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GICE Honors**Congratulations on Prof. Huei Wang Awarded Ministry of Education's National Chair Professorship**

GICE Prof. Huei Wang Awarded Ministry of Education's National Chair Professorship, announced on September 18th by the Ministry of Education. Prof. Wang is the holder of "Engineering and Applied Science" section of National Chair Professorship. The term of this National Chair Professorship is three years. We are very proud that Prof. Wang stands out in a number of outstanding scholars in this extremely rigorous selection process.

Prof. Wang specialized in Monolithic Microwave/Millimeter-Wave Integrated Circuit (MMIC) and Radio Frequency Integrated Circuit (RFIC). The applications of RF/Microwave/ Millimeter-wave integrated circuits have been applied to wireless communications, satellite and radar transceivers, and astronomy observations, and etc. Prof. Wang's recent research focuses on using unlicensed band around 60GHz, especially in 60GHz CMOS (complementary metal oxide semiconductor) RFIC technologies.

Over the years with GICE, Prof. Wang has received many academic awards, including IEEE Fellow, National Science Council's Outstanding Research Award, IEEE Distinguished Microwave Lecturer, and the Academic Achievement Award from Ministry of Education. Now, on top of all these, he leaps to glory again by awarded National Chair Professorship. This is certainly again an acknowledgement for Prof. Wang's achievement.

Congratulations on Prof. Shi-Chung Chang appointed NCC Commissioner

GICE Prof. Shi-Chung Chang has been appointed National Communications Commission (NCC) full-time commissioner on Aug. 1, 2010. NCC is responsible for regulating the telecommunications and broadcasting sectors in Taiwan. The NCC consists of 7-full-time commissioners, and the term of office is four years.

Over the years with GICE, Dr. Chang has taught courses on optimization and information, control and games. He has been conducting research on distributed decision making and recently on mechanism design with applications to

telecommunications, network management and power systems. Now he has this opportunity in NCC to work on and contribute to many challenging problems at the policy level, regarding enhancement of effective competition in digital convergence, promotion of sound development of the telecommunications and broadcasting sectors, protection of public interests, and promotion of cultural diversity and respect for the disadvantaged. Dr. Chang will continue, but in reduced hours, to give lectures and advise students at GICE during his term of office.

Upcoming Events:

Sep 27-29
**2010 ICT Event
 Taiwan Session and
 Exhibition**
 Brussels Expo,
 Brussels, Belgium

Oct 31 - Nov 4
**2010 TI Educators
 Conference & Taiwan-
 Mainland University TI
 DSP Invitational Contest**
 Communication
 Research Center, NTU

Technology Developed in GICE

Cooperative and Cognitive Wireless Communications *from Communication and Signal Processing Group*

Cooperative communication and networking design is a promising paradigm for future wireless telecommunication systems. Cognitive radio seeks opportunistic transmission in under-utilized wireless spectrum to enhance system performance. Cooperative and cognitive wireless network has also been considered as an indispensable component for the next-generation wireless communication systems.

In this research project, we aim for investigating cognitive-based cooperative communications and networking systems to enhance performance. To achieve this goal, we look into theoretic problems and solve practical system design issues. Recently, we have published three papers in a cognitive radio special issue (IEEE Transactions on Vehicular Technology, May 2010 Issue) and won the best paper award in ICC 2010.

In traditional wireless networks, communicating devices "talk" to each other directly over a wireless link. In order to improve link quality, each device may use multiple antennas (e.g., multiple-input-multiple-output (MIMO)) and obtain the so-called spatial diversity gain. However, the MIMO technology could be expensive to simple portable devices in terms of hardware complexity and power consumption. Cooperative transmission resolves this issue by introducing third-party "relay" devices. The relay devices act as

virtual antennas for the communicating devices and thus, provide the same spatial diversity as the MIMO technology without use of multiple antennas.

To make best use of cooperative transmission, participating devices --- including the source, destination and relay(s) --- must (1) exchange link-quality information and then (2) adapt the cooperation strategy to the ever-changing wireless environment. In this project, we studied these two issues, and designed novel signaling mechanisms and cooperation strategies. Two signaling mechanisms were proposed, one for contention-based networks and the other for reservation-based networks. The contention-based mechanism requires individual relays to self-evaluate their contribution to cooperative transmission. Each potential relay then selects a backoff based on its self evaluation and contends to be the relay for the communicating devices. With such a design, over-the-air signaling between communicating devices is minimized. The reservation-based mechanism uses the Ecma-368 standard as the baseline. With the help of Beacon Protocol in the Ecma-368 standard, communicating devices can identify their common neighbors without any additional overhead. By knowing their common neighbors and corresponding link-quality information, the communicating devices can select the best relay (i.e., one of their common neighbors) for cooperative transmission. In either approach, the cooperation transmission follows the same strategy as shown in Figure 1. Here, once the signal-to-noise ratios of source-relay link, source-destination link and relay-destination link are determined, the best

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GICE Honors

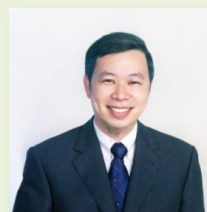
Congratulations on winning Best Paper Award of 2010 IEEE International Conference on Communications

S.Y. Lien, K.C. Chen, "Cognitive Radio Resource Management for QoS Guarantees in Autonomous Femtocell Networks", *IEEE International Conference on Communications*, Cape Town, 2010.



Prof. K.C. Chen and student Shao-Yu Lien received Best Paper Award at the 2010 IEEE International Conference on Communications (ICC 2010), Cape Town, South Africa, on May 25, 2010.

Message from the Director



Kwang-Cheng Chen

*Professor &
GICE Director*

GICE Newsletter has moved into a new semester, again with great news for our faculty and students, from international and domestic communities.

Please enjoy reading and give us feedback so that we can improve our presentation further.

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modulation scheme is obtained.

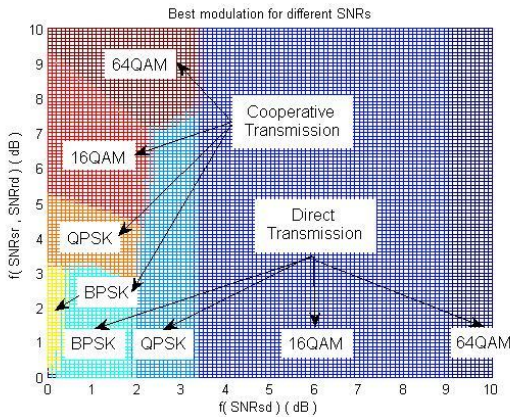


Figure 1: Adaptive modulation for cooperative transmission

Although the proposed mechanisms and strategy improve the throughput of a single communicating pair by 20 to 60% (depending on the channel condition), such improvement is obtained with the expense of additional power consumption at the participating relay(s). This additional power consumption includes not only the transmission power for forwarding the data to the destination but also the power consumed upon receiving the data from the source. Without considering the latter, the use of cooperation transmission cannot be fully justified. Figure 2 shows the throughput improvement with the consideration of receiving power at the relay. In this figure, all three cases --- namely direct, cooperative and multi-hop transmission --- have the same average power (i.e., total energy divided by the total time). As one can see, the improvement of cooperative transmission is significantly reduced.

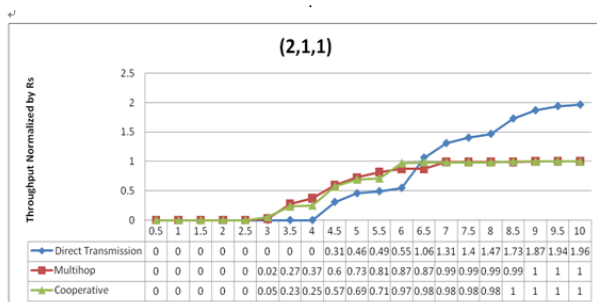


Figure 2: Throughput comparison when considering the receiving power

Another aspect of cooperation transmission that is usually overlooked is spatial reusability. Spatial reusability allows physically-separated communicating pairs to transmit simultaneously so that better spectrum efficiency is achieved. Although the use of relay(s) provides additional spatial diversity to the source-destination pair, it reduces the overall spatial reusability since the

neighbors of the participating relay(s), which are not the neighbors of the source or destination, also must remain silent during the cooperative transmission. As a result, less communicating pairs can transmit simultaneously. Such observation implies that even though the throughput of a single communicating pair can be increased via cooperation, the throughput of the entire network may not benefit from cooperative transmission. In general, our simulation shows that 20% less communicating pairs can transmit simultaneously when using cooperative transmission.

Throughout this two-year project, we have thoroughly investigated cooperative transmission from various aspects including power consumption and overall network throughput. Two new medium access control (MAC) protocols are proposed for both contention-based and reservation-based networks. Our research suggests that cooperative transmission is a promising and feasible 4G technology but must be carefully employed, especially in peer-to-peer wireless networks.

Cognitive radio enhances wireless communication performance through context-aware sensing and adaptation. Cooperative relay improves network connection quality and system throughput. An integrated design that benefits from both technologies can opportunistically exploit cooperation between network nodes. Motivated by both concepts, we propose a relay scheme called Cognitive-Enhanced Secondary-Assisted Relay (CESAR) mechanism to enhance the performance of contention-based cognitive radio networks. The basic idea of CESAR mechanism is as follows: when the packet transmission from a primary sender is failed with a high probability, secondary users who overhear the packet may launch the relay transmissions to recover the transmission (Figure 3).

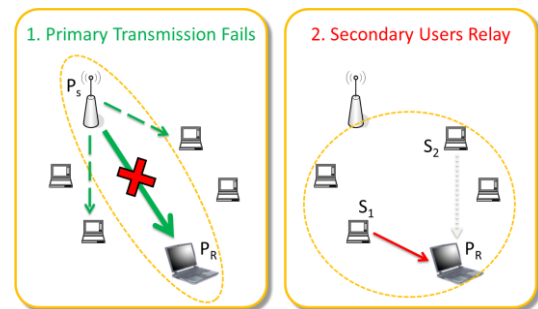


Figure 3: CESAR Mechanism

We first consider a centralized approach Error Minimization mode (CESAR-EM), which optimizes the system throughput. The centralized-approach aims to optimize the overall system performance.

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However, this may not be practical to cognitive radio networks with distributed secondary users. In reality, rational but selfish users may choose the actions that benefit themselves most whereas degrading the overall system performance.

Individual rationality, i.e., the willingness of users to follow the designed mechanism, is a crucial element in distributed wireless networks. In addition, the interaction among secondary users in distributed wireless system is complex and may be unpredictable if the mechanism is not properly designed. The stability of a proposed mechanism should be investigated carefully to ensure the functionality of the wireless system. Hence, we apply game theory to analyze the distributed system with complex interactions among objects. With game theory, we could analyze and predict the stable state, denoted as equilibrium, of a system. We investigate CESAR Game, a game-theoretic model for CESAR mechanism. The characteristics of battery constraints and selfishness of secondary users are modeled in CESAR Game, and thus we can investigate the interactions among these users and predict their behaviors under various scenarios.

We propose CESAR-AM (Altruistic mode) for CESAR mechanism without any incentive design: a secondary user is not rewarded by additional benefit when he/she successfully relay a packet. We analyze the Nash Equilibrium in CESAR-AM and find out it leads to a near-optimal system operating point when the network is not battery-constrained. However, when the network is battery-constrained, CESAR-AM is inefficient since the battery consumption of relay is too costly and few users will help relay in Nash Equilibrium.

To reduce inefficiency caused by selfish user behavior, we introduce CESAR-IM (Incentive mode) to encourage secondary users to join the relay set. In CESAR-IM, an additional slot is allocated as a reward to the secondary user successfully relays the

packet. The Nash Equilibrium in CESAR-IM is a Dominant-Strategy Nash Equilibrium, which means each player has a unique best strategy regardless what others do. This greatly reduces the implementation complexity.

The simulation results (Figure 4) show that CESAR mechanism can efficiently enhance the system throughput of the cognitive radio networks. CESAR-EM provides the optimal system throughput but is not implementable if users are distributed operating and selfish. CESAR-AM provides a little improvement from non-relay scheme because most users do not relay due to battery concerns. In contrast, CESAR-IM's enhancement on the system throughput is much larger than CESAR-AM's since most users are motivated to help relay for primary users.

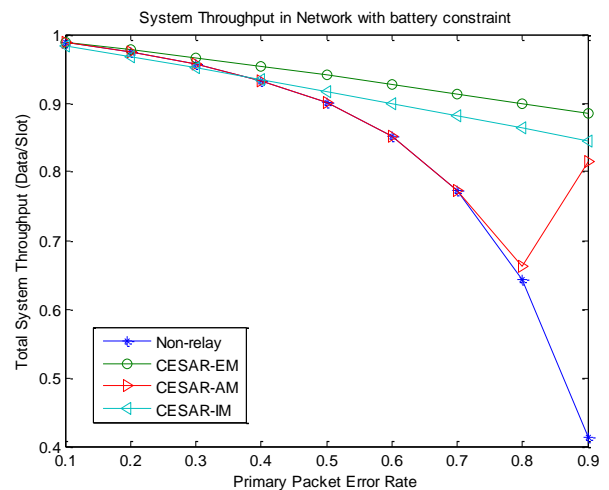


Figure 4: Simulation Results

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Compact UWB Aperture Antenna and Band-Notched Design from Electromagnetics Group

The antenna researches in GICE cover the researches of antenna theory, design, and applications for high-performance wireless communication systems. The focused research topics include EBG antennas with metamaterial, MIMO antennas, UWB/broadband and multiband antennas, and antenna miniaturization. Researches also involved in the multi-faculty joint project responsible for the millimeter-wave antenna design integrated with RF circuitry in a compact module/packaging. Here we introduce the works mainly accomplished by Prof. Yi-Cheng Lin of the Electromagnetics Group.

Since the Federal Communication Commission (FCC) allocated the ultrawideband (UWB) radio system frequency from 3.1 to 10.6 GHz, it has been a highly competitive topic in both academy and industry communities of telecommunications. In particular, the antenna of ultrawide bandwidth is the key component to the implementation of the UWB system.

In his highly cited paper "Compact Ultra wideband Rectangular Aperture Antenna and Band-Notched

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Technology *(continued from page 4)*

Designs" (*IEEE Transactions on Antennas and Propagation*, Vol. 54, No.11, Nov. 2006), Professor Lin presented a simple and compact UWB aperture antenna with extended band-notched designs. The antenna consists of a rectangular aperture on a printed circuit board ground plane and a T-shaped exciting stub, as shown in Fig. 1. The proposed planar coplanar waveguide fed antenna is easy to be integrated with RF/microwave circuitry for low manufacturing cost. The antenna is successfully designed, implemented, and measured. A compact aperture area of $13 \times 23 \text{ mm}^2$ is obtained with promising performances, including broadband matched impedance, stable radiation patterns, and constant group delay. The correlation between the mode-based field distributions and radiation patterns is discussed. Extended from the proposed antenna, three advanced band-notched (5–6 GHz) designs are also presented as a desirable feature for practical UWB applications—reducing the in-band interference with WLAN 802.11a. Fig. 2 shows the geometry and dimensions of these three designs. The first design embeds an isolated slit of total length equal to half a wavelength for the frequency at 5.5 GHz inside the T-stub, as shown in (a). The second design employs two open-end slits at the top edge of the T-stub, as shown in (b), where the effective length of each slit is around quarter wavelength for the 5.5 GHz

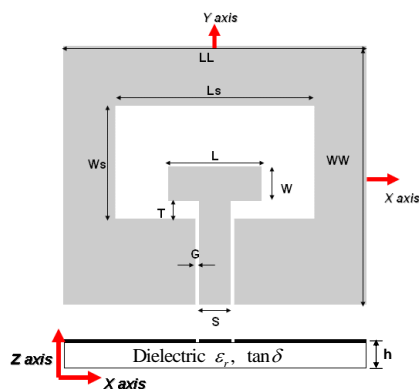


Fig. 1. Geometry and configuration of the proposed antenna.

resonance. The third design utilizes two parasitic strips of half a wavelength at 5.5 GHz, as shown in (c).

Generally speaking, the design concept of the band-rejection function is to make the input impedance singular (minimum resistance close to zero) at the sub-resonant frequency. To implement it, a narrow-band resonant structure is added to the original wide-band antenna area. Based on this concept, the above three designs using the isolated slit, the open-end slits, and the parasitic strips, as illustrated in Fig. 2(a)–(c), are individually accomplished with the proposed UWB antenna.

The design merit is that no extra tuning is needed for the original UWB antenna dimensions while incorporating the band-notched design. The simulation and measurement results of the proposed antenna show a good agreement in terms of the return loss and radiation patterns.

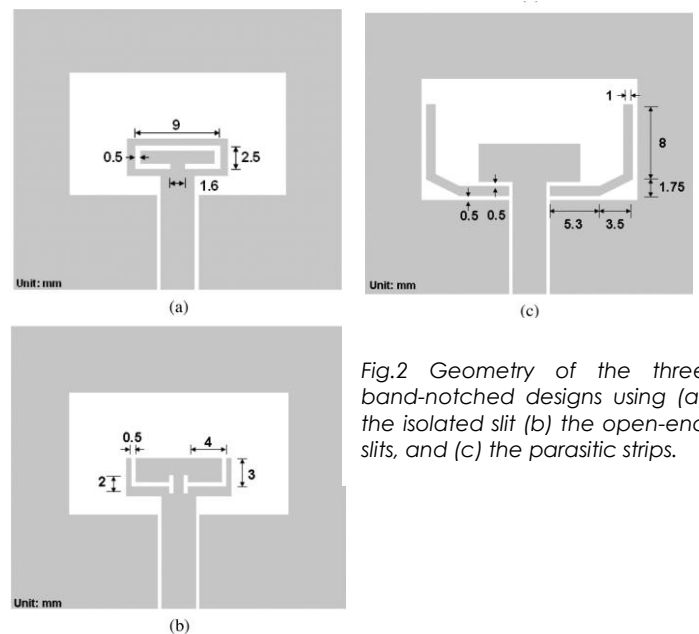


Fig.2 Geometry of the three band-notched designs using (a) the isolated slit (b) the open-end slits, and (c) the parasitic strips.

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Communication Research Center

2010 EM Education Initiative-Summer Program

"2010 EM Education Initiative - Summer Program" was held on 2 August to 6 August 2010 in National Taiwan University. The invited speakers are among the best and the brightest, and therefore attracted many graduate students nationwide to



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Upcoming:

Sep 27-29

**2010 ICT Event
Taiwan Session and
Exhibition**Brussels Expo,
Brussels, Belgium

National Science Council and EU-FP7 ICT National Contact Office will have an opportunity to show Taiwan's achievements in ICT fields and seek for more chances on international academic cooperation. A networking session which will be composed by Taiwan professionals will introduce the strength on ICT research in Taiwan. Also, a Taiwan booth will show the research achievements of several National Science and Technology Programs and demo products from successful industrial representatives.

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Communication Research Center

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participate in the seminar. It received encouraging responses and the outcomes are fruitful. The number of attendees was impressive and as many as 32 graduate schools have joined the efforts.

The seminar was originated from the discussion which was lead by IEEE EMC Chapter Chair Song- Tsuen Peng and other experts and professionals in EM fields. Professor Ruey-Beei Wu and Professor Huei Wang from GICE of NTU initiated this summer program to be organized by Communication Research Center of NTU.

One of its resolutions was to kick off a seminar for the new graduate students to review the primary knowledge and

grasp the research trends on EM theory and applications in the summer before they enroll the graduate schools.

Mandated to uplift the research momentum in electromagnetic (EM) field and to attract young talents to do R&D, the joint meeting received enthusiastic participation and constructive comments from the Chapter Chairs and members in EM field in Taiwan. With strong financial support from MTT Chapter chaired by Fu-Tsan Tsai, the seminar was held by NTU Communication Research Center, thereby fully utilizing NTU's influence to gather venerable professors as speakers and to set up good holding patterns.

2010 Norway-Taiwan ICT Workshop

After the successful UK-Taiwan ICT workshop held on March 2010, the upcoming Norway-Taiwan ICT workshop on 14-15 June 2010 at National Taiwan University (NTU) with the cooperation of Communication Research Center (CRC), NTU and British Trade and Cultural Office (BTCO), was ended in a satisfactory.

Academic researchers from University of Oslo and Norwegian University of Science and Technology together with industrial researchers discuss potential cooperation on green technology and biotechnology with the academic and industrial researchers in Taiwan.

With jointly great help from both governments, the Deputy Minister of National Science Council, Cheng-Hong Chen and the Director of Department of International Cooperation, Ching-Ray Chang, and the representative professor of the Research Council of Norway, Torbjørn Svendsen were present at the opening ceremony.

In the opening, the Deputy Minister of National Science Council, Cheng-Hong Chen highlights the six main flourished industries based on the core competence of ICT in Taiwan. The

representative professor of the Research Council of Norway, Torbjørn Svendsen introduces the strategic ICT research in Norway. The speakers include five professors from Norway's top universities and six industry representatives and four distinguished professors from Taiwan.

Around 100 participants joined the workshop in which many experts from academia and industry lively discuss in technical, application and current market situation, future research direction perspectives.

This workshop focused on robust wireless system, biomedical technologies and health care applications, and ICT-enabled green

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Communication Research Center *(continued from page 6)*

technologies. Biotechnologies are generally applied to the development of health-related devices and pharmaceuticals. With the development of biotechnologies in recent decades, now it is very good time to bring the biomedical technologies to improve the everyday life. To reduce the global CO2 emissions, green technologies recently bring lots of the attention. To significantly shrink carbon emissions, energy-efficient wireless technology is one of the most potential striving directions.

Wireless mobile communication and the development of communication software are

two of the high-performance ICT technologies in Norway. On the other hand, ICT technologies have been the most well-developed and successful industries in Taiwan. The great achievement in ICT industries, especially in wireless communication, make strong opportunities and foundations in both side to build world-class potential leading technologies in the future.

Relying on the fruitful experiences and high willingness on both Taiwan and Norway, we expect great success in Norway-Taiwan win-win cooperation.

Activities

2nd NTU/KAIST Workshop on Signal Integrity and EMC

After the first successful workshop hold by Graduate Institute of Communication Engineering (GICE) of NTU and Department of Electrical Engineering of Korea Advanced Institute of Science and Technology (KAIST) at KAIST, Korea in summer 2009, it is a great honor that the 2nd NTU/KAIST Workshop on Signal Integrity and EMC was hold here at NTU on July 6th, 2010. The workshop invited research teams from NTU and KAIST to present their latest developments and future trends.

The workshop was chaired by GICE professors Ruey-Beei Wu, Hsin-Chia Lu, and Tzong-Lin Wu, and KAIST professor Joung-ho Kim. Twelve research topics which include TSV design, eye diagram modeling, common-mode noise suppression, and more, were presented by Ph.D. program students of both sides. The workshop not only successfully attracted students, but also the industrial specialists. With a total of 113 participants, 54 were from the industrial field, including companies like ASUS, TSMC, MSI, ITRI, and more.

Through the workshop, attendants not only impressed by the enthusiastic interaction between NTU and KAIST, but also broadened their vision for the future trend at the area of SI and EMC in advanced packaging and PCB design.



2nd NTU/KAIST Workshop on Signal Integrity and EMC was hold on July 6th, 2010.

GICE Holds "The 1st Advanced Engineering Program in Telecommunication Network Technologies of Chunghwa Telecomm" Certificate Conferral Ceremony

GICE holds the certificate conferral ceremony for "The 1st Advanced Engineering Program in Telecommunication Network Technologies of Chunghwa Telecom" on July 28. Launched in 2008, the program is held by GICE and Chunghwa Telecom Co., Ltd. (CHT), the most experienced and largest integrated telecommunication operator in Taiwan.

In response to promoting the Chunghwa Telecom Corporate University and its human resources development, the CHT Program provides its staff to



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Activities *(continued from page 7)*

advance their expertise in telecommunications network technology, foster CHT elites, and reserve the future teachers in telecommunications training.

Through competitive selection among the CHT staff, 50 potential talented employees can participate in the program each year. The two-year program was taught by GICE and NTU professors every Saturday. Courses include Digital Communication, VoIP Network System, Mobile Communications, Multimedia networking, Digital Video Technology, Vehicle Communication Technologies, Special Topics on Network Application & Service Management, and Network & Computer Security.

With 50 graduates of the 1st CHT Program this year, Chairman and CEO of Chunghwa Telecom Co., Ltd. Dr. Shyue-Ching Lu and Vice President of NTU Prof. Tai-Jen George Chen both attended the conferral ceremony. Before the ceremony, the program members also share attendees their works and projects through an achievement exhibition.

With the success of "Advanced Engineering Program in Telecommunication Network Technologies of Chunghwa Telecom" in the past two years, GICE and CHT are now in the member selection process for the 3rd CHT Program, which will begin in September 2010.

Corner of Student News

by Wen-Su Su

Telecommunication Laboratories Chunghwa Telecom Co. Ltd. Wireless Communications Laboratory

GICE and Chunghwa Telecom Co., Ltd. began to co-host the Advanced Engineering Program in Telecommunication Network Technologies two years ago. The program holds on Saturdays and provides eight fundamental telecommunication courses specially designed for CHT staff.

I graduated from the Dept. of Communication Engineering of NCTU, and worked at Chunghwa Telecom Co. Ltd. after graduation. I was fortunate to become one of the student members in the program, and was able to receive a two-year training of telecommunication at the best university in Taiwan. It is an extraordinary experience for me to have the chance to go back to school after 8 years of work at CHT.

After leaving the campus for years, I need to review some basic knowledge of probability and Engineering Mathematics to catch up the class. During these two years, I often went to the library after work to do homework, researches, and studies. With my background in communication engineering, I had the advantage to help classmates to review the lessons before exams. Through every discussion and meeting, it also helped me to understand the materials more thoroughly.

Albert Einstein once said, "Imagination is more important than knowledge." The real power comes from creation, and creation comes from imagination. Here at GICE, I met Prof. K. C. Chen, who emphasizes the inspiration during the class. It is impressive that when he taught each significant communication theory, he would mention the origins of the invention and the achievements of the inventors. Prof. Chen often encourages us with an ancient Chinese saying with the meaning like "As long as you are willing to do something, you can achieve the goal." This also inspires my interests in researches on "Cognitive Radio Technology" for my final project, which was a brand new topic to me. The project paper was also being published on Telecommunication Laboratories Technical Journal of CHT.

During the two-year program, it is honored to acquire knowledge from eight elite professors. Not only did these courses built a solid foundation for my expertise, but also the learning experiences definitely helped me to encounter future challenges more easily.



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