National Taiwan University
Graduate Institute of Communication Engineering Newsletter

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In this issue

Upcoming Events:

May 23
Prof. Chih-Chun Wang Visit
School of Electrical & Computer Engineering, Purdue University

Technology Developed in GICE

Synthetic Quasi-TEM Transmission Lines for CMOS System on Chip

from Electromagnetics Group

Transmission line-based circuits consume expensive chip area in MMIC technology, thus minimizing the circuit area is crucial for microwave application. The complementary-conducting-strip transmission line (CCS TL), which is a type of synthetic quasi-TEM transmission line, has been successfully employed for compact integrated circuit applications. The CCS TL is constructed by a cell-based design on the silicon substrate. Figure 1 shows the 3-dimenstional, top, and cross-sectional view of the unit cell. The signal traces on the top metal layer are meandered, and the ground plane is made up of lower metal layers connected with embedded vias.

The CCS TL provides several advantages including:

1. Flexible synthesis of quasi-TEM guiding characteristics with cell-based design.
2. A wide range of characteristic impedance.
3. Compact size with meandering structures.
4. Tradeoff between circuit area and transmission line loss is available.
5. Required metal density in CMOS design rules is easier to meet.

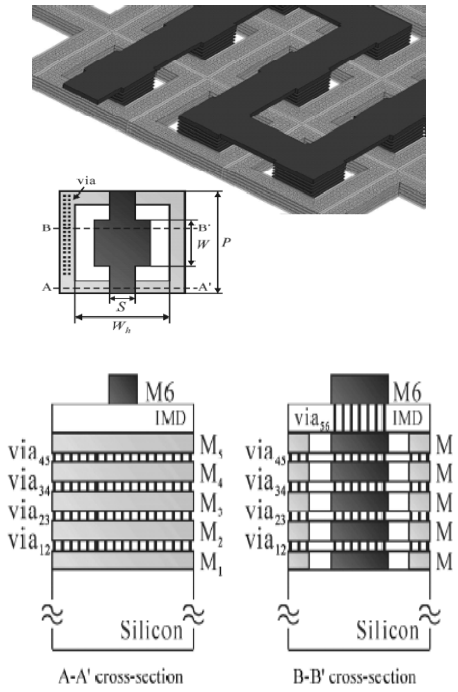


Fig. 1 3-D, top, and cross-sectional view of the CMOS CCS TL unit cell.

Coupled transmission lines are also designed in a similar structure. The signal trace is replaced with two coupled lines. An example of the meandered coupled line is shown in Fig. 2(a). The above advantages of CCS TL also apply in realizing CCS coupled lines. The design of the directional couplers based on CCS coupled lines achieve tighter coupling and more compact size than the design based on the conventional edge-coupled microstrip lines.

(Continued on page2)

GICE Honors

Professor Tzong-Lin Wu

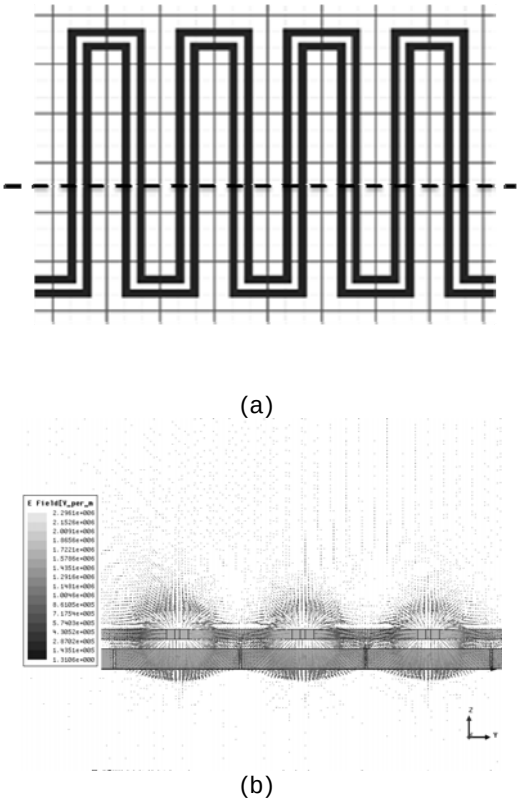
Congratulations on winning IEEE Transactions on Advanced Packaging 2010 Best Paper Award

"Noise Coupling Mitigation in PWR/GND Plane Pair by Means of Photonic Crystal Fence: Sensitivity Analysis and Design Parameters Extraction" VOL. 33, NO. 1, March 2010.

Technology (continued from page1)

As the coupled lines are meandered, symmetry of mode propagation is a problem because the even-odd mode analysis is usually applied in coupled line circuits. To investigate the asymmetry problem of the meandered CCS coupled lines, the asymmetric coupled-line analysis is adopted to observe the potential mode asymmetry. The meandered lines are modeled as straight asymmetric coupled lines. Mode asymmetry is able to be quantitatively defined by the relative mode amplitude of both modes during the analysis. A tight coupler is designed on CMOS technology and analyzed with this model. The analysis has shown that the coupled lines still carry nearly ideal even and odd modes. In Ansoft HFSS simulation, 3-dimentional electromagnetic field distribution can be plotted with exact even- and odd-mode excitation. Figure 2(b) is the electric field distribution of the meandered coupled lines under even-mode excitation, and no significant difference is observed. These results show that the symmetry of the meandered coupled lines is well maintained. The symmetric coupled-line model is still a good approximation in this meandered coupled-line design.

A CMOS vector-sum based phase shifter is fabricated by using 0.18 m 1P6M CMOS technology. Figure 3 shows the chip photo of the phase shifter with a chip size of 560 m 560 m excluding the contacting pads. The phase shifter consists of one 3-dB directional coupler, two phase-invertible variable attenuators (PIVAs), and one power combiner, are realized by using synthetic transmission lines for the circuit miniaturization. The phase shifting is accomplished by combining two vector signals after performing the signal processing in the complex domain. The processing is initiated by performing the in-phase and quadrature-phase decomposition of the input signal with the coupler. After decomposing the input signal, the two output signals of the coupler enter into two PIVAs. The PIVA performs the magnitude adjustments of the input signal with either in-phase or out-of-phase shifting. Finally, the power combiner gathers the signals at the outputs of two PIVAs to complete the processes. Figure 4 shows the relative phase shifting for all 16 states of the proposed design. Each adjacent state has a constant phase difference of 22.5 degree. From 22 to 26 GHz, the measured phase error is kept below 1.5 degree.



(a)

(b)

Fig. 2 (a) Meandered layout of CCS coupled lines. (b) Electric field distribution along the dash line is plotted by Ansoft HFSS with even-mode excitation.

Message from the Director

Kwang-Cheng Chen

Professor &
GICE Director

We keep sharing good news with our readers in this Newsletter. Prof. Tzong-Lin Wu co-authored a paper to receive the best paper award from the IEEE Transactions on Advanced Packaging 2010. It is the second time for GICE professors to receive this recognition (earlier 2007). In the mean time, CRC gracefully hosted a major visit to NTU consisting of global leaders who have strong influence on research directions in science and technology, by briefing research accomplishments from various Institutes in the College of Electrical Engineering and Computer Science.

Technology (continued from page2)

The features of the proposed phase shifter are as follows:

1. Low phase error and magnitude variation within 360-degree phase shifting.
2. The high phase and power linearity.
3. The compact design by using synthetic transmission line approach.

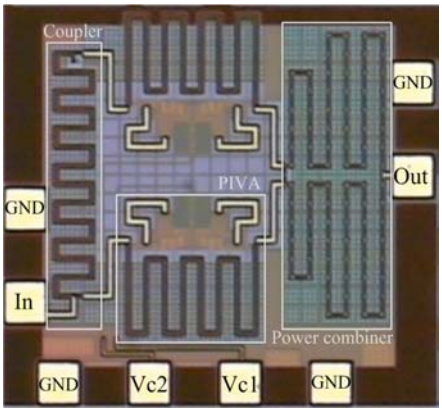


Fig. 3 The chip photo of the K-band CMOS vector-sum based phase shifter in 0.18 m 1P6M CMOS technology.

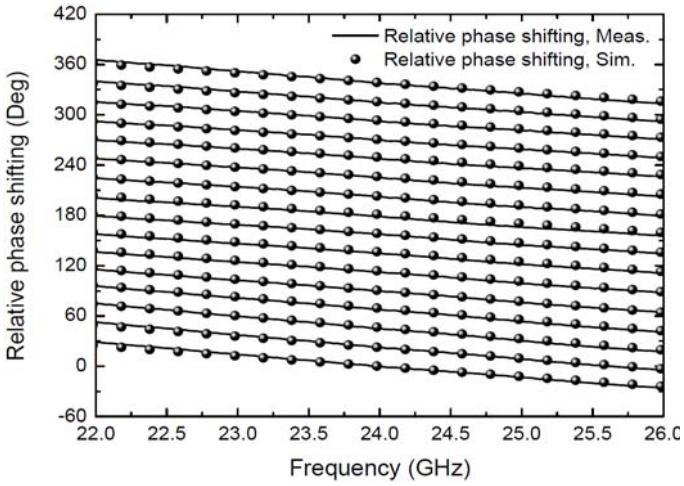


Fig. 3 Measured and simulated relative phase shifting of the proposed phase shifter.

For more information please contact:
Professor Ching-Kuang C. Tzuang
Email: cktzuang @cc.ee.ntu.edu.tw

Spectrally Precoded OFDMA With Cyclic Prefix and Unconstrained Guard Ratios

from Communication and Signal Processing Group

Rectangularly pulsed orthogonal frequency-division multiple access with cyclic prefix (CP-OFDMA) has received great interest since it enables efficient implementation using discrete Fourier transform (DFT), has high spectral efficiency and increased robustness against channel dispersion and multipath fading, and provides good tolerance for symbol timing errors in asynchronous multiple-access communications. Despite these advantages, the rectangularly-pulsed CP-OFDMA signal is discontinuous and thus exhibits large power spectral sidelobes decaying asymptotically as f^{-2}, with f being the frequency in hertz. These large power spectral sidelobes interfere adjacent bands severely and thus need to be suppressed as much as possible.

In order to suppress the power spectral sidelobes, the technique of spectral precoding has been proposed by Prof. Chung and his doctoral students. Fig. 1 depicts the considered spectrally precoded CP-OFDMA system. In each CP-OFDMA signaling interval, the source generates a vector of complex-valued symbols which can be uncoded data, coded symbols or pilot symbols and have arbitrary statistics. The symbol vector is first processed by a data-independent precoding matrix and then modulated by the conventional CP-OFDMA modulator. Here, the spectral precoder is used to shape the power spectrum of the transmitted CP-OFDMA waveform. By choosing the precoding matrix properly, the transmitted CP-OFDMA signal can exhibit a desirable power spectrum.

From the theory of Fourier analysis, if a signal has continuous derivatives up to the (…-1)-th order at all time instants, the Fourier transform of the signal has spectral sidelobes decaying asymptotically as f^{-2K-2}. In light of this fact, a precoder constraint has been derived to ensure that the corresponding spectrally precoded CP-OFDMA signal has continuous derivatives up to the (…-1)-th order at all time instants and thus exhibits extremely small spectral sidelobes decaying as f^{-2K-2}. Two types of spectral precoders, namely correlative and orthogonal precoders, have also been designed to satisfy this constraint. When …≧1, because these spectrally precoded CP-OFDMA signals exhibit much smaller spectral sidelobes than nonprecoded OFDMA signal, the spectrally precoded CP-OFDMA signals can provide more

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Technology (continued from page 3)

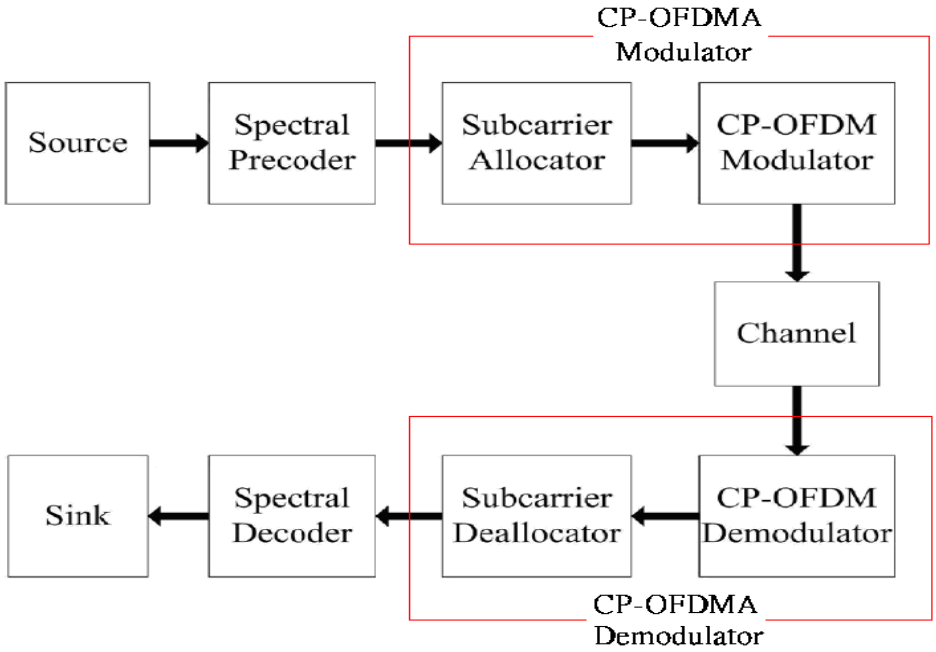

Fig. 1. Spectrally procoded CP-OFDMA system.

compact spectrums and thus induce less interference to adjacent bands.

To evaluate the spectral sidelobe suppression capability, the out-of-band power fraction which denotes the fraction of total power not captured in a given frequency band is used as a performance measure. Fig. 2 illustrates the comparison of out-of-band power fraction among spectally precoded and nonprecoded CP-OFDMA signals. As shown, spectally precoded CP-OFDMA signals can provide much more compact spectrum than nonprecoded CP-OFDMA signal.

To sum up, the technique of spectral precoding has been proposed to mitigate the large power spectral sidelobe problem for rectangularly pulsed CP-OFDMA. Particularly, a precoder constraint has been derived in conjunction with the design of some useful precoders. Numerical result shows that the spectral precoding technique can significantly suppress the power spectral sidelobes of CP-OFDMA signals.

Although spectral precoding achieves satisfactory results, there are still several open topics in this research area. For example, because the large peak-to-average-power ratio (PAPR) is also a major drawback for OFDM system, the joint precoding for spectral sidelobe suppression and PAPR reduction and the spectral precoding for nonlinearly amplified OFDM are both interesting research topics and deserve further investigation.

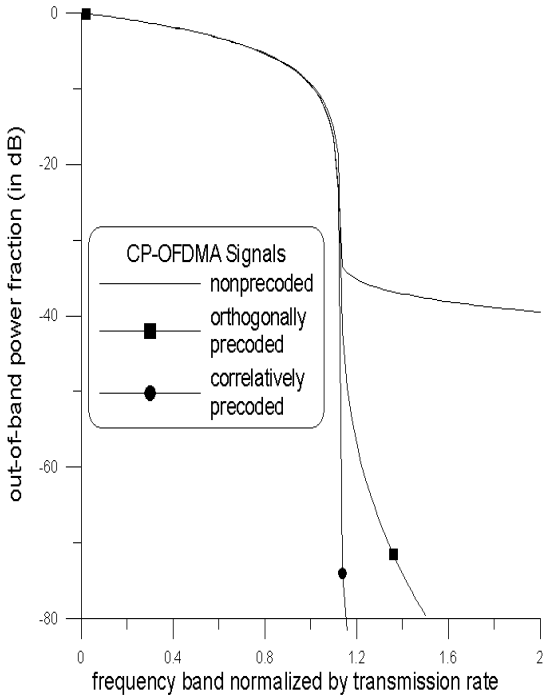

Fig. 2. Fractional out-of-band power characteristics of spectrally precoded and nonprecoded CP-OFDMA signals.

For more information please contact:
Professor Char-Dir Chung
Email: cdchung@cc.ee.ntu.edu.tw

Co-author of the article: Wei-Chang Chen, PhD Candidate of NTU GICE

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Technology (continued from page 4)

MAC FER-Based Codec Adaptation for Multimedia Streaming Over Wireless Networks

from Communication and Signal Processing Group

Transmitting real-time multimedia data has been a big challenge for wireless communications. The quality of service (QoS) experienced by the multimedia traffic is subject to the time-variant characteristics of the wireless channels. In this study, a cross-layer algorithm is proposed to combat the wireless channel variation by adjusting the multimedia codec settings according to the MAC frame error rate (FER) in real-time. The proposed algorithm is computational efficient and the numerical experiments show that the cross-layer algorithm indeed achieves better performance even when the wireless channels are in severe conditions.

Since the introduction of the 802.11 wireless local area network (WLAN), the technology has achieved tremendous success due to its convenience of accessing the Internet. The introduction of the 802.11a and 802.11g further increased the transmission rate, and thus made real-time multimedia transmission over WLAN a practical application. However, the QoS requirements, such as delay, packet loss rate, etc., need to be constantly maintained to provide high quality multimedia transmission services. Owing to the time-varying channel characteristics in wireless environments, it is a big challenge to constantly maintain the QoS of wireless multimedia transmission services.

In this study, a cross-layer codec adaptation algorithm is developed. Due to the short-term oscillation of channel state information (CSI) commonly used in wireless environments, it is our opinion that switching codec solely based on the instantaneous CSI or short-term averaged CSI could over-tune the codec. Instead, we should also take the possible channel variation behaviors in the near future into consideration. Based on this idea, our proposed algorithm uses the MAC FER observed in certain periods as the codec setting switching criterion. In each observation period, which consists of a fixed number of MAC frame transmissions, the observed FER is compared to a set of pre-determined threshold values to determine the codec setting for the next observation period. The major achievement in this study is to analytically find the codec switching thresholds that optimize the expected PSNR.

As previously mentioned, our proposed scheme considers the channel variation behaviors in the

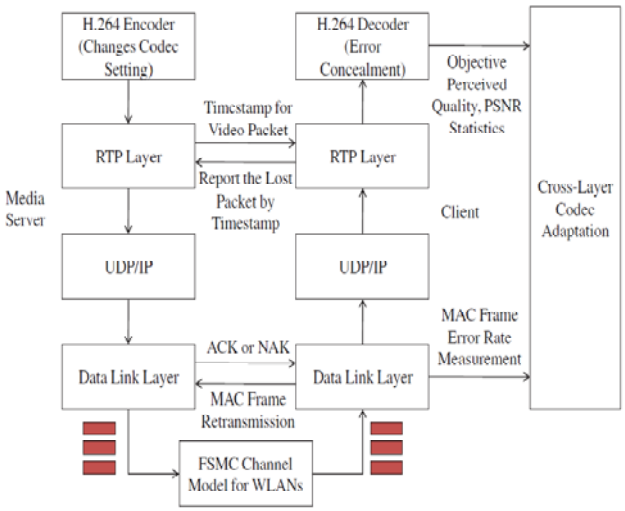

Figure 1. The cross-layer optimized protocol stack for wireless H.264 video transmissions. (Figure 1 of [1]).

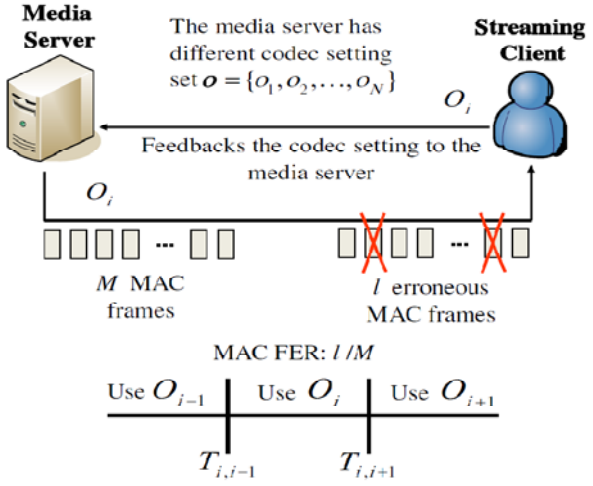

Figure 2. The FER-based codec adaptation algorithm for wireless multimedia transmissions. (Figure 5 of [1]).

next observation period. This is done by deriving the FER distribution from the possible state transition behaviors of the finite state Markov channel (FSMC) model in each observation period. The expected PSNR can thus be obtained from the derived FER distribution. And the optimization is done by setting the codec switching thresholds judiciously. Notice that the optimal threshold values can be calculated off-line to support real-time multimedia streaming.

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Technology (continued from page 5)

This scheme does not pose any restrictions on the codec. That is, it can be applied to any codec with PSNR versus FER simulated off- line. Numerical experiments show that the derived PSNR analysis matches well with the simulated PSNR, and the proposed algorithm significantly improves the PSNR by 5 dB.

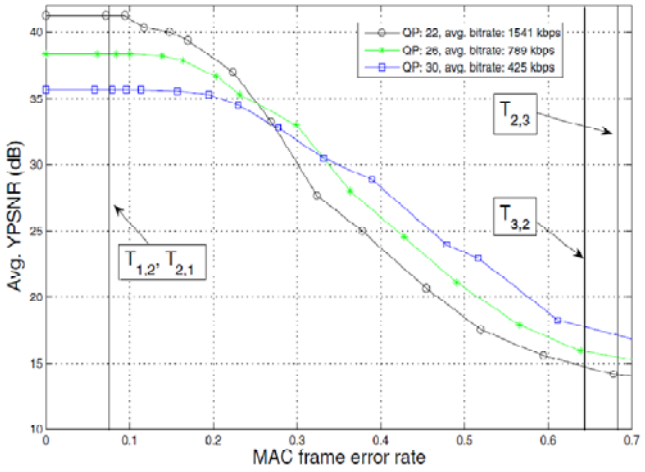

Figure 3. Optimal codec switching thresholds with PSNR versus FER under codec setting adaptation at γ_0 = 7 dB and f_m = 8 Hz. (Figure 7 of [1])

The frame-by-frame YPSNR of one particular video transmission is shown in Figure 4 as an example. The codec setting adaptation scheme achieves excellent video quality when the link adaptation layer encounters lower MAC FER, and on the other hand incurs less quality degradation when the link adaptation layer encounters higher MAC frame FER. As the numerical results show, the proposed scheme outperforms the three other codec settings {o_1, o_2, o_3} with the average YPSNR gain of 4.5101, 4.7900 and 3.2331 dB, respectively.

To sum up, a cross-layer design for optimizing PSNR by switching video codec settings based on the observed MAC FER has been proposed. The expected PSNR analysis has been derived to find the optimal codec switching thresholds for the observed MAC FER. Numerical results show that the proposed algorithm introduces significant PNSR gain for wireless multimedia streaming.

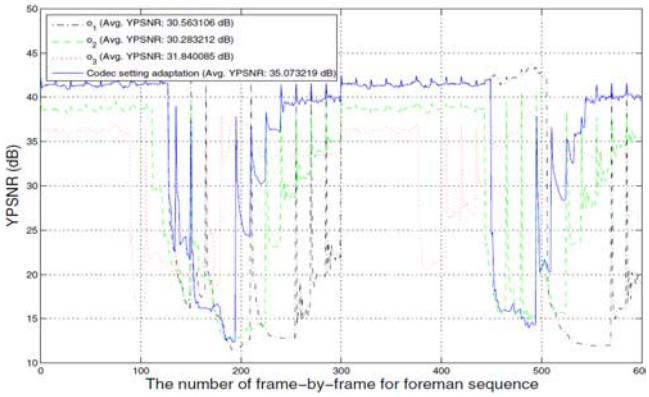

Figure 4. Frame-by-frame YPSNR under codec setting adaptation at γ_0 = 8 dB and f_m = 8 Hz. (Figure 8 of [1])

References
[1] C. Chiang, Z. Wu, C. Shih, P. Yeh, and H. Hsieh, "MAC FER-Based Codec Adaptation for Multimedia Streaming over Wireless Networks," *IEEE 10th International Symposium on a World of Wireless, Mobile and Multimedia Networks.*

For more information please contact:
Professor Ping-Cheng Yeh
Email: pcyeh@cc.ee.ntu.edu.tw

Co-author of the article:
Yeh-Chi Lee, Research Assistant of Digital Wireless Communication Lab., NTU GICE

Communication Research Center

Welcome Global Science Leaders Visiting EECS NTU

With the cooperation by National Science Council (NSC), Office of International Affairs National Taiwan University, College of Electrical Engineering and Computer Science National Taiwan University and Communication Research Center NTU, the visit to EECS NTU for the delegates from Global Science Leaders Forum was successfully carried out in Barry Lam Hall 201, NTU on April 27th, 2011. The visiting science leaders from different countries included Mr. Andrew W. Reynolds, Adviser to the Secretary of State, U.S. Department of State, Mr. Peter Gluckman, Chief Science Advisor to the Prime Minister, New Zealand, Mr. Minh-Hà Pham-Delègue, Director, International Cooperation-CNRS and so on. Their dedication to addressing science, engineering and technology issues in global community has been much appreciated around the world.

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Communication Research Center (continued from page 6)

Through the visit, science leaders from different countries and the faculty of EESC NTU had chance to strengthen outreach to the international S&T community and facilitate international cooperation in related fields. To begin, GICE Director Kwang-Cheng Chen greeted the delegates and gave an introduction of EECS NTU. Director Chen talked about the departments and institutes of EECS NTU which are constantly making efforts to promote the status of Taiwan's technological development, economy growth and the professionals in Electrical Engineering and information related industries, synchronizing with international research trend. Dept. EE Distinguished Professor Professor Ren C. Luo was invited to share research achievements in the fields of cognitive systems and robotics. Prof. Luo talked about sensor-based intelligent robotic systems, multi-sensor fusion and integration for the developments of medical and health care robotics.

(Upper right)Dept. EE Distinguished Prof. Ren C. Luo
(Bottom right) GICE Director K. C. Chen
(Bottom left) Dept. EE Professor Jyh-Horng Chen
(Upper left) Ph.D. Student Da-Yuan Huang, instructed by GINM Director Yi-Ping Hung

After that, BEBI Prof. Jyh-Horng Chen was invited to present the topic of the next generation MRI Series—Wideband MRI: MR for Higher Resolution and Quicker Imagining, through which the advanced technologies studied by the Medical Imaging Lab & Interdisciplinary MRI/MRS Lab were introduced as well. Next, Grad. Inst. Networking and Multimedia Ph.D. Student Da-Yuan Huang, instructed by GINM Director Yi-Ping Hung gave an account of the research achievements of interaction between human and touch devices, including I -m-Top system and I-m-Pro system. As Da-Yuan Huang presented, I-m-Top system was a touch table device, which allowed users to use their fingers or tangible objects to interact on the touch table surface. I-m-Pro system was an extended application based on I-m-Top system, which performed a new way to interact beyond the surface with their mobile devices. In his talk, Da-Yuan Huang also mentioned the application of the systems to Yongzheng Exhibition in National Palace Museum.

Finally, the progressive demonstrations of the communication & transition application examples studied by research groups of the EECS NTU were deployed and exhibited such as 802.11a, UWB Compatible 60 GHz Wireless Multi-media Data Transmission Platform and 60-GHz Short-Range Link. During the demonstration, there were many technical challenges, recent advancement and new opportunities discussed among the visiting delegates and demonstrators.

Research demonstration: 60-GHz Short-Range Link.

Activities

2011 Telecom Innovation & Application Contest Explanation Session

Chunghwa Telecom Co., Ltd. (CHT) held an explanation session for 2011 Telecom Innovation & Application Contest with GICE on 7th April, 2011. Launched in 2003, CHT provides a direct way for people to show their talents and creativities in digital fields. In order to promote the development of telecom applications and digital industries, CHT has hold the contest since 2003 and appealed to many telecom-related people who can be encouraged to work into research and innovation

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Activities (continued from page 7)

in the telecom field. Thus, it will prosper the digital industries and improve the quality of people's digital appliances. CHT Training Department V.P. Jeng-shiung Tsai, GICE Director Kwang-Cheng Chen, GICE Prof. Zsehong Tsai and GINM Director Yi-Ping Hung participated in the explanation session. Also prizewinners of the last contest in 2010 attended and were rewarded.

Throughout the explanation session, CHT and GICE explained the goal and rules of the contest; furthermore, they encouraged more interested people to participate in the contest. With the effort of CHT and GICE, more and more people pay attention to Telecom Innovation & Application Contest and it is more emphasized in the telecom-related field.

Prof. Zsehong Tsai explains the contest

GI CE Director Kwang-Cheng Chen awards the first-prize student

Corner of Student News

by Huei-Shan Lin

The Graduate Students Study Abroad Program sponsored by the National Science Council (NSC) intends to subsidize Taiwanese Ph.D. students to conduct research at an accredited academic institute abroad for a maximum of one year. Last year I obtained this grant and went to Supélec (France) to conduct a research about the hybrid filter bank (HFB) system. It was intended to realize analog-to-digital conversion with the versatility concerning bandwidth or resolution by a multi-channel structure. The research team in Supélec has worked on this topic for years, and got abundant experimental results and experiences. However, the remaining problem was that the system was quite sensitive to the analog variations. My research work there focused on analyzing the sensitivity in order to obtain a robust design of HFB. It was a brand new research topic for my background. Also, it was the first time for the research team to take insight into this problem and few experiments have been done, which really posed challenges to us.

During the first several months, we had tried several approaches to re-design the digital parts of the HFB system to alleviate the sensitivity but the efforts were in vain. Based on the analysis results, we concluded that the problems could't be solved if we only focused on the digital parts to amend the analog imperfections. Thus, we started to re-design the analog parts. A realistic model for the stochastic behavior of the system error was built to which different realizations of analog circuits were considered. Finally we got an obvious improvement on the system. Although the new design introduced new problems, we managed to find the solutions to control the sensitivity within a certain tolerance.

The two advisors in Supélec, Mr. Duhamel and Mrs. Lelandais-Perrault had inspired me with different thoughts towards problems. Besides, I learned to adapt to foreign environments, to observe local cultures and to deal with issues of administrative formalities and personal accommodations on my own. It was interesting to get along with international colleagues, which provided me the chance to polish my language skills. The learning trip to France really broadens my viewpoint and benefits me a lot.

National Taiwan University
Graduate Institute of
Communication Engineering

No.1, Sec.4, Roosevelt Road,
Taipei 10617, Taiwan

Phone
+886-2-3366-3075

Fax
+886-2-2368-3824

E-mail
gice_newsletter@cc.ee.ntu.edu.tw

Visit us at:
www.comm.ntu.edu.tw

Editors
Min-Chieh Cheng
Hsin-Jung Huang
Shin-Yu Chen