdoor environments such as cellular system is required. We plan measurement in outdoor environment for MIMO system.

**Propagation characteristics in outdoor environment for MIMO system**
(by Tomoshige Kan)

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**UWB Localization**
(by Dashti Marzieh)

- UWB signals have relative bandwidth larger than 20% or absolute bandwidth of more than 500MHz. This property allows extremely accurate location estimates using time-based techniques via UWB radios.
- The time of arrival (TOA) data fusion method is based on combining estimates of the TOA of the MS signal when arriving at three different BSs.
- An important source of error is in the case where there is no line of sight from the mobile station to the BSs.
- A geometrical constrained data fusion scheme could be used to reduce the effect of such NLOS conditions. The constraint can be the distances between the BSs.

- Hybrid localization method can be used to have a more accurate location estimate. Linear combination of more than one schemes (for example; ToA and AoA) can be done.
**Propagation Laboratory**

**Advanced radio instrumentation and measurement techniques**

- **Propagation measurement system for ETC gate** (by Assist. Prof. M. Kim)
  - Electronic Toll Collection (ETC), an application of Dedicated Short Range Wireless Communication (DSRC), had suffered from wrong operations due to multi-path problems. To specify the multi-path characteristics useful propagation measurement system was devised.

- **Features of proposed system**
  - This system can estimate not only spatial power distribution but also the scattering process and the intensity of incident signals with real ETC signals.
  - The measurement can be conducted driving the vehicle that loads this system without closing the ETC lane for the measurement.

- **Measurement principle**
  - The vehicle for measurement performs burst-wise data capture with constant time interval passing through the ETC gates at around 20km/h.
  - The triggers at start and end points of burst data capture are issued by laser sensors located in the vehicle.
  - After data capturing, the power spectra are generated by beamforming with burst data along X-axis.
  - From the resulting spectrum we can determine the DOA at the position x as

\[
\theta_x = \cos^{-1}\left(\frac{z_y}{\sqrt{z_y^2 + z_x^2 + z_z^2}}\right)
\]

- **Radio source localization using array antennas based on fingerprint techniques in outdoor environment** (by Panarat Cherntanomwong)
  - Instead of using the measured signal subspace to construct the database, the interpolated signal subspaces obtained by priori known signal subspaces are used. (The subspace matching is an algorithm to estimate the transmitter location by matching two signal subspaces.)
  - The performance is verified by the outdoor experiment estimating the transmitter (car) position in the racing car circuit.

- **Other related topics**
  - Cognitive radio coexisting with TV broadcasting services (by Po Kim Tho)

- **Research Objectives**
  - Investigation of the applicability of IEEE 802.22 WRAN to Japan.
  - Study the impact of IEEE 802.22 WRAN system on TV systems.
  - Study of spectrum sensing for cognitive radio.

- **IEEE 802.22 Wireless Regional Area Network**
  - Spectrum Sensing
    - Energy detector
    - Replica-Correlation Detector
    - Cyclostationarity Detector
  - Energy Detector Model
    - In order to allow CR for IEEE 802.22 system operate in TV band, probability of detection is greater than 0.9 and probability of false alarm is less than 0.1 should be met.