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C1. Land Mobile Communication System

Land mobile communication systems, such as LTE and 4G communication systems, have been actively investigated in Japan for these three years. A lot of papers for OFDM-MIMO have been published in Japan. In addition, there exit a lot of technical keywords for land mobile communication systems, e.g., frequency domain equalization, Turbo equalization, multi-hop technique, cognitive radio and software defined radio (SDR).

Experimental results of MIMO transmission systems have been reported several authors.
Regarding to MIMO-OFDM, experimental results on real-time packet transmission over 1Gbps has been reported using 4 by 4 MIMO and MLD based signal detection for 4G communication systems [Higuchi et al, 2006].
Performance of 4 by 4 MIMO spatial multiplexing has been evaluated in actual indoor environment. Cumulative distribution function (CDF) of channel capacity has shown that MIMO spatial multiplexing in the LOS environment provides higher channel capacity than that in the NLOS environments [Nishimoto et al, 2007].
Regarding to MIMO eigenmode transmission system, an adaptive algorithm that accounts for channel state information (CSI) imperfection and practical operating conditions has been proposed. Experimental results and computer simulation have confirmed that this scheme is robust and superior to the conventional schemes [Ting at al, 2006].

Radio signal processing technologies for land mobile radio communication systems have been actively investigated.
Frequency domain equalization (FDE) techniques for block CDMA transmission have been investigated. It has been confirmed that frequency-domain block spread CDMA is a good solution for mitigation of performance degradation due to multi-access interference (MAI) [Adachi et al, 2007].
Frequency domain soft-interference canceling MMSE Turbo equalization has been investigated. In this paper, a computationally efficient method for computing extrinsic information transfer (EXIT) function of the equalizer has been proposed [Kansanen et al, 2007].

From the system point of view, several techniques have been proposed for performance enhancement and complexity reduction.
For OFDM/TDMA systems, channel estimation scheme has been proposed using carrier interferometry (CI). It has been confirmed that the proposed scheme can perform accurate channel estimation [Yokomakura et al, 2007].
In order to mitigate peak to average power ratio (PAPR) for single carrier PSK signals, the trellis shaping technique has been combined with iterative decoding of concatenated channel coding. Simulation results have confirmed that this scheme can achieve significant coding gain [Tanahashi et al, 2007].

In order to mitigate PAPR for MIMO-OFDM signals, subcarrier-block phase hopping scheme has been investigated. Computer simulation has confirmed that this scheme can drastically reduce PAPR and can improve its performance in comparison with the conventional MIMO-OFDM [Ishida et al, 2007].

Multi-hop cooperative sending and transmit power control based on interference information has been investigated for cognitive radio. Computer simulation results have been confirmed that this scheme is helpful to protect interference [Yu, 2007].
In order to derive accurate soft decision for reduced complexity MLD for MIMO spatial multiplexing, simple estimation method for lost likelihood information has been proposed. Computer simulation results have confirmed that this scheme has excellent performance keeping small hardware complexity [Higashinaka et al, 2007].
(H. Kubo)

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C2. Satellite Communication Systems

Research and development projects in the field of satellite communication systems, such as the laser communication, mobile satellite communication, and wideband internetworking satellite communication has been executed in Japan for these three years.

(1) OICETS [T. Jono, et al., 2007]
The Optical Inter-Orbit Communication Engineering Test Satellite (OICETS, Japan name "KIRARI") was developed by the Japan Aerospace Exploration Agency (JAXA) [K. Nakagawa, et al., 1995], [T. Jono, et al., 1999] and was launched into low earth sun-synchronous orbit at an altitude of 610 km and an inclination of 97.8 degree on 23 August 2005.

A main objective of OICETS was to demonstrate the free-space inter-orbit laser communications (forward: 2.048Mbps, return: 49.3724Mbps) by using of intensity modulation, or On-Off Keying (OOK) and direct detection system.

The inter-orbit demonstration was carried out with the cooperation of the Geostationary Earth Orbit (GEO) satellite, the Advanced Relay and Technology Mission (ARTEMIS) developed by the European Space Agency (ESA) [M. Faup, et al., 1996], [T. T. Nielsen, et al., 2002]. These results show more than 90 % probability of acquisition and less than 10^{-6} bit error rate. Moreover, a Low Earth Orbit (LEO) to ground laser bi-directional communication demonstration was carried out with the cooperation of the Optical Ground Stations (OGSs), one of which was developed by the National Institute of Information and Communications Technology (NICT) in Japan, and the acquisition and tracking of the OICETS satellite were successful by 100 % without bad weather conditions and the bidirectional optical communication link was successfully established [M. Toyoshima, et al., 2006]. The other portable OGS was developed by the German Aerospace Center (DLR) and the optical downlink experiment was conducted on European grounds [N. Perlot, et al., 2007].

(2) ETS-VIII
The Engineering Test Satellite VIII (ETS-VIII, Japanese name "KIKU-8") was developed by the JAXA, NICT, and Nippon Telegraph and Telephone Corporation (NTT) and was launched into geostationary orbit at 146 degrees east longitude on 18 Dec. 2006.

The aim of this project is to develop fundamental technologies for mobile satellite handheld phone services and digital sound broadcasting services using the S-band frequency [N. Hamamoto, et al., 2003]. The goal of this project are to develop the following new technologies, in-orbit tests, and experiments such as large-scale satellite-borne deployable reflector (19m x 17m), mobile satellite

communications using small ground stations such as handheld terminals (about 300g) [K. Yonezawa, et al., 1998], [Y. Kawakami, et al., 1998].

This satellite was shifted to operational phase in May 2007 after 4-months in-orbit tests. The demonstrations of data/video transmission and the voice communication via this satellite that assumed the use in the disaster spot were carried out in Sep. 2007 and Jan. 2008. The basic experiments and the application experiments will be performed for several years.

(3) WINDS

Wideband Internetworking engineering test and Demonstration Satellite (WINDS) is an experimental satellite aiming at research and development of broadband satellite communications system which takes part in construction of worldwide broadband networks.

Its origin is the Gigabit Satellite R&D started in Communications Research Laboratory (CRL, one of former bodies of NICT) in 1992, and fundamental technologies such as Ka-band active phased array antenna, satellite onboard modem and high speed baseband switch were developed in this project [N. Kadowaki, et al., 1999]. From 2001, full scale experimental satellite project as WINDS executes by JAXA and NICT [N. Kadowaki, et al., 2007].

This satellite is equipped with the Multi-Beam Antenna (MBA), the Multi-Port Amplifier (MBA), the Ka-Band Active Phased Array Antenna (APAA), and the Advanced Baseband Switch (ABS) as the key sub-systems. The data transmission is up to 2 channels of 1.2 Gbps using 5 m class aperture antenna in bent-pipe mode and 3 channels of 155 Mbps using 45 cm aperture antennas in on-board switching mode. This satellite was launched into geostationary orbit in Feb. 2008.
(A. Kato)

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C3. Digital Broadcasting System

There are many research and development activities in the field of digital broadcasting system such as digital terrestrial television broadcasting (DTTB) and television broadcasting for mobile in Japan for these three years.

Japanese digital television standard, ISDB-T (Integrated Services Digital Broadcasting for Terrestrial), has already been standardized by the Japanese radio and broadcasting standardization body, ARIB (Association of Radio Industries and Businesses) in 2001[ARIB, 2001]. DTTB service based on ISDB-T began in 2003 at Tokyo, Nagoya and Osaka, and deployed all the major cities in Japan at the end of 2006. ISDB-T employs OFDM (Orthogonal Frequency Division Multiplex) technique as well as the European DTTB standard, DVB-T (Digital Video Broadcasting for terrestrial). The ISDB-T signal is transmitted through 5.6MHz frequency band composed of 13 frequency segments. Each segment has a bandwidth of 432kHz. It is capable of using a part of segments for transmitting different programs and can be received by a narrowband receiver. DTTB service dedicated for mobile phones and terminals, which use one out of 13 segments for mobile, began on April 2006.

Since battery size is strictly limited in mobile and handheld terminals, power consumption of the narrow-band ISDB-T receiver is a major problem. An RF (Radio Frequency) front-end circuit, whose bias is controlled by the received signal quality, was developed in order to reduce the average power consumption [Sakai, et.al. 2007]. The proposed RF front-end has two modes. The one is low-NF and high power consumption mode, and the other is high-NF and low power consumption one. The baseband module measures the modulation error ratio (MER) at the quadrature amplitude modulation (QAM) demapper, and controls RF front-end. The low NF mode is chosen when MER is lower than the threshold. In order to further minimize the power consumption, an improved control algorithm was proposed [Kim, et.al, 2007]. This scheme uses MER as a control criterion. However, the low NF mode is used only in the region around the target MER.

The multipath fading and Doppler spreading are major problems especially in the reception of DTTB on fast moving vehicle. In order to solve these problems, joint use of the pre-FFT (Fast Fourier Transform) combining adaptive array antenna and post-FFT space diversity combining was proposed [Pham, et.al. 2006, 2008]. The Doppler spread compensator based on linear array antenna was proposed [Yu, et.al. 2007].

Although ISDB-T is robust to multipath and the required CNR (Carrier-to-Noise power Ratio) is lower than that of analog television, poor reception areas still remain in shadowed areas. In order to reduce the poor reception areas, retransmission is made based on the radio-on-fiber (RoF) technique [Maeda, et.al, 2005].
(M. Okada)

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C4. Array Antenna and Signal Processing

Research and development activity in the field of radio communication systems, such as the fourth-generation mobile/cellular radio and wireless LAN systems has been very active in Japan for these three years. Especially, MIMO propagation [Y. Karasawa, 2005], [Y. Ogawa, et al., 2005] and capacity analysis in case of multi-keyhole environment [M. Tsuruta, et al., 2007] were conducted.

Development of Experimental setup and experimental study on MIMO system were also well investigated. Platforms for MIMO systems were developed [K. Mizutani, et al., 2006], and transmission performance was measured [H. Nishimoto, et al., 2007]. Devices for MIMO system such as dual polarization antenna [N. Kumar, et al., 2006] and beam-scanning array antenna with tunable reactance devices were also developed [N. Honma, et al., [2005].

Study on adaptive arrays and SDMA (Space Division Multiple Access) technologies have still active in this period. Performance of several SDMA techniques were compared [Y.Jia, et al., 2006] and SDMA configuration using polarization control was proposed [K. Komiya, et al., 2005]. Furthermore, an adaptive beamforming method using MEMS [Q. Tran, et al., [2006] and real-time ML detectors [T. Koike, et al., 2006] for SDMA were developed.

Array signal processing for terrestrial television broadcasting were very active because the digital broadcasting based on OFDM technology was serviced in the end of 2003. A pre-FFT OFDM adaptive array with eigenvector combining was proposed [S. Hara, et al., 2006]. A Doppler spread compensator using dipole array antenna [Y. Yu, et al., 2007] and implementation of adaptive array antenna for digital television broadcasting [D. Pham, et al., 2006] was well investigated.

Estimation of direction of arrival was also one of the attractive issues in the array signal processing. Since the estimation techniques utilizing signal sub-space concept has very high resolution performance, the research in this field was very active [N. Kikuma, 2005]. Not only estimation for the direction of arrival but also the estimation for number of arrival waves were studied [Y. Ishikawa, et al., 2006]. It was also reported that the estimation accuracy was improved by calibration and spatial smoothing [P. Cherntanomwong, et al., 2007].
(M. Fujimoto)

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C5. Radio Resource Management

Recent research and developments in the field of radio resource managements for cellular, wireless LAN, other wireless access, and heterogeneous wireless, have been still active in these three years, and many researches for cross layer management which provide radio and network resource managements on the cross layers combined with Layer 1, 2, 3 and uppers, have been found. The lack of radio frequency resources has been more and more serious and in order to improve the spectrum utilization efficiency, system capacity, or throughput, the cooperation among physical and upper layers has become important.

For the evolved UTRA, Single-Carrier (SC)-FDMA based multiplexing of L1/L2 control signaling was proposed for downlink scheduling, link adaptation, hybrid ARQ (automatic repeat request) with soft-combining [Kawamura et. al., 2007]. The software defined radio platform for W-CDMA, IEEE802.11a/b, and digital terrestrial broadcasting have been developed toward user centric radio resource management for cognitive radio communication systems [Harada, H. 2005].
In the field of WLAN systems, which share a few channel in unlicensed band and are provided by many AP set up in disorder, many radio resource managements cooperated among multi-layers have been proposed. A fair allocation method of radio resources in WLAN area overlapped among different domains was proposed [Matsunaga et. al., 2004]. An adaptive resource allocation scheme for video stream according to video stream character and user mobility in WLAN was proposed [Minoda et. al., 2005]. Some AP selection methods based on 802.11e standard have been developed. An association mechanism called HRFA (high-rate first association) in IEEE802.11e WLAN networks was proposed to achieve the load balancing and efficient use of radio resources [Takeuchi et. al., 2007]. Radio Agent selecting a proper AP among QAPs (QoS supported AP) and non-supported APs to satisfy both of load balancing and QoS was proposed by using the presence function of SIP (session initiation protocol) in Layer 7 [Morioka et. al, 2006] A new wireless resource management mechanism with AP resource management server with SIP proxy and 802.1x

authentication server was proposed to guarantee minimum available WLAN bandwidth for real-time applications [Tamura et. al., 2005]. A cooperative scheme for APs and STAs in order to attain efficient and fair sharing of resources of WLAN was proposed and its prototype system was developed [Fukuda et. al., 2007]. In order to QoS guarantee in home networks composed with wired and wireless Ethernet, a new mechanism development for topology discovery and resource reservation have been also started in the consumer communications [Ando et. al., 2004].

Researches in user centric radio resource managements have been also active. A novel mechanism was proposed for a mobile user to select an optimal network from the heterogeneous multimedia networks based on the user-centric performance, that is the user-perceived quality of service (QoS) and user-centric cost, that is measured by the user's willingness to pay the price and allow for the consumption of the mobile terminal's resources [Kafle et. al., 2005]. In order to realize user centric resource management, quality of experience (QoE) measure that is the user utility for different types of wireless services is required. The utility for the video quality and video download services were measured by subjective assessments, and a new service management scheme to maximize user utility for given throughput was proposed [Shutto et. al., 2007].
(K. Tsukamoto)

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C6. Microwave Passive Circuit

With the development of Wireless communication system, high performance of small-size, low-loss, multi-band, and wideband are required for microwave and millimeter-wave passive devices such as a resonator, filter, power divider/combiner and directional coupler, etc. Several approaches and new techniques are currently in the practice for their development purposes.

Reduced-size couplers with planar circuit-type have been reported using lumped-element circuits[J. Yamasaki, et al., 2005], slow-wave structures [T. Fujii, et al., 2005, 2007], and broadband / multi-band dividers/couplers have been developed [T. Kawai, et al., 2006], [S. Tanigawa, et al., 2007]. Microstrip-type multi-way power dividers with broadband characteristics can be obtained [M. Kishihara, et al., 2006]. Moreover, miniature planar filters have been developed using High-Temperature Superconductor [Z. Ma et al., 2006], and several types of UWB filters have been reported [K. Li et al., and D. Kurita et al., 2007]

Several components such as corner [K. Toda, et al., 2006], directional couplers [M.Kishihara, et al., 2007] in E-plane and H-plane waveguide have also been illustrated based on E-plane and H-plane circuit approaches. Furthermore, Substrate-Integrated Waveguide (SIW) hybrids [I. Ohta et al., 2007] based on above design procedure are proposed, these circuit are useful for millimeter-wave regions. Waveguide filters and resonators using frequency selective surfaces have been reported [H. Ohira et al., 2005], and leakage properties of stub-loaded ridge-rectangular waveguides have been rigorously analyzed [M. Tsuji et al., 2005]

Furthermore, study and development of metamaterials include double negative or left-handed materials have been active in these years. Novel two-dimensional negative refractive index structure has been reported [N. Matsunaga et al., 2006], and its application to antenna system has been developed [T. Kaneda et al., and S. Matsunaga et al., 2006].
(T. Kawai)

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C7. Microwave Active Circuit

In RF/Microwave/Millimeter wave region, we have two major evolutions of semiconductor device: high frequency performance of submicron CMOS device and high breakdown voltage/high frequency performance of the wide band-gap device.

Regarding the first topic of above, lithography rule for large scale logics is still shifting to deep sub-micron less than 65nm in 2007 [STARC 2007] in Japan, as in world-wide roadmap [ITRS 2007]. The cutoff frequency of CMOS transistor reaches over-100GHz. This means good capability of Millimeter wave CMOS transistor. For high-speed radio transceivers, Millimeter wave CMOS RF-ICs have been reported for radio functionalities [Shigematsu 2005], [Mitomo 2007] [Ishibashi 2007] of low noise amplifiers, frequency mixers, oscillators and frequency dividers. In parallel, RF-system level constructions have been done for Gbps-class radio transmission systems with GaAs device [Maruhashi 2005]. Millimeter wave CMOS devices have been applied to the similar systems, instead of GaAs devices [Mitomo 2007].

Regarding the second topic, high voltage operation and high frequency one are in the trade-off issue. Thus there are two research directions toward high power and high frequency in wide band-gap devices as GaN. The C-band GaN HEMT amplifier has achieved output power of 220W in pulse operation by optimization of electrode-layout for thermal resistance reduction, [Yamanaka 2007]. The Ka-band AlGaN/GaN HEMT with quarter-micron T-shaped gate has achieved output power of

5.8 W in CW and linear gain of 9.2 dB [Inoue 2005].

In addition to above topics based on semiconductor improvements, there have been the following technical interests.

For the next generation mobile communication system as WiMAX and LTE, multi-carrier systems employed for high speed radio transmission. This makes higher crest factor in modulated signal in transmitters and higher dc power for keeping low leakage power to adjacent channel. For improvement of non-linear distortion in HPAs, several system-level approaches have been demonstrated. In [Matsunaga 2007], DC bias voltage is controlled by envelope voltage of input modulated signal. In [Horiguchi 2007], combination of digital predistortion architecture and improved Doherty amplifier has been demonstrated for OFDM transmitters.

In future cellular phone system, we have additional frequency resources after termination of analog TV system in Japan. In the situation, multi-band frequency allocation for cellular phone system will be done to increase transmission capacity. MEMS migrated high power amplifier has been proposed for small sized/high efficiency multi-band high power amplifier [Fukuda 2005].

Phase noise of oscillators has been represented by well-known Leeson's formula with oscillators' Q. However, we had no clear definition of oscillators' Q. In [Ohira 2007], theoretical formulas of oscillators' Q can be defined under the circuit theory. The substituted formulas are effective for low noise oscillator design.
(K. Itoh)

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C8. UHF Band RFID System

RFID (Radio Frequency Identification) is an automatic recognition technology that accesses data in the memory of the integrated circuit chip by using a radio communication technology. The one that the antenna was connected with the RFID chip is called the RFID tag. RFID tag is called IC tag. Passive type RFID tag doesn't have the battery, rectifies the electromagnetic radiation from the tag reader/writer, and operates the circuit. Moreover, it doesn't have the radio frequency transmitter in oneself so that RFID tag may reply by the back scattering method. The application starts in wide fields of the production line of the factor, the personal authentication, distribution, and the circulation, etc. RFID is international standardized as ISO18000 series. 915MHz band, it is ISM band, is used in the United States etc. for UHF band RFID, and 860MHz band is used in Europe etc. 950MHz band became the candidate of UHF band RFID in Japan. PDC (Personal Digital Cellular) system had used 950MHz band in Japan, the cellular phone system had changed to CDMA (Code Division Multiple Access) system from PDC, so 950MHz band is not used by cellar phone system in 1994.

The trial experiment of UHF band RFID came to be conducted in various industrial fields such as construction, publication, the consumer electronic, the medicines, and department stores from 1994[J. Mitsugi, et al.,2006],[Y. Kawakita, et al.,2006]. A severe regulation was provided for a spurious radiation because the cellular phone used the frequency of neighborhood in Japan. 950MHz band became possible the legal use of RFID in April, 1995. Moreover, the interference avoidance technology between the reader writers by the career sense method was included in the law in January, 1996.

As the research and development concerning the integrated circuit chip for RFID tag, the Ministry of Economy, Trade and Industry promoted the project “Hibiki” that was the achievement of five yen tag inlet during August, 2006 [A. Honzawa, et al.,2007]. In addition, tag that improved security was developed after August 2006. Besides “Hibiki” project, RFID tag equipped with a high-speed, mass memory that sounded and used FeRAM (Ferroelectric Random Access Memory) appeared [H. Nakamoto, et al.,2007].
The antenna that miniaturized tag was researched and developed so that it was installed in the center part of CD or DVD [A. S. Andrenko, et al.,2007]. On the chip antenna was researched and developed as an attempt that tag size reducing more [H. Abe, et al.,2005], [M. Usami, 2006].

As the RFID system, it researched concerning interference [Y. Tanaka, et al.,2007] and the readout performance improvement technology of the simultaneously multiple tag data access method, etc [J. Mitsugi, et al.,2007], [T. Maniwa,et al.,2007].

UHF band RFID is applied to the stock management of the household appliance store, the production control of the personal computer, the application of the Toyota just-in-time system to the production system, the lending management of crates, and the management of the uniform, etc. as a present business system.

It is scheduled for UHF band use for not only a passive type but also active type RFID to be examined in 2007, and to become possible to use in 2008.
(T. Maniwa)

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C9. Ubiquitous Power Source

Ubiquitous Power Source (UPS) was proposed in Japan [Shinohara et al, 2005] and research and development activity has been higher in Japan for these three years.

Weak point of future ubiquitous information society is power source. We can get information in every time and in everywhere in the ubiquitous information society. However, all information equipments like note PC, mobile phone, and PDA, need battery and the other power source. The power source restraints the time and the place of the ubiquitous information society. So the UPS supplies wireless power via microwave. We use only carrier of the non-modulated/modulated microwave to transmit the wireless power. Passive RF-ID is close to the UPS.

Key technology is rectenna, rectifying antenna, which rectify the microwave to DC with high efficiency. The RF-ID has the rectenna in the chip. Some developments of the rectenna for the RF-ID or the UPS have been done in Japan [Shinohara et al., 2004] [Takagaki et al, 2006] [Kitayoshi et al, 2006]. They use Shottokey Barrier Diodes for the rectifier of the rectenna. The SBD is not special and only for the communication system.

In Japan, research and development activity of the wireless power transmission (WPT) for the Space Solar Power Satellite/Station (SPS) has been high for over twenty years [Matsumoto, 2002][Fujita et al., 2007] [Mihara et al., 2007]. The UPS is based on the WPT technologies.
(N. Shinohara)

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