Introduction of AWCC at UEC

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1.Overview of AWCC

1.1 Objective for establishment

Advanced Wireless Communication research Center (AWCC) at The University of Electro-Communications was established in April 2005. This center is a unique academic research center specialized for wireless communication. The objective of this center is "AWCC contributes to the creation of intelligent and flexible communication environments through a study of information and communication technologies (ICT), particularly focusing on wireless communication technologies, in which our university has traditional advantages."

Fig.1 AWCC.

1.2 Organization of AWCC

The director of AWCC is Prof. Karasawa. Members of AWCC are classified into three types. The first type is core members who are full time or concurrent professors working at AWCC. The second type is cooperative members who are professors in UEC. Cooperative members join research projects in AWCC by making use of their specialties. The last type is advisory members who are selected from leading companies and institutes as distinguished research fellows. In 2006, five core members, 16 cooperative members and seven advisory members join AWCC. In addition to these members, the graduate and undergraduate students study in each laboratory.

1.3 Overview of Research Targets in AWCC

The research targets in AWCC are summarized in Fig.2.

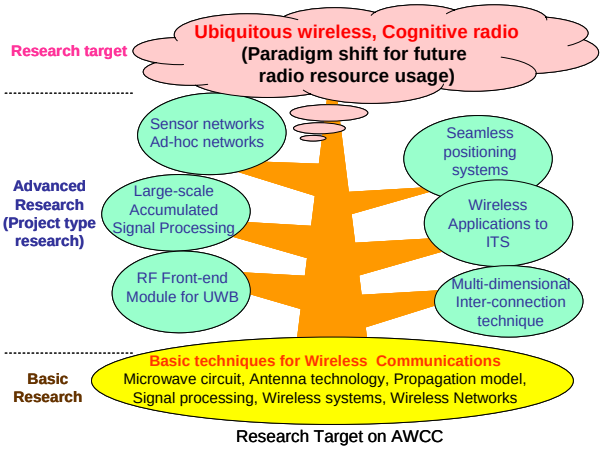

Fig.2 Summary of research targets in AWCC

The key research target of AWCC in the first phase from 2005 to 2010 is "Ubiquitous wireless and cognitive radio –paradigm shift for future radio resource usage–." For achieving this goal, the basic and advanced researches are ongoing. The examples of the research topics are shown below.

- Multi-dimensional Wireless Inter-connection Technologies
- Large-scale Accumulated Radio Signal Processing
- Non-linear System Design in Complex Wireless Systems
- Seamless Positioning System
- Wireless Applications to ITS
- QoS for All-IP Mobile Network
- Large-scale Wireless Sensor Network Technologies
- Signal Transmission Scheme for Ubiquitous Wireless Devices
- RF Front-end Module Development for UWB
- High-efficiency Wireless Transmission scheme
- Wireless Baseband Transmission Scheme
- Cognitive Radio (Target to future spectrum usage)

Some of them are cooperative research topics with industrial companies and some of them are funded by national projects. Some activities of them are shown in the next section.

2. Research Topics in AWCC

2.1 Radiowave Propagation

A member, Prof. karasawa, has a long historical background over a quarter of a century on radiowave propagation studies in the fields of multipath fading due to sea surface reflection, tropospheric and ionospheric scintillations, and rain attenuation as well

as radio-meteorology. Based on the background, studies on multipath propagation theory and modeling in wideband mobile wireless communications systems become main topics of AWCC. The book authored by Karasawa, "Radiowave Propagation Fundamentals for Digital Mobile Communications" published from Corona Ltd. is the one and only book in this topical area in Japan.

A highlight of recent propagation study is development of a channel model for evaluation of OFDM characteristics where the tail of delay profile exceeds guard interval. We call this model "Equivalent transmission-path model for OFDM (ETP-OFDM)". We will continue the study on channel modeling under extremely severe multipath environment having large delay spread and large Doppler spread. Bridging a gap between "Propagation" and "Systems" for future wireless systems designing would be our main concern.

2.2 MIMO

In recent years, using signal processing array antennas both at the access point (or base station) and user terminals, MIMO (multi-Input Multi-Output) has popular research field of next-generation mobile communication systems. The increase of system capacity without increasing the transmission power or frequency bandwidth has made the MIMO system unique and efficient in data transmission. In AWCC, we study antennas and propagation related MIMO technologies with application to various communication systems as shown in Fig. 3.

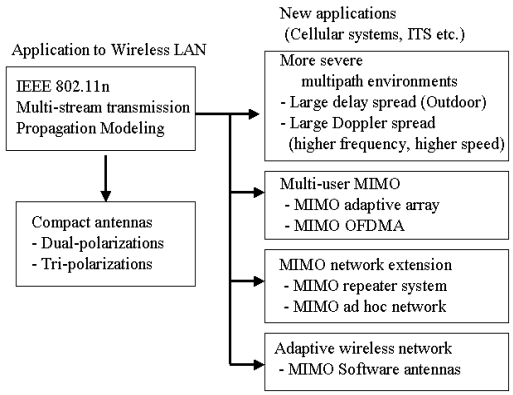

Fig.3 Antennas and propagation related MIMO research topics.

In topics given in Fig. 3, one topic, a tri-polarization antenna for MIMO, is introduced here. In order to realize a compact antenna for MIMO systems, we have proposed a triple-polarization antenna which is composed of a dual polarized (V, H) circular patch antenna and a monopole (Z) on the patch. Figure 4 shows the basic configuration of the antenna. Since this antenna has three branches (namely, V, H, and Z), it can be used as a 3x3 MIMO system where high capacity communication can be expected in the case of multipath-rich environment.

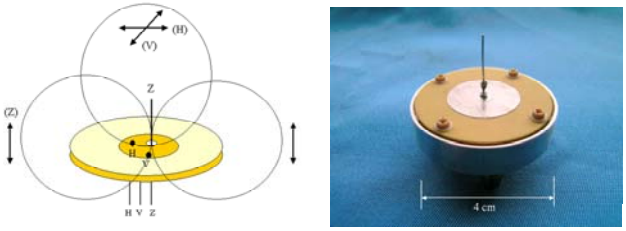

Fig.4 A compact MIMO antenna utilizing tri-polarizations.

2.3 Positioning

Positioning technology is being pursued for navigation and other applications in the indoor area where GPS can not be used. There exist several approaches for this purpose. However, the cost of the system becomes serious if all the indoor area will be covered.

Our approach is focused on the hybrid system. One is autonomous navigation system. Terrestrial magnetism sensor, gyro compass and step sensor are equipped to estimate differential position during walking. The other one is spot navigator which indicates the user location at certain intervals. Bluetooth and ZigBee equipment are considered for this purpose. Kalman filter combines the measured data obtained by these equipment and gives best estimation result for location.

Figure 5 shows estimated trajectory using Bluetooth triangulation method combined with the autonomous system.

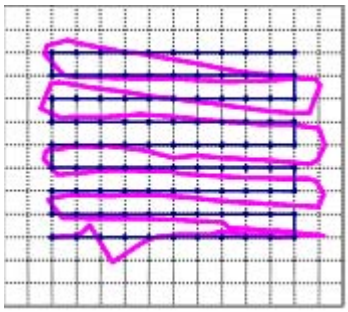

Fig.5 Estimated trajectory. (1 division = 2 m)

Figure 6 shows the experimental result carried out at the underground area in Shinjuku station Tokyo. Location error caused by the autonomous navigation system was corrected by the spot navigators. Only four spot navigators are necessary for covering 400m x 200m area.

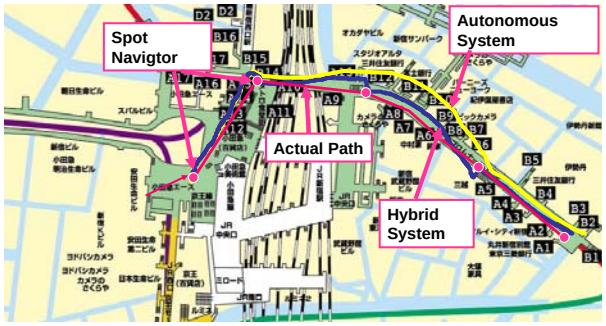

Fig.6 Hybrid navigation in Shinjuku underground area.

The advantage of this system is low infrastructure cost. Likewise car navigation, human navigation may be provided with low subscribing expense using this

system. There will be many applications for this system in the Ubiquitous era.

2.4 Device

For device development on the next generation radio systems, where high-efficiency / broad-band / super-linear characteristics are mandatory, fundamental microwave design technologies based on simultaneous simulation including electro-magnetic fields and semiconductor device physics have been being developed as described in Fig. 7.

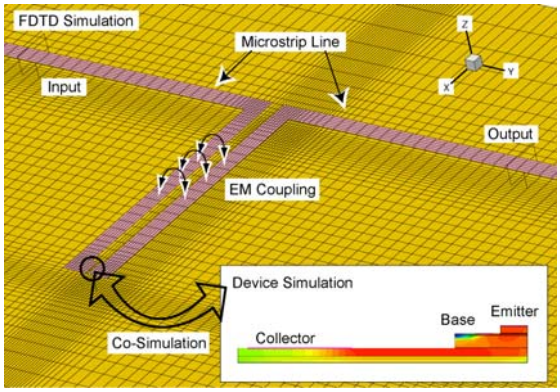

Fig.7 Electro magnetic fields/Semiconductor co-simulation using FDTD method.

Using the technology, complicated microwave nonlinear phenomena such as the long finger effects for microwave active devices and 3rd order inter-modulation distortion phenomena due to thermal memory effects have been successfully analyzed.

As an example of the advanced design method, an InGaP/GaAs HBT MMIC amplifier with an active balun for UWB systems has been developed (Fig. 8).

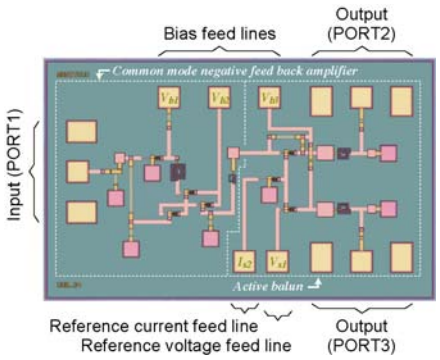

Fig.8 MMIC amplifier with active balun.

This MMIC is used to drive a self-complementary UWB antenna and a four coupled lines differential mode band pass filter (BPF) covering a 3.1-10.6GHz band, which have been developed also in AWCC.

A microwave class-F high efficiency amplifier with more than 80 % collector efficiency, considering up to 7th order of higher harmonic frequency has been proposed and developed. A new lumped element circuit topology for class F amplifier was also proposed in our laboratory.

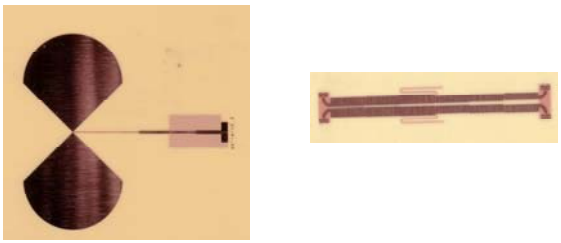

Fig.9 Planar self-complementary antenna (left) and differential mode BPF (right).

These technologies will be applied to new devices and new materials such as GaN devices and nano structure devices for microwave and millimeter wave applications.

2.5 Wireless Sensor Network

A large-scale sensor network is expected to be an indispensable infrastructure to support secure and safe society and life in the future. Since a large number of distributed wireless sensor devices communicate autonomously in ad hoc mode, the following issues should be investigated.

- Lossless multi-hop communication

  In multi-hop wireless communications, packet loss happens even if one of the links on a hop root fails to transmit the packet. They are temporally caused by radio environment change and mobility of devices. Therefore, a countermeasure is important to cover temporary link quality degradation. A path diversity technique using multiple routes and a fast path-repairing rooting technique are studied for this object.

- Multiple access method for ad-hoc networks

  A decentralized wireless resources (frequency, time, and /or code) sharing technique should be developed so that each device recognizes of local wireless environment and fully utilizes wireless resources available in the environment.

- Large-scale ad-hoc networking

  Since a large number of distributed wireless devices join a sensor network, a dynamic network formulation method is essential in order to adapt itself to frequent change of network elements. Also, rapid root discovery and root repairing methods are essential for devices to communicate within a reasonable delay.

- Low power operation of radio module

  Power consumption requirement for sensor devices are very severe. For low power operation, High efficiency RF circuits and antenna, state-of-the-art RF LSI process, low power transmission scheme, and MAC (Medium Access Control) protocol supporting high-rate sleep mode are key technologies.

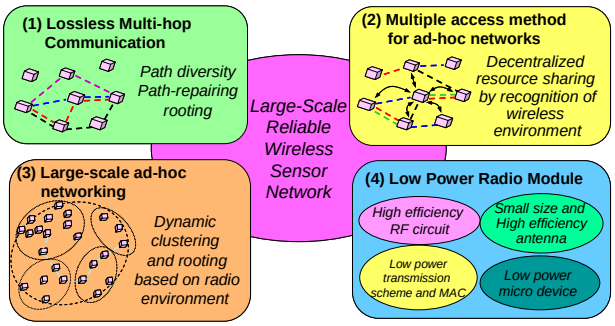

Fig.10 Research topics on wireless sensor networks.

2.6 Cognitive Radio

Cognitive radio is the intelligent radio system that can adaptively change the parameters by recognizing the surrounding radio environment. By using the recognition ability of the cognitive radio, the radio terminal can establish the communication in an unused frequency band adaptively. Therefore the cognitive radio is expected to be a solution for the shortage of the radio frequency resource. This is because the cognitive terminals can use the frequency bands which are assigned to the primary system, like TV band, cellular system, microwave relay system and others by avoiding interference toward the primary system. The image of the cognitive radio in which the secondary cognitive terminal finds the most suitable frequency for communication under the primary system is shown in Fig. 11.

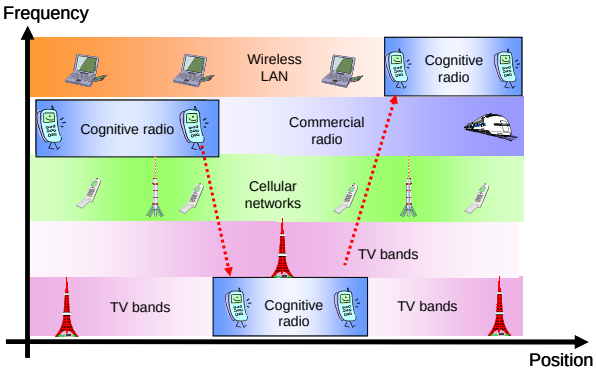

Fig.11 Image of cognitive radio under primary systems.

The researches for cognitive radio have been just started in the world and Japanese academic research is a very few. AWCC is targeted to be one of the key bases of the cognitive radio in Japan. In order to realize the cognitive radio, a lot of problems are still remained. How can we obtain the radio environment information? How can we find an unused band? How can we mitigate the interference toward the primary users? And so on. In AWCC, in order to solve the above problems, many kinds of researches for cognitive radio are discussed through the fundamental theory to the practical measurement and the practical devices.

In order to realize the cognitive radio without large interference toward the primary systems, we propose a concept of ad-hoc cognitive radio as shown in Fig. 12.

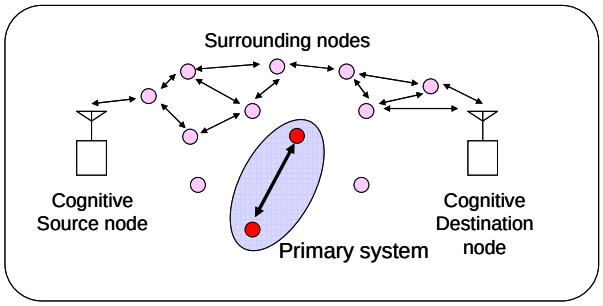

Fig.12 Ad-hoc cognitive radio.

In ad-hoc cognitive radio, in order to establish the secondary radio networks under the existence of the primary systems, a small power multi-hop communication is used for secondary radio networks. The examples of ongoing our research topics related to cognitive radio are as follows.

- Routing method for ad-hoc cognitive radio
- Radio environment recognition method for cognitive radio
- Protocols for ad-hoc cognitive radio
- Signal processing for cognitive radio
- Frequency sharing method between primary and secondary systems

3. Future Direction of AWCC

AWCC promotes cooperative research projects such as;

- Industry-cooperative researches by AWCC members and Industry R&D members.
- Group researches by competitive research funds, scientific research fund, etc.

Cooperation with wireless research institutes of overseas is considered such as joint research and exchange of students and researchers.

AWCC welcomes Doctoral Course students from industries and overseas who will explore future wireless world with untiring zeal and excellent technical skills. Doctoral degrees can be obtained in one year minimum.

If you are interested in AWCC, please contact to us according to the following information.

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