2003.2.15

Executive Summary of
Advanced Technologies for Telecommunications (B)

The mainproject " Advanced Technologies for Telecommunications（B）" has three subprojects, " Microwave and Millimeter-WaveTechnologies（B1）," Communications and Networking Technologies（B2）", and " Wireless Multimedia over IP : Technologies and Applications（B3）". The goal of this project is to establish the key technologies for " millimeter-wave wireless broadband multimedia network " such as the 60-GHz WLAN. To this end, the above subprojects are well planned and organized so that the technical results obtained can be effectively integrated. Given below are the excecutive summaries of the subprojects.

I. Microwave and Millimeter-Wave Technologies (B1)

1. Abstract

Microwave and millimeter-wave (300 MHz - 300 GHz) technologies are very important in civil and military applications. These frequency bands have the advantages: higher antenna gain, wider bandwidth, smaller physical size, and lower attenuation in bad weather condition compared with infrared and light wave. The goal of this subproject is to establish the key technologies for monolithic microwave integrated circuits (MMIC), and to accomplish a MMIC chip set for W-band (75-110 GHz) transceiver module. The research topics include (1) passive components and antennas, and (2) high frequency integrated circuits. This goal requires the integration of top technologies in electromagnetic waves and solid-state devices.

2. Previous Results

With the research plan from the year of 2000 to 2002 focused on the Ka- to V-bands (26-75GHz), this subproject has accomplished the development of various key components in transceiver modules and the integration design. Most of the components have been fabricated and measured to demonstrate their excellent performance. Based on the achievements, the research works in the past three years have led to fruitful results of 41 international journal papers (published and accepted), 94 published international conference papers, 8 patents, and 59 students graduated (Ph.D: 8, MS: 51).

3. Research Team

Principal Investigator : Chun-Hsiung Chen
Co-Principal Investigators : Powen Hsu, Ruey-Beei Wu
Professors : Tah-Hsiung Chu, Huei Wang, Shey-Shi Lu, Chin-Chun Meng
Post Doctor Researcher : Hsin-Chia Lu

4. Research Description for the Last Year

4.1 Research of Passive Components and Antennas

1) Design and Analysis of Passive Components

In this year, various key passive components at V- and W-band (50-100 GHz) will be investigated, including transitions, filters and mixers. Specifically, we will develop new transition structures from metallic waveguide to planar transmission lines (CPW and microstrip line) and flip chip transitions from CPW of chip to substrate; meanwhile we will also focus on V-band CPW ring filter and W-band metallic waveguide image reject filter. In addition, several new structures of uniplanr mixers will also be investigated. The contents of research consist of the design, simulation, fabrication, and measurement for the above-mentioned passive components.

2) Design and Analysis of Planar Antennas

The research of this year will include: (a) To analyze the CPW fed patch or slot antennas for wireless applications. Besides, we also plan to complete the design of several linearly and circularly polarized antennas. (b) To use the above-mentioned antenna elements to design the two-dimensional CPW fed circularly polarized patch arrays or linearly polarized slot arrays, which can be used for point to point wireless communications.

4.2 Research of High Frequency Integrated Circuits

1) Design of Millimeter-Wave (MMW) Integrated Circuits

The research focus of this year will follow trace of the development of V-band MMW integrated circuit accomplished last year, and then extend to next higher frequency band, that is, W-band (75-110 GHz). The circuits to develop include low noise amplifiers, power amplifiers, mixers, oscillators etc. Due to the higher frequency, the requirement of the models and fabrication need to be more accurate. Also, the more serious coupling effects in circuits will need more careful full-wave EM simulations and design techniques. After the design and layout of the integrated circuits, the chips will be sent to foundries for fabrication. The chip measurement results are expected by the end of this year.

2) Device Measurement and Model Development

In the device modeling, we will focus on the phase noise of oscillators. Several important parameters that affect phase noise such as the transistor size, bias current, and the inductance will be investigated. In addition, we also plan to use the high frequency and dc measurements to determine and optimize the device structures. Regarding the measurement techniques, we will use the "multi-mode TRL calibration" to measure the "multi-port scattering matrix" for a multi-port circuit. There will be two tasks, which are the calibration of multi-port vector network analyzer and the measurement of antenna polarization characteristics.

5. Fund

In this year, this subproject has 2,972,000 NT$ for personnel, 400,000 NT$ for overseas travels, and 1,241,000 NT$ for operation fee and overhead, totally with a budget of 4,613,000 NT$.

6. Expected Achievement

The expected achievements for the year of 2003 are:

- to become an international millimeter-wave technology center (up to 100 GHz)
- to form a solid foundation of millimeter-wave industry for next generation
- to train the RF engineers for wireless communications
- to promote the relations between Taiwan and international microwave societies.

We expect to publish 14 SCI and EI referred journal papers, 20 international conference papers, and graduate 6 PhD plus 16 master students in the coming year.

II. Communications and Networking Technologies (B2)

1. Abstract

The advanced communications and network technologies subproject (B2) includes wireless communications, networking, and wired broadband technologies. In wireless communications, we will upgrade the home made channel measurement system, characterize multi-input / multi-output channels, develop baseband signal processing IC, develop channel coding, and study Beyond 3G mobile communications. For the network technologies, we will focus on broadband network architecture real time multimedia transmission, MPLS and data mining. In the wired broadband area, we will design and fabricate multiwave length laser chip, study wave length surveillance scheme, investigate access technique, study switching architectures and their performance, and design advanced optical components.

2. Previous Results

This subproject spans for four years. In the first year, we set up a broadband vector channel sounder measurement system, proposed an intelligent antenna structure, investigated the channel estimation method, combined the dual frequency scheme and orthogonal frequency allocation to improve the system performance. For the networking part, we developed a real-time multimedia transmission scheme and wireless bandwidth allocation algorithm, proposed a multimedia multicasting mechanism and a data mining model. In broadband communications, we made significant progress in multi-wavelength semi-conductor laser design, wave length conversion, and fiber grating. We also proposed and analyzed the perfect difference codes for synchronous optical CDMA.

In the second year, we established a broadband MIMO channel measurement system based on RF network analyzer; we utilized the concepts of turbo codes and trellis codes to achieve a large free distance and a thin distance spectrum; we developed a multi-user detection and synchronization structure for software radio system; we also designed a digital processor for the OFDM and CDMA-based software radio. In the networking related research, we proposed two queuing models to evaluate the MPLS performance. In broadband wired communication research, we implemented an 8*8 100 Mb/s scalable variable length packet switch. We also developed new approaches to monitor fast tunable

lasers and designing Raman amplifiers. In addition, we developed and fabricated long-period fiber grating for optical communications.

In the third year, the research achievements are: established the MIMO wide band channel measurement system based on the broadband vector channel sounder system; measured the channel characteristics for W-CDMA systems; proposed a novel signal design for FH-MFSK signaling and a low complexity multiuser detector; designed trellis codes and fabricated a beamforming baseband IC for uplink W-CDMA systems. In the networking part, we finished MPLS analysis, established a WLAN TV network, and modeled mobile IP. For the broadband wired communication part, we investigated EPON technology and implemented an 8*8 1Gb/s Ethernet scalable variable length packet switch. We also made a breakthrough in developing devices such as single chip multi-wavelength laser arrays of 50 GHz spacing, all-optical decision gates and fiber grating.

3. Research Team

The principal investigator of this subproject is Professor Jingshown Wu and the co-principal investigators are Professor Hsueh-Jyh Li, Professor Hen-Wai Tsao, and Professor Kwang-Cheng Chen. Other team members include Professor Mao-Chao Lin, Professor Tzi-Dar Chiueh, Professor Zsehong Tsai, Professor Ming-Syan Chen, Professor Wanjiun Liao, Professor Lon A. Wang, Professor San-Liang Lee, Dr. Jyh-Tsung Hsieh, Dr. Kar Sabyasachi, Dr. Oleg Ivanov, Dr. Malla Reddy, Ms. Gade. Sreedevi, Mr. Wui-Kuang Kho, Ms. Chia-Fang Chang, and 35 Ph.D. and master students.

4. Research Description for the Last Year

The research and development of networks and communications technologies become so important. The communications and networking subproject will focus on the related advanced technologies. Generally, a communication network consists of backbone and access. The backbone network is based on optical fiber communication technology to provide large transmission capacity. Access network employs wired technology to offer broadband transmission and utilizes wireless for mobile services. The research of wireless communication will study the channel characteristics and enhances the spectrum utilization efficiency by adaptively adjusting protocols, modulation, and signal processing algorithm according to the channel condition. The study of Internet will concentrate on the network architecture and protocols to provide various services with different quality of services. The high capacity network research will emphasize on dense wavelength division multiplexing (DWDM) technology and investigate new architecture, transmission, and switching methods. In order to form solid focal points, in wireless communication part, we shall target at intelligent antenna communication systems, software radio, wireless broadband networks, and wideband CDMA. In networking research, we shall concentrate on broadband Internet, advanced applications and policy. For high capacity wired communications, we shall focus on high-capacity fiber network architecture, high speed switching, DWDM, IP over DWDM, and state-of-the-art electro-optic devices and circuits. We shall also integrate research with National Chiao Tung University in W-CDMA and software radio.

The main research topics for this year are wireless communications, baseband circuits and integrated chip design, multiple input multiple output (MIMO) channel measurements and transmission performance evaluation, next generation wireless technologies, broadband wireless internet, mobile communication and its access on broadband data infrastructure, and multi-user detection techniques. In broadband networking, the broadband research team will cover topics in advanced multimedia/video proxy mechanism, QoS control, service convergence of mobile and broadband network, integration of broadband protocol and multimedia, network planning and performance evaluation, real time wireless multimedia, and the establishment of indoor/outdoor wireless TV trial environment. In broadband wired communications the research topics include: transmission and switching for internet and DWDM, multiple access networking techniques, advanced optical-electronic devices and the switching and architecture design and implementation for high performance packet switching.

5. Fund

In this year, we have 4,402,000 NT dollars for personnel, 3,389,000 NT dollars for equipment, and 637,000 NT dollars for operation fee and overhead, totally we have 8,428,000 NT dollars.

6. Expected Achievement

In this year, we will develop and propose some advanced technologies in the areas of wireless communications, networking, and broadband wired communications theoretically or experimentally. Jointly with other subprojects including Microwave and Millimeter-Wave Technologies (B1), Communications and Networking Technologies (A3), Modeling of Wideband Vector Radio Channels for Wireless Communications (A4), Development of Antenna and RF Front-End Technologies (A5), this subproject aims to provide some key element for a 60GHz WLAN platform which has the similar specs of IEEE 802.11a. This platform will be the working environment for the Intelligent Signal Processing and Multimedia Information Environment (B3). We will introduce new channel code design, improve multi-user detection method, design OFDM and WCDMA baseband signal processing circuits, establish a 60 GHz channel characteristic measurement system. For the network research, we will tune up the WLAN TV experimental network, propose network data mining scheme, design VOIP gateway and complete the wireless Internet study. For the broadband wired communications, we will implement an 8*8 1Gb/s-per-port core switching system, propose an effective surveillance scheme for DWDM networks, fabricate new lightsources and innovatory optical components. It is expected to produce at least 15 top journal papers, numerous conference papers, a few patents and technology transfer.

III. Wireless Multimedia over IP: Technologies and Applications（B3）

1. Abstract

With the fast development and natural convergence of Internet, wireless and multimedia technologies, wireless multimedia over IP has been an important trend for communication

technologies with many technical challenges and very high potential. The huge volume of data and intensive computation requirements necessary for multimedia information processing integrated with wireless transmission problems such as the multi-path fading, dynamically available bandwidth and power and high bit error rates and packet loss rates have created plenty of research issues to be investigated. This subproject is to develop some key technologies for wireless multi-media over IP focused on two central tasks: multi-media information streaming and retrieval over wireless networks. Although the emphasis is on basic research, some prototype systems may be integrated when possible to demonstrate the feasibility of the results.

2. Previous Results

This subproject spans for four years. In the first year, the title of the subproject was "Intelligent Signal Processing and Multi-media Information Environment," in which the term "intelligent signal processing" indicated that the new technology of digital signal processing tends to utilize more external knowledge outside the signals themselves and make the processing algorithms more adaptive with learning capabilities, and by "information environment" we meant different terminal equipments and relevant software and network technologies, plus the "network content", or the knowledge and information over the networks. The subject areas under this theme included: (1) Intelligent Advanced Signal Processing, (2) Chinese Natural and Spoken Language Processing, (3) Video/Audio Processing, (4) Bio-signal Processing, (5) Multi-media Signal Processing, (6) Processor and Chip Design, and (7) System Integration, where (2)-(4) are processing technologies for different types of signals surrounding (1) to form the core technology, (6) provides the key components, while (5) and (7) are integration technologies. Substantial research results were obtained in that year.

In the second year, under the request of the review committee organized by the Ministry of Education, a new focused direction for this subproject was developed with title, "Wireless Multimedia over IP: Technologies and Applications". The huge volume of data and intensive computation requirements necessary for multimedia information processing integrated with wireless transmission problems such as the multi-path fading, dynamically available bandwidth and power and high bit error rates and packet loss rates have created plenty of research issues to be investigated. Three core areas were identified within this new direction:

(1) improved transmission technologies under wireless environment,

(2) multi-media information streaming under wireless environment, and

(3) content-based multimedia information retrieval under wireless environment.

In this year, some improved technologies for OFDM was proposed in the core area (1) above, and some key technologies for video scalability and error correction/concealment/resilience techniques was developed in the core area (2) above, and some content-based speech, image and 3-D object retrieval technologies were developed in the core area (3).

In the third year, the research in the above three core areas were continued. For the improved transmission technologies in (1), a new set of optimal structures for decision feedback equalizers to be used in multi-user detection was developed. For the multi-media

information streaming in (2), an improved error handling scheme using video proxy was developed, which includes hand-off functionality across different wireless cells. A hardware EPEG-4 FGS video encoding engine as well as a software stand-alone H.264 video compression embedded system were developed. Both of them were able to perform low bit rate video compression in real-time. Integrated with the scalability and error handling functions developed in the previous year, two versions of complete content flow mechanisms for multi-media information streaming over wireless were developed, one based on the MPEG-4 international standard framework, the other on the industry platforms with Microsoft solutions. For the multi-media information retrieval in (3), an initial music retrieval system was developed, various models for speech information retrieval with different indexing features were tested too. A very efficient new 3D object retrieval approach was proposed. This approach was based on matching the projected 2D shapes for 3D objects and is compatible to MPEG-7 framework, with a demonstration system available over the web for test. Finally, a prototype system integrating various technologies above in (2) (3) has been successfully implemented. With this system, users can retrieve Chinese multi-media news (text/speech/video) over the wireless network by voice interaction with a notebook PC and/or a PDA, while the retrieved news can be streamed over to the user terminal.

3. Research Description and the Plan for the Last Year

With the fast developments of network and information technologies, the future networks will soon integrate all human knowledge, information and services globally, while the most attractive representation for these human knowledge, information and services will be in form of multi-media signals. On the other hand, the wireless communications are creating a whole variety of user terminals for future networks such as handsets, PDA's and other hand-held devices. They offer network access at any time, from anywhere, while being small in size and light in weight. As a result, the keyboards and mice convenient for personal computers won't be convenient any longer, and the multi-media signals will be the most convenient interface for all user terminals. Furthermore, the problems for wireless multi-media are three-fold. At the link level, the time-varying fading and noise characteristics give much higher error rates with bursty errors, while the much smaller and dynamic bandwidth gives much lower and changing bit rates. At the transport level, for real-time purposes TCP/IP can't be used and the bit errors will be translated into packet loss. At the application level, multi-media applications usually require real-time continuous transmission of huge quantities of data. All the above creates a plenty space for research with unlimited number of problems.

The approach for wireless multi-media proposed in this subproject is as follows. First, improved transmission technologies can be developed to offer better link quality at the link level, while better protocols can be developed to accommodate multi-media traffic and link unreliability at the transport level. More importantly, at the application level, which is the core of multi-media technologies here, a set of "convergence functionalities" can be developed. Hopefully with this set of functionalities, the wireless link/transport level problems can become transparent to the core multi-media technologies, and the core multi-media technologies can be shielded from, and equally applicable to, all link/transport

environments. Examples for such functionalities include media encoding scalability and error concealment. Of course, all the multi-media core technologies also need to be more robust to combat with residual errors, and good example for such robustness technologies include signal verification and error resilience. Intelligent user interface for different terminals are also important. Since the above approach is quite broad, two central tasks for this subproject have been identified: multimedia information streaming and retrieval over wireless networks. So the research works performed in this subproject will be surrounding these two central tasks. Although the emphasis of this subproject is on basic research, some prototype systems may be integrated when possible to demonstrate the feasibility of the results.

With the above objectives, this subproject includes three core areas:
(1) improved transmission technologies under wireless environment,
(2) multimedia information streaming under wireless environment, and
(3) content-based multimedia information retrieval under wireless environment,
where (1) is to try to improve the transmission quality and efficiency of wireless networks directly from the link and transport levels, (2) is focused on media encoding scalability and error correction/concealment/resilience as well as the overall content flow mechanism so as to take care of the dynamic bandwidth/power and high bit error rates of wireless networks, with a purpose to achieve smooth and continuous multimedia communications in the wireless networks, and (3) is to help the users to retrieve under wireless environment the desired multimedia information out of the huge volume of information over the networks.

With the results obtained in the 3 previous years as summarized in (2), the efforts to be made in the last year will be to continue all the works achieved in these three years in the three core areas as mentioned above, and try to come up with a good solution for wireless multi-media by integrating the developed technologies together. Another possible goal is hopefully to try to integrate in some form the results obtained here with the available results from the other two subprojects, if possible.

4. Research Team

The principal investigator of this subproject is Professor Lin-Shan Lee and the co-principal investigators are Professor Soo-Chang Pei, and Professor Ja-Ling Wu. Other team members include Professor Jyh-Ho Chen, Professor Liang-Gee Chen, Professor Yu-Min Lee, Professor See-Mat Phoong, Professor Shyh-Kang Jeng, Professor Wen-Chin Chen, Professor Ming Ouhyoung.

5. Fund

In the last year, we have 6,321,000 NT dollars for personnel, 5,506,500 NT dollars for hardware/software, and 2,477,500 NT dollars for operation fee and overhead. So the total budget for this subproject is 14,305,000 NT dollars in the last year.