2009/2010
Annual Report

DEPARTMENT OF ELECTRICAL ENGINEERING

DEPARTMENT OF ELECTRICAL ENGINEERING
Korea Advanced Institute of Science and Technology

KAIST

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KAIST

DEPARTMENT OF
ELECTRICAL ENGINEERING

2009/2010
Annual Report

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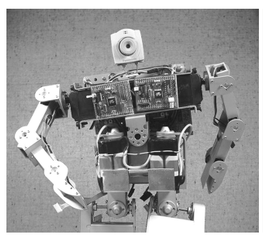
Department of Electrical Engineering

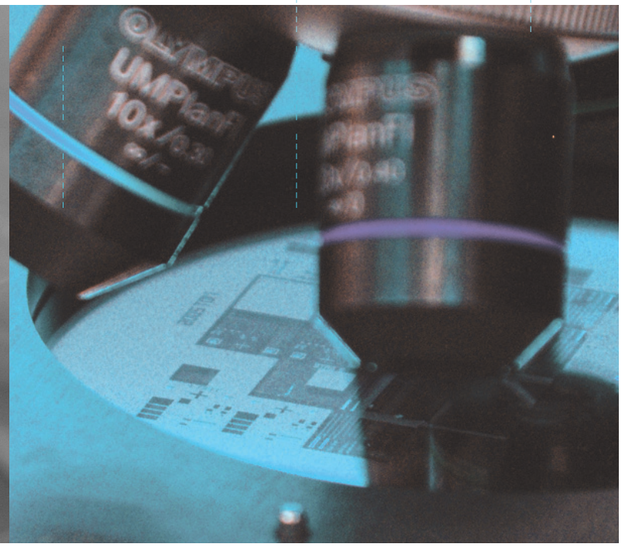
ANNUAL
REPORT
2009/2010

IN THE BEGINNING OF 2009, INFORMATION AND COMMUNICATIONS UNIVERSITY (ICU) WAS MERGED INTO KAIST.

GIVEN THAT NEARLY HALF OF THE STUDIES AT ICU FOCUSED ON ELECTRICAL ENGINEERING, THE MAJOR CONTRIBUTION OF ICU JOINED OUR DEPARTMENT, THE DEPARTMENT OF ELECTRICAL ENGINEERING (EE) AT KAIST.



Message from the Department Head



DEPARTMENT OF ELECTRICAL ENGINEERING

June 2010

HyunWook Park

Professor and Department Head
Department of Electrical Engineering

In the past few years, our university ranking has been drastically improving. In 2009, The London Times ranked KAIST as 21 among the world's top 100 technology universities in information technology and engineering. Our department is in the center of KAIST information technology and has contributed to the improvement in the academic ranking. The Electrical Engineering (EE) department has started to expand its research area to brain engineering as well as network computing. This expansion is just the first step in implementing our long-term goal, which is to become a world-leading department in information technology.

We have experienced many fast and drastic changes in the last four years, such as changes in the faculty tenure system and the tuition policy for undergraduate and graduate students, offering all of the undergraduate lectures in English, and integrating new admission standards for prospective undergraduate students. Most of the changes have adapted well to our system and we did our best to integrate the new policies successfully, which has made us stronger in the field of worldwide competition. However, we still have some tasks and policies that need to be refined. We do believe that we have the strength and ability to improve the policies and make changes by ourselves.

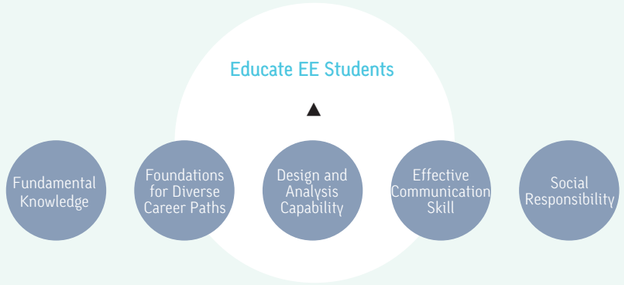
At present, the Department of Electrical Engineering at KAIST is the largest department in Korea, with 89 professors, more than 1,500 students (approximately 500 undergraduate and 1,000 graduate students), and 19 administrative and technical staff members.

This annual report highlights the various activities undertaken in 2009 and in the first half of 2010 by our faculty members, students, and staff. This year, we made great progress and produced outstanding research results. Our research centers worked closely with the government and industries, we strengthened our national research laboratories, and we gained a considerable amount of research funding. All of these achievements would not have been possible without the efforts of every member of the KAIST EE department.

We know we have a lot of things to do to realize our vision of becoming the best EE department in the world. Everyone in the Department of Electrical Engineering at KAIST is ready to listen to your suggestions and ideas that may improve the Department of Electrical Engineering. I would like all of you to remain interested in the Department of Electrical Engineering at KAIST and watch us become one of the best departments in the world.

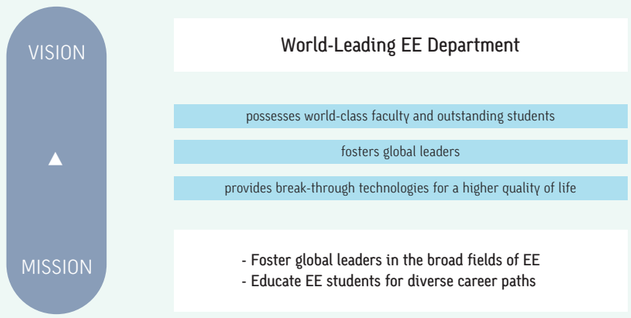
EE Vision

Mission Statements
(Undergraduate)



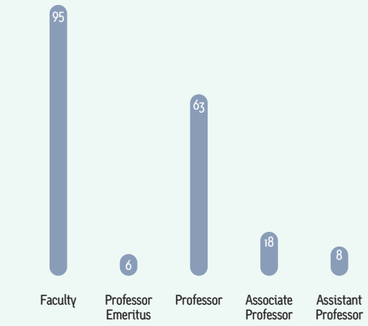
Mission Statements
(Graduate)

Vision Statements

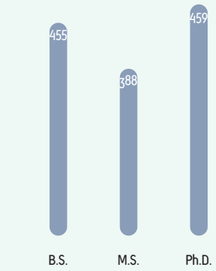


Overview

Faculty (Apr. 2010)



Student Enrollment (Apr. 2010)



Degrees Awarded (Feb. 2009 - Feb. 2010)

FACILITIES

7 Buildings
3 Research Groups
89 Laboratories
20 Research Centers

RESEARCH FUND (2009)

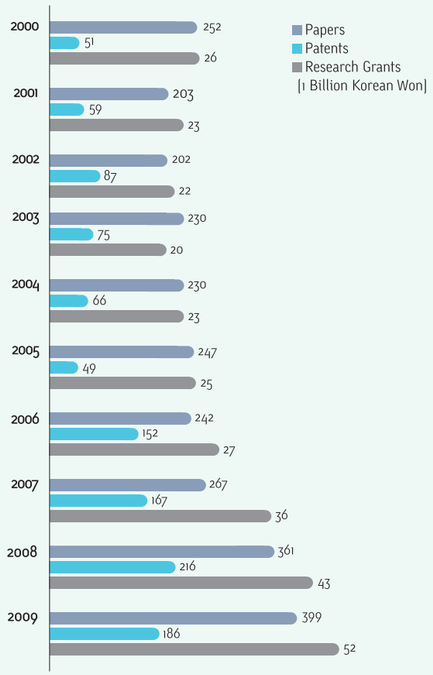
$ 52 Million

DEPARTMENT SCHOLARSHIPS

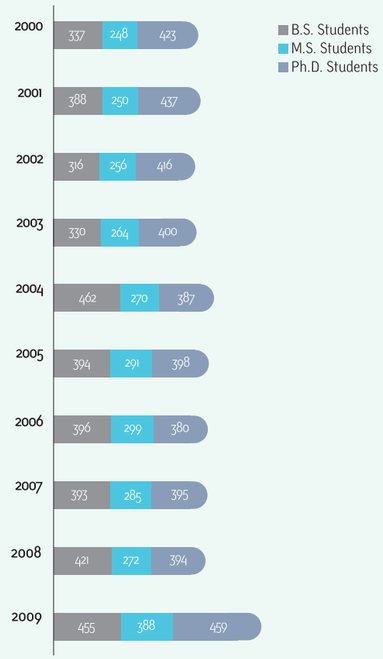
- Creative Activity Prize -
  donated by the families of EE graduate students
- Distinguished Thesis Prize -
  established by the trust fund of Prof. Song-Bae Park
- Han Chul Hee Scholarship -
  donated by Prof. Chul Hee Han
- Hwang Yoon-Ho Scholarship -
  donated by Mr. Yoon-Ho Hwang
- Il-Soo Scholarship -
  donated by the father of Prof. Young-Se Kwon
- Kim Choong-Ki Scholarship -
  donated by Dr. Hyung-Kyu Lim
- Lee Min-Hwa Scholarship -
  donated by Dr. Min-Hwa Lee
- No Yop Scholarship -
  donated by No Yop Culture Foundation
- Sang-Ae Scholarship -
  donated by Sang-Ae Foundation
- So-Chun Scholarship -
  donated by the father of Prof. Myung Joong Youn
- Suk Rim Scholarship -
  donated by Suk Rim Academic Foundation
- Un Chong-Kwan Scholarship -
  donated by Prof. Chong-Kwan Un

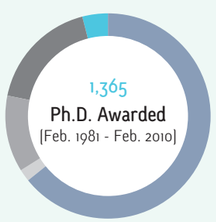
Statistics

Papers, Patents, and Research Grants

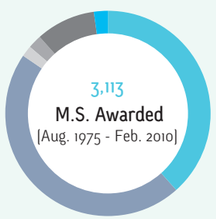


Student Enrollment





- Industries 853
- Government Agencies 18
- Educational Institutes 135
- Research Institutes 320
- Others 39



- Industries 1211
- Advanced to Higher-Degree Programs 1385
- Government Agencies 55
- Educational Institutes 68
- Research Institutes 312
- Others 82

- Industries 489
- Advanced to Higher-Degree Programs 1396
- Government Agencies 23
- Educational Institutes 3
- Research Institutes 13
- Others 138

Brief History

1970's

1971
- Establishment of Korea Advanced Institute of Science (KAIS) at Hongneung, Seoul
- **Profs. KunMo Chung and Jung-Woong Ra joined the Department**

1973
- **Profs. Jae-Kyoon Kim and Song-Bae Park joined the Department**
- First entrance ceremony for the MSE program

1975
- **Prof. Choong-Ki Kim joined the Department**
- First graduation ceremony for the MSE program
- First entrance ceremony for the Ph.D. program

1977
- **Profs. Zeungnam Bien and Chong-Kwan Un joined the Department**

1978
- **Profs. Zang-Hee Cho and Sang-Yung Shin joined the Department**
- Development of adaptive delta modulation system for defense applications (Prof. Chong-Kwan Un)
- Development of facsimile machine (Prof. Jae-Kyoon Kim)

1979
- **Prof. Young-Se Kwon joined the Department**
- Development of KAISEM, a 4 dof robot-arm manipulator (Prof. Zeungnam Bien)

1980's

1980
- Establishment of Korea Advanced Institute of Science and Technology (KAIST), merged with Korea Institute of Science and Technology (KIST)
- Development of LPC vocoder (Prof. Chong-Kwan Un)

1981
- First graduation ceremony for the Ph.D. program
- Development of 512-bits mask-programmable ROM (Prof. Choong-Ki Kim)

1982
- Development of statistical time-division multiplexer (Prof. Chong-Kwan Un)

1983
- **Profs. Gyu-Hyeong Cho, Myung Jin Chung, Myunghwan Kim, Chong-Min Kyung, Hwang Soo Lee, Kyu Ho Park, and Myung Joong Youn joined the Department**

1984
- Establishment of Korea Institute of Technology (KIT) starting the undergraduate program
- **Prof. Seong-Dae Kim joined the Department**
- **Profs. Choon Gil Kim, Joon Soo Kim, Ju-Jang Lee, Koeng Su Lim, and Byung Cheol Shin joined KIT**
- Development of turret servo drive system (Prof. Myung Joong Youn)

1990's

| 1985
- **Profs. Soon Dal Choi, Kwang-Ho Yim, and Dong-Jo Park joined KIT**
- Development of 2-Tesla nuclear magnetic resonance imaging system (Prof. Zang-Hee Cho)
- Development of packet switching equipment, KORNET (Prof. Chong-Kwan Un)

| 1986
- **Profs. Kwyro Lee and Soo-Young Lee joined the Department**
- **Profs. Byung Kook Kim, Hyung-Myung Kim, Noh-Hoon Myung, and Dan Keun Sung joined KIT**
- First entrance ceremony for KIT
- Development of ultrasonic imaging system (Prof. Song-Bae Park)

| 1987
- **Prof. Jong Beom Ra joined the Department**
- **Profs. Chul Hee Han and Sang Woo Kim joined KIT**

| 1988
- **Prof. Iickho Song joined the Department**
- **Profs. Jong-Hwan Kim and Jong-Tae Lim joined KIT**
- Implementation of two-dimensional optical neural network (Prof. Sang-Yung Shin)
- Development of 45-Mbps video codec (Prof. Jae-Kyoon Kim)
- Development of vertically integrated AlGaAs laser and JFET (Prof. Young-Se Kwon)

| 1989
- KIST separated from KAIST
- KAIST merged with KIT and moved to Daejeon
- Former faculty members of KIT joined the Department as of September 1
- **Prof. Yong Hoon Lee joined the Department**
- **Profs. Hyo Joon Eom, Songcheol Hong, Yoon Kyu Jhee, and Hee Chul Lee joined KIT**
- Development of 4-legged robot (Prof. Zeungnam Bien)
- Development of KAICUBE-I, a parallel computer (Prof. Myunghwan Kim)

| 1990
- First graduation ceremony for the undergraduate program
- Detected the fourth infiltration tunnel excavated by North Korea (Prof. Jung-Woong Ra)

| 1991
- **Prof. Tag Gon Kim joined the Department**

| 1992
- **Profs. Joohwan Chun, In So Kweon, and Cheol Hoon Park joined the Department**
- Launched the satellite KITSAT-1 into orbit (Prof. Soon Dal Choi)
- Development of HDTV encoder (Prof. Jong Beom Ra)

| 1993
- **Profs. Lee-Sup Kim and HyunWook Park joined the Department**
- Launched KITSAT-2 into orbit (Prof. Soon Dal Choi)
- Prof. Choong-Ki Kim was awarded a Hoam Prize

| 1994
- **Profs. Yun Chur Chung and Beom-Seop Kim joined the Department**
- Development of KAICUBE Hanbit-1, a 2-Gflops parallel computer (Prof. Kyu Ho Park)
- Profs. Soon Dal Choi, Choong-Ki Kim, Jae-Kyoon Kim, and Song-Bae Park were elected Members of Korean Academy of Science and Technology (KAST)

| 1995
- Development of digital adaptive equalizer ASIC (Prof. Chong-Min Kyung)
- Development of wireless IR printer-sharing unit (Prof. Sang-Yung Shin)
- Prof. Choong-Ki Kim was elected a Fellow of the Institute of Electrical and Electronics Engineers (IEEE)
- Prof. Zang-Hee Cho was awarded a Korea Engineering Award

| 1996
- **Profs. Joungho Kim, In-Cheol Park, Hyung Cheol Shin, and Eui-Sik Yoon joined the Department**
- Prof. Song-Bae Park was awarded an In-Chon Academic Award

| 1997
- Establishment of Information and Communications University (ICU)
- **Prof. Chang Hee Lee joined the Department**
- **Profs. Sang-Gug Lee, Seong-Ook Park, Yong Man Ro, Giwan Yoon, and Chan-Hyun Youn joined ICU**
- Development of 50-MHz Pentium chip (Prof. Chong-Min Kyung)
- Development of intelligent wheelchair (Prof. Zeungnam Bien)
- Prof. Jong-Hwan Kim founded the Federation of International Robot-Soccer Association
- Prof. Choong-Ki Kim was awarded an Order of Civil Merit (Mo-Ran)

2000's

| 1998

- Profs. Dong-Ho Cho, Daeyoun Park, and Hoi-Jun Yoo joined the Department
- Profs. Hae-Wook Choi, Jun Kyun Choi, Minsoo Hahn, Youngnam Han, Man Seop Lee, Hyo-Hoon Park, Hong-Shik Park, Sin-Chong Park, Yong Hyub Won, and Hyung-Joun Yoo joined ICU
- First entrance ceremony for the graduate program of ICU
- Development of room-temperature IR sensor (Prof. Songcheol Hong)
- Development of fiber back-haul network for wireless CDMA service (Prof. Yun Chur Chung)
- Development of sign-language translation system (Prof. Zeungnam Bien)
- Prof. Zeungnam Bien was elected a Member of KAST
- Prof. Song-Bae Park was elected a Member of the National Academy of Engineering of Korea (NAEK)
- Prof. Jae-Kyoon Kim was awarded an Order of Civil Merit (Suk-Ryu)

| 1999

- Profs. Yoon Heung Baek, Kyounghoon Yang, and Chang Dong Yoo joined the Department
- Profs. Minho Kang, Joongsoo Ma, and Chul Soon Park joined ICU
- First graduation ceremony for the graduate program of ICU
- Launched KITSAT-3 into orbit (Prof. Dan Keun Sung)
- Development of 3-dimensional integrated inductor (Prof. Choong-Ki Kim)
- Profs. Young-Se Kwon and Sang-Yung Shin were elected Members of KAST
- Prof. Jung-Woong Ra was awarded an Order of Civil Merit (Mo-Ran)

| 2000

- Profs. Song Chong and Gun-Woo Moon joined the Department
- Profs. Hoi-Rin Kim and Hyuckjae Lee joined ICU
- Development of CMOS oscillator for cellular systems (Prof. Beom Seop Kim)
- Development of medical diagnosis simulator based on 3-dimensional virtual reality image (Prof. Jong Beom Ra)
- Development of all-optical WDM network testbed with 4 optical cross-connects (Prof. Yun Chur Chung)
- Profs. Sang-Yung Shin and Myung Joong Youn were elected Members of NAEK
- Prof. Song-Bae Park was awarded a Korea Engineering and Technology Award
- Prof. Chong-Min Kyung was awarded an Order of Civil Merit (Suk-Ryu)
- Prof. Iickho Song was awarded a Young Scientists Award from KAST

| 2001

- Profs. Jin Sik Choi and Munchurl Kim joined ICU
- Development of 0.25-micron standard cell library (Prof. Chong-Min Kyung)
- Development of bluetooth baseband chip (Prof. In-Cheol Park)
- Demonstration of Tbps fiber-optic transmission (Prof. Yun Chur Chung)
- Development of speech-recognition phone conversation recorder (Prof. Kwyro Lee)
- Prof. Hyo Joon Eom was elected a Member of KAST

| 2002

- Prof. Jun-Bo Yoon joined the Department
- Profs. Hyuncheol Park, Kye Yonug Park, and Mincheol Shin joined ICU
- First entrance ceremony for the undergraduate program of ICU
- Development of active robot vision camera system (Prof. Myung Jin Chung)
- Prof. Jung-Woong Ra was elected a Member of KAST

| 2003

- Profs. Joonhyuk Kang and Desok Kim joined ICU
- Launched STSAT-1 designed for the astronomic studies into orbit (Prof. Jong-Tae Lim)
- Development of prototype radio in compliance with IEEE 802.15.4 standard for wireless personal area network (Prof. Kwyro Lee)
- Prof. Kwyro Lee was elected a Member of NAEK
- Prof. Zeungnam Bien was awarded an Order of Science and Technology Merit (Hyeoksin Medal)

| 2004

- Profs. SeongHwan Cho, Yang-Kyu Choi, Youngsoo Shin, and Jong-Won Yu joined the Department
- Prof. Jeongseok Ha joined ICU
- Foundation of the National Nanofab Center
- Development of low-noise CMOS-based 13-GHz distributed oscillator (Prof. Eui-Sik Yoon)
- Development of RITY, a robot with gene and chromosome (Prof. Jong-Hwan Kim)
- Prof. Chong-Min Kyung was elected a Member of KAST
- Profs. Yun Chur Chung and Chong-Min Kyung were elected Members of NAEK
- Prof. Jae-Kyoon Kim was awarded an Order of Service Merit (Ok-Jo Geun-Jung)
- Prof. Jong-Tae Lim was awarded an Order of Science and Technology Merit (Doyak Medal)

| 2005

- **Profs. Kyung Cheol Choi and Sae-Young Chung joined the Department**
- **Profs. Changick Kim and June-Koo Kevin Rhee joined ICU**
- 1000th Ph.D. graduated from the Department
- Development of tactile sensor imitating human skin (Prof. Eui-Sik Yoon)
- Prof. Iickho Song was elected a Member of KAST
- Prof. Ju-Jang Lee was elected a Fellow of the Society of Instrument and Control Engineers (SICE)

| 2006

- **Prof. Seunghyup Yoo joined the Department**
- **Prof. Pravin N. Kondekar joined ICU**
- Development of the world smallest 3-nm transistor (Prof. Yang-Kyu Choi)
- Development of the system-in-chip RFID reader (Prof. Jong-Hwan Kim)
- Demonstration of low-power communication through human body (Prof. Hoi-Jun Yoo)
- Prof. Yun Chur Chung was elected a Fellow of IEEE
- Prof. Iickho Song was awarded an Achievement Award from the Institution of Engineering and Technology (IET)

| 2007

- **Profs. Byung Jin Cho and Youngchul Sung joined the Department**
- **Profs. Wan Choi and Seung-Tak Ryu joined ICU**
- Development of 8-nm flash memory device (Prof. Yang-Kyu Choi)
- Development of prototype technologies for highly efficient PDP lighting (Prof. Kyung Cheol Choi)
- Prof. Yun Chur Chung was elected a Member of KAST
- Prof. Jung-Woong Ra was elected a Member of NAEK
- Prof. Zeungnam Bien was elected a Fellow of IEEE

| 2008

- **Prof. Yung Yi joined the Department**
- Development of HanSaRam-VIII, a humanoid robot (Prof. Jong-Hwan Kim)
- Development of quantum-effect based multiplexer IC (Prof. Kyounghoon Yang)
- Prof. Jung-Woong Ra was elected a Member of the National Academy of Sciences (NAS)
- Profs. Ju-Jang Lee and Hoi-Jun Yoo were elected Fellows of IEEE

| 2009

- Merger of KAIST and ICU
- Former faculty members of the ICU joined the Department as of March 1
- **Profs. Hyeon-Min Bae, Dae-Shik Kim, Junmo Kim, and Jaekyun Moon joined the Department**
- **Prof. Soo-Young Lee re-joined the Department**
- Profs. Yong Hoon Lee and Dan Keun Sung were elected Members of NAEK
- Profs. Jong-Hwan Kim, Chong-Min Kyung, and Iickho Song were elected Fellows of IEEE
- Prof. Jung-Woong Ra was awarded a Korea Engineering Award

| 2010

- **Profs. Seok-Hee Lee, KyoungSoo Park, and Kyoungsik Yu joined the Department**
- Prof. Chang Hee Lee was elected a Fellow of IEEE

Professors Emeritus

Bien, Zeungnam
Professor Emeritus

- Ph.D., University of Iowa (1975)
- Automation System, Intelligent Fuzzy Control, Service Robotics
- zbien@ee.kaist.ac.kr

Choi, Soon Dal
Professor Emeritus

- Ph.D., Stanford University (1969)
- Satellite Communication, Remote Sensing
- sdchoi@ee.kaist.ac.kr

Kim, Choong-Ki
Professor Emeritus and Distinguished Professor

- Ph.D., Columbia University (1970)
- Semiconductor Engineering, Infrared Detecting Device Development
- ckkim@ee.kaist.ac.kr

Kim, Jae-Kyoon
Professor Emeritus

- Ph.D., University of Southern California (1971)
- Video Coding, Visual Communication Systems
- kimjk@ee.kaist.ac.kr

Park, Song-Bae
Professor Emeritus

- Ph.D., University of Minnesota (1968)
- Ultrasonic Systems
- sbpark@ee.kaist.ac.kr

Ra, Jung-Woong
Professor Emeritus

- Ph.D., Polytechnic Institute of Brooklyn (1971)
- Scattering of EM Waves by Dielectric Wedge, Inverse Scattering, Underground Tomogram
- rawoong@ee.kaist.ac.kr

Research Groups

CIRCUITS AND SYSTEMS

Bae, Hyeon-Min	Assistant Professor
Cho, SeongHwan	Associate Professor
Chung, Myung Jin	Professor
Hahn, Minsoo	Professor
Kim, Byung Kook	Professor
Kim, Changick	Associate Professor
Kim, Dae-Shik	Professor
Kim, Hoi-Rin	Associate Professor
Kim, Jong-Hwan	Professor
Kim, Junmo	Assistant Professor
Kim, Lee-Sup	Professor
Kim, Munchurl	Associate Professor
Kim, Seong-Dae	Professor
Kweon, In So	Professor
Kyung, Chong-Min	Professor
Lee, Ju-Jang	Professor
Lee, Soo-Young	Professor
Lim, Jong-Tae	Professor
Moon, Gun-Woo	Professor
Park, HyunWook	Professor
Park, In-Cheol	Professor
Ra, Jong Beom	Professor
Ro, Yong Man	Professor
Shin, Youngsoo	Associate Professor
Yoo, Chang Dong	Associate Professor
Yoo, Hoi-Jun	Professor
Youn, Myung Joong	Professor

Bae, Hyeon-Min
Assistant Professor

Ph.D., University of Illinois, Urbana-Champaign (2004)
hmbae@ee.kaist.ac.kr
http://nais.kaist.ac.kr

Nanoscale Advanced Integrated Systems Laboratory

The research of the Nanoscale Advanced Integrated Systems Laboratory (NAIS) focuses on system aware mixed mode IC design and 100Gb/s broadband IC design for next generation broadcasting networks.

System level performance driven adaptive reconfigurable mixed mode IC design technique: In this design, the system level signatures of the underlying physical artifacts will be monitored and processed using adaptive and statistical signal processing to determine optimal strategies for error-compensation, reconfiguration, and adaptation of architectural and circuit level parameters. A mixed mode IC designed with such scheme can overcome the fundamental performance trade-offs existing in non-adaptive conventional mixed mode communication ICs and ultimately improve the baseline performance. As this technique would enable a complete system IC to operate as an evolving organism, self-healing capability would be a valuable byproduct of this scheme.

The steady growth in demand for bandwidth is facing the data-rates in the 100s of Gb/s in optical communications. Such high-speed systems suffer from impairments such as dispersion, noise, and process non-idealities. Due to the difficulty in implementing multi-Gb/s transmitters and receivers in silicon, conventionally, high-speed links were implemented primarily with simple analog circuits employing only minimal signal processing. However, the relentless scaling of feature sizes exemplified by Moore's law has enabled the application of sophisticated signal processing techniques to overcome such problems prevalent in complex transceivers operating at 100s of Gb/s. Newly developed 100Gb/s CAUI receiver has met all the stringent and complex specifications while mitigating inherent circuit level issues through a variety of innovations at the algorithmic, architectural and circuit levels.

Key Achievements

[1] H.-M. Bae, J. Ashbrook, J. Park, N. Shanbhag, A. Singer, and S. Chopra, "An MLSE receiver for electronic dispersion compensation of OC-192 fiber links," *IEEE J. Solid-State Circuits,* vol. 41, no. 11, pp. 2541-2544, Feb. 2006. [Best Paper of the Year Award for 2006, IEEE Solid-State Circuits Society, Nov. 2006.]

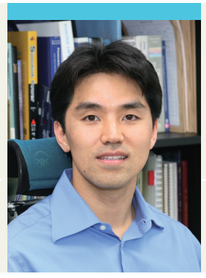
[2] A. Singer, N. Shanbhag, and H.-M. Bae, "Electronic dispersion compensation: Signal processing for fiber optical links," *IEEE Signal Process. Mag.,* vol. 25, no. 6, pp. 110-130, Nov. 2008.

[3] H.-M. Bae, J. Ashbrook, N. Shanbhag, and A. Singer, "A fast power transient management for WDM add/drop networks," *IEEE J. Solid-State Circuits,* vol. 43, no. 12, pp. 2958-2966, Dec. 2008.

Achievements in 2009/2010

[1] H.-M. Bae, J. Ashbrook, and N. Shanbhag, *Variable gain amplifier having dual gain control,* 07592869, USA, Sep. 2, 2009.

[2] H.-M. Bae, J. Ashbrook, and N. Shanbhag, *Variable gain amplifier having variable gain DC offset loop,* 07695085, USA, Mar. 24, 2010.



Cho, SeongHwan
Associate Professor

Member, IEEE

Ph.D., Massachusetts Institute of Technology (2002)
chosta@ee.kaist.ac.kr
http://ccs.kaist.ac.kr

Communication Circuits and Systems Laboratory

The Communication Circuits and Systems Group explores emerging technologies for various high-performance, low-power wired and wireless communication systems. Our main area of focus is in the design and implementation of analog and mixed-signal integrated circuits with multiple layers of system abstraction in mind, from communication protocols and system architectures to circuit techniques. Our recent research topics include low power communication circuits, digital transceivers, and the bio-sensor network.

As a key building block of low power communication system, we demonstrated a state-of-the-art ultra low power frequency synthesizer, and proposed another state-of-the-art digitally-controlled injection-locked frequency divider. For the implementation of digital receivers, we proposed a digital PLL (DPLL) architecture with novel sub-feedback loop which reduces the effect of quantization. We also proposed a low power time-based ADC architecture that can directly digitize the RF signal without any use of large passive devices such as inductors, which is an attractive solution for direct RF sampling in deep-submicron processes (Fig. 1(a)). In addition, we have proposed a novel low-power digital-friendly transmitter architecture which does not use mixers or DACs. In the bio-sensor area, we are investigating a novel magnetic-stimulation-based bio-sensor and a novel bio-impedance measurement system (Fig. 1(b)).

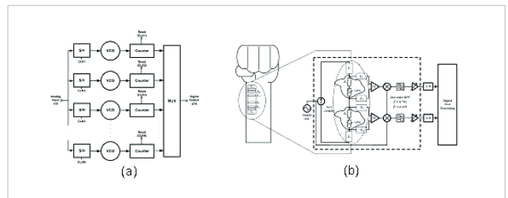


Fig. 1

Key Achievements

[1] Y.-G. Yoon, J. Kim, T. K. Jang, and S. H. Cho, "A time-based bandpass ADC using time-interleaved voltage-controlled oscillators," *IEEE Tr. Circuits, Syst. I,* vol. 55, no. 11, pp. 3571-3581, Dec. 2008. [Guillemon-Cauer Best Paper Award, IEEE Circuits and Systems Society, May 2009.]

[2] D. Park and S. H. Cho, "A 1.8 V 900 uW 4.5 GHz VCO and prescaler in 0.18 um CMOS using charge-recycling technique," *IEEE Microw., Wireless Components Lett.,* vol. 19, no. 2, pp. 104-106, Feb. 2009.

[3] J. H. Lee and S. H. Cho, "An 80uW 10MHz 67ppm/°C CMOS reference clock oscillator with a temperature compensated feedback loop in 0.18um CMOS," *IEEE Symp. VLSI Circuits,* Kyoto, Japan, June 2009.

Achievements in 2009/2010

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[2] J. Kim, T.-K. Jang, Y.-G. Yoon, and S. H. Cho,"Analysis and design of voltage-controlled oscillator-based analog-to-digital converter," *IEEE Tr. Circuits, Syst. I,* vol. 57, no. 1, pp. 18-30, Jan. 2010.

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Robotics Research Laboratory

The Robotics Research Laboratory (RRLAB) has mainly focused on developing robot systems for human-robot interaction, rehabilitation, and 3D world modeling.
It is essential to determine the regions where vehicles can reach and to plan the paths where vehicles should go when it comes to UGV navigation. Path planning and reachable region determining require 3-dimensional models. Therefore, effective reconstruction of terrain in 3-dimensions is needed for UGV navigation. Therefore, we have developed a multi-sensor based real time world modeling algorithm to improve the UGV navigation ability. The developed algorithm is a simple and effective refinement method for multi-sensor 3D reconstruction.

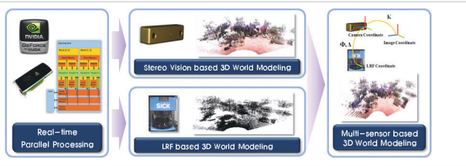

Fig. 1 3D sensing and reconstruction

The facial robot called 'Doldori' has focused on the relationship between facial expressions and emotions. A novel linear dynamic affect-expression model is introduced to implement a robot's facial expressions. We also have developed 'FRESi', a simulator with another facial design, to express more abundant robot's emotional states for the robot.

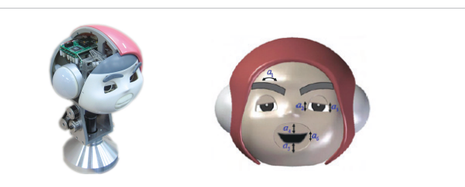

Fig. 2 Facial robot 'Doldori'

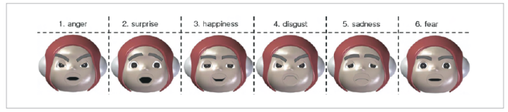

Fig. 3 'Doldori' with 6 basic emotional expressions

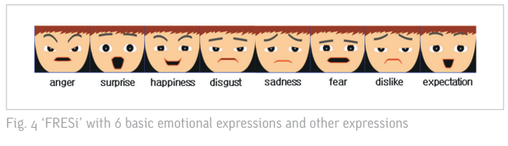

Fig. 4 'FRESi' with 6 basic emotional expressions and other expressions

Key Achievements
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[3] H. S. Lee, J. W. Park, and M. J. Chung, "A linear affect-expression space model and control points for mascot-type facial robot," *IEEE Tr. Robotics,* vol. 23, no. 5, pp. 863-873, Oct. 2007.

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[1] K. H. An and M. J. Chung, "Cognitive face analysis system for future interactive TV," *IEEE Tr. Consumer Electron.,* vol. 55, no. 4, pp. 2271-2279, Nov. 2009.
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Speech and Audio Information Laboratory

The research areas of Speech and Audio Information Laboratory (SAIL) cover the speech, audio, and bio signal processing. Our research has been focused on noise reduction for speech interfaces, HMM-based speech synthesis, and multi-channel/multi-object audio coding.

Noise Reduction: The performance of speech interfaces tends to be severely degraded by interfering noises. Thus, beamforming algorithms have been suggested for non-stationary noise reduction. The beamforming is a spatial filtering that estimates the target signal arriving from a desired direction. For the improvement of performance, SAIL has developed a probabilistic adaptation mode controller and an efficient channel mismatch compensator.

HMM-Based Speech Synthesis (HTS): HTS is the suitable text-to-speech system for the embedded applications because it shows high synthetic speech quality for very small-size DB and requires low computational power. In HTS, speech parameters are statistically modeled by context-dependent HMMs. We have proposed a novel two-band excitation model to improve the synthetic speech quality.

Multi-Channel/Multi-Object Audio Coding: The demand for multi-channel audio services has been increased. Multi-channel audio signals can be represented by using mono or stereo downmix signal and the side information. SAIL has proposed a residual coding technique, which is an efficient method of mastering signal processing for audio quality improvement with small increase of bit-rate.

The Others: We have also studied the automatic classification method of pathological and normal voice using higher-order statistics, and the technique for automatic arterial stiffness diagnosis using a photoplethysmogram.

Key Achievements
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[1] S. Han, S. Jeong, and M. Hahn, "Optimum MVF estimation-based two-band excitation for HMM-based speech synthesis," *ETRI J.,* vol. 31, no. 4, pp. 457-459, Aug. 2009.
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Real Time Control Laboratory

Research in the Real-Time Control (RTC) Laboratory has been focused on the followings: Real-time control system and robot control system. Real-time control systems include reliable process control systems, real-time systems, and automotive control; robot control systems include mobile robot sensing, navigation, localization, and manipulator control.
Real-time system is a system that must satisfy explicit (bounded) response-time constraints or risk severe consequences, including failure. For real-time computer-controlled systems, control performances of tasks as well as energy consumption of overall system must be optimized. A control task does not have a fixed period but a range of periods in which the control performance varies.

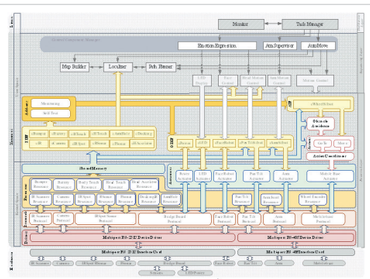

Fig. 1 Structure design of a real-time control system

We research various optimal mobile robot control topics. The optimal control for mobile robots is essential in battery-powered mobile robots. This topic includes main problems like energy-constraint, time-constraint, etc. Also, localization for mobile robots is a basic research in multi-task mobile robots to recognize where it is and where to go. Since many sensors are used, this topic includes sensor-fusion research, sensor information processing, etc. Furthermore, various mobile robot control technologies are also researched.
From our two main researches, we developed various control systems. For example, we developed an intelligent powered wheelchair with ultrasonic distance measuring system to meet the needs of users. Also, the researches for unmanned nuclear, bio, and chemical reconnaissance systems have been conducted.

Key Achievements

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[3] B. J. Choi, S. W. Kwak, and B. K. Kim, "Design and stability analysis of single-input fuzzy logic controller," *IEEE Tr. Syst., Man, Cybern.,* vol. 30, no. 2, pp. 303-309, Apr. 2000.

Achievements in 2009/2010

[1] H. J. Sohn and B. K. Kim, "VecSLAM: An efficient vector-based SLAM algorithm for indoor environments," *J. Intell. Robotic Syst.,* vol. 56, no. 3, pp. 301-318, Oct. 2009.
[2] H. S. Lee and B. K. Kim, "Co-scheduling of processor voltage and control task period for energy-efficient control system," *ACM Tr. Embedded Computing Syst.,* vol. 18, no. 3, pp. 15-24, Feb. 2010.

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Computational Imaging Laboratory

The Computational Imaging Laboratory (CI Lab) has achieved innovative research work in the areas of image understanding, pattern recognition, computer vision, intelligent schemes for digital TV, 3D video processing, medical imaging, and advanced video coding. Currently, the main research topics of CI Lab are largely divided into three subareas: 3D conversion, human computer interaction, and medical imaging.
3D Conversion: The CI Lab is researching the real-time 3D conversion algorithm of 2D video for 3DTV and mobile displays. Various other methods for conversion are being studied such as object extraction, geometric context understanding, motion analysis, and global scene structure understanding. We are also studying 3D conversion of still images. An object segmentation method using region-based graph cut and an improved inpainting algorithm is being developed for 3D conversion.
Human Computer Interaction: The CI Lab had already successfully developed moving object detection and human/animal classification algorithms which can be applied to various classification problems. Now, we are studying human action recognition system, and gesture recognition study has been started as an application and expansion of this human action recognition.
Medical Imaging: We had developed overlapped nuclei segmentation algorithm for quantitative analysis of cell images, and now we are investigating multi-scale image analysis for treatment evaluation of trabecular bone and prostate cancer detection in low-resolution pathological image.

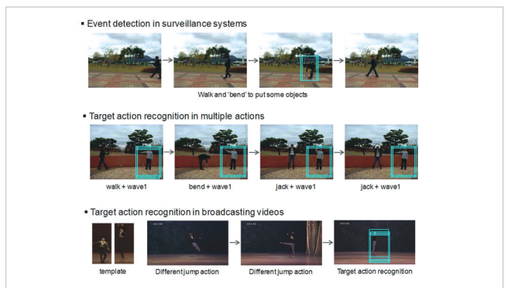

Fig. 1 Human action recognition

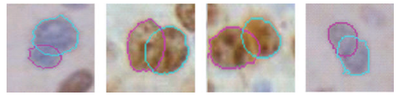

Fig. 2 Nuclei cell segmentation

Key Achievements

[1] C. Kim and J.-N. Hwang, "An integrated scheme for object-based video abstraction," *ACM Int. Multimedia Conf.,* Los Angeles, USA, Oct. 2000.
[2] C. Kim and J.-N. Hwang, "Fast and automatic video object segmentation and tracking for content-based applications," *IEEE Tr. Circuits, Syst. Video Techn.,* vol. 12, no. 2, pp. 122-129, Feb. 2002.
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Brain Reverse Engineering and Imaging Laboratory

With 50 million neurons and several hundred kilometers of axons terminating in almost on trillion synapses for every cubic centimeter, and consuming only about 12 watts energy for the entire cortex, the brain is arguably one of the most complex and densely packed, yet highly efficient information processing systems known. It is also the seat of sensory perception, motor coordination, memory, and creativity - in short, what makes us human.
The goal of our lab is straightforward, yet anything but easy: to understand how our brain works! Not in the next 1000 years; not in 100; but in 20! How are we going to achieve such an ambitious goal? We believe that recent advances in brain imaging, hierarchical recurrent temporal memory, complex brain network theory, and neuro-robotics in conjunction with the gargantuous corpus of experimental data lay foundation to a perfect storm towards the first release candidate of a correct theory of brain mechanisms. This future theory of natural automata will have to satisfy von Neumann's observation of the brain as a cognitive engine that combines minimum logical depth with maximum logical breath.

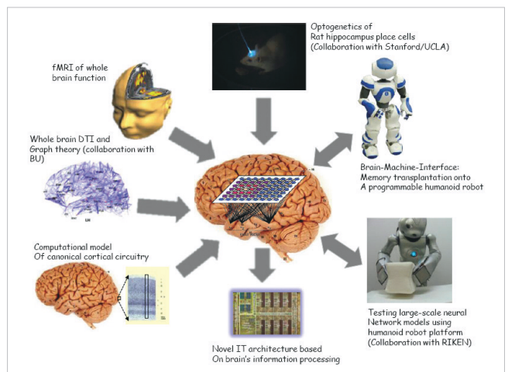

Fig. 1

<Research Interests>
- Systems, Developmental, and Computational Neurosciences
- Functional and Connectivity Mapping of the Human Brain
- Brain Plasticity and Development
- Brain Reading
- Developmental Robotics
- Diffusion Tensor Imaging and Computational Neuroanatomy
- MRI of Neurodegeneration
- Visual Neuroscience
- Development of Extremely High-Field (7T+, 14T) MRI

Key Achievements

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Speech Recognition Technology Research Laboratory

The Speech Recognition Technology Laboratory (SRT-Lab) has focused on developing speech and audio signal processing systems related to speech recognition, speaker identification and verification, keyword spotting, audio indexing and retrieval, music retrieval, and multi-modal interface. Speech recognition refers to the process of translating the input speech signal obtained from a microphone or telephone into a word or a sentence. The recognition results can be used to command or control a system, or they can be used as an input to a system which understands speech. As a result, speech recognition technology has enabled human beings to communicate more naturally with computers or machines. Speech recognition, a tool for advanced user interface, has recently become a part of our lives, in forms such as mobile device user interface, speech controlled computers, various speech guidance systems, car navigation systems, robot interface, and home automation systems. In addition, audio indexing and retrieval is an emerging technology including music summarization, musical instrument identification, music recommendation, music genre classification, speech/music discrimination, mood classification, and many other audio information processing techniques.
Major achievements in the last year are as follows:

- A voice activity detection based on statistical models using reliable frequency bands of input speech was proposed and applied to speaker recognition in adverse environments.
- Feature compensation and model adaptation methods based on histogram equalization were proposed for robust speech recognition.
- New utterance verification methods were proposed for a very large vocabulary (more than 3×10^5 words) speech recognition system which was designed for car navigation.
- Robust speaker recognition methods were proposed for the use in home robot systems, and the key idea was on how to combine the information from multiple channels.

Key Achievements

[1] M.-S. Park, H.-R. Kim, and S. H. Yang, "Frequency-temporal filtering for a robust audio fingerprinting scheme in real-noise environments," *ETRI J.,* vol. 28, no. 4, pp. 509-512, Aug. 2006.
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Achievements in 2009/2010

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Robot Intelligence Technology Laboratory

The Robot Intelligence Technology (RIT) Laboratory has been focused on researches in ubiquitous robots (Ubibot), genetic robots (Genebot), and multi-agent systems (MAS) based on the multilayer architecture for cyber-physical robot systems (CPRS).

Ubibot: Rity and Geney have their own motivations, homeostases, and emotions where the desired behavior is decided from these internal components. As a mobile robot, a wheeled-type robot (Mybot) has been developed, and Rity in the software system can be transmitted to Mybot and control Mybot. As a humanoid robot, HanSaRam (HSR) has been developed since 2000. Also, a robotic fish, Fibo has been developed.

Genebot: Evolutionary generative process for an artificial creature's personality (EGPP) has been proposed to create an artificial genome for software robots. A bear-type intelligent robot (GomDoll), which endows hardware robots with the genome code, has been developed.

MAS: MiroSot, RoboSot, HuroCup in the research for FIRA robot soccer, a vector field navigation method using the position and velocity vectors of robots has been proposed. To achieve high mobility in RoboSot soccer games, an omni-directional platform with three omniwheels has been developed. Note that HSRs have been participating in the HuroCup.

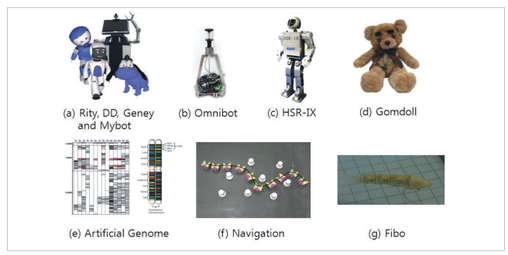

Fig. 1

Key Achievements

[1] J.-M. Yang, I.-H. Choi, and J.-H. Kim, "Sliding mode control of a nonholonomic wheeled mobile robot for trajectory tracking," *IEEE Int. Conf. Robotics, Automation,* Leuven, Belgium, May 1998.
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Statistical Inference and Information Theory Laboratory

The researches of the Statistical Inference and Information Theory Laboratory focus on development of theoretical methods which can be applied to image processing, computer vision, pattern recognition, and machine learning. In particular, our research contributions are mostly based on the Bayesian detection theory and more advanced methods such as nonparametric statistical methods. The key research contributions are introduced below.

Face Recognition
Illumination variation is one of the main obstacles for face recognition, as face images change significantly under illumination changes. We proposed a method of preprocessing input images so that the output images are much less sensitive to illumination changes. We also proposed a classifier fusion method for constructing a stronger classifier out of multiple individual classifiers.

Image Segmentation and Statistical Analysis of Shapes
The nonparametric statistical methods have been applied to an image segmentation problem, where this problem is formulated as a maximization of the mutual information between a binary label indicating foreground/background and pixel intensity. This work has unified several existing statistical approaches to image segmentation, enlarging the class of images that can be well segmented and has inspired many extensions, such as colored and/or textured image segmentation techniques.
In addition, we have been working on the problem of statistical analysis of shapes. In particular, we proposed a framework to learn and model a prior distribution in a space of shapes based on available example shapes. This problem involves many challenging issues such as representation of the shape, analysis of resulting Riemannian structure of the shape space, and definition of probability density functions in the shape space. We proposed viable estimates of the probability density functions in the Riemannian space without having to compute the Riemannian metric, namely the geodesic distance. Based on these results, we developed a shape-based image segmentation technique, which outperforms traditional approaches based on principal component analysis of shape variations.

Key Achievements

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Achievements in 2009/2010

[1] W. Hwang, H. Ren, H. Kim, S.-C. Kee, and J. Kim, "Face recognition using gender information," *IEEE Int. Conf. Image Process.,* Cairo, Egypt, Nov. 2009.
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Multimedia VLSI Laboratory

Our research focuses on efficient multimedia contents processing widely based on algorithm, hardware/architecture, and high speed CMOS serial data transmission. Since the establishment in 1993, many brilliant results have been published in various international journals and conferences. Currently, we work in 2 teams: multimedia SoC design team and SoC circuit design team.
The multimedia SoC design team is working on 3D graphics acceleration engine design, computer vision, and augmented reality. Including quality enhancement and simulation, based on software, multimedia SoC design team has researched hardware architecture design for real time complex applications.
The SoC circuit design team is focusing on high performance CMOS serial link transceiver design such as a clock and data recovery, a spread spectrum clock generator, all-digital phase-locked loops/delay-locked loops, and signaling techniques. Recently, SoC circuit design team is interested in high speed memory interface and low power display interface.

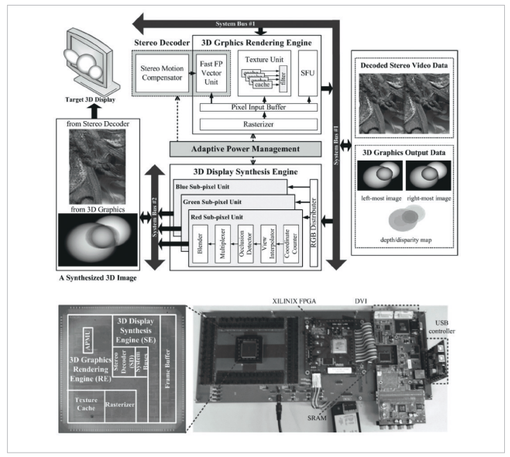

Fig. 1

Key Achievements

[1] C.-H. Yu, K.-S. Chung, D.-H. Kim, and L.-S. Kim, "An energy-efficient mobile vertex processor with multithread expanded VLIW architecture and vertex caches," *IEEE J. Solid-State Circuits,* vol. 42, no. 10, pp. 2257-2269, Oct. 2007.
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Laboratory for Multimedia Computing, Communications and Broadcasting

Laboratory for Multimedia Computing, Communications and Broadcasting (MCCB Lab) currently conducts research in the areas of video coding, pattern recognition and machine learning, image analysis and understanding, and visual quality human assessments on 3D video contents.
The research being carried out in MCCB Lab has aimed at looking forwards future applications with ultra high definition TV (UHDTV) and 3DTV from next-generation video coding research, smart surveillance from image analysis and understanding, personalized (IP) TV program recommender and scheduler based on machine learning, and 3D content safety on visual quality modeling and assessment research.
The MCCB Lab enlarges its research activities on next-generation video coding in conjunction with ISO/IEC MPEG and ITU-T VCEG international standardization activities. The research outcomes are proposed to the international standardization bodies and the active standardization effort is then made on the technical proposals of MCCB Lab to be adopted as international standards. Research on user preference reasoning for automatic (IP) TV recommendation is to enhance the use accessibility and the interaction between (IP) TV program contents and their related contents from the Web such as YouTube. This is a knowledge based smart user interface which is distinguished from GUI. Intelligence is involved in automatic and personalized reasoning for the TV program recommendation on users' preference based on pattern recognition and machine learning.
Due to the recent popularity of the movie 'Avatar', 3D contents have drawn much attention to the visual media. However, studying visual fatigue on 3D video is a key issue in conjunction with human factor research. We are studying the visual features that can be used as clues to model human visual fatigue on 3D video contents such as stereoscopic video, multi-view video, and 2D-to-3D converted video. Visual assessments on full-, partial-, and no-reference models are all studied for 3D (IP) TV and 3D mobile TV applications.

Key Achievements

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Visual Communications Laboratory

The Visual Communications Laboratory (VCL), a member of Information Systems Group (ISG), was established in 1984. The research area of VCL covers image/video processing, 2D/3D computer vision, pattern, and image/video coding. Specifically, we are focusing on the followings: (a) image-based rendering of 3D objects (b) development of pattern systems for faces, industrial parts, military vehicles, etc. (c) data compression of 3D information for transmission, storage, reconstruction, or retrieval of the data (d) development of key algorithms (e.g. 3A and ISP) for digital cameras.

The main aim of the 3D reconstruction research is to enable reconstruction of extract 3D shape and surface of an object from images taken from multiple point-of-views, and thereby produce an image from a desired viewpoint by the user. This includes research of recovery and storing of 3D geometry and texture data, and generation of an intermediate view image. The 3D reconstruction technology, with advancement in 3D display and computer graphics technologies, is seen as the core in producing a more realistic and interactive scenes.

Pattern is another key research topic at VCL. The entire pattern field is being researched, which varies from feature extraction to classifier construction. Creation of recognition systems that could be used in various applications such as face recognition and detection would be attempted with the result of the research.

Researches related to video coding, another key research topic in this lab, include establishing general purpose video coding and also on coding of 3D geometry and texture data for efficient 3D video coding. It is expected that these research will play a vital role in bringing about the ultra definition television, 3DTV, or others that will be flourishing in near future.

In addition, researches are also being done on visual surveillance and image enhancement. Advancement from researches at VCL may be used not only for the corresponding research fields, but the three key research topics compensate each other, and consequently, may bring out new technologies such as intelligent visual surveillance, 3D video coding, 3D face recognition, and so on.

Key Achievements

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Robotics and Computer Vision Laboratory

The research of the Robotics and Computer Vision Laboratory (RCV Lab) focuses on computer vision systems for robotic vision and media applications. The research topics include object recognition, 3D reconstruction and optimization, mobile robot SLAM navigation, sensor fusion for mega city modeling, robust feature extraction and matching, and others within the related field. Recently, a novel method for tracking a target from an image (or images) has been developed. Instead of using traditional perspective cameras, we prefer working with catadioptric images in order to gather much more information from the environment and, therefore, improve the robustness of the object tracking. We have first addressed the typical problems caused by using the particle filter method in catadioptric images. Then, we have presented two techniques to correctly deal with strong distortions inherent to catadioptric images.

Another recent work on object categorization has provided the community a novel concept for solving the problem. Using the ordinary bag-of-words method, we have introduced the contextual relations between local paths from the images. For 3D reconstruction and optimization problems, we have proposed several methods for bundle adjustment to have the fastest computational time and still allow the same or better performance of the optimization of a very large size dataset of cameras. We have also proposed a hand-held fusion sensor system for calibration, motion estimation, and accumulated error reduction for 3D reconstruction. The proposed method consists of four cameras and two 2D laser scanners to obtain a wide field-of-view. This new approach allows to boost the advantages and reduce the lacks of two sensor systems.

In addition, we are working on various tasks related to national defense and developing vision systems in cooperation with many companies, as well as media applications.

Key Achievements

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VLSI Systems Laboratory

The research of the VLSI Systems Laboratory is exciting and rewarding, and focusing on two; energy-aware smart camera and 3D IC. Firstly, we designed the smart camera system based on the energy-rate-distortion optimization (ERDO), considering the whole process from event detection, encoding, transmission/recording. Secondly, we designed the 3D IC platform for low-energy mobile set and server applications supporting optimal task and data assignment while minimizing energy consumption with constraints in power, execution time, and temperature.

Energy-Aware Smart Camera System: One of the most important tasks in a battery-operated smart camera is simple: extending its lifetime. Therefore, ERDO is crucial for detecting, capturing, encoding, transmitting, and storing data. Bit rate is determined to minimize the energy consumption of the memory-constrained wireless surveillance camera system based on ERDO of the whole system.

3D IC Platform: With surging cost for advanced lithography in IC manufacturing, 3D IC has become a must for any further integration of storage as well as data processing functions in a small available footprint. Due to the high power density of 3D IC, however, chip energy consumption and performance need to be co-optimized by considering the chip temperature and leakage. We developed algorithms for both energy-minimal and performance-maximal 3D multi-core architectures in the system-level design stage: firstly, we developed cache data-mapping algorithms to minimize system energy consumption and maximize the system performance; then, we developed temperature-aware dynamic power management algorithms based on the dynamic voltage and frequency scaling (DVFS) method to judiciously exploit temperature slacks of each core.

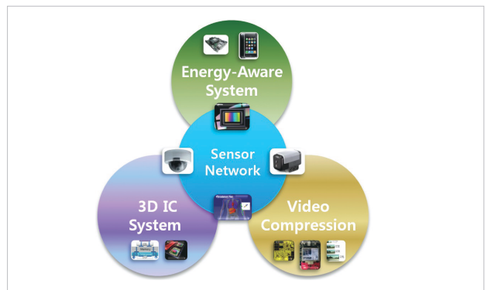

Fig. 1

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Future of Beyond Human Intelligence Laboratory

The Future of Beyond Human Intelligence Laboratory (FHI) has been focusing on the development of intelligent control theories and their application to the real robotic systems. The research topics include machine learning and soft computation, vision based control, intelligent transportation systems, mobile robotics, rehabilitation robots, evolutionary emotional robots, construction of emotional model and ubibot in ubiquitous environments, genetic algorithms, chaos control, sensor systems, and variable structure controls.

Recently, the research projects based on the intelligent control technology for robot system are studied as follows: real-time welding gap/profile monitoring technology, unmanned ground vehicle (UGV) for the military application, and vision based human-robot interaction algorithm for intelligent robots.

In a welding project, 3D measurement systems for robotics are developed. The system consists of a PC-based camera and a stripe-type laser diode. A mechanism adjusting the beam angle and the focus is devised, image processes are implemented, and a 3D shape is reconstructed for robot manipulation.

In UGV project, we have developed the unified hierarchical path planning algorithm which consists of global and local path planner. For global path planning, we convert the given DEM, FDB, and risk map to the mobility (velocity) map and search the optimal path of the unmaned vehicle in an outdoor environment. For local path planning, we have newly developed a virtual tangential vector (VTV) algorithm and emergency level around (ELA) using LMS. VTV is similar to VFF, but it can generate more smooth and short trajectories. ELA is a simple, but powerful obstacle-avoidance technique.

In the project of the vision based human-robot interaction, we proposed an algorithm to detect humans using vision system in the indoor robot. For the potential objective of this project, we will develop the scheme for mobile robots to recognize and identify a specified person, and interact with him/her.

Key Achievements

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Computational NeuroSystems Laboratory

The Computational NeuroSystems Laboratory (CNSL), in collaboration with the Brain Science Research Center, has worked on computational models of brain information processing mechanisms and their applications to brain-like intelligent systems, such as the artificial brain (ABrain). The main achievements include (a) auditory models for speech feature extraction (b) sound localization and blind signal separation (c) top-down selective attention model for robust recognition and multi-modal information fusion (such as audio-visual integration for lip-reading) (d) feature extraction, selection, and adaptation for diverse applications (image recognition, text mining, emotional speeches, and EEG) (e) neuromorphic chips such as silicon cochlea and learning chips.

Based on these works, an ABrain has been developed in the last ten years as a testbed of human-like intelligent systems. The new extension in this direction includes signal enhancement based on ICA with additional constraints (mainly for speech and EEG signals), and discriminant feature extraction for the recognition of subtle differences (such as emotion in speeches and EEG signals, facial expressions, musical timbers, etc.).

Recently, CNSL is further extending its research toward higher-level cognitive functions for artificial cognitive systems. Computational models of active learning, knowledge development, situation awareness, explicit and implicit human intention, and decision making are also being investigated. Furthermore, the next-generation user interfaces are under development using eye-gaze and dry-electrode EEG headsets.

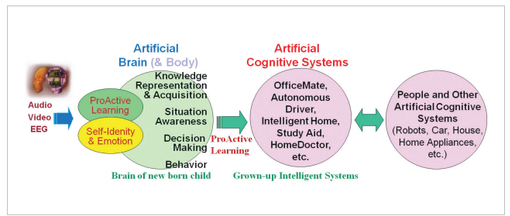

Fig. 1

Key Achievements

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Achievements in 2009/2010

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System Theoretic Analysis and Control Laboratory

The aim of the System Theoretic Analysis and Control Laboratory is to study the theoretical aspect of nonlinear control systems and communication systems, and to develop the application algorithms for airborne spotlight synthetic aperture radar (SAR) and satellite systems.

The study of nonlinear control systems has focused on analyzing the stability of nonlinear systems and controlling the singularly perturbed systems. The study of communication systems has focused on improving the performance of congestion control for power efficiency, scheduling for quality of services (QoS) and multiuser diversity, and channel estimation over time-varying channels.

The development of the SAR systems has focused on implementing SAR simulator for 10-30cm resolution and chirp pulse generator with 500MHz.

The development of satellite system has focused on the global positioning system receiver (GPSR) and the s-band transmitter (STX).

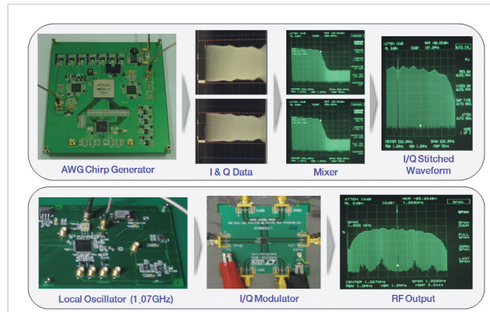

Fig. 1 Chirp generation for SAR system

Fig. 2 STX primary for satellite system

Key Achievements

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Display Power Circuit Laboratory

Fig. 1

The Display Power Circuit Laboratory (DPCL) has focused on the developing high-efficiency, high-power density conversion systems for the following applications: information display system, automotive electronics, server power system, and IT computing devices.

LED Driver System for LCD TV: To reduce the power consumption and realize high efficiency and low cost LED driver system, DPCL newly proposed a two dimensional channel-driving employing X-Y channel-driving technique for 46" LCD TVs.

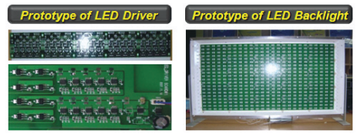

Fig. 2

High Efficiency and Power Density Platform for Server Power and Adapter: To realize the high-power density and high-efficiency of server power and adapter, DPCL proposed new topologies employing low conduction loss and reduced size.

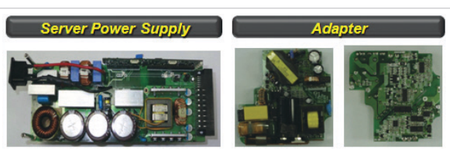

Fig. 3

Li-Ion Battery Unit for STSAT-3: To realize the power management system for lithium-ion battery, DPCL proposed and implemented the protection circuits and equalizer circuit for a satellite called STSAT-3.

Sensorless Automatic Charge Equalizer for Li-Ion Batteries: To ensure safety of lithium-ion battery, as well as its prolonged the lifetime, DPCL proposed a new charge equalization converter without the sensor of small-sized sensor and high-efficiency for HEV lithium-ion cells.

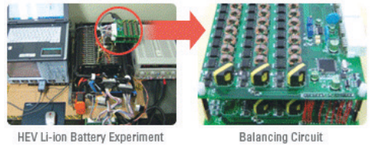

Fig. 4

Key Achievements

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Image Computing Systems Laboratory

The research of the Image Computing Systems Laboratory (ICSL) has been focused on medical imaging, video coding, stereo image processing, and automatic target recognition. Our medical imaging system area consists of brain functional studies, parallel imaging, cellular MRI, EEG signal processing, and visualization of 3D brain images from the magnetic resonance imaging (MRI).

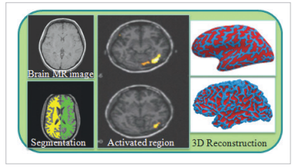

Fig. 1 Medical imaging system

In video coding parts, we have mainly focused on H.264 and the future video coding standard. We have designed a new intra-frame coding scheme which divides a frame into two subframes: one is coded as a conventional intra frame, and the other as an interpolation-based predictive coding scheme.

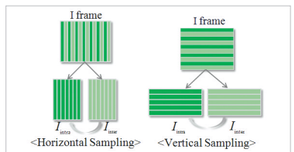

Fig. 2 Video coding scheme

The study of stereo image processing has mainly focused on the conversion techniques of 2D to 3D. The proposed 2D to 3D conversion method generates accurate multiple views from single-view sequences.

Automatic target recognition is also one of our research interests. In order to deal with appearance changes, we have proposed a particle filter-based tracker which adapts the intensity and orientation histograms on scale-space as the observation model.

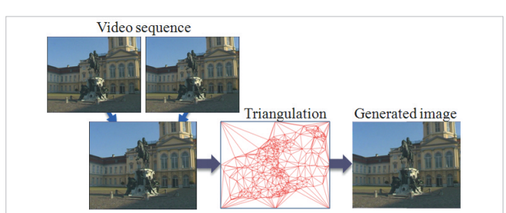

Fig. 3 2D to 3D conversion method

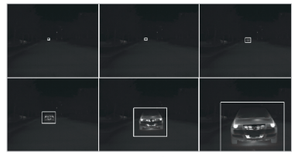

Fig. 4 Automatic target tracking

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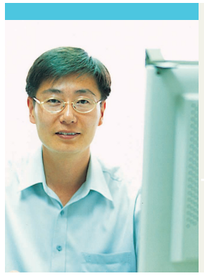

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Integrated Computer Systems Laboratory

The researches conducted in the Integrated Computer Systems (ICS) Laboratory have been focused on the design of embedded processors and computationally intensive function blocks for multimedia, and communication systems.

The Design of Microprocessors: Many different processors have been developed such as Intel-486 and Pentium-compatible processors, audio processor, single-chip programmable SoC platform, multithreaded VLIW processor, and multithread embedded processor. A 32-bit embedded processor including on-chip bus suitable for embedded systems has been developed together with its corresponding development environment such as compiler, assembler, and debugger.

The VLSI Design for Multimedia Signal Processing: ICS Lab has mainly focused on high-performance architectures and low complexity algorithms. An efficient approach to accelerate the context-based adaptive binary arithmetic coding (CABAC) decoding for H.264/AVC and appropriate hardware structure for JPEG 2000 have been proposed. Real-time hardware for making stereo vision from two images has also been proposed, and an efficient image signal processing structure for CMOS image sensors has been developed to achieve high image quality with one third of data by moving color correction and white balancing to the front of the demosaic.

VLSI Design for Communication Systems: We have proposed new synchronization architectures, fast Fourier transform (FFT) and turbo decoder for WiMAX systems. For the coarse time synchronization and fractional carrier frequency offset estimation, a disjoint architecture is proposed to reduce the hardware complexity and power consumption. We proposed a novel method to jointly estimate the fine symbol timing offset and the integer carrier frequency offset as well. The proposed FFT algorithm can reduce the table size to half, while retaining the simple structure. An energy-efficient single input single output decoder based on border metric encoding is especially suitable for the non-binary circular turbo decoding.

Key Achievements

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Image Systems Laboratory

The research of the Image Systems Laboratory (ISL) focuses on image processing. The field includes image and video processing, medical image processing, and 3D visualization systems. Some research topics recently conducted in ISL are as follows.

To improve the vessel quantification performance in a 3D CT image, we developed an active tube model-based method to quantify the geometric parameters of an abnormal vessel. Conventional approaches usually produce inaccurate clinical information for an abnormal vessel due to complex local curvatures on the centerline. The developed method overcomes this problem of incorrect local curvatures on the centerline and provides good vessel quantification results.

Secondly, in order to solve a multi-sensor image registration problem, we aimed to design a robust and accurate similarity measure by using gradient-based statistical information. In this method, a novel entropy measure is suggested on the basis of a 3D joint histogram incorporating edginess and gradient vector flow information. Through quantitative evaluations, the method was proven to provide improved robustness with the same accuracy compared to the existing approaches.

Thirdly, we are working on a challenging problem in optical flow based video deinterlacing. Since estimated optical flows mostly include some errors in video sequences, which cause significant artifacts in motion compensation process, we propose flow vector reliabilities in terms of motion linearity, uniqueness, and the consistency in a flat region. In addition, by utilizing intensity reliability based on the field parity information, we generate deinterlaced images by minimizing the introduction of artifacts and maximizing the image resolution.

Finally, in order to consider the contrast enhancement and image fusion simultaneously, we developed a unified multi-sensor image fusion system. In this system, a fusion strategy is based on a framework of the contrast enhancement algorithm using subband decomposed multiscale retinex. Therefore, even if two input images have a poor contrast, we can generate a high-contrast fused image.

Key Achievements

[1] D.-G. Kang, D. C. Suh, and J. B. Ra, "Three-dimensional blood vessel quantification via centerline deformation," *IEEE Tr. Medical Imaging,* vol. 28, no. 3, pp. 405-414, Mar. 2009.
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[1] Y. G. Lee and J. B. Ra, "New image multiplexing scheme for compensating lens mismatch and viewing zone shifts in three-dimensional lenticular displays," *Optical Engin.,* vol. 48, no. 4, pp. 044001-1-7, Apr. 2009.
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Image and Video Systems Laboratory

The Image and Video Systems Laboratory (IVY Lab), founded in 1997, conducts research in the area of multimedia processing and communication. The main research topics of IVY Lab are summarized below.

Semantic Image/Video Indexing, Retrieval, and Filtering for Social Media Applications: Multimedia processing in online social media applications has recently emerged as an area of intense research and development. IVY Lab developed a novel and effective face indexing/search method for social media applications, combining both context- and content-based informations.

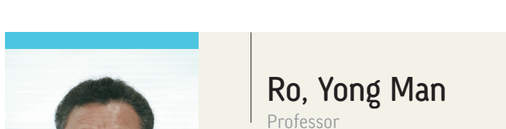

Fig. 1 Automatic face indexing in personal photos

Color Face Recognition and Biometric Security: Face recognition is an active area of research, with a significant applicational potential. IVY Lab developed a novel technique for color-based face detection and recognition. This technique is highly robust to degraded face images, suffering from low spatial resolution, high compression, and blurring noise.

Fig. 2 Privacy protection in video surveillance

Video Content Adaptation and Quality Measurement: To guarantee optimal consumption of image and video contents in heterogeneous usage environments, IVY Lab has developed adaptation techniques and a video quality metric for the H.264/SVC standard. A video quality metric for 3-D video content is currently under development.

Medical Image Processing: IVY Lab conducts research in the area of computer aided diagnosis (CAD) in medical imagery and multiple energy X-ray absorptiometry (MEXA) image processing. We developed new techniques for automatic mass detection in harmonic ultrasound images. Techniques for noise reduction and image enhancement in MEXA images are investigated as well.

Fig. 3 Automatic tumor diagnosis system

Key Achievements

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Achievements in 2009/2010

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VLSI Design Technology Laboratory

Very large scale integration (VLSI) chips are virtually everywhere now: in cell phones, in iPods and MP3s, in game consoles, etc. It is VLSI design technology that enabled an amazing innovation. The VLSI Design Technology Laboratory focuses on a broad range of VLSI design technology (tools and methodologies) topics, and includes performing world class research, which, at the same time, has an industrial impact. Our recent works and interests include low-power and low-leakage circuits and their designs (power-gating, body bias, dual-Vt, and dual-Vdd), high performance designs (pulsed-latch circuits and dual-edge-triggered circuits), structured ASICs (mask reuse methodology and selectively patterned masks), statistical design (yield analysis and latch design), and high-level syntheses (latch architecture, dual-Vdd architecture, and power-gated circuits).

We proposed autonomous power-gating that eliminates a need for the sleep signals, which reduces leakage, mode-transition energy, as well as congestion, compared with previous power-gating. We also proposed active-mode power-gating to extend the application of basic power-gating to reduce active leakage; it shares clock gating signal to shut down the part of the design during the active mode without affecting the functionality of the remaining parts.

Pulsed latch is driven by a brief clock pulse. Therefore, it offers the simple timing model of flip-flops while retaining superior design parameters of latches, which makes it an ideal sequencing element for achieving both high-performance and lower-power designs. To achieve higher performance, we formulated the problem of allocating pulse widths and scheduling of clock skews to minimize the clock period of pulsed-latch circuits; we also formulated the problem of combining retiming with pulse width allocation and achieve the same effect. To achieve lower power consumption, we proposed clock gating of pulsed-latch circuits, called pulser gating, to reduce the clocking power of pulsed-latch circuits.

In recent scaled technologies, statistical design is becoming even more important as the impact of process variations on the circuit performance is increasing. We studied methods to improve the timing yield by considering variations of clock networks and pulsed-latches.

Key Achievements

[1] Y. Shin and K. Choi, "Power conscious fixed priority scheduling for hard real-time systems," *Design Automation Conf.,* New Orleans, USA, June 1999.

[2] Y. Shin, K. Choi, and T. Sakurai, "Power optimization of real-time embedded systems on variable speed processors," *Int. Conf. Computer-Aided Design,* San Jose, USA, Nov. 2000.

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Multimedia Processing Laboratory

The MultiMedia Processing Laboratory (MMPLAB) is interested in the application of machine learning and digital signal processing. MMPLAB has been trying to apply several state-of-the-art machine learning algorithms to multimedia signal processing. Using advanced machine learning theory and signal processing techniques, multimedia signals such as speech, audio and video are processed for various applications including analysis, enhancement, recognition, processing, and security.

MMPLAB has considerable achievements in several research areas. MMPLAB proposed a novel quantum hashing algorithm for multimedia identification that leads to the improvement of the existing multimedia identification performance. In addition, psychoacoustically constrained and distortion minimized speech enhancement algorithm is proposed that outperforms some of the more popular algorithms. MMPLAB also developed a robust audio/video fingerprinting system, large vocabulary continuous speech recognition system, humming-based music retrieval system, simple free viewpoint video system, and speech based human-computer conversation system.

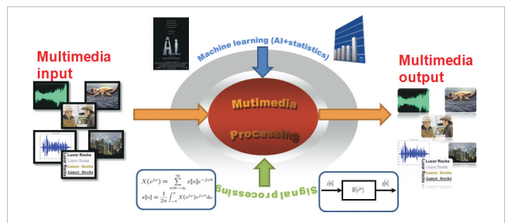

Fig. 1

Key Achievements

[1] J. Seo, J. A. Haitsma, T. Kalker, and C. D. Yoo, “A robust image fingerprinting system using the Radon transform,” *Signal Process.: Image Comm.,* vol. 19, no. 4, pp. 325-339, Apr. 2004.
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Achievements in 2009/2010

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Semiconductor System Laboratory

Bio Microsystems SoC: To meet the demands of the ubiquitous era, the Semiconductor System Laboratory (SSL) focuses on the development of SoCs that enable convergence of biology and electronics for well-being of human life. Our research fields include body channel communication (BCC), planar-fashionable circuit board (P-FCB), and wearable network. BCC enables low energy-per-bit communication via body coupling; P-FCB provides a means to form a pervasive, wearable computer into clothes; and wearable network conveniently connects devices and sensors around the body with low energy consumption.

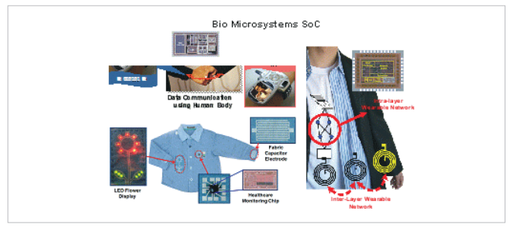

Fig. 1

Brain-Mimicking Vision SoC: The network-on-chip (NoC) has been replacing the traditional bus-based on-chip interconnections to meet the huge bandwidth requirements of recent many-core chips. To realize NoC, SSL has developed specification and C-level simulator for NoC architecture and protocol explorations, and multi-core vision SoC for image processing and object recognition applications. Real-time operation is achieved by silicon-brain architecture that is composed of brain mimic visual attention, neural networks, and fuzzy logic implemented in conventional silicon based VLSI.

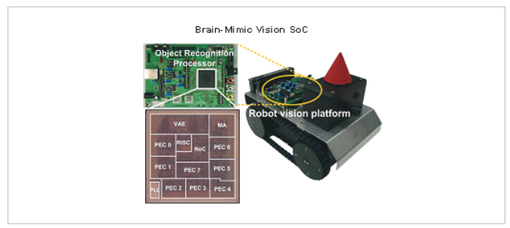

Fig. 2

Key Achievements

[1] K. Kim, S. Lee, J.-Y. Kim, M. Kim, and H.-J. Yoo, “A 125 GOPS 583 mW network-on-chip based parallel processor with bio-inspired visual attention engine,” *IEEE J. Solid-State Circuits,* vol. 44, no. 1, pp. 136-147, Jan. 2009.
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Power Electronics Laboratory

The Power Electronics Laboratory (PELab), led by Professor Myung Joong Youn since 1983, has focused on developing new control algorithms for motor driving system, battery management system, and other power electronics related areas, and high-efficiency, high-density power conversion systems for following applications: display driver circuit, lighting system, and battery management system. Nowadays the research topics and projects are mainly on the digital power systems such as the LCD backlight unit, the LED lighting system, and the server power system.

TFT-LCD needs light sources called the backlight unit (BLU) for the information display. The widely used BLU is a CCFL which requires more lamps in order to satisfy the larger size of its screen. However, due to the characteristic differences of the CCFL, the currents flowing in each lamp show a deviation error and unbalances the brightness of the screen. To balance the brightness of the screen, we have developed the digital current balancing technique so that the currents of lamps become equal. This method does not need analog devices such as current balance transformer which is often used for conventional circuits.

LED has been increasingly used in these days as an eco-friendly device. LED makes various colors, which could be used for the cure of emotional disorder of human beings. To make LEDs give out different lights, driving circuits and color control algorithms are needed. By employing digital power platforms, the LED emotional lighting system has been developed in which one MCU chip controls the driving circuit and color control at the same time.

The last topic is to develop digital controls of high-efficiency, high-power density power supply for the server computers. The server power supply is divided into two main stages: PFC and DC/DC. Each stage needs the control ICs for the proper operations and more ICs for the functioning of server power operation. However, by employing a digital power platform, the whole operation as the server power supply is implemented. Only two MCUs are used to work the server power supply properly.

Key Achievements

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Communications and Information Systems Laboratory

The research of Communications and Information Systems Laboratory (CISL) can be divided into three subareas: mobile cellular communication network and protocol, cognitive autonomous communication network and protocol, and online electric vehicle system.
Mobile cellular communication network and protocol consider 3G, 4G, Beyond 4G, and 5G communication systems. The most recent technology such as orthogonal frequency division multiple access (OFDMA) and beam division multiple access (BDMA) are actively studied. Also, the modeling and performance analyses of medium access control, resource management, handover, network architecture, and routing have been researched in the various network environments such as the homogeneous, heterogeneous, multi-hop relay, and femtocell networks.
In cognitive autonomous communication network and protocol, we are especially interested in peer-to-peer communications, ad-hoc networks, tactical networks, and cognitive radio systems. For this research, radio spectrum management, QoS provisioned MAC protocol, energy-aware routing protocol, and sensor clustering and cooperation have been performed.
We also participate in international standardization activities by proposing several outstanding contribution documents for IEEE 802.16m. Recently, a priority based uplink random access strategy, which is designed to improve the performance of the bandwidth request procedure of the user, is suggested and accepted to the standard. Moreover, an efficient fault management scheme that aims to provide reliable services for the events of access point outage is also adopted.
In addition, in online electric vehicle (OLEV) system, we are developing an electric vehicle with a new concept. The charging of the vehicle is obtained from underground via wireless inductive power transfer. Especially, magnetic communication technology has been researched for segment operation and location acquisition. Presently, inductive power transfer based power supply infrastructure and electric vehicle system developed in cooperation with many researchers at KAIST have been implemented and tested at Seoul Grand Park.

Key Achievements

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Broadband Network Laboratory

The research of Broadband Network Laboratory (BNLAB) focuses on new media, with research topics such as open IPTV, mobile IPTV, and contents delivery network (CDN).
Open IPTV: IPTV is one of the representative services that converge telecommunications and broadcasting technology along with innovative devices and web services. It also refers to multimedia services such as television, video, audio, graphics, and data delivered over IP-based networks that managed to support the required level of quality, security, interactivity, and reliability. The term ‘open’ indicates participation of new providers throughout its contents-platform-network-terminal, also called the ‘CPNT’ value chain. Our research focuses on the processes of exchanging such data and information among participants with evolutionary approaches.

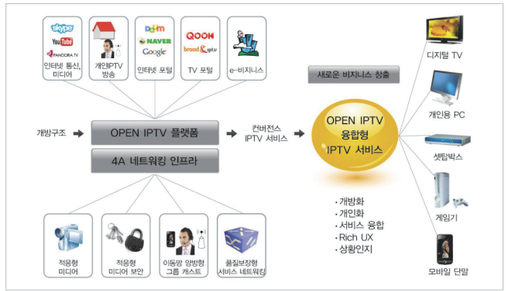

Fig. 1 Open IPTV research

Mobile IPTV: As the various mobile applications grow around world, the demand for mobile streaming services is also increasing rapidly. In this area, we are focusing on wireless streaming services in the heterogeneous wireless networks such as WiMAX, WLAN, 3G, and Beyond 4G. Our research interests include key technologies for wireless multicast and broadcast services related to bandwidth management, rate adaption, multi-user OFDM system, and group management.
We are also interested in standard activities for mobile IPTV. We have published several papers and standards with the above subjects.
Mobile CDN: As the size of data delivered by a network to end-users increases, for example, changing from voice to video, complexity of network design and operation also increases. To solve this problem, BNLAB focuses on mobile CDN and peer-to-peer (P2P) CDN, as well as traditional CDN, in terms of how to store and deliver contents to end-users with maintaining stability of network. In addition, we are working on international standardization of content delivery because unifying method proxy servers of CDN communicate with each other and exchange contents among them.

Key Achievements

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Achievement in 2009/2010

[1] Y. H. Kwon, M. G. Kim, S. G. Choi, and J. K. Choi, “A study of a new multicast traffic control policy based on the number of receivers and its evaluation in TDM-PON systems,” *IEICE Lett.,* vol. E93-B, no. 1, pp. 162-165, Jan. 2010.

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Wireless Communication Systems Laboratory

The Wireless Communications System Laboratory [WCSL] researches communication theory and information theory for the advancement of wireless communications. The focus of our research is on bridging the gap between the information theory and communication theory. We identify its theoretical capacity and performance limits and thereof rooms to improve and investigate advanced techniques for improving the capacity and performance. We find our theoretical applications to network MIMO, cooperative communications, cognitive radio, and interference management for next generation wireless systems. WCSL is led by Prof. Wan Choi, who is the recipient of IEEE Vehicular Technology Society Jack Neubauer Memorial Award in 2002, IEEE Vehicular Technology Society Dan Noble Fellowship Award in 2006, and IEEE Communications Society Asia Pacific Young Researcher Award in 2007. He serves as an associate editor for IEEE Transactions on Wireless Communications.
Our on-going research progress of 2009 and 2010 is summarized as follows:

1] Cooperative communications: We have studied various strategies for maximizing the benefits of cooperation among communication nodes and reducing losses caused by half duplexing at relay nodes. We have proposed several novel theoretical and practical techniques and identified their ultimate gains.
2] Cognitive radio: We have derived the average achievable capacity of a secondary network in cognitive radio systems and analyzed its asymptotic behaviors to characterize the multiuser diversity gains in cognitive radio systems. We have also studied a leverage of combining two different spectrum sharing schemes in terms of queueing theory.
3] Limited feedback: The capacity of feedback links is typically limited and shared by multiple users. Using the random vector quantization theory, we have studied and identified the optimal strategy of feedback capacity sharing in MIMO broadcast channel when feedback capacity is limited.
4] Interference management and network MIMO: Recognizing that interference management is essential for achieving high spectral efficiency, we have studied interference channel models connected with practical wireless communication environments. Practical distributed beamforming techniques have been developed and theoretically analyzed when the available information is limited or asymmetric.

Key Achievements

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[2] W. Choi and J. G. Andrews, “Downlink performance and capacity of distributed antenna systems in a multicell environment,” *IEEE Tr. Wireless Comm.,* vol. 6, no. 1, pp. 69-73, Jan. 2007.
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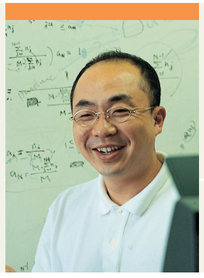
Achievements in 2009/2010

[1] J. Ryu and W. Choi, “A simple linear multiuser precoding technique in cellular relay networks,” *IEEE Comm. Lett.,* vol. 17, no. 1, pp. 12-14, Jan. 2010.
[2] W. Choi, D. I. Kim, and B.-H. Kim, “Adaptive multi-node incremental relaying for hybrid-ARQ in AF relay networks,” *IEEE Tr. Wireless Comm.,* vol. 9, no. 2, pp. 505-511, Feb. 2010.



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Wireless Information Systems Research Laboratory

The Network Systems [NETSYS] Laboratory has been focusing on the research of wireless network based on the broad knowledge gained from the wired network research. There are three research groups: Cellular Network Group, Wireless Mesh Network Group, and Mobility Group.
Cellular Network Group studies resource allocation algorithms to efficiently share scarce wireless resources in future mobile networks.
Wireless Mesh Network Group develops new architecture and protocols for wireless mesh networks.
We deployed a world-class wireless mesh network testbed in the undergraduate dormitory area of KAIST. It provides unique experimental experiences on large-scale multi-hop wireless networks and helps verify the performance of our network protocols. We also designed a common code architecture which gives flexibility for protocol implementation on the mesh testbed.
Mobility Group studies human mobility characteristics and their impact on wireless networks including delay tolerant networks [DTN]. We designed a novel mobility model called the self-similar least action walk [SLAW] which captures the least action principle in human trip planning.

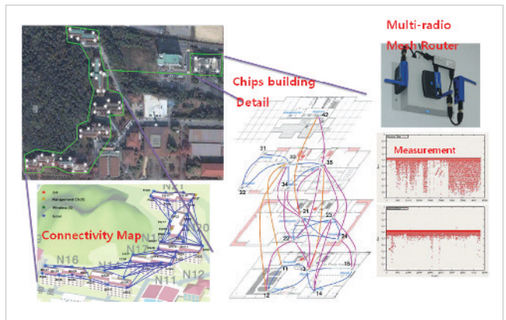

Fig. 1

Key Achievements

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[2] K. Son, S. Chong, and G. De Veciana, “Dynamic association for load balancing and interference avoidance in multi-cell networks,” *IEEE Tr. Wireless Comm.,* vol. 8, no. 7, pp. 3566-3576, July 2009.
[3] K. Lee, Y. Yi, J. Jeong, H. Won, I. Rhee, and S. Chong, “Max-contribution: On optimal resource allocation in delay tolerant networks,” *IEEE Int. Conf. Computer Comm.,* San Diego, USA, Mar. 2010.

Achievements 2009/2010

[1] S. Chong, J. Lee, S. L. Shrestha, Y. Kim, and N. Song, *Method and system to support quality of service in broadband wireless network,* 0931828, Korea, Dec. 7, 2009.
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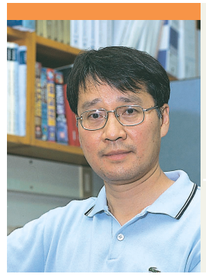

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Scientific Computing Laboratory

In the Scientific Computing Laboratory, we develop signal processing algorithms mainly for wireless communication and radar systems, as well as relevant small-scale hardware systems whenever necessary. In recent years, we have also worked on image signal processing.

Wireless Communications: We have developed algorithms and analyzed performance of the physical-layer of the 4G communication systems and, more specifically, of the multiple-input multiple-output (MIMO) communication systems. Our current research interests include new problems in the MIMO relay channels.

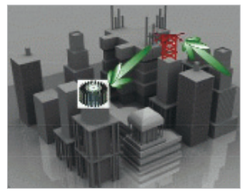

Fig. 1 Antiaircraft cylindrical multi-array

Radar Systems: Our research topics range from the classical beam synthesis problem to the recent topics such as distributed or multi-static radar systems. We are new developing an active radar system with a cylindrical multi-array, in collaboration with Samsung Thales.

Image Synthesis: Our research has mainly focused on the integration of the infrared image and target-tracking based on image information. As one of the results from this study, we have developed an infrared scene generator (IRSG) software with C++.

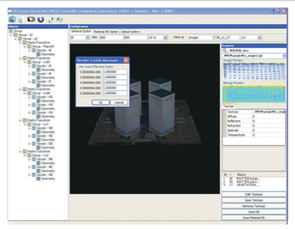

Fig. 2 IRSG software

Key Achievements

[1] K. Lee and J. Chun, "Symbol detection in V-BLAST architectures under channel estimation errors," *IEEE Tr. Wireless Comm.,* vol. 6, no. 2, pp. 593-597, Feb. 2007.
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[3] S. Kim and J. Chun, "Capacity and performance of lattice reduction aided linear processing with lattice encoding and decoding in limited feedback systems," *IEEE J. Select. Areas Comm.,* vol. 26, no. 8, pp. 1567-1577, Oct. 2008.

Achievements in 2009/2010

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[2] B. W. Jung, R. S. Adve, J. Chun, and M. C. Wicks, "Detection performance using frequency diversity with distributed sensors," *IEEE Tr. Aerosp. Electron. Syst.* (to be published)

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Wireless Communications Laboratory

Our research focuses on information theory and its applications to wireless communications. Specifically, we characterize the fundamental limits of various wireless and wireline communication channels including the broadcast, relay, and interference channels, wireless ad hoc networks, and flash memory. Based on this, we develop technologies that can enhance the performance of the present systems. For example, we develop and patent new key technologies for the next generation wireless standards including dirty paper coding, network coding, rateless coding, and new cooperation strategies for relay networks. Some of our recent results include the following:

- Capacity characterization for a class of multicast tree networks: Information-theoretic capacity is characterized for the first time for a non-trivial class of noisy networks with an arbitrary number of nodes. Submitted to IEEE Transactions on Information Theory. Invited to give a presentation at Information Theory and Applications Workshop held in San Diego, USA in February 2010.
- Noisy network coding: Full information theoretic generalization of network coding for noisy relay networks. Includes as special cases many celebrated classical results such as the max-flow min-cut theorem, network coding, approximate capacity characterization for Gaussian relay networks, and compress-and-forward relaying. Joint work with Young-Han Kim (UCSD) and Abbas El Gamal (Stanford). Submitted to IEEE Transactions on Information Theory. Invited to give a presentation at IEEE Information Theory Workshop held in Cairo, Egypt in January 2010.
- Approximate capacity characterization for multi-source relay networks: Approximate capacity is characterized for the first time for multi-source multi-hop networks. Joint work with Syed A. Jafar (UC Irvine). Submitted to IEEE Transactions on Information Theory. Invited to give a presentation at Allerton Conference on Communication, Control, and Computing, held in Monticello, USA in September 2009.

Key Achievements

[1] S.-Y. Chung, G. D. Forney, T. J. Richardson, and R. Urbanke, "On the design of low-density parity-check codes within 0.0045 dB of the Shannon limit," *IEEE Comm. Lett.,* vol. 5, no. 2, pp. 58-60, Feb. 2001.
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[3] S.-H. Lee and S.-Y. Chung, "Capacity of a class of multicast tree networks," *Inform. Theory, Appl. Workshop,* San Diego, USA, Feb. 2010. (invited paper)

Achievements in 2009/2010

[1] H. T. Do and S.-Y. Chung, "Linear beamforming and superposition coding with common information for the Gaussian MIMO broadcast channel," *IEEE Tr. Comm.,* vol. 57, no. 8, pp. 2484-2494, Aug. 2009.
[2] W. Nam, S.-Y. Chung, and Y. H. Lee, "Capacity of the Gaussian two-way relay channel to within 1/2 bit," *IEEE Tr. Inform. Theory.* (to be published)

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Lightwave Systems Research Laboratory

Since it was established by Prof. Y. C. Chung in 1994, the Lightwave Systems Research (LSR) Laboratory has been focusing on various research activities of lightwave systems and related technologies. One of the main focuses of our lab is to identify the fundamental limitations imposed on the lightwave systems and discover new practical solutions to overcome them. Our research activities include both experimental and theoretical works. We have a well-equipped lab to support these activities with state-of-the-art test gears and various types of advanced components.
The followings are our core competence, mission, applications, and major achievements.

- Core Competence:
  - Lightwave systems technology
- Mission:
  - To create a world-leading knowledge base in lightwave communication systems, subsystems, networks, and related technologies
- Applications:
  - High-capacity, all-optical core networks
  - Long-distance transmission systems
  - Metropolitan area networks
  - Broadband access networks
  - Fiber backhaul networks for wireless application
- Major achievements:
  - 5.12Tb/s (128 x 40Gb/s) WDM system
  - New fiber design for high-capacity WDM systems
  - KAIST all-optical network (KAON) testbed
  - Optical cross-connects and optical add/drop multiplexers
  - Bi-directional WDM SHR network
  - Passive optical network for microcellular CDMA PCS
  - Multi-purpose fiber-optic access network
  - WDM PON and spectrum-sliced light source
  - High-speed LAN at 10Gb/s and beyond
  - Optical performance monitoring techniques
  - Advanced fiber designs

Recently, we have worked on various aspects of lightwave communication systems including 100G transmission systems, multi-level modulation techniques, performance monitoring techniques, WDM PONs, coherent receivers, and high-speed MMF systems.

Key Achievements

[1] J. H. Lee, D. K. Jung, C. H. Kim, and Y. C. Chung, "OSNR monitoring technique using polarization-nulling method," *IEEE Photon. Techn. Lett.,* vol. 13, no. 1, pp. 88-90, Jan. 2001.
[2] J. H. Lee and Y. C. Chung, "Improved OSNR monitoring technique based on polarization-nulling method," *Electron. Lett.,* vol. 37, no. 15, pp. 972-973, July 2001.
[3] E. S. Son, K. H. Han, J. K. Kim, and Y. C. Chung, "Bidirectional WDM passive optical network for simultaneous transmission of data and digital broadcast video service," *IEEE J. Lightw. Techn.,* vol. 21, no. 8, pp. 1723-1727, Aug. 2003.

Achievements in 2009/2010

[1] Best Paper Award, Photonics Conference, Dec. 2009.
[2] K. Y. Cho, A. Agata, Y. Takushima, and Y. C. Chung, "Performance of forward-error correction code in 10-Gb/s RSOA-based WDM PON," *IEEE Photon. Techn. Lett.,* vol. 22, no. 1, pp. 57-59, Jan. 2010.

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Coding, Communications, and Information Theory Laboratory

The research interests of the Coding, Communications, and Information Theory (CCIT) Laboratory include the general areas of communications, error-control coding, and information theory. CCIT Lab has been working on challenging problems in physical layer security and error-control coding (ECC) for solid state drives (SSDs). These works are sponsored by NRF, MKE, etc.
Physical Layer Security: Due to the broadcast behavior of wireless mediums, it has become essential to address the inherent security issues in wireless environments. In conventional approaches, the security issues have been addressed in the layers above the physical layer. On the contrary, the physical layer security provides solutions to the security issues in the physical layer, which may supplement the conventional systems or pave the way for cross-layer optimizations for the future security systems. As a part of the research activities, CCIT Lab has studied secure wireless sensor networks, and recently proposed a secure type-based multiple access protocol (TBMA) that guarantees unconditional perfect security for wireless sensors with limited computing power. CCIT Lab also actively investigates the secret key extraction from the channel statistics. These works are collaborated with Georgia Tech in USA and Swansea University in UK.
Error Control Coding for Solid State Drives: Solid-state drives (SSDs) are considered as one of the next-generation mass storage devices. It employs NAND flash memories with single-level cells (SLCs) or multi-level cells (MLCs). Although the cost efficiency of the MLCs makes MLC-based SSDs more preferable to the market, more errors are likely to happen in MLCs; thus demands on customized error-control coding (ECC) for the SSD have been ever growing. CCIT Lab investigates theoretic limits of bit density of SSDs, customized ECCs for SSDs with MLCs and their encoder/decoder structures with lower complexity. These works are collaborated with partners in industries and academia.

Key Achievements

[1] J. Ha and S. W. McLaughlin, "Low-density parity-check codes over Gaussian channels with erasures," *IEEE Tr. Inform. Theory,* vol. 49, no. 7, pp. 1801-1809, July 2003.
[2] J. Ha and S. W. McLaughlin, "Rate-compatible puncturing of low-density parity-check codes," *IEEE Tr. Inform. Theory,* vol. 50, no. 11, pp. 2824-2836, Nov. 2004.
[3] J. Ha, J. Kim, D. Klinc, and S. W. McLaughlin, "Rate-compatible punctured low-density parity-check codes with short block lengths," *IEEE Tr. Inform. Theory,* vol. 52, no. 2, pp. 728-738, Feb. 2006.

Achievements in 2009/2010

[1] J. Choi and J. Ha, "Rate optimization to minimize distortion for source-channel coded H-BLAST with SIC decoding," *IEEE Comm. Lett.,* vol. 13, no. 2, pp. 115-117, Feb. 2009.
[2] C. Jung, J. Choi, and J. Ha, "Asymmetric power allocation to improve convergence rate of iterative receivers," *IEEE Comm. Lett.,* vol. 13, no. 8, pp. 579-581, Aug. 2009.

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Wireless Innovative Technologies Laboratory

The research of the Wireless Innovative Technologies Laboratory (WIT) focuses on wireless communication and networking. WIT is conducting research to improve the wireless network performance, and design innovative and efficient algorithms for current and next wireless communication systems.
The research direction of WIT is mainly radio resource management (RRM) that will be the main issue of the future wireless networks due to the lack of wireless resources such as frequency, power, space, code, and so on.
The main objective in radio resource management is to optimally utilize limited wireless radio resources. Since the radio resource management scheme is positively necessary in any wireless technologies, radio resource management researches are recently noticeable by attaching up-to-date technologies such as MIMO-OFDM, multicell coordination, cooperative network, network coding, cognitive radio, etc.
WIT currently is conducting a survey on optimal radio resource allocation method for IEEE 802.16m, 3GPP HSPA and LTE system investigation with ETRI and Samsung. In addition, for the prior occupation of next generation wireless communication technologies, WIT is working on the study for 5G key technologies with SKT. As well as commercial wireless networks, WIT is researching on designing MIMO radar with the National Defense and Science Institute to detect unidentified aircrafts using a commercial wireless network for increasing detection probability without any suspicion to the enemy. In addition, in the ITRC-BcN center, WIT is working on wired and wireless convergence networks, as well as heterogeneous wireless networks which consist of diverse network topology such as macro, micro, pico, femto cells, etc., for future network environment. Since heterogeneous networks are of more complicated environments than homogeneous networks from the point of view of interference, scheduling, power allocation, and handoff, we are working on challenging problems in heterogeneous networks.

Key Achievements

[1] H. Kim and Y. Han, "A proportional fair scheduling in multicarrier transmission systems," *IEEE Comm. Lett.,* vol. 9, no. 3, pp. 210-212, Mar. 2005.
[2] K. Kim, Y. Han, and S. Kim, "Joint subcarrier and power allocation in uplink OFDMA systems," *IEEE Comm. Lett.,* vol. 9, no. 6, pp. 526-528, June 2005.
[3] J. Koo, Y. Han, and J. Kim, "Handoff effect on CDMA forward link capacity," *IEEE Tr. Wireless Comm.,* vol. 5, no. 2, pp. 262-269, Feb. 2006.

Achievements in 2009/2010

[1] I. Kim, Y. Han, and H. Chung, "An efficient synchronization signal structure for OFDM-based cellular systems," *IEEE Tr. Wireless Comm.,* vol. 9, no. 1, pp. 99-105, Jan. 2010.
[2] S. Han, H. Kim, Y. Han, and J. M. Cioffi, "Efficient power allocation schemes for nonconvex sum-rate maximization on Gaussian cognitive MAC," *IEEE Tr. Comm.,* vol. 58, no. 3, pp. 753-757, Mar. 2010.

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Advanced Radio Technology Laboratory

The research of the Advanced Radio Technology Laboratory (ART LAB) focuses on techniques for advanced wireless communication systems. These technologies include multiple-input multiple-output (MIMO), smart antenna, orthogonal frequency division multiplexing (OFDM), collaborative signal processing, and spectral estimation. The research direction of ART LAB is two-fold: firstly, ART LAB is trying to advance the fundamental understanding of digital communication techniques that will become the main issue of the area in the future; secondly, ART LAB is conducting research to apply the wireless communication technologies to location or ranging area and to devise innovative methods for current and next wireless communication systems.
Recently, MIMO techniques, one of the research areas in ART LAB, have received attention due to the increase of link reliability and spectral efficiency over wireless fading channels without expending more time and bandwidth. Multi-antenna technique has been adopted to many standards such as mobile WiMAX and 3GPP LTE. Robustness and efficiency of OFDM and a transmission technique based upon the idea of frequency-division multiplexing (FDM) are also important advantages for transmitting data at high data rates required by future broadband applications.
In addition, cooperative communication systems, such as multi-cell coordinated system and relay based system, provide a reliable data transmission that satisfies user's QoS, which makes itself focus of the next communication generation. The ranging (location) technique, the other area of ART LAB research, provides various services such as location-based services and GPS-less geolocation system. IEEE 802.15.4a is the standard considering ranging technology.
ART LAB applies these technologies to various applications such as 4G wireless, UWB, indoor localization, sensor networks, and cognitive radio.

Key Achievements

[1] J. Kim, J. Kang, Y. Kim, Y. Kim, H. Kim, J. Son, and H. Park, *Ranging system and method thereof,* 7439904, USA, Apr. 11, 2006.
[2] J. Cha and J. Kang, "Efficient V-BLAST detection using modified Fano algorithm," *IEICE Tr. Comm.,* vol. E89-B, no. 6, pp. 1955-1959, June 2006.
[3] Student Paper Award, Triangle Symposium on Advanced ICT, Oct. 2009.

Achievements 2009/2010

[1] W. Shin, S. J. Lee, D. Kwon, and J. Kang, "LMMSE channel estimation with soft statistics for turbo-MIMO receivers," *IEEE Comm. Lett.,* vol. 13, no. 8, pp. 585-587, Aug. 2009.
[2] K. Lee, Y. Kim, and J. Kang, "A novel orthogonal space-time-frequency block code for OFDM systems," *IEEE Comm. Lett.,* vol. 13, no. 9, pp. 652-654, Sep. 2009.

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Laboratory for Integrated Network Engineering

Recently, emerged are broadband convergence networks (BcNs) that provide mixed multimedia services to handle wired/wireless, voice/data, and data communication/broadcast. BcNs require tremendous data transmission capacity and interworking among heterogeneous networks. Especially, the interaction between IP networks and optical networks became one of the pivotal issues in supporting high quality of services (QoS), fast speed, broad bandwidth, security, and so on. However, there are not too many experts in this area.
This Laboratory for Integrated Network Engineering (LINE) pursues the goal of making a global leader in the area of researching inter-operation of existing IP networks, intelligent optical internet, and wireless networks. LINE also makes a lot of effort in building global human networks. In order to make global leaders, LINE supports lab members with not only enough financial assistance, but also technical helps by connecting experts of famous universities, research institutes, and so forth, to lab members, so that lab members are able to produce a plenty of high quality of journal papers and international conference papers.
LINE members have experienced technical skills through industrial projects given by Samsung, ETRI, KT, KTF, and so on. LINE is eagerly recommending research activities abroad. Some members have already experienced abroad research activities in the U.S. and Australia, and the candidate nations and universities are diversifying every year. To build global human networks, LINE has relations with UC Davis in the U.S., University of Melbourne in Australia, Tokyo University in Japan, and several tens of universities in Korea. Internally, all lab members who are now in the lab or who graduated university have continuous relations and give various advice to each other. Most of the lab members have been achieving remarkable research outcomes by publishing journals and conference papers and by improving technical skills needed in industry laboratories. Current research areas of LINE are optical internet technology, traffic engineering and QoS support mechanism, fiber to the home (FTTH) networks, home network technology, broadband convergence networks, wired/wireless integration, and the next generation wireless network technology.
In addition, ubiquitous network is one of the interesting research fields.

Key Achievements

[1] S. Y. Oh, H. H. Hong, and M. Kang, “A data burst assembly algorithm in optical burst switching networks,” *ETRI J.,* vol. 24, no. 4, pp. 311-322, Aug. 2002.
[2] J. Y. Choi, H. L. Vu, C. W. Cameron, M. Zukerman, and M. Kang, “The effect of burst assembly on performance of optical burst switched networks,” *Lecture Notes Computer Sciences,* Berlin, Germany, Aug. 2004.

Achievements in 2009/2010

[1] J. J. Yoo, T. Y. Kim, H. H. Yun, B. W. Kim, N. U. Kim, J. G. Kim, B. R. Jung, and M. Kang, *Dynamic multicast group management and service wavelength allocation method for communication broadcasting convergence service in WDM-PON,* 7,583,669 B2, USA, Sep. 1, 2009.
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Communications Signal Processing Laboratory

The Communications Signal Processing Laboratory (CSPLAB) has researched on wireless communications, image processing, and radar signal processing. CSPLAB is now focusing on the wireless communication. A variety of research topics in wireless communications are studied in CSPLAB.
In orthogonal frequency division multiplexing (OFDM) systems, the research on the frequency offset estimation and inter-carrier interference cancellation is ongoing.
In ad-hoc relay networks over IEEE 802.16 orthogonal frequency division multiple access systems, the ranging protocol and call admission control are studied.
In wireless multiple-input multiple-output (MIMO) relay systems, the source and relay precoder design problems with partial channel state information (CSI) such as mean and covariance information of channels are investigated. The partial CSI schemes are essential for a practical communication system with a limited feedback rate.
Recently, the cognitive radio and femtocell systems have gained a lot of interest from the researchers for the efficient use of limited resources. In a cognitive radio system which includes a primary user (spectrum licensed user) and a cognitive user (spectrum unlicensed user), spectrum sensing, cognitive user resource allocation, and cognitive relay network related topics are studied. In a femtocell, which is a small cellular base station designed for use in residential or small business environments, the channel and power allocation for femtocell users are studied.
A number of other research projects were completed and there are also ongoing projects in CSPLAB: a project on the precoder design in MIMO relay systems; and a project on the UWB rader signal processing for discrimination between human and animals.
The research is much more concentrated on theoretical and academic studies rather than practical device experiments in CSPLAB.
Above all, the research topics are open. Every student studies topics and improves his/her research capabilities through laboratory seminars and group studies with all the laboratory members.

Key Achievements

[1] Y. Yoon and H.-M. Kim, “An efficient blind multiuser detection for improper DS/CDMA signals,” *IEEE Tr. Vehic. Techn.,* vol. 55, no. 2, pp. 572-582, Mar. 2006.
[2] T.-S. Kang and H.-M. Kim, “Optimal beam subset and user selection for orthogonal random beamforming,” *IEEE Comm. Lett.,* vol. 12, no. 9, pp. 636-638, Sep. 2008.
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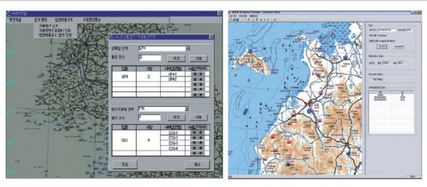
Systems Modeling and Simulation Laboratory

The Systems Modeling and Simulation (SMS) Laboratory is devoted to researching theory and applications of modeling, simulation, and analysis of discrete event systems. The modeling framework in our research is discrete event systems specification (DEVS) formalism, which supports specification of discrete event models in a hierarchical modular manner. Research emphases are split into two areas: methodology and tools for (1) systems analysis at a high level and for (2) simulator development and interoperation.

The first area is to develop a new framework for the efficient analysis of complex systems, such as application-specific digital systems, using discrete event system M&S. The framework includes a DEVS specification language, realization of the DEVS formalism in MATLAB/Simulink, and an operation and interconnection sharing algorithm for reconfiguration overhead reduction using static partial reconfiguration.



(a) Scenario Writer (a) Scenario Viewer

Fig. 1

The second area is mainly aimed at the development of high level architecture (HLA) compliant military war game simulators. Such simulators should be interoperable with other simulators through HLA and run time infrastructure. SMS Lab has developed a set of tools for development of simulators which meet the standard: DEVSim++, KHLAAdaptor, and KComLib. The tools set has been used to develop three major military war game simulators in Korea such as the Chunghae Simulator of the Navy, the Changkong Simulator for the Air Force, and the Chunjabong Simulator for the Marine (shown in the figure above).

Key Achievements

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Mobile Communications Laboratory

Our research covers two major areas: mobile communications and networks.
In the mobile communications, we are researching on
1. OFDM-based communication system - frequency and time synchronization
2. Mobile WiMAX system - PHY and MAC
3. IEEE 802.16m-based communication system - PHY and MAC
4. IMT-advanced (4G) system - PHY and MAC
5. Femto-cell system - PHY and MAC
6. Broadcasting system - T-DMB and ISDB-T PHY simulator
7. Channel coding - Viterbi, turbo, and LDPC

For mobile networks area, significant research achievements have been made on
1. Mobile ad hoc network (MANET) - MAC and routing
2. Wireless mesh network (WMN) - MAC and routing
3. Military tactical communication network - requrements, architecture, and QoS
4. Mobile router with sensor networks
5. Wireless sensor network (WSN) - MAC and routing
6. Wireless local area network (WLAN) - enhancements for very high throughput less than 6GHz

Key Achievements

[1] B. C. Kim and H. S. Lee, "Performance comparison of route metrics for wireless mesh networks," *IEICE Tr. Comm.,* vol. 89, no. 11, pp. 3124-3127, Nov. 2006.
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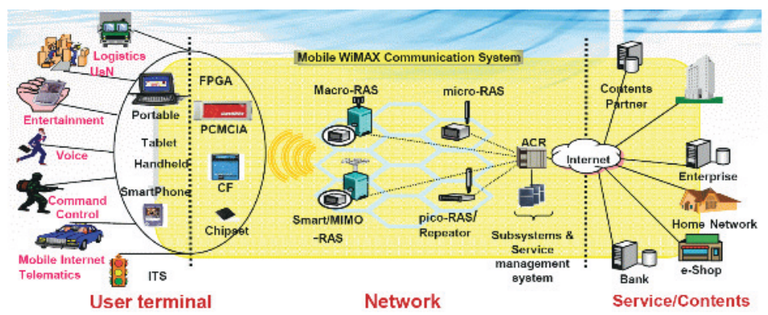
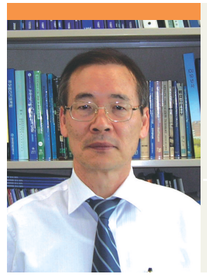


Fig. 1



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Radio and Communications Laboratory

Research interests of the Radio and Communications Laboratory (RCLab) include fundamentals of wireless communications and 4G related communication systems such as cognitive radio (CR), dynamic spectrum access (DSA), wireless channel modeling, and radio frequency identification (RFID).

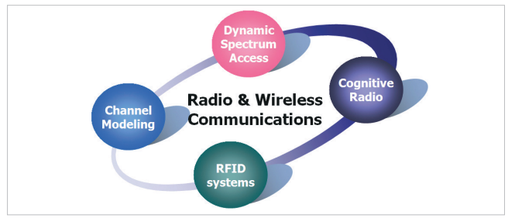

Fig. 1

CR: CR technology utilizes unused frequency bands in licensed bands by using fine spectrum sensing techniques. RCLab has studied on spectrum sensing technology and carried out the research for standardization in IEEE 802.22 WRAN. Recently, issues on CR control channel or rendezvous in CR networks are interesting research topics for us.
DSA: While the demand for the limited spectrum resource is causing the spectrum scarcity, DSA has recently received a great attention due to the ability to improve spectrum utilization. RCLab is working on political and engineering issues related to DSA such as public safety spectrum management and interference management.
Wireless Channel Modeling: To guarantee a reliable performance measurement of next generation wireless communication systems, practical observation and modeling of wireless channels need to be established. We aim at developing a novel wireless channel model of cooperative communications based on an IMT-advanced system.
RFID: RFID is one of the key technologies for ubiquitous communications, which use radio frequency waves to identify, track, or categorize objects. We are researching new protocols for the arrangement of an efficient RFID system especially one which considers anti-collision among various types of readers.

Key Achievements

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Digital Communications Laboratory

The Digital Communications Laboratory (DCL) actively conducts research on physical layer design and signal processing for various communication systems including next generation mobile communication and military communication systems. DCL has been collaborated with other laboratories in KAIST, to design overall communication systems and implement signal processing techniques. The lab's research activities are being funded by the Ministry of Knowledge Economics, Agency for Defense Development, and private companies such as Samsung Electronics. Some highlights of the research are described as follows.
Next Generation Mobile Communication Systems: Various techniques for increasing capacities of wireless network are being investigated. Recently proposed techniques include beam division multiple access (BDMA), which is a simple but effective location based service for cellular downlink, pre-nullification for full-duplex relaying, cooperative cognitive radio for cellular uplink, multi-way relaying, some modifications of interference alignment, and digital pre-distortion schemes for wide-band power amplifiers supporting dynamic frequency allocation. In this research we collaborate with professors D. H. Cho, S.-Y. Chung, and Y. Sung.
Military Communication Systems: A hybrid of cellular and ad-hoc network is investigated to support high data rate, yet flexible and secure communications.

Key Achievements

[1] I. Kim, I.-S. Park, and Y. H. Lee, "Use of linear programming for dynamic subcarrier and bit allocation in multiuser OFDM," *IEEE Tr. Vehic. Techn.,* vol. 55, no. 4, pp. 1195-1207, July 2006.
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Mobile Multimedia Laboratory

The Mobile Multimedia Laboratory (MMLAB) has focused on designing wireless communications network architectures and protocols and evaluating network performances. Currently, we are developing communication protocols and algorithms to service a large number of real-time traffic flows efficiently in a multi-hop wireless mesh network. Our target real-time traffic includes voice, video, and sensed data. Our particular emphasis is placed on developing expandable multi-channel multi-radio medium access and routing protocols that easily adjust to geographically differing traffic densities. We are also developing congestion and admission control policies that produce a high capacity while satisfying a given quality of service. We are building simulation programs and prototype systems to verify the performance and the ultimate usability.

The followings are brief summaries of the current and previous research areas:

- Wireless mesh network
  - Multi-channel multi-radio MAC and routing protocols
  - IEEE 802.11 with RF beamforming technology
  - Wireless mesh network testbed
- 3GPP LTE SON: femtocell
  - SON for transmit power of FemtoAP
  - Femtocell testbed
- Wireless sensor network
  - Power saving mechanism
  - Sensor MAC and routing protocols
  - Indoor localization

Key Achievements

[1] M. Seo and J. Ma, "Dynamic channel selection with snooping for multi-channel multi-hop wireless networks," *IEICE Tr. Comm.,* vol. E91-B, no. 8, pp. 2752-2756, Aug. 2008.
[2] C. Kim, H. Kim, Y. Kim, and J. Ma, "Capacity-aware routing with hop-count constraint and its adaptivity," *Int. Interdisc. J.,* vol. 12, no. 4, pp. 827-838, Jan. 2009.
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Achievements in 2009/2010

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Communications and Storage Laboratory

The Communications and Storage Laboratory (ComSto Lab) has its origin in the Communications and Data Storage Lab (CDS Lab) that was founded by Prof. Moon at the University of Minnesota, USA, in 1990, as he was joining the electrical and computing engineering department there as an assistant professor. The lab has since been well-recognized internationally for its innovative research and commercialization efforts in signal processing and coding related to achieving high-density storage and high-rate communications.

The maximum transition run length (known as MTR code in industry) code invented in the lab, for example, had become widely used in high-density disk drives through the late 1990's and early 2000's, as an effective means to pack bits more densely in thin film recording disks. In 2009, MTR patent had also become a part of the patent pool for technologies that are essential for manufacturing BluRay optical storage devices. In 2001, Prof. Moon co-founded, partly based on the technologies developed in his lab, a wireless chip start-up Bermai, Inc. in the Silicon Valley to design and manufacture chips and systems to enable fast wireless access in local area networks. The wireless technologies developed by Bermai are now a part of wireless homenetworking products manufactured and marketed by DSPG, a publicly-traded company.

In 2009, Prof. Moon relocated his lab to the department of electrical engineering at KAIST, renaming it as 'ComSto Lab', and joined KAIST as a professor. At KAIST, Prof. Moon continued his research on the general area of high-speed communication and high-density storage.

ComSto Lab's current research emphasis is on how to design coding and equalization geared to known or partially-known interferences. Interference-dominant channels are an important current trend in many crucial communication systems including high-speed computer buses, wireless femto cells, high-density flash memory, high-density hard disk drives, multi-giga networks, and underwater communications. ComSto Lab's interests cover a broad spectrum of disciplines ranging from mathematical theory to low-complexity FPGA/VLSI architecture solutions, all with applications to communication and storage in mind.

Key Achievements

[1] J. Moon and B. Brickner, "Maximum transition run codes for data storage systems," *IEEE Tr. Magn.,* vol. 32, no. 5, pp. 3992-3994, Sep. 1996.
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[3] J. Park and J. Moon, "Error-pattern-correcting cyclic codes tailored to a prescribed set of error cluster patterns," *IEEE Tr. Inform. Theory,* vol. 55, no. 4, pp. 1747-1765, Apr. 2009.

Achievements in 2009/2010

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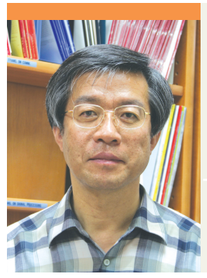

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Information Processing and Systems Laboratory

The Information Processing and Systems Laboratory (IPSL) is led by professor Dong-Jo Park. IPSL is focusing on two major parts: wireless communication and image processing systems. Research topics on wireless communication include synchronization, channel estimation, channel coding, pre-coding, and interference management for future wireless communication systems; image processing areas include video coding, target detection and tracking.

Wireless Communication Systems: One of the promising candidates for the 4G wireless communication system is LTE-advanced organized by 3GPP. LTE-advanced systems can improve spectral efficiency of whole cell users and especially for cell-edge users by coordinating multiple transmission/reception. For one of our lab projects, we are proposing patents for LTE-advanced systems and for Beyond 4G systems. Especially, we expect that the transmitter and receiver are closer to each other to increase the system capacity of a wireless link. In this environment, system performance is dominated by interference rather than noise so that interference management (e.g. interference alignment (IA), dirty paper coding (DPC), multi-user beam-forming, etc.) is the most important problem in increasing system capacity.

Image Processing Topics: Motion estimation via the block matching algorithm (BMA) has been adopted in all the video coding standards. Although the full-search algorithm (FSA) is the best BMA when it comes to motion estimation accuracy, its high computational load limits its practical usage. Therefore, we study a novel candidate sub-sampling technique (CPST) and a fast template matching scheme using integral images. In the video analytics, we are interested in developing a system which can detect and track moving objects automatically. Since the information from a single camera is limited, the performance of the tracking system is degraded as moving objects approach each other. In order to tackle this occlusion problem, we are researching detection and tracking algorithms that can deal with input sequences from multiple cameras simultaneously.

Key Achievements

[1] B. G. Kim, J. I. Shim, and D. J. Park, "Fast image segmentation based on multi-resolution analysis and wavelets," *Pattern Recogn. Lett.,* vol. 24, no. 9, pp. 2995-3006, Nov. 2003.
[2] M. K. Oh, B. Chung, R. Harjani, and D. J. Park, "A new noncoherent UWB impulse radio receiver," *IEEE Comm. Lett.,* vol. 9, no. 2, pp. 151-153, Feb. 2005.
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Achievements in 2009/2010

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Multimedia Traffic Engineering Laboratory

The Multimedia Traffic Engineering Laboratory (MTELAB) has primarily been focusing on a broad range of the traffic management technologies for next generation networks (NGN) such as QoS provisioning, traffic and congestion control, resource management, traffic measurement, network reliability, and protocol engineering. Presently, MTELAB is interested in three major parts: quality measurement of BcN service, future network traffic engineering, and quality of experience (QoE).

To guarantee network service quality, we focus on the development of measurement techniques such as bandwidth measurement and application identification, and based on these, we study quality guarantee methods for network coding and bio-inspired network engineering in various network conditions.

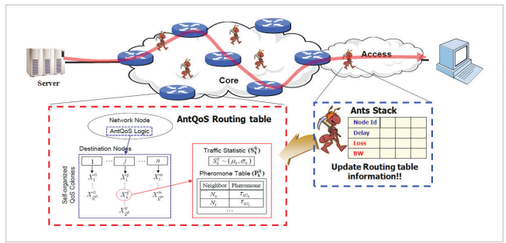

Fig. 1 Bio-inspired bandwidth allocation and CAC technique for QoE provisioning

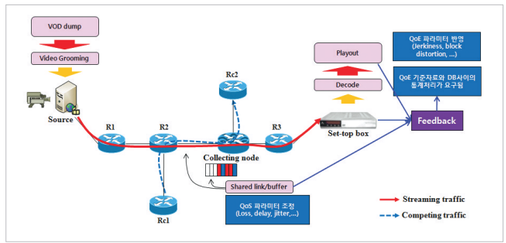

Fig. 2 Correlation derivation between QoS and QoE for video service

Concurrently, MTELAB is also interested in QoE, one of the promising future issues, and is actively contributing to the international standardization works of NGN, especially to the study group 12 of ITU-T.

Key Achievements

[1] I. T. Han and H. S. Park, "An integrated home server for communication, broadcast reception, and home automation," *IEEE Tr. Consumer Electron.,* vol. 52, no. 1, pp. 104-109, Feb. 2006.
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Achievements in 2009/2010

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Laboratory for Information Transmission

The Laboratory for Information Transmission (LIT) has been focusing on design and analysis of modern wireless communication systems. The main research areas are: multi-user communications, multi-carrier transmission on fast fading channel, link adaptation, MIMO network coding, and visible light communications (VLC).

Multi-cell, Multi-user MIMO: MIMO schemes are essential in modern wireless communication systems. Several algorithms related to space-time coding, low complexity MIMO detections, and precoding have been investigated to improve the system performance and reduce the complexity. Beyond these, we extend our study on the multi-cell, multi-user MIMO systems to reduce the inter-cell or inter-user interferences. For example, we study on the user scheduling and precoding algorithms associated with limited feedback environment and effects of spatial correlation in multi-cell MIMO systems.

OFDM ICI Cancellation: Next generation mobile communications based on OFDM is required to operate in rapidly time-varying environment. In this effort, we propose a channel estimation, equalization, and pre-coding schemes that suppress the effect of inter-carrier interference (ICI) due to mobility. Subcarrier-clustering and sharing techniques make it possible to develop the robust and low-complexity suppression schemes.

Link Adaptation: The quality of wireless channel varies with time and frequency. Therefore, link adaptation can be used to improve transmission performance. We proposed a new link adaptation approach adjusting the transmission parameters of the modulation level, coding rate, and spatial streams together. In addition to throughput improvement, low complexity and limited feedback are becoming increasingly important for link adaptation. We also developed a closed form expression of instantaneous bit error rate to efficiently control feedback information and quality of service.

MIMO Network Coding: Network coding has been proposed to maximize the flow of information in a network by linearly combining nodes. We focus our study on network coding combined with MIMO schemes to increase the throughput/reliability.

Key Achievements

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Networked and Distributed Computing Systems Research Laboratory

The Networked and Distributed Computing Systems Research Laboratory (NDSL) focuses on the performance, reliability, scalability, and security issues of the design and implementation of networked computer systems. Main research topics include scalable content distribution networks (CDNs), high-performance network server design, low-cost network infrastructure for the developing world, and network security. Our research goal is to find the fundamental design principles in building innovative computer systems that can be used to improve the quality of our daily computing life. We draw the techniques from an operating system and apply them to design novel networked systems. NDSL currently works on the following projects.

Network Infrastructure for the Developing World: We have developed a highly-efficient caching storage system, HashCache, that can store billions of objects in a low-cost laptop. HashCache can serve as inexpensive cache storage for Web and WAN acceleration for the developing world. HashCache was chosen as one of the top 10 technologies for 2009 by the MIT Technology Review magazine.

Scalable Networked Systems on Commodity Computer Hardware: PC-based software routers provide inexpensive platforms for flexible packet processing that reflects the modern network traffic demand. The main problem of software routers, however, is its low performance. We are building the fastest software router for a regular PC that can forward IP packets at the speed of 40+ Gbps. Our software router scales the computation power by exploiting graphics processing units (GPUs). GPUs provide ample computation power for data-parallel workloads and are ideal resources for parallel packet processing. We are also working on secure sockets layer (SSL) acceleration with GPUs.

Secure Network Framework: We look into the various issues in network security. Using secure hardware chips, such as the trusted platform module (TPM), we are building a network framework to eliminate security attacks such as DDoS, click frauds, spamming, etc.

Key Achievements

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[1] A. Badam, K. Park, V. Pai, and L. Peterson, "HashCache: Cache storage for the next billion," *USENIX Sympo. Networked Syst. Design, Implem.* Boston, USA, Apr. 2009.
[2] V. Pai, A. Badam, S. Ihm, and K. Park, "First-class access for developing-world environments," *CCC Workshop Computer Science, Global Developm.,* Berkeley, USA, Aug. 2009.

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Computer Engineering Research Laboratory

The Computer Engineering Research (CORE) Laboratory has contributed to (1) embedded systems, (2) hardware/software architecture of storage systems, and (3) the cloud computing system.

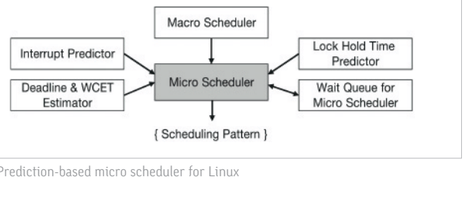

Fig. 1 Prediction-based micro scheduler for Linux

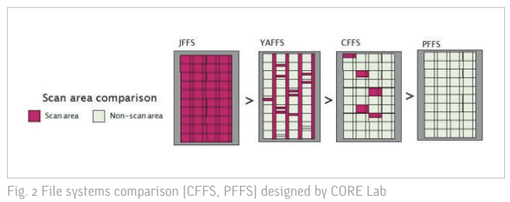

Fig. 2 File systems comparison (CFFS, PFFS) designed by CORE Lab

Fig. 3 Constructed cloud testbed at KAIST

We have developed several techniques (prediction-based micro-scheduler, interrupt handler migration, etc.) for embedded operating systems, and several flash file systems (CFFS, HFFS and PFFS) exploiting emerging memory technologies such as the PRAM. We also developed an energy-efficient MAC protocol (LAS-MAC) for the ubiquitous wireless sensor network and its testing environment. In addition, we have studied various user interfaces for a wearable computer, future museum, etc. Finally, we constructed a cloud R&D testbed (600 core, 1.3TB Memory, and 300TB Storage) at KAIST. This testbed was utilized by three research institutes (Seoul National University, University of Paris VI, and KAIST), and companies, for research on security, semantic search engine, searchable media broadcasting services, and even as a platform itself.

Key Achievements

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[1] J. Lee and K. H. Park, "Prediction-based micro-scheduler: Toward responsive scheduling of general-purpose operating systems," *IEEE Tr. Computers,* vol. 58, no. 5, pp. 648-661, May 2009.
[2] S. H. Baek and K. H. Park, "Striping-aware sequential prefetching for independency and parallelism in disk arrays with concurrent accesses," *IEEE Tr. Computers,* vol. 58, no. 8, pp. 1146-1152, Aug. 2009.

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Convergence and Advanced Network Engineering Laboratory

The Convergence and Advanced Network Engineering Laboratory (CANE LAB) has been established with a vision of educating and training world-class scholars and engineers in the area of networks and communications. We have two important philosophies: create the first new ideas, and be the first in practical applications. The lab has been producing sophisticated research results in the worldwide community. The main research area of CANE LAB focuses on ubiquitous wireless networks and broadband convergence networks beyond plain wireless networks and optical networks. Recently, we have been pioneering a new research topic by applying physics into network routing and information systems in wireless networks research area. This is being further extended to studies of nature-inspired IT technologies. Especially, the testbed which consists of one hundred nodes, as a result of autonomous load-balancing filed-based anycast routing (ALFA) research, will raise our competitiveness in this field.
In the area of optical networks, we investigate Ethernet networks and packet-optical networks. Especially, CANE LAB is recognized as one of the world leaders in developing Ethernet ring protection technology, providing key solutions for the framework design, switching behaviour, and multi-ring protection. Meanwhile, we are actively participating the standard organization such as IEEE and ITU-T. For example, we annually present more than ten consents at the organizations. As a result, we have accomplished the world's first commercialization of ERP technology by joint research with ETRI and Actus Networks in 2009.
In optical networks, we have introduced for the first time all-optical OFDM transmission theory for high data transmission. All-optical transmission is one of the strongest candidate for 100Gbps or higher data transmission, which reduces optical transmission penalties due to optical non-linearity and chromatic dispersions. We proposed an all-optical DFT/IDFT processor at first, and we are now playing a lead role in that area through a variety of applications.

Key Achievements

[1] J. K. Rhee, D. Chowdhury, K. Sing Cheng, and U. Gliese, "DPSK 32x10 Gb/S transmission modeling on 5x90 km terrestrial system," *IEEE Photon. Techn. Lett.,* vol. 12, no. 12, pp. 1627-1629, Dec. 2000.
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Achievements in 2009/2010

[1] S. Jung, K. Malaz, and J. K. Rhee, "Distributed potential field based routing and autonomous load balancing for wireless mesh networks," *IEEE Comm. Lett.,* vol. 13, no. 6, pp. 429-431, June 2009.
[2] S. Jung, D. Lee, K. Malaz, and J. K. Rhee, "Autonomous load balancing anycast protocol for wireless mesh networks," *IEEE Workshop Hot Topics Mesh Networking, World Wireless, Mobile, Multimedia Networks,* Kos, Greece, June 2009.

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Statistical Signal Processing Laboratory

Research activities in the Statistical Signal Processing Laboratory have mainly been on the fundamental theory and applications of various communication/signal processing techniques. Particularly, we have focused on studies related to weak signal detection, code acquisition, and frequency synchronization, and have obtained various interesting results. Recently, we have investigated the following quintessential techniques for the next-generation communication: ① decoding schemes for the multiple-input multiple-output (MIMO) systems and ② spectrum sensing schemes for cognitive radio.

1. Decoding schemes for MIMO systems:
   We have proposed a near maximum likelihood (ML) scheme for the decoding of MIMO systems. By employing the metric-first search method, Schnorr–Euchner enumeration, and branch-length thresholds in a single frame systematically, the proposed technique provides higher efficiency than other conventional, near-ML decoding schemes.
2. Spectrum sensing schemes for cognitive radio:
   Employing the generalized likelihood ratio test detector on each antenna branch and exploiting nonlinear diversity combining strategies, we have proposed a class of spectrum sensing schemes for cognitive radio with receive diversity. The performance characteristics of the proposed scheme have been analyzed in comparison with those of conventional schemes in Gaussian noise with various fading conditions.

The research results have been recognized in its significance and originality, having been published in an internationally reputable journal. The results are theoretically interesting, and at the same time, practically applicable in many areas. Currently, we are working on challenging problems in recurrent neural networks and MIMO systems. Specifically, we are studying a class of recurrent neural networks in the identification of finite state automata. In MIMO systems, applying the signal detection theory to the tree search, we are investigating a novel decoding scheme that offers significantly lower computational complexity than conventional decoders.

Key Achievements

[1] Y. H. Kim, I. Song, S. Yoon, and S. R. Park, "An efficient frequency offset estimator for OFDM systems and its performance characteristics," *IEEE Tr. Vehic. Techn.,* vol. 50, no. 5, pp. 1307-1312, Sep. 2001.
[2] I. Song, J. Bae, and S. Y. Kim, *Advanced Theory of Signal Detection,* Springer, 2002.
[3] I. Song, H. G. Kang, and T. An, *A novel complexity reduced maximum likelihood decoding method for multi-input multi-output systems,* 2442075, UK, Oct. 15, 2008.

Achievements in 2009/2010

[1] T. An, I. Song, H. Kwon, Y. H. Kim, S. Yoon, and J. Bae, "Decoding with expected length and threshold approximated (DELTA): A near ML scheme for multiple input multiple output systems," *IEEE Tr. Vehic. Techn.,* vol. 58, no. 7, pp. 3234-3246, Sep. 2009.
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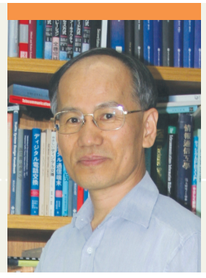

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Communication Networks Research Laboratory

The research activities at Communication Networks Research (CNR) Laboratory have focused on radio resource management and hybrid automatic repeat request transmission schemes for next generation mobile communication networks, interference mitigation schemes for wireless networks, quality of service (QoS) guarantee for communication networks, and machine type communication research for next generation network environment, especially for the smart grid network system.

We have proposed an orthogonal resource hopping multiplexing (ORHM) scheme in downlink and an orthogonal resource hopping multiple access (ORHMA) scheme in uplink. ORHM scheme yields a statistical multiplexing gain in downlink and ORHMA scheme provides a new multiple access technique to improve the uplink capacity of mobile communication networks.

Furthermore, a novel hybrid multiple access (HMA) scheme, which combines ORHMA and scheduling-based multiple access schemes, has been proposed for next-generation mobile communication networks and presented as a contribution to the IEEE 802.16m standardization meeting held in January 2008.

We have carried out several research projects such as Beyond 4G mobile communication systems, hybrid radio resource management for relay-based cellular networks, airborne communication protocols for tactical information communication networks (TICN), development of a simulator for the 3GPP LTE-advanced system, and mobile WiMAX system design.

Key Achievements

[1] S. M. Shin, C. H. Cho, and D. K. Sung, "Interference-based channel assignment for DS-CDMA cellular systems," *IEEE Tr. Vehic. Techn.,* vol. 48, no. 1, pp. 233-239, Jan. 1999.
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Achievements in 2009/2010

[1] C. Y. Jung, H. Y. Hwang, D. K. Sung, and G. U. Hwang, "Enhanced Markov chain model and throughput analysis of the slotted CSMA/CA for IEEE 802.15.4 under unsaturated traffic conditions," *IEEE Tr. Vehic. Techn.,* vol. 58, no. 1, pp. 473-478, Jan. 2009.
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Wireless Information Systems Research Laboratory

The research of the Wireless Information Systems Research Laboratory (WISRL) focuses on wireless communication and networking. The research topics include signal processing, statistical inference and communication theory with applications to next generation wireless networks, sensor networks and smart infrastructure, and related fields. The research direction of WISRL is two-fold: first, WISRL is trying to advance the fundamental understanding of large networks that will be the main issue of the system area in the future; second, WISRL is conducting research to improve the performance and devise innovative methods for current and next wireless communication systems.

Theory for Large Networks: One of the most important and long-standing open problems in the field of communications and networking is the lack of its general theory. This open problem is closely related to designing and commercialization of many types of important wireless networks. In this area, we investigate the possibility of the development of new abstractions and general theory capturing the essence of multi-node large networks, which may not be the Shannon framework.

Next Generation Wireless Networks: In this area, WISRL is conducting research on wireless communication systems and networks from the perspective of commercial applications such as 3G, 3G LTE/4G, and Beyond 4G. We are trying to come up with new wireless communication methods or architectures with significant performance improvement. Currently, we are working on interference management for next generation interference-limited wireless networks, and especially, the interference alignment as a potential candidate. We have invented a recursive algorithm for interference alignment based on least squares to minimize the norm of interference misalignment. Our algorithm obtains interference-aligning beam vector solution as an additive update of the previous value for time-varying channels, reduces the complexity drastically compared with the previous methods, and provides a commercial possibility for the idea.

Key Achievements

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[2] Y. Sung, L. Tong, and H. V. Poor, "Neyman-Pearson detection of Gauss-Markov signals in noise: Closed-form error exponent and properties," *IEEE Tr. Inform. Theory,* vol. 52, no. 4, pp. 1354-1365, Apr. 2006.
[3] Y. Sung, X. Zhang, L. Tong, and H. V. Poor, "Sensor configuration and activation for field detection in large sensor arrays," *IEEE Tr. Signal Process.,* vol. 56, no. 2, pp. 447-463, Feb. 2008.

Achievements in 2009/2010

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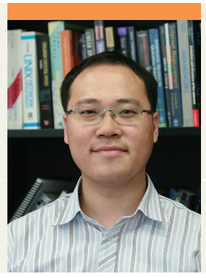

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Laboratory of Network Architecture, Design, and Analysis

The Laboratory of Network Architecture, Design, and Analysis (LANADA) was established in August of 2006, by Prof. Yung Yi. LANADA has conducted research on futuristic communication networking systems with its aim from fundamental theories and transferring it to practice. Nowadays, the communication networking systems have been changed vertically and horizontally at an alarming rate. Horizontally, various network infrastructures such as broadband access networks, wireless cellular/ad-hoc networks, wired core networks, and overlay networks have been evolved and combined together; and vertically, the division of each layer has become more ambiguous and cross-layer network designs are becoming more and more preferable. LANADA has focused on developing algorithmic and practical solutions of important networking problems, and their performance evaluation and analysis over various communication networking systems. We try to start looking at many problems fundamentally from theories and transfer them to practice by developing theory-driven algorithms and protocols.

Recently, we also expanded our interest in economic aspects in communication networking systems and network greening, which started to receive significant attentions these days, and are challenging due to its necessity to view problems from various angles and tools such as stochastic theory, control theory, economic theory, optimization theory, and even biological theory.

LANADA has established a strong collaboration with other research groups inside and outside of Korea, such as SK Telecom, Korea Telecom, North Carolina University, Princeton University, University of Texas at Austin, Microsoft Research lab, and Chinese University of Hong Kong, and strongly recommends the students in our group to visit and jointly research with them. Our lab consists of one postdoctoral research associate, three Ph.D., six M.S., one undergraduate student, and many domestic and international collaborators. Our recent research publications appear at various top conferences and journals, such as IEEE Infocom, ACM Mobihoc, ACM Sigmetrics, and IEEE/ACM Transactions on Networking.

Key Achievements

[1] Y. Yi and S. Shakkottai, "Hop-by-hop congestion control over a wireless multi-hop network," *IEEE/ACM Tr. Networking,* vol. 15, no. 1, pp. 133-144, Feb. 2007.
[2] Y. Yi and S. Shakkottai, "On the elasticity of marking functions in an integrated network," *IEEE Tr. Automatic Control,* vol. 54, no. 2, pp. 323-336, Feb. 2009.
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Advanced Network and Computing Laboratory

The Advanced Network and Computing Laboratory (ANCL), a founder of Grid Middleware Research Center, has been focusing on advanced computing middleware and development of service management systems in advanced networks, e.g. next generation network and future Internet. Especially, grid policy quorum-based resource management (PQRM) developed through the ITRC project for the past four years was evaluated as one of the best research projects by the government, Ministry of Education, Science and Technology in 2008.

We are also developing nano-sensor integrated micro-computing (NSIMC, Fig. 1) applicable for healthcare system, which is a sort of biocomputing system for the identification of metabolic mechanism using the biochemistry index of human cells. The NSIMC provides the clinical decision for the patient's metabolic syndrome using energy-circulation model in the cell-mitochondria and the collaborative environment for medical doctors, scientists and specialists.

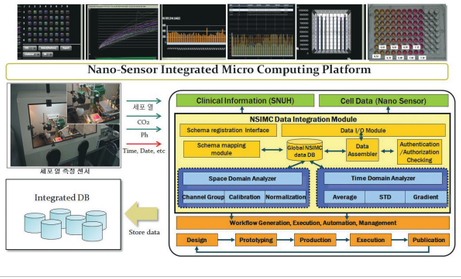

Fig. 1 NSIMC system architecture

As for biocomputing, we are developing an e-Organ simulation system that is utilizing cyber computing for in silico drug discovery to identify new drugs effectively from metadata of chemical compounds. This system provides high performance computing for experiments of drug discovery with coordination and efficient execution management of geographically distributed complex applications. Furthermore, this system helps researchers share multidisplinary computing, collaboration and simulation results. In 2010, ANCL starts a new national project for cloud computing-based personal mobile application system, which is being considered for commercial services.

Key Achievements

[1] S. Jung, C.-H. Youn, T.-S. Choi, T.-S. Jeong, D. Lee, and K.-S. Min, "Policy management for BGP routing convergence using inter-AS relationship," *J. Comm., Networks,* vol. 3, no. 4, pp. 342-350, Dec. 2001.

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Hong, Songcheol	Professor
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Kim, Joungho	Professor
Kwon, Young-Se	Professor
Lee, Chang Hee	Professor
Lee, Hee Chul	Professor
Lee, Kwyro	Professor
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Lee, Sang-Gug	Professor
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Myung, Noh-Hoon	Professor
Park, Chul Soon	Professor
Park, Hyo-Hoon	Professor
Park, Seong-Ook	Professor
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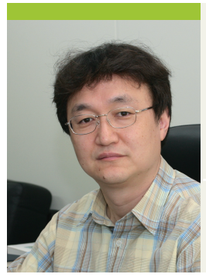
Shin, Sang-Yung	Professor
Won, Yong Hyub	Professor
Yang, Kyounghoon	Professor
Yoo, Hyung-Joun	Professor
Yoo, Seunghyup	Associate Professor
Yoon, Giwan	Professor
Yoon, Jun-Bo	Associate Professor
Yu, Jong-Won	Associate Professor
Yu, Kyoungsik	Assistant Professor



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Nano IC Technology Laboratory

The Nano IC Technology (NIT) Laboratory has been launched in 2007 by Prof. Byung Jin Cho. Research focus of the lab is to develop new technologies for future IC devices based on nano technology. The current research activities include near term solutions for DRAM and flash technology as well as long term solutions for future nano-IC devices such as graphene-based devices and nano energy devices.

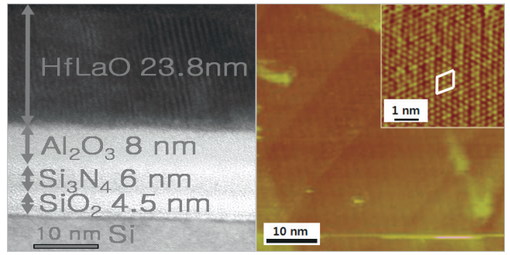

Fig. 1 TEM image of high-K thin film stack for flash memory device

Fig. 2 STM image of mono-layer graphene on platinum

The NIT Lab developed La doped cubic structured-HfO_2 (HfLaO) as a new high-K material which has the highest K value among HfO_2 based dielectrics. Fabricated together with ZrO_2, planar cell capacitors satisfy 30nm DRAM technology specification and can be directly applicable to DRAM manufacturing. A new blocking oxide for charge trap type flash memory device was also developed, demonstrating improved erase speed and P/E window as well as the charge retention property.

Large area, high quality graphene, which is a single layer of carbon atoms in honeycomb structure, is synthesized on thin film Pt for the first time, then successfully transferred on SiO_2. Now NIT Lab has world-top level graphene synthesis technology. In addition, a non-volatile resistive memory using graphene oxide is developed and it shows excellent flexibility and retention properties. Other technologies to realize graphene based integrated circuit are being actively studied, including the interaction between graphene and dielectrics, hybrid (organic/inorganic) gate dielectrics, etc.

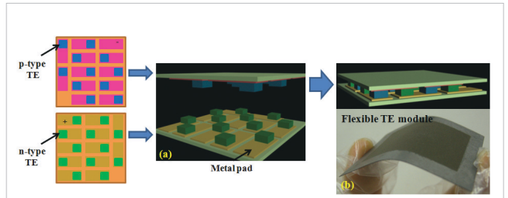

Fig. 3 Flexible thermoelectric module fabricated by screen printing method

The thin film thermoelectric module, which converts thermal energy to electric energy, is successfully made by the screen printing method using low-cost and eco-friendly materials and processes. This technique enables us to fabricate flexible thermoelectric modules that can be applied to arbitrary shaped heat sources.

Achievements in 2009/2010

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Circuit Design and System Application Laboratory

The Circuit Design and System Application Laboratory was established in KAIST in 1984. Nine masters students and ten doctoral students in our laboratory are currently enrolled in the graduate courses of KAIST. The research and administrative members in our laboratory are led by professor Gyu-Hyeong Cho. Major research areas are focused on designing analog IC, power management IC, display driver IC, and bio-chips.

1. **Power Management IC (DC-DC Converter)**
   IC is important in portable electronic devices which get their operation powers from batteries. Power management technology can generate various controlled voltages from a battery which are required for the sub-circuits in the device. SIMO can generate multiple controlled voltages from a single battery with a single inductor, which can reduce the size and cost of the DC to DC converters.
2. **Class-D Audio Amplifier and Envelop Modulator for Polar RF Transmitters**
   Class-D audio amplifiers have significant advantages in many applications (lower power dissipation, circuit board space and cost, and battery life extension).
   Moreover, the combination of class-D, which is the extension of DC-DC converter, and class-AB has been successfully implemented in envelope modulator for polar RF transmitter suitable for EDGE communicational standard by extending the operation speed.
3. **Data Drivers for LCD and AMOLED Displays**
   Our researches in data driver ICs for displays are mainly focused on high resolution and low power-consumption in driving schemes. Another special interest in our research is aiming at AMOLED displays. Innovative driving schemes and dedicated circuits for AMOLED drivers have been developed for fast and accurate AMOLED data driver ICs.
4. **Bio-Chip for a Biological Molecule**
   In order to analyze a bio-molecule in the experiment laboratory, complex processes are required. These processes require much time and expense, a large size of equipments and work spaces. Thus, our researches are focused on design diagnosis chips using antigen-antibody reaction, impedance detection chips, and FET sensor using surface.

Key Achievements

[1] Y. J. Woo, H. P. Le, G. H. Cho, G. H. Cho, and S. I. Kim, "Load-independent control of switching DC-DC converters with freewheeling current feedback," *IEEE J. Solid-State Circuits,* vol. 43, no. 12, pp. 2798-2808, Dec. 2008.

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[3] Y. J. Jeon, H. M. Lee, S. W. Lee, G. H. Cho, H. R. Kim, Y. K. Choi, and M. H. Lee, "A piecewise linear 10 bit DAC architecture with drain current modulation for compact LCD driver ICs," *IEEE J. Solid-State Circuits,* vol. 44, no. 12, pp. 3659-3675, Dec. 2009.

Achievements in 2009/2010

[1] C. Kim, C. S. Chae, Y. S. Yuk, Y. G. Kim, J. K. Kwon, and G. H. Cho, "A 105dB-gain 500MHz-bandwidth 0.1Ω-output-impedance amplifier for an amplitude modulator in 65nm CMOS," *IEEE Int. Solid-State Circuits Conf.,* San Francisco, USA, Feb. 2010.

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System VLSI Laboratory

Main research interests of the System VLSI Laboratory (SVL) are reconfigurable system algorithm core IP design, MPSoC based intelligent cell design, and energy harvesting convergence system sensor/actuator network design.
Reconfigurable System Algorithm Core IP Design: One of the big issues in advanced system design is how to effectively implement its complex algorithms with real-time and low-power requirements. The SVL's approach is to thoroughly analyze the system algorithms and devise some optimal architectures meeting conflicting system requirements. These architectures are system algorithm core IPs. System algorithms of interest in the lab are those of cryptography, 3D-multimedia, and mobile communication. Currently, we are focusing on cryptography algorithm core IP and digital radio frequency transceiver's all-digital PLL (ADPLL) IP.
MPSoC Based Intelligent Cell Design: 'Small, Green, and Smart' is today's keyword. To achieve this, the lab, SVL, is conducting research on MPSoC based Intelligent Cell. Cells are composed of MPSoC, i.e., many microprocessors and/or DSPs, memories, and on-chip network (OCN). It is very small, consumes low energy, and analyzes very complex phenomena. MPSoC based intelligent cell design includes parallel processing, energy calculation methodology, network parameter evaluation and modeling, and SoC design methodology. Main application areas of interest are noisy video and audio signal processing.
Energy Harvesting Convergence System Sensor/Actuator Network Design: A world wide issue is 'IT Convergence'. That is to apply well advanced IT technologies to science and engineering. In this regard, the SVL is focusing on energy harvesting convergence system, sensor/actuator network design in the ocean, and fishery science/engineering and plant science. The electric energy is obtained by conversion from the sun, wind, wave, and movement. The science and engineering requirement adapted sensors and actuators are properly applied to the system in question, and optimally networked. The R&D is to be done in cooperation with the KAIST Digital Media Laboratory (DML) that has long been conducting advanced multi-disciplinary media projects. Presently, we are conducting an IT convergence project with the National Fishery Research and Development Institute (NFRDI) on an energy harvesting under-sea light emitting module for jigging fishery.

Key Achievements

[1] W.-C. Song, H.-W. Choi, S.-U. Kwak, and B.-S. Song, "A 10-b 20-Msamples/s low-power CMOS ADC," *IEEE J. Solid-State Circuits,* vol. 30, no. 5, pp. 2827-2847, May 1995.
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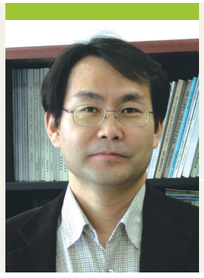

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Advanced Display and Nano Convergence Laboratory

The Advanced Display and Nano Convergence Laboratory (ADNC Lab) has focused on advanced displays and nano convergence devices, especially flexible and transparent display devices and plasmonic applications for display and energy devices. The Center for Advanced Flexible Display Convergence (CAFDC) directed by the ADNC Lab was chosen as an Engineering Research Center (ERC) by the National Research Foundation of Korea (NRF), funded by the Ministry of Education, Science and Technology (MEST). In the impending society, the paradigm for information display devices is moving from conventional displays to novel display devices such as flexible displays and transparent displays. In the near future, there will likely be a huge demand for new display applications. Prototype flexible photoluminescent display and transparent plasma display have been proposed, and the research for improving reliability of display devices is underway. Moreover, development of flexible transparent display is in progress.

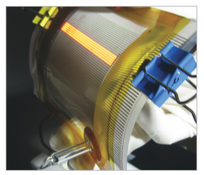

Fig. 1 Flexible photoluminescent display

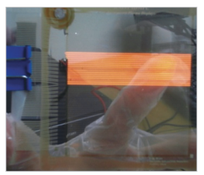

Fig. 2 Transparent plasma display

Surface plasmon-enhanced spontaneous emission rate phenomena were applied in order to improve the efficiency of OLEDs and PDP phosphors in research that utilized Ag cluster-incorporated nano-structures. Ag cluster-deposited cathode structures and solution-based coated Ag nano-particles were studied in an effort to improve the efficiency of the OLEDs and PDP phosphors, respectively. In addition, Ne emission-induced secondary electron emission (SEE) enhancement in the MgO layer, the dielectric protecting layer of a PDP, was studied using localized surface plasmon resonance on the surface of spray-coated Au nano-particles.

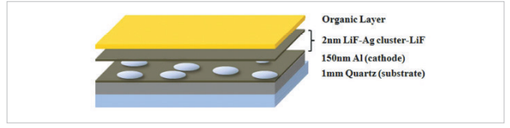

Fig. 3 A sample for SP-enhanced fluorescence by Ag clusters

Key Achievements

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Achievements in 2009/2010

[1] C. S. Choi, S. I. Ahn, and K. C. Choi, "The compact size piezoelectric transformer to lower an operating voltage of plasma display devices," *Int. Meeting Inform. Display,* Ilsan, Korea, Oct. 2009. (Outstanding Poster Paper Award, Korean Information Display Society, Oct. 2009.)
[2] K. C. Choi, S. H. Kim, C. Jang, K. J. Kim, and S. I. Ahn, "Fabrication of flexible photoluminescent display for improving reliability," *Int. Meeting Inform. Display,* Ilsan, Korea, Oct. 2009. (invited talk)

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Nano-Oriented-Bio-Electronics Laboratory

The Nano-Oriented Bio-Electronics Laboratory (NOBEL) centralizes its endeavour toward two branches; research for fusion of nano- and bio-technology, and exploratory devices. In the field of bio research, a nanogap field effect transistor (FET) fabricated by standard CMOS process was proposed for label-free detection of biomolecules such as avian influenza. The nanogap FET biosensor monitors the change of the threshold voltage which originates from the change of the dielectric constant as a result of immobilized biomolecules in the nanogap. Biomolecules can also be detected by charge pumping technique. These biomolecules provide additional trap states and charges in the dielectric and it is observed through the charge pumping current. These approaches enable researchers to realize on-chip integration of biosensors with readout circuits and signal processing through the same steps, compatible with conventional CMOS processes.

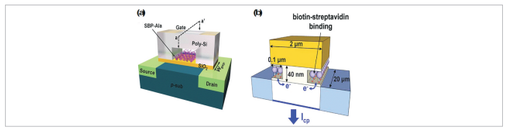

Fig. 1 Schematic of (a) nanogap FET and (b) charge pumping method

NOBEL has also focused on the Si-based exploratory device. One is a monolithic integration of NEMS-CMOS for mechanically flip-flopped fin memory transistor via full CMOS process technology. Even if a convergence of NEMS into CMOS technology is an essential factor for a viable product, NEMS memory devices are not commonly co-fabricated with CMOS circuits due to the dissimilarity in their fabrication processes. We demonstrated it with an established CMOS technology using FinFET for CMOS logic and fin flip-flop actuated channel (FinFACT) for NEMS memory. The other is a dopant segregated Schottky-barrier (DSSB) SONOS device for the 'world-best' high speed flash memory with low operation voltage. The sharp dopant-segregated Schottky contact at source side generates hot electrons, and enables high injection at a low voltage.

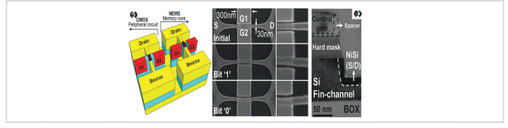

Fig. 2 Schematic/SEM image of (a) FinFACT and TEM image of (b) DSSB SONOS device

Key Achievements

[1] Y.-K. Choi, N. Lindert, P. Xuan, S. Tang, D. Ha, E. Anderson, T.-J. King, J. Bokor, and C. Hu, "Sub-20nm CMOS FinFET technologies," *IEEE Int. Electron Dev. Meeting,* Washington, USA, Dec. 2001.
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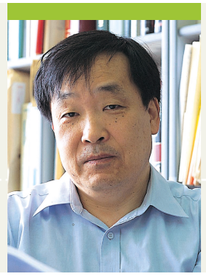

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Electromagnetic Wave Laboratory

The Electromagnetic Wave Laboratory aims for the development of new analytic solutions to electromagnetic problems. Our research activities cover a wide range of electromagnetics and microwave engineering. The research topics include electromagnetic wave scattering, antennas, and waveguides.
We are mainly interested in studying electromagnetic scattering, diffraction, and radiation problems. We solve the problems by using the Fourier transform and mode matching technique. We are also interested in electromagnetic interference and compatibility (EMI/EMC), electrostatic/magnetostatic problems, and acoustic problems. We have been conducting various projects supported by governmental organizations. We analyzed the radiation properties of the leaky wave antennas and Vivaldi slot antennas. We developed the solution tool of EMI problems. Also we worked on the project of the corrugated circular waveguide and EMI software supported by various government research establishments. The development of a new mathematical technique for wave scattering and diffraction is the goal of the Electromagnetic Wave Laboratory.

Key Achievements

[1] H. H. Park and H. J. Eom, "Electromagnetic penetration into a rectangular cavity with multiple rectangular apertures in a conducting plane," *IEEE Tr. Electromagn. Compat.,* vol. 42, no. 3, pp. 303-307, Aug. 2000.
[2] Y. H. Cho and H. J. Eom, "Analysis of a ridge waveguide using overlapping T-blocks," *IEEE Tr. Microw. Theory, Techn.,* vol. 50, no. 10, pp. 2368-2373, Oct. 2002.
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Wave Embedded Integrated Systems Laboratory

The research area of the Wave Embedded Integrated Systems Laboratory covers RF transceiver for wireless communication and RADAR systems. There are two groups that dedicate to each research topic: future transceiver (FT) and system-on-a-chip (SOAC).
The main topics of FT group are CMOS power amplifier and digital-RF transmitters, which are the most important issues that determine the performance of various mobile handset applications. Recently, many efforts have been made to improve the efficiency of a power amplifier which consequently affects the life-time of a cell-phone battery. Digital-RF transmitter is the new research area which will lead to the increased flexibility, programmability and better tolerance against PVT variation.

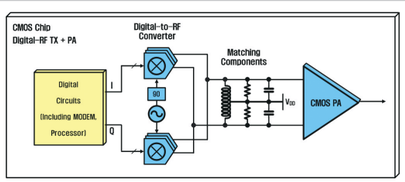

Fig. 1

Another research group, SOAC, focuses on sensor system using miniaturized radar. This group has pursued studies of radar systems, which can be applied to various industries, based on the Si semiconductor design technology. The SOAC group is mainly interested in RF front-end of miniaturized radars. A radar sensor system detects the position (range and angle) and the velocity of target by the echo signal returning from the target. This group has been studied remote bio-sensors which extract heart-beats and respiration signals, and image sensor which can get the information of distance and shape of an object for the application of the robot vision.

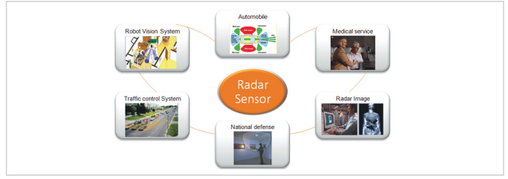

Fig. 2

Key Achievements

[1] D. Hah, E. Yoon, and S. Hong, "A low-voltage actuated micromachined microwave switch using torsion springs and leverage," *IEEE Tr. Microw. Theory, Techn.,* vol. 48, no. 12, pp. 2540-2545, Dec. 2000.
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Achievements in 2009/2010

[1] H. Lee, C. Park, and S. Hong, "A quasi-four-pair class-E CMOS RF power amplifier with an integrated passive device transformer," *IEEE Tr. Microw. Theory, Techn.,* vol. 57, no. 4, pp. 752-759, Apr. 2009.
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Medical Image and Signal Analysis Laboratory

Our research mainly focuses on the development of techniques for medical image and signal analyses. We have been trying to improve a conventional diagnosis that relies on the visual interpretation of images from a diseased tissue or electronic signals from subjects. Research techniques include signal/image processing, feature calculation, and pattern recognition that can eventually be applicable to the development of novel computer aided diagnosis or detection (CAD). These CAD methods often help clinicians to detect abnormal attributes from a patient's data in a more accurate and efficient manner so that the best clinical decision can be made repeatedly and reliably. Recently, in the fields of several human diseases, we have been actively developing a number of CAD methods applicable to the detection of a rarely occurring form of atrial fibrillation, cancer areas in prostate tissue slides, and bone healing after dental treatments.
Silent atrial fibrillation is difficult to detect early due to its rare occurrence. Since it is associated with strokes, its early detection is important. We are trying to improve the prediction of atrial fibrillation subjects by analyzing dynamic patterns representing the correlation of two successive heartbeat intervals. Using this method along with visual interpretation of electrocardiogram (ECG), a cardiologist may be able to improve his or her ability to detect a rarely occurring episode of atrial fibrillation.
Due to the advancement of automated microscopes, a whole histologic tissue can be digitized within several tens of minutes producing a vast amount of image data (more than 20 Gbytes per slide). Since the visual interpretation of these large images by pathologists can be tiresome and costly, a fully automated analysis of these images is highly anticipated. However, due to the heterogeneous nature of malignant tissues, it remains a difficult task.
Dental X ray images are commonly used to assess the treatment efficacy following the lesion treatment. However, visual interpretations of subtle bone changes in routine X-ray images are not reliable due to the variations in X-ray imaging factors. We have developed a multiscale image analysis technique for quantitative assessment of bone healing patterns that should aid dental radiologists to detect treatment failures early for the timely retreatment or intervention.

Key Achievements

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Achievements in 2009/2010

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[2] S. Kim, H. Jeong, H. Choi, and D. Kim, "Automatic histologic grading for lobular carcinoma in situ," *World Congress Medical Phys. Biomed. Engin.,* Munich, Germany, Sep. 2009.

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Terahertz Interconnection and Package Laboratory

The research of the Terahertz Interconnection and Package Laboratory (TERA Lab) focuses on three-dimensional integrated circuit (3-D IC) systems. With the increasing demands on high performance electronic devices with smaller form factor, interconnection and I/O density have also dramatically increased. Therefore, it is becoming more important to integrate various functional ICs in one small united system. As a powerful solution to increase packaging density and system performance simultaneously to realize 3-D IC, through silicon via (TSV) is a core technology which provides a vertical interconnection with greatly reduced interconnect length among stacked dies as shown in Fig. 1. Another key item for 3-D IC is a silicon interposer which can integrate heterogeneous dies with providing not only the horizontal interconnect from inter-metal or re-distribution layer (RDL), but also the vertical interconnect from TSVs.

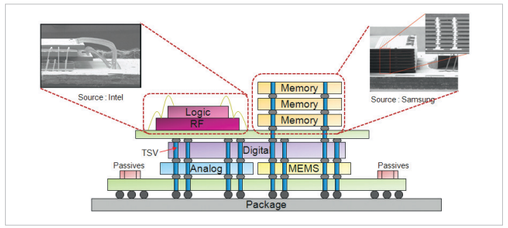

Fig. 1 Concept of 3-D IC

Therefore, researches of the TERA Lab is focusing on 3-D IC designs considering signal integrity (SI), power integrity (PI), routability for interconnects, power consumption, and thermal reliability issues.
Especially, since signal integrity cannot be guaranteed because of capacitive and lossy characteristics of TSV, the TERA Lab has focused on electrical modeling of TSVs and analysis of crosstalk issues due to highly denser I/Os. Achievements of the TERA Lab in 2009 included proposing scalable TSV model and analyzing TSV-to-TSV or TSV-to-active circuit crosstalk effects to guarantee SI and PI. By using these achievements, the TERA Lab developed design methodologies for advanced 3-D IC design.

Key Achievements

[1] D. H. Jung, C. H. Ryu, H. S. Kim, C. H. Lee, J. H. Kim, K. C. Bae, J. H. Yu, H. J. Yoo, and J. H. Kim, "Chip-package hybrid clock distribution network and DLL for low jitter clock delivery," *IEEE J. Solid-State Circuits,* vol. 41, no. 1, pp. 274-286, Jan. 2006.
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Achievements in 2009/2010

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Opto-Electronics Laboratory

The Opto-Electronics Laboratory was founded in 1979 and has been interested in demonstration of high speed optical and wireless communication systems using technology integration based on optical device technology (LD, LED, PD), electronic device technology (HBT, MESFET, FECFET), and package technology (SiOB, SOPS). Since the foundation of the Opto-Electronics Laboratory, we have tried to pursue a unique and creative evolution for our research topics.
We propose that the microwave packages consist of selectively anodized aluminum substrate for high power package modules. Using a selectively anodized aluminum substrate, high power bare MMICs are mounted on the aluminum to dissipate easily heat from bare chips and high quality passive devices are made on the thick alumina (anodized aluminum) region. The requirement for electronic devices and systems with small size, light weight, and high integration and performance demands that electronic package and substrate companies develop substrates with low cost, excellent thermal and electrical properties. Low-cost, ultra-thin, and compact package technology is proposed using selective anodized aluminum substrate. Fig. 1 shows the proposed structure of the package with the tolerance of size variation. Using the process of anodization, a thick selectively anodized aluminum oxide (Al_2O_3) with high dielectric properties is formed on an aluminum substrate. High-performance passive circuits are integrated on the thick Al_2O_3 film. Active bare chips or MMIC dies are usually mounted on the aluminum substrate, which works as a path for thermal dissipation, and the signal lines are interconnected using bonding wires. A more advanced technology named the 'pocket embedding package (PEP)' was developed to achieve a size reduction and electrical performance improvements. Using the PEP technology, the active dies are embedded inside the package to dissipate heat effectively from chips and reduce the dimensions and height of the package.

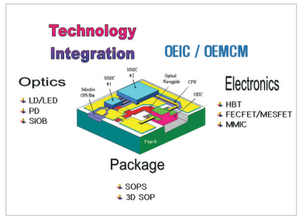

Fig. 1

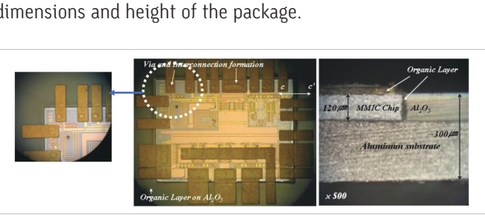

Fig. 2

Key Achievements

[1] S. K. Yeo, K. M. Kim, Y. S. Kwon, and J. H. Chun, "Quasi-coaxial vertical via transitions for 3-D packages using anodized aluminum substrates," *IEEE Microw., Wireless Components Lett.,* vol. 19, no. 6, pp. 365-367, June 2009.
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[1] S. K. Yeo and Y. S. Kwon, "Three-dimensional interconnect for multilayer module packages with a selectively anodized aluminum substrate," *IEEE Electron Dev. Lett.,* vol. 45, no. 13, pp. 678-680, June 2009.
[2] J. M. Yook, K. M. Kim, and Y. S. Kwon, "Suspended spiral inductor and band-pass filter on thick anodized aluminum oxide," *IEEE Microw., Wireless Components Lett.,* vol. 19, no. 10, pp. 620-622, Oct. 2009.

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Photonic Networks Research Laboratory

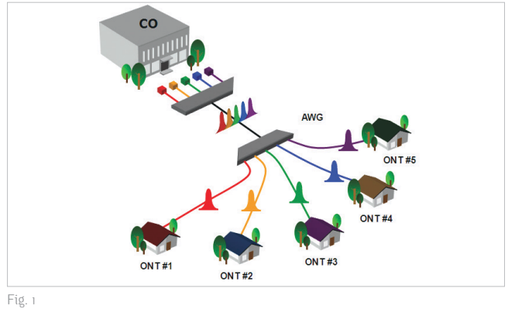

Fig. 1

Quadruple play services, converged service of voice, data, wireless, and video, will play a key role in the future access networks. This will simplify network management and billing systems. Further simplification of the network will be accomplished by employing fiber-to-the home (FTTH) based on a passive optical network (PON). A wavelength division multiplexing (WDM)-PON is considered to be the ultimate goal of the access networks, since it can deliver almost unlimited dedicated bandwidth with protocol transparency. The Photonic Networks Research Laboratory (PNRL) has been focusing on technologies enabling optical access networks, such as WDM-PON architectures including high-speed WDM-PONs based on wavelength-locked Fabry-Perot laser diodes (F-P LDs). To make WDM-PONs reliable and field deployable, protection methods and low noise BLS based on mutually injected F-P LDs with RF modulation were investigated. We also investigated methods to use mutually injected F-P LDs as a broadcasting light source. We improved transmission capacity by reducing intensity noise in the wavelength-locked F-P LD using a polarization independent F-P LD. Moreover, we derived analytic expression for relative intensity noise (RIN) and theoretical model of wavelength-locked F-P LD to understand physical mechanism clearly. We also proposed an evolution scenario from the existing time division multiplexing-PON (TDM-PON) to WDM-PON, with video overlay and a remotely reconfigurable remote node (RN) to provide next generation services (WDM-PON) from legacy services (TDM-PON). For the WDM-PON using tunable lasers, we proposed an automatic wavelength control system by detecting backscattered power or beating noise.
As stated above, PNRL has an infrastructure for research on breaking through technologies for photonic networks.

Key Achievements

[1] H. Kim, S. Kang, and C. Lee, “A low-cost WDM source with an ASE injected Fabry-Perot semiconductor laser,” *IEEE Photon. Techn. Lett.,* vol. 12, no. 8, pp. 1067-1069, Aug. 2000.
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[1] J. Moon, K. Choi, S. Mun, and C. Lee, “An automatic wavelength control method of a tunable laser for a WDM-PON,” *IEEE Photon. Techn. Lett.,* vol. 21, no. 5, pp. 325-327, Mar. 2009.
[2] J. Jeong, H. Lee, and C. Lee, “1.25-Gb/s operation at 50-GHz channel spacing based on intensity noise suppression of wavelength-locked Fabry-Perot laser diode,” *IEEE Photon. Techn. Lett.,* vol. 21, no. 9, pp. 602-604, May 2009.

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Infrared Image Sensor Laboratory

Infrared detector is the main research theme of the Infrared Image Sensor Laboratory (IRIS LAB). We focused on the cooled type infrared sensor prior to 2005, and transition to the uncooled type has been made afterwards. Our research result has led to the beginning of an infrared camera venture company, I3system, whose CEO is the first Ph.D. alumni of the IRIS LAB.
Now, we are focusing on the uncooled infrared detectors which are expected to be used more widely than the cooled one for their low price and reasonable performance.
Currently, the infrared sensor team in our laboratory is studying the novel bolometer material and the micro-cantilever type capacitive IR sensor which uses bi-material effect (Fig. 1). The former is under a brisk research whereas the latter is at the finishing step.

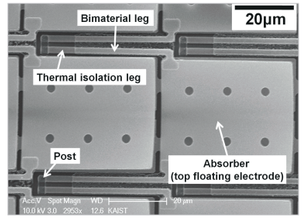

Fig. 1 IRIS capacitive IR sensor

Along with our IR sensor research, the packaging team in our laboratory is focusing on the vacuum package for the infrared sensor. To prevent thermal loss and enhance the responsivity of the infrared sensor, the vacuum packaging becomes a key technology. Besides, the packaging is the most expensive part of the infrared sensor fabrications. Thus, we are studying wafer level vacuum packages with high IR transmission and high vacuum level for low cost sensor packages.
The IRIS LAB also researches the radiation hardness for aerospace electronics. Radiation damage on integrated circuit due to an incident energetic particle causes functional failure of the electronic device and bit flip in memory devices. The radiation hardening of Si integrated circuit for aerospace electronics is investigated through consideration of radiation total ionizing does (TID) damage and single event effect (SEE) damage by a cosmic ray or particles in the Van Allen belt. To minimize the radiation damage, the hardening work should be performed at both the cell level and the circuit level. We are researching device simulations for evaluating effectiveness of a proposed rad-hard MOSFET structure designed by layout modification technique, and circuit design solutions for high performance rad-hard ICs.

Key Achievements

[1] J. K. White, C. A. Musca, H. C. Lee, and L. Faraone, “Hydrogenation of ZnS passivation on narrow-band gap HgCdTe,” *Appl. Phys. Lett.,* vol. 76, no. 17, pp. 2448-2450, Apr. 2000.
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[3] B. H. Kim and H. C. Lee, “Smart TDI readout circuit for long-wavelength IR detector,” *Electron. Lett.,* vol. 38, no. 16, pp. 854-855, Aug. 2002.

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[2] I. W. Kwon, H. J. Son, D. S. Kim, C. H. Hwang, Y. S. Lee, and H. C. Lee, “A cantilever-type uncooled infrared detector with high fill-factor and low-noise characteristic,” *IEEE Electron Dev. Lett.,* vol. 30, no. 6, pp. 635-637, June 2009.

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Wireless Physical Layer Communication Laboratory

The research of the Wireless Physical Layer Communication Laboratory (WPCL) focuses on the wireless physical layer communication system, which includes both the RF and baseband analog/digital circuitry, specifically the low power CMOS circuit design. In addition to R&D, we are highly emphasizing a high-tech entrepreneurship.
The recent R&D topic is the development of multi-band/multi-mode programmable radio receivers and SAW-less RF transceiver for software defined radio (SDR). Modern cellular phones are expected to have more than 10 radios, mobile TV, WLAN, Bluetooth, RF-ID, and so forth. The above technology is possible when the challenges of broadband matching, wide band selectivity/sensitivity, a sufficient gain with wide bandwidth, a high linearity, and a small noise are settled nicely. It is a great challenge to provide this with acceptable performance with the smallest form factors and cost. To provide solutions for the challenges based on double-conversion TV tuner IC development using silicon BiCMOS in the early 1990's, Kwyro Lee and his colleagues have invented many novel ideas, such as highly linear CMOS circuits using multiple gated transistor (MGTR) techniques, CMOS complementary parallel push-pull (CCPP) amplifiers, polylithic integration of SAW reference oscillators, and an image rejection with digital compensation. Our research team has successfully developed a 2.4GHz single-chip transceiver radio for ZigBee/IEEE 802.15.4 applications among wireless personal area network (WPAN) standards, and the developed radio chip is utilized to implement a health monitoring MICROS system.
Our recent research includes user interface (UI) technology for a mobile information device in the future. Touch sensors, sensing algorithms and modeling, and feedback techniques are the main issues. Using mutual capacitive sensing method, we have developed the high performance CMOS touch sensor read-out IC (ROIC).

Key Achievements

[1] P. Choi, H. Park, S. Kim, S. Park, I. Nam, T. Kim, S. Park, S. Shin, M. Kim, K. Kang, Y. Ku, H. Choi, S. Park, and K. Lee, "An experimental coin-sized radio for extremly low-power WPAN (IEEE 802.15.4) application at 2.4 GHz," *IEEE J. Solid-State Circuits,* vol. 38, no. 12, pp. 2258-2268, Dec. 2003.
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[2] D. Im, H. Kim, and K. Lee, "A CMOS resistive feedback differential low-noise amplifier with enhanced loop gain for digital TV tuner applications," *IEEE Tr. Microw. Theory, Techn.,* vol. 57, no. 11, pp. 2633-2642, Nov. 2009.

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Photonics Application Laboratory

We fabricated various micro-/nano-structures on glass by changing the various laser parameters of a Ti: sapphire femtosecond laser to find the interaction of femtosecond laser with glass material. It was found that regular and closely joined spherical nano-structures were increased with the increase of speed of the translation stage. Nano-structures down to 16nm was fabricated on a glass material. The size of the micro lines were decreased with the decrease of laser energy per pulse. As the pulse duration was increased, the number of structures (holes, micro- and nano-structures) was more when the laser was applied twice (forward and backward) compared to one time laser shine.
Due to the rapid growth of internet with a new generation of services and applications, the demand for a faster and cheaper access network has been rising. Mostly, time division multiplexed (TDM)-PON is deployed in all parts of the world. In order to mitigate the future demand, some next generation PON systems have been investigated by the researchers. In this research, we will examine the current status of PONs and investigate the probable future PONs. We will also explain the smooth migration process from the current status to the future technologies. Architecture of a self-restored tree-type hybrid wavelength division multiplexed/TDM-PON (WDM/TDM-PON) has been proposed for migrating from TDM to WDM-PON. The proposed architecture has the ability to provide the networking support to multiple WDM-PONs and TDM-PONs simultaneously. Due to the restorable capacity of the architecture, the availability of the system has increased. In addition, cost analysis of different PON architectures are performed and compared with the cost of the proposed architecture. It is found that the proposed architecture provides a more cost-effective solution.
We studied the temperature effects on anomalous radio duct propagation in the Korean coastal region. It was found that atmospheric radio ducts can trap VHF/UHF radio waves and propagate them over long distances. 284.4625MHz Japanese radio wave signal measurements show that the radio waves are propagated to Korean coastal regions when the ground temperature exceeds 10℃. This paper discusses the reasons for the existence of this critical temperature threshold.

Key Achievements

[1] S. Ahn, I. Cho, B. Rhee, and M. Lee, "Pluggable optical board interconnection system with flexible polymeric waveguides," *IEEE Photon. Techn. Lett.,* vol. 20, no. 8, pp. 572-574, Apr. 2008.
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Achievements in 2009/2010

[1] M. S. Ahsan, M. S. Lee, S. H. S. Newaz, and S. M. Asif, "Migration to the next generation passive optical network," *Int. Conf. Computer Sciences, Converg. Inform. Techn.,* Dhaka, Bangladesh, Dec. 2009.
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Micro-Radio Laboratory

The Micro-Radio Laboratory (μ-Radio Lab) has focused on CMOS integrated circuit designs since 1998. The main research area consists of RF front-end, baseband analog, mixed-mode (synthesizer, ADC/DAC), high speed optical circuits, and digital calibration techniques. The lab's research topics include DTV tuner, impulse-radio UWB (IR-UWB) radar, wake-up receiver, digital RF system, display semiconductor, FM receiver, advanced transceiver system modeling, etc. Some of the research details are as follows.

Digital TV Tuner: In line with digital convergence on video and TV technology, the μ-Radio Lab has made a persistent effort in DTV tuner IC development, and developed a DVB-T/DVB-H dual band tuner and an ISDB-T tuner. Now the research phase moves to a multi-standard DTV tuner development which covers ATSC, DVB-T, DVB-C, and open-cable.

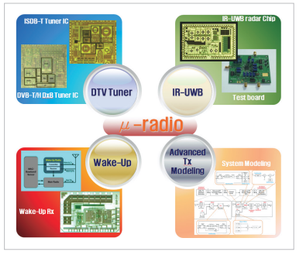

Fig. 1

Impulse Radio UWB Application: The μ-Radio Lab developed a low-power IR-UWB transceiver for IEEE 802.15.4a standard and low-power, low-cost, and low-complexity IR-UWB radar for movement detection.

Wake-Up Receiver: Low power consumption is one of the major design issues in wireless sensor networks due to its limited battery life. The key issues are ultra-low power consumption, extremely short latency, and reliability. The μ-Radio Lab has developed a few μA current consumption wake-up receivers.

Advanced Transceiver System Modeling: To save the time and cost of an IC development, a precise and predictable SoC modeling is demanded. The research includes behavioral modeling for individual blocks, performance parameter extraction from the blocks, and performance prediction with simulation. In addition, the effect of substrate coupling is modeled. The μ-Radio Lab recently focuses on an optimal RF architecture development for the 3GPP LTE specification.

Key Achievements

[1] H. H. Nguyen, H. N. Nguyen, J. S. Lee, and S. G. Lee, "A binary-weighted switching and reconfiguration-based programmable gain-amplifier," *IEEE Tr. Circuits, Syst. II: Express Briefs,* vol. 56, no. 9, pp. 699-703, Sep. 2009.

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[3] J. P. Hong and S. G. Lee, "Low phase noise Gm-boosted differential gate-to-source feedback Colpitts CMOS VCO," *IEEE J. Solid-State Circuits,* vol. 44, no. 11, pp. 3079-3091, Nov. 2009.

Achievements in 2009/2010

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Nano IC Technology Laboratory

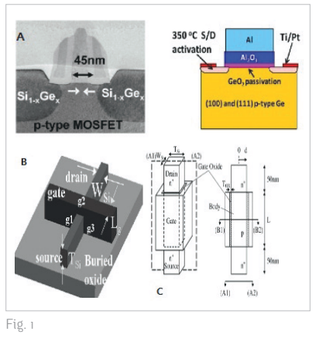

Fig. 1

The research of the Nano IC Technology Laboratory (NIT) focuses on nano scale CMOS devices and processing. The research topics include high mobility channel devices, 22nm logic transistor device/processing development, transistor threshold voltage variability, and vertical cell transistor DRAM.

A) High Mobility Channel Device: As the device is scaling down, the doping concentration of substrate has to increase due to preventing the transistor from the short-channel effect. Because of this doping concentration, the mobility in channels is decreasing by impurity scattering. As generation proceeds, therefore, mobility enhancement technology need high performance transistors. Our research group is going to investigate this topic by using strain technology and germanium based transistors.

B) 22nm Logic Transistor Device/Process: One of the major problems for scaling CMOS is the high leakage problem. Leakage current increases with conventional planar MOSFET when scaled down. Recently, tri-gate has been investigated seriously because of its better short-channel effect characteristics and high performance. Our goals in this topic are low leakage current and high on-current at the low threshold voltage.

C) Vertical Cell Transistor: Conventional planar DRAM has a weakness in integration because there is a limit for the reduction of cell size. Recently, vertical DRAM cell has been used to reduce cell sizes. But there is a problem related with the floating body effect which is originated from a body contact problem. The goals in this topic are understanding and modeling this problem.

D) Transistor Threshold Variability: Threshold mismatch is considered as a barrier for the future scaling technology. There are many factors which have impacts on this variation. Our purposes in this topic are verifying the factors which influence the threshold mismatch, and improving this problem.

From these topics, ultimately, NIT pursues high performance transistors with extremely small sizes which can be affordable.

Key Achievement

[1] S. Tyagi, C. Auth, P. Bai, G. Currello, H. Deshpande, S. Gannavaram, O. Golonzka, R. Heussner, R. James, C. Kenyon, S.-H. Lee, N. Lindert, M. Liu, R. Nagisetty, S. Natarajan, C. Parker, J. Sebastian, B. Sell, S. Sivakumar, A. St. Amour, and K. Tone, "An advanced low power, high performance, strained channel 65nm technology," *IEEE Int. Electron Dev. Meeting, Techn. Dig.,* Washington, USA, Dec. 2005.

Achievement in 2009/2010

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Semiconductor Energy Laboratory

The research of the Semiconductor Energy Laboratory (SEL) has been focused on developing and analyzing new and efficient photo-voltaic devices, low cost solar cell module fabrication methods, transparent conductive oxide, and new texturing method and its application. Transparent resistive random access memory (TRRAM) is also investigated.
For the high efficiency thin film solar cell, design of tandem structure is very important. We have protocrystalline silicon solar cell technologies, which show low-degradation characteristics. In the tandem solar cell, the protocrystalline silicon cell could be used as the top cell.
For the low-cost thin film silicon solar cell module fabrication, new integration methods are developed without laser scribing. We have cluster multiplicity systems for integrated solar cell mini modules. With the newly developed integration method, silicon solar cell layers are not air exposed in the fabrication process, so that we can expect the low-cost high-efficiency solar cell module fabrication.
The fabrication of a fully transparent resistive random access memory (TRRAM) device based on an ITO (indium tin oxide)/ZnO/ITO capacitor structure and its resistive switching characteristics are investigated. The fabricated TRRAM has a transmittance of 81% (including the substrate) in the visible region and an excellent switching behavior under 3V.
Also, We report the room temperature fabrication of highly transparent and flexible resistive random access memory devices on a flexible substrate. The ITO/Ag/ITO multilayered bottom electrode provides a superior flexibility as well as a high transparency compared to devices with ITO single bottom electrode during repetitive bending tests. The devices exhibit a high transmittance and excellent reliability of data retention. Moreover, they show a consistent memory performance even under thermal stress. The results of this study provide a breakthrough solution for the era of transparent and flexible electronic systems in the near future.

Key Achievements

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Achievements in 2009/2010

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Electromagnetic Theory and Technology Laboratory

The Electromagnetic Theory and Technology Laboratory's research activities are divided into two groups: electromagnetic wave theory and RF system development. In the electromagnetic wave theory research group, the research topics include development of wave propagation prediction model for next generation mobile system and DTV broadcasting, hybrid analysis technique for wave scattering by inlet geometries, RCS modeling and analysis, and target recognition inclusive of radar signal processing. Analysis of electromagnetic signal interference and jamming effect is also one of the main topics in this group.
In the RF system development group, research activities include development of the dual polarized array antenna, active phased array antenna without phase shifter, oscillator design using electromagnetic band gap (EBG), new type of RFID tag antennas, and meta-material issues and high integrity wideband SAR front-end.

Representative research topics are following.

- Development of electromagnetic environment prediction model
- RCS modeling and analysis
- Target recognition and motion compensation techniques
- Active phased array antenna without phase shifters

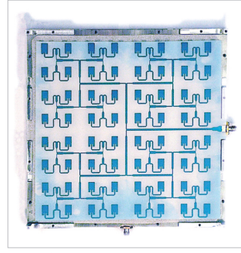

Fig. 1 8 by 8 DBS array antenna

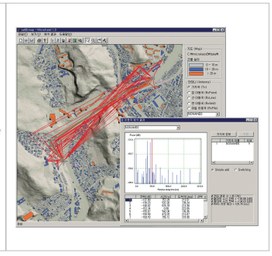

Fig. 2 DRT simulator for 3D ray tracing

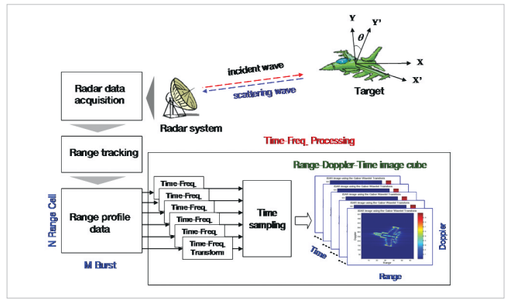

Fig. 3 Motion compensation technique for ISAR image

Key Achievement

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[2] S. Y. Kim and N. H. Myung, "An optimal antenna pattern synthesis for active phased array SAR based on particle swarm optimization and adaptive weighting factor," *Progress Electromagn. Research C,* vol. 10, pp. 129-142, 2009.

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Microwave and Microsystems Laboratory

The Microwave and Microsystems Laboratory (MICROLAB) has focused on researching microwave and millimeter-wave circuits and systems to cope with demands of the next generation mobile communications. The primary studies being undertaken by the lab are the designing of RFICs for intelligent radio and millimeter-wave circuits for Gbps high data rate wireless communications, and their implementation to radio systems. These are also the major research objectives of the Intelligent Radio Engineering Center (IREC), which is supported as an Engineering Research Center (ERC), a center-of-excellence program, by Ministry of Education, Science, and Technology (MOEST) and National Research Foundation (NRF) since 2005.

An intelligent radio can change its frequency, band-width, and modulation autonomously according to the communication environment, a core solution for the software defined radio and cognitive radio. The ultimate aim of MICROLAB's current line of research is to arrive at the "universal radio solution with unlimited connectivity" in a form of a CMOS single chip, to cope with convergence among mobile, WLAN, WPAN, broadcasting, and sensor networks. In 2008, a single path reconfigurable CMOS RF was investigated for an intelligent solution for the 800MHz~6GHz multi-band multi-mode communication and it is currently under design with 180nm CMOS. At the same time, power amplifier RFICs are being studied for the intelligent radio.

Furthermore, 60GHz radio SoC and SoP have been studied for high data rate WPAN/WLAN and wireless full HD video transmission applications. A very low-power single chip 60GHz receiver integrating a low noise amplifier (LNA), a mixer, a driver amplifier, a frequency doubler, and a voltage controlled oscillator (VCO) has been developed with the 130nm CMOS technology. Currently, a transmitter and an enhanced version of the receiver are under development with the 65 and 90nm CMOS technology. System packaging of the 60GHz transmitter and receiver that have been implemented monolithically together with antennas for high data rate video transmission. A high data rate communiction of up to 3Gbps has been demonstrated, and an HD video transmission test was successfully accomplished with the SoP radios.

Key Achievements

[1] Y. S. Noh and C. S. Park, "PCS/W-CDMA dual-band MMIC power amplifier with a newly proposed linearizing bias circuit," *IEEE J. Solid-State Circuits,* vol. 37, no. 9, pp. 1096-1099, Sep. 2002.

[2] J. H. Kim, J. H. Kim, Y. S. Noh, and C. S. Park, "An InGaP-GaAs HBT MMIC smart power amplifier for W-CDMA mobile handsets," *IEEE J. Solid-State Circuits,* vol. 38, no. 6, pp. 905-910, June 2003.

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Achievements in 2009/2010

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[2] S. Y. Kang, J. Y. Jang, I. Y. Oh, and C. S. Park, "A 2.6mW low power digitally-controlled variable gain amplifier," *IEEE Microw., Wireless Components Lett.,* vol. 20, no. 3, pp. 172-174, Mar. 2010.

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Photonic Computer Systems Laboratory

The Photonic Computer Systems Laboratory studies next generation computers in which high speed data are transmitted through photons, instead of electrons. Our research requires creative challenges in wide areas, including design of new architecture for photon-interfaced computers, signal protocol for high speed data transmission between MPU and memory, development of electro-optic hybrid boards, design of low-power consumption interface ICs for electron-photon signal conversion, compact integration of optoelectronic devices, and low cost packaging of optical modules.

We have demonstrated various optical-link platforms based on the electro-optic hybrid boards for computer applications. Optical links of FPGA MPU-to-memory, PCI express-to-MPU, and optical USB-to-MPU were first demonstrated in our laboratory. Signal protocol for optical link between PCI express and MPU above 5Gb/s was proposed in coorperation with ETRI. Also, we first developed the 10Gb/s-level interface ICs possessing versatile functions of bidirectional data transmission, clock distribution and recovery, serialization and deserialization of digital photon signals, etc. PCB-compatible electro-optic hybrid boards and cost-effective packaging schemes were developed in cooperation with LG Innotek. From this scheme, we recorded the lowest optical loss below -1dB in the photon-data-transmission through the hybrid board. Based on these achievements, we now move to implement nanophotonics-based computer systems. Especially, Si-photonics-based interface modules and nanophotonic circuits are studied. For practical system applications, we also developed the wireless and optical interconnect combined high speed transmission systems, such as intra-building security networks using HD camera systems.

Key Achievements

[1] T.-H. Ngo, N. T. H. Nguyen, I. A. Ukaegbu, T.-W. Lee, and H.-H. Park, "Bidirectional CMOS transceiver with automatic mode control for chip-to-chip optical interconnects," *IEEE Photon. Techn. Lett.,* vol. 21, no. 17, pp. 1241-1243, Sep. 2009.

[2] Y.-T. Han, J.-U. Shin, S.-H. Park, S.-P. Han, Y. Baek, C.-H. Lee, Y.-O. Noh, H.-J. Lee, and H.-H. Park, "Fabrication of 10-channel polymer thermo-optic digital optical switch array," *IEEE Photon. Techn. Lett.,* vol. 21, no. 20, pp. 1556-1558, Oct. 2009.

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Microwave and Antenna Laboratory

The research of the Microwave and Antenna Laboratory (MALAB) covers a wide range of next generation wireless communication antenna, including the active integrated antennas, adaptive array antenna, diversity and digital beam-forming antenna, wireless sensor, multiple input multiple output (MIMO) antenna measurement system techniques, and wireless communication systems.

Adaptive array antenna and beam-forming antenna are used to maximize the effectiveness of the antennas covering a wide service area. Not like normal passive antennas, they detect and control the shape of the beam in realtime, thereby increasing the effectiveness of the antenna.

People will not have to tune the antenna to change the beam pattern for different cases, but the antenna itself will change the beam pattern by phase shifting, and other variety of methods.

The MIMO antenna measurement is also important for the next generation 4G wireless communications. MIMO is a technique which is used by wireless systems to increase the diversity or transceive multi channels simultaneously. Multi reflection exists in real world so analyzing and studying how these multi reflection affects the antennas are very important for the performances of the antennas. Our lab uses a reverberation chamber to reproduce the multi reflection environment which is just like the real world for the measurement.

Our lab's research environment fosters the student for creative research and world leader in modern wireless communication, microwave, and smart antennas by addressing the needs of industry, government, and scientific community.

Key Achievements

[1] K.-H. Kim, Y.-J. Cho, S.-H. Hwang, and S.-O. Park, "Band-notched UWB planar monopole antenna with two parasitic patches," *Electron. Lett.,* vol. 41, no. 14, pp. 783-785, July 2005.
[2] Y.-J. Cho, K.-H. Kim, D.-H. Choi, S.-S. Lee, and S.-O. Park "A miniature UWB planar monopole antenna with 5-GHz band-rejection filter and the time-domain characteristics," *IEEE Tr. Ant., Prop.,* vol. 54, no. 5, pp. 1453-1460, May 2006.
[3] R. A. Bhatti and S.-O. Park "Hepta band internal antenna for personal communication handsets," *IEEE Tr. Ant., Prop.,* vol. 55, no. 12, pp. 3398-3403, Dec. 2007.

Achievements in 2009/2010

[1] J.-H. Lee, J.-M. Hwang, D.-H. Cho, and S.-O. Park, "Noninvasive biosignal detection radar system using circular polarization," *IEEE Tr. Inform. Techn. Biomed.,* vol. 13, no. 3, pp. 400-404, May 2009.
[2] R. A. Bhatti, Y.-T. Im, and S.-O. Park, "Compact PIFA for mobile terminals supporting multiple cellular and non-cellular standards," *IEEE Tr. Ant., Prop.,* vol. 57, no. 9, pp. 2534-2540, Sep. 2009.

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Bit Engineering Laboratory

The Bit Engineering Laboratory is focused on the research of optimized system-on-chip (SoC) design methodology of wireless communications system, especially on the wireless local area network (WLAN) system. The research direction of the Bit Engineering Laboratory is two-fold.

1. Research of Next-Generation Wireless LAN: WLAN is an emerging wireless communications technology thanks to the increasing market demand on Wi-Fi embedded portable devices such as smart phones, tablets, netbooks, and so on. The Bit Engineering Laboratory covers the WLAN standards such as IEEE 802.11 legacy, 11a OFDM, 11e QoS, 11i encryption, 11n high speed, 11p WAVE, 11s Mesh, and 11ac very high speed standards, which are the most recent protocols. For the medium access control (MAC) layer of WLAN, we study the algorithm to enhance spectral efficiency and the QoS of systems, such as link adaptation, admission control, scheduling, and so on. For the physical layer, channel coding, MIMO detection, noise compensation, and channel estimation technologies are studied. We also research RF technologies with delta-sigma modulation, digital-to-RF converter, and digital resampling. Cross-layer optimization is also one of the key research topics in this lab.

2. Research of SoC Design: Based on the knowledges of standards and optimization methodologies, the Bit Engineering Laboratory carries out the implementation of WLAN systems. Our design approach starts from electronics system level (ESL) design approach. SoC architecture prototyping is performed using SystemC language, and the design space is optimized for CPU, BUS, and memory through advanced simulation technology. Based on this post-validation and optimization of SoC architecture, the system is divided into software and hardware modules. These are implemented to FPGA platforms then verified.

Recently, the Bit Engineering Laboratory focuses on reconfigurable system designs and implementations. For this purpose, we study multi-processor based full software implementation technology for WLAN systems. Full digital implementation of RF transceiver is also our issue of interest.

Key Achievements

[1] S. Park, G. Kim, S.-C. Park, and W. Kim, "A digital-to-analog converter based on differential-quad switching," *IEEE J. Solid-State Circuits,* vol. 37, no. 10, pp. 1335-1338, Oct. 2002.
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Achievements in 2009/2010

[1] C. S. Park, K. K. Parhi, and S.-C. Park, "Probabilistic spherical detection and VLSI implementation for multiple-antenna systems," *IEEE Tr. Circuits, Syst. I,* vol. 56, no. 3, pp. 685-698, Mar. 2009.
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Mixed Signal Integrated Circuits Laboratory

The Mixed-Signal Integrated Circuits Laboratory (MSICL) is working on analog and mixed-mode circuit designs including data converters, amplifiers, filters, display drivers, and so forth. Currently, low power data converters are being actively studied in MSICL with two major design methodologies: design renovation of traditional architectures and hybridizing architectures for optimized performance.

Design Renovation: Recently, we have developed a new error correction technique for SAR ADC, which speeds up the conventional 10b ADC by 40% with ignorable hardware overhead. The 550uW 10b 40MS/s prototype ADC was awarded a bronze prize in the 10th semiconductor design contest. A low-power, high-speed pipelined ADC is also being investigated for next generation communication systems and high performance video front-end applications. The proposed residue amplifier settles at the speed comparable to that of the open-loop amplifier and provides the settling accuracy comparable to that of the closed-loop amplifier. For low power flash ADC, a static-power free interpolation technique has been developed. A 6b 4GS/s prototype ADC is estimated to consume less than 50mW.

Hybrid Architectures: Power saving in ADC is further pursued by developing new architectures. The flash-TISAR architecture can possibly replace traditional flash ADCs with comparable conversion speed and excellent power efficiency. The speed limitation of the SAR ADC is overcome by a new multi-bit cyclic SAR ADC architecture. A 8b 500MS/s prototype is expected to consume less than 5mW.

Others: Building blocks for 60GHz RF system including DAC, VGA, and filter have been designed with theirs own power-saving techniques.

Key Achievements

[1] S. T. Ryu, B. S. Song, and K. Bacrania, "A 10-bit 50-MS/s pipelined ADC with opamp current reuse," *IEEE J. Solid-State Circuits,* vol. 42, no. 3, pp. 475-485, Mar. 2007.
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[3] Bronze Prize, Korean Intellectual Property Office, Nov. 2009.

Achievements in 2009/2010

[1] B. R. S. Sung, S. H. Cho, C. K. Lee, J. I. Kim, and S. T. Ryu, "A time-interleaved flash-SAR architecture for high speed A/D conversion," *IEEE Int. Symp. Circuits, Syst.,* Taipei, Taiwan, May 2009.
[2] S. H. Cho, H. D. Lee, K. D. Kim, S. T. Ryu, and J. K. Kwon, "Dual-mode VCO gain topology for reducing in-band noise and reference spur of PLL in 65 nm CMOS," *IET Electron. Lett.,* vol. 46, no. 5, pp. 335-337, Jan. 2010.

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Computational Nanotechnolgy Laboratory

In the Computational Nanotechnology Laboratory (CNL), our main research activity lies in developing in-house nano-electronic device simulators based on the quantum mechanical principles. Our developed tools are aimed to be deployed in web-based simulation portals such as nanoHUB for public access.

Recently, we have completed the development of an in-house simulator for nano-scale field effect transistors. The simulator features self-consistent, full-quantum transport calculation based on the multi-band k·p method, and encompasses simulations for nanowire devices, ultra-thin body devices, Schottky barrier devices, and tunnel devices. The simulator is highly efficient; it is very much comparable to the tight-binding-based simulators in quality but orders of magnitude faster and resource-saving. An in-depth investigation on p-type nanowire MOSFETs and channel-orientation influence on the p-type Schottky barrier MOSFETs have been perfomed using the simulator. A web-based version of the simulator has been recently uploaded to nanoHUB for public access (http://www.nanohub.org/toos/kpnanofet).

We have started a new research project aimed at a practical, yet realistic, device simulation which links first-principle calculations and device-level simulations. In a collaboration with a research group specialized in the ab-initio calculations, the band gap profiles and dielectric constants along the Si-dielectric interface of a CMOS device was calculated based on the density functional theory. The interface model was combined with the device simulation based on the non-equilibrium Green's function to accurately assess the device performance. In particular, drain and gate leakage currents in double-gate, ultra-thin body transistors have been calculated using the interface model from the first-principle calculations. We are currently trying to devise an interface model for high-K gate dielectrics with defects.

We have recently expanded our research interest to spintronics devices with spin-torque oscillations. Although in a very early stage, we expect to contribute to the exciting field of spin devices with an RF application in mind.

Key Achievements

[1] M. Shin, "Computational study on the performance of multiple-gate nanowire Schottky-barrier MOSFETs," *IEEE Tr. Electron Dev.,* vol. 55, no. 2, pp. 737-742, Mar. 2008.
[2] M. Shin, "Multi-gate nanowire FET," *Simulation tool on nanoHUB,* DOI: 10254/nanohub-r2704, May 2008.
[3] M. Shin, "Quantum simulations of ballistic nanowire field effect transistors," in R. A. Meyers, Ed., *Encyclopedia Complexity, Systems Science,* Springer, 2009. (invited article)

Achievements in 2009/2010

[1] M. Shin, "k·p based quantum simulation of silicon nanowire pMOSFETs," *IEEE Nanotechn.,* Genoa, Italy, July 2009.
[2] M. Shin, "Full quantum simulation of hole transport and band-to-band tunneling in nanowires using the k·p method," *J. Appl. Phys.,* vol. 106, no. 5, pp. 054505-1-10, Sep. 2009.

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Electro-Optics Laboratory

The Electro-Optics Laboratory (EOL) is engaged in the experimental and theoretical studies of integrated optical waveguide devices for optical communications, optical signal processing, and optical sensing. Current research interests include silicon photonic devices, surface plasmon polariton (SPP) devices, and polymer optical waveguide devices.

Silicon Photonic Devices: Conventional silica or polymeric planar lightwave circuits are not compatible with electric ICs on the same substrate, and their elements are relatively large since the refractive index difference between the core and the cladding is small. In order to overcome these problems, a silicon optical waveguide with a high index contrast has been actively investigated. Thus, silicon photonic wires attract much attention recently. With rich experiences in working on polymeric optical waveguide devices, we have successfully demonstrated new silicon photonic wire devices such as an ultra-short polarization splitter (PS) and a long period grating (LPG) filter.

SPP: For the development of submicron optical devices, the SPP waveguide device is one of the most promising solutions due to its submicron mode size. The dielectric-embedded metal structure for SPP modes, as in the metal-insulator-metal optical waveguide, makes it possible to overcome the diffraction limit. However, the SPP waveguide has a large propagation loss, though the long range SPP (LRSPP) waveguide with relatively low propagation loss has been reported. To investigate the coupling between the SPP waveguide and silicon photonic nanowire, we design and fabricate a hybrid directional coupler between the SPP waveguide and the conventional silicon waveguide.

Key Achievements

[1] C. H. Lee, T. H. Yoon, and S. Y. Shin, "Period doubling and chaos in a directly modulated laser diode," *Appl. Phys. Lett.,* vol. 46, no. 1, pp. 95-97, Jan. 1985.
[2] G. H. Song and S. Y. Shin, "Design of corrugated waveguide filters by the Gel'fand-Levitan-Marchenco inverse scattering method," *J. Optical Soc. America A,* vol. 2, no. 11, pp. 1905-1915, Nov. 1985.
[3] J. S. Jang, S. W. Jung, S. Y. Lee, and S. Y. Shin, "Optical implementation of the Hopfield model for two-dimensional associative memory," *Optics Lett.,* vol. 13, no. 3, pp. 248-250, Mar. 1988.

Achievements in 2009/2010

[1] B. K. Yang, S. Y. Shin, and D. Zhang, "Ultrashort polarization splitter using two-mode interference in silicon photonic wires," *IEEE Photon. Techn. Lett.,* vol. 21, no. 7, pp. 432-434, Apr. 2009.
[2] J. T. Kim, J. J. Ju, S. T. Park, M. S. Kim, S. K. Park, and S. Y. Shin, "Hybrid plasmonic waveguide for low-loss lightwave guiding," *Optics Express,* vol. 18, no. 3, pp. 2808-2813, Feb. 2010.

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Photonic Energy and Signal Processing Laboratory

The Photonic Energy and Signal Processing (PESP) Laboratory has primarily focused on developing key optical modules for optical networks, hologram ID tags, and optical energy conversion applications. The research is categorized into three main areas.

Next RFID: Hologram ID Tag System

The hologram identification (ID) tags are known to be one of the most anti-counterfeit ID solutions with high storage density and durable strength against tag damages. They can potentially be applicable to a wide area of certificates, credit cards, currencies, industrial products, etc.

Fig. 1 Application areas of hologram ID tags

Solar Cell and Quantum-Dot LED

As photonic energy sources, quantum-dot solar cells and LEDs are being studied in the lab. In order to increase the energy conversion efficiency, noble structures of quantum dots have been adopted for both of these two devices. In parallel, an inkjet printing process is also examined to easily fabricate these devices at a low cost.

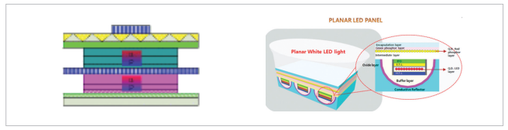

Fig. 2 Structures of a solar cell and a quantum-dot LED under study

Photonic Signal Processing

Our lab is a leading group in the world for the key photonic devices using single-mode Fabry-Perot laser diodes (FP-LD). The conventional multimode FP-LD was successfully converted to a single-mode FP-LD using a technique of commercial TO-can packages. Wavelength converters and optical flip-flop devices are typical targets using single-mode FP-LDs in our lab.

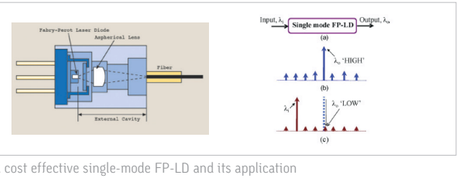

Fig. 3 A cost effective single-mode FP-LD and its application

Key Achievements

[1] Y. Noh, J. Kim, M. Yang, H. Choi, H. Lee, Y. H. Won, and S. Han, "Thermooptic 2x2 asymmetric digital optical switches with zero-voltage operation state," *IEEE Photon. Techn. Lett.,* vol. 16, no. 2, pp. 446-448, Feb. 2004.
[2] Y. Jeong, J. Cho, H. Lee, H. Yoo, and Y. H. Won, "All-optical flip-flop based on the bistability of injection locked Fabry-Perot laser diode," *Optics Express,* vol. 14, no. 9, pp. 4058-4063, May 2006.
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Achievements in 2009/2010

[1] M. Uddin, J. Lim, Y. Jeong, and Y. H. Won, "All-optical digital logic gates using single-mode Fabry-Perot laser diodes," *IEEE Photon. Techn. Lett.,* vol. 21, no. 29, pp. 1468-1470, Oct. 2009.
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High Speed Nanoelectronics Laboratory

The High Speed Nanoelectronics Laboratory (HSNL) conducts research in next-generation devices and ICs with focus on high speed and high functional applications. The lab is currently involved in four research categories: (a) quantum-effect based nano devices and high speed circuits, (b) InP-based optical detector, (c) Si-based optoelectronics, and (d) high frequency, high power devices and MMICs.
In research based on the quantum/nano device, the RTD, which has the unique negative differential resistance and very high speed switching characteristics, enables us to develop ultra high speed and extremely low power analog and digital ICs. By using RTD based NDR ICs, next-generation high speed optical communication system, nano/bio sensor system, and artificial neural network systems can be achieved.

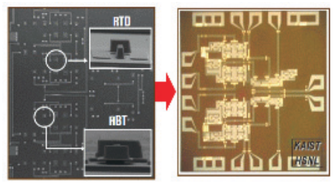

Fig. 1 World best high speed 4:1 multiplexer.

The research of optical detectors is focused on developing high sensitivity single photon avalanche diodes (SPAD) for the applications of 3D imaging and laser radar (LADAR). For the LADAR system, the device technology of InGaAs/InP SPAD arrays is being developed.
Si-based optoelectronic sensors are also being researched for commercial camera applications such as CMOS image sensors (CISs) and Si based APD. To improve the performance of the sensors, new photodetector structures are being developed and analyzed. The designed sensors are promising candidates for the cost effective, high performance imaging applications.

High frequency and high power MMICs for the next-generation T/R module systems have been developed, by using the InP/InGaAs diodes which have excellent microwave performances such as high breakdown voltage, low insertion loss, high isolation, and high cut-off frequency. A BCB-based multi-layer MMIC technology has been established to reduce the size and cost of MMICs. We have also been investigating next-generation high power GaN-based devices for microwave applications.

Key Achievements

[1] S. Lee and K. Yang, "Sub-1V supply self-adaptive CMOS image sensor cell with a 86dB dynamic-range," *IEEE Electron Dev. Lett.,* vol. 28, no. 6, pp. 492-494, June 2007.
[2] S. Choi, Y. Jeong, J. Lee, and K. Yang, "A novel high-speed multiplexing IC based on resonant tunneling diodes," *IEEE Tr. Nanotechn.,* vol. 8, no. 4, pp. 482-486, July 2009.
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Achievements in 2009/2010

[1] J. G. Yang and K. Yang, "Broadband InGaAs PIN traveling-wave switch using a BCB-based thin-film microstrip line structure," *IEEE Microw., Wireless Components Lett.,* vol. 19, no. 10, pp. 647-649, Oct. 2009.
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Communication Devices and Systems Laboratory

The research of the Communication Devices and Systems Laboratory (CoDeS) is focused on the RF technology for the next generation wireless communications. Diverse wireless services, various wireless standards, and digital/RF technologies will be merged in the next generation wireless terminals. We will develop technologies of digital RF transceivers for wideband OFDM signals as a core technology of the next generation wireless convergence transceivers. For the implementation of an efficient multi-standard transceiver with a high flexibility, we have been trying to substitute as many functions of RF blocks with digital circuitry as possible instead of minimizing RF parts. Digitalization of RF function results in a highly efficient system with a high integration, an improved noise, a reduced cost, and a low power consumption.
Aims of our research are developing ADPLL-based digital polar transmitters and sampler-based digital RF receivers. Our research focuses on technologies of digital RF for OFDM signals of which the carrier frequency is 5.8GHz, and the bandwidth is up to 100MHz. For the digital RF transceiver, digitally controlled oscillator (DCO), 6-bit digital to RF converter (DRFC), digital to time coverter (DTC), and time to digital converter (TDC) are designed and implemented. The designed DCO has a frequency resolution of about 14kHz in 5.8GHz and the measured switchable discrete capacitance of 32aF is obtained by using the novel varactor pairs. To support OFDM system with a wide bandwidth, a high resolution and a low latency of TDC are required. The designed TDC achieves a time resolution of 2ps and a relatively low latency with a 5GHz clock. These results are sufficient to support 802.11n and Wi-Max with a 20MHz bandwidth. Recently, we are highly interested in developing discrete time filters, digital down converters, and digital power amplifiers.
The other research topic of our lab is the CMOS transceiver for multi-standard RFID readers, which supports the various high frequency (HF) band standards, such as 14443-A/B, 15693, 18000-3, etc. We also try to reduce the analog parts and many of them are substituted by digital counterparts. Since our RFID transceiver does not use the conventional analog parts and any capacitor with a large size, the chip area of it is extremely compact and the cost can be minimized.

Key Achievements

[1] Y.-K. Jang, J.-H. Kim, and H.-J. Yoo, "Reconfigurable CMOS mixer for multi-standard applications," *IEICE Tr. Electron.,* vol. E88-C, no. 12, pp. 2379-2381, Dec. 2005.
[2] S.-H. Shin, J.-H. Kim, and H.-J. Yoo, "A multistandard RF front-end using varactor controlled tunable interstage matching network," *IEEE Radio, Wireless Symp.,* Long Beach, USA, Jan. 2007.
[3] C.-H. Kim, S.-H. Shin, and H.-J. Yoo, "A low phase noise and low power series coupled quadrature VCO using reconfigurable LC tank," *IEEE Radio, Wireless Symp.,* Orlando, USA, Jan. 2008.

Achievements in 2009/2010

[1] S.-S. Yoo, Y.-C. Choi, H.-J. Song, and H.-J. Yoo, "A 5.9 GHz LC-based digitally controlled oscillator with high frequency resolution using novel varactor pairs," *IEEE Radio-Frequency Integr. Techn.,* Singapore, Dec. 2009.
[2] Y.-H. Kim, Y.-C. Choi, M.-W. Seo, S.-S. Yoo, and H.-J. Yoo, "A CMOS transceiver for a multistandard 13.56-MHz RFID reader SoC," *IEEE Tr. Indust. Electron.,* vol. 57, no. 5, pp. 1563-1572, May 2010.

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Integrated Organic Electronics Laboratory

The Integrated Organic Electronics Laboratory (IOEL), established in August, 2006, focuses on developing novel device architectures and integrated systems based on organic semiconductors and conductors in three major areas: display and lighting, energy, and flexible low-cost electronics. Research on organic light-emitting diodes (OLEDs) for displays and lighting applications constitutes one of IOEL's top-priority research efforts, and is being pursed mostly in device level innovation that reflects the application-specific needs from practical or system level perspectives.
Key efforts are also being made in achieving reliable and scalable organic photovoltaic (OPV) technologies that are balanced with continual improvement of power conversion efficiency. Another integral part of IOEL's research effort is to develop reliable, high performance electronic devices and integrated circuits based on organic thin-film transistors (OTFTs), metal oxide thin-film transistors (MOxTFTs), and memory devices for low-cost and flexible alternatives to existing technologies.

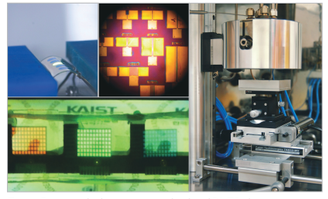

Fig. 1 Organic light-emitting diodes (OLEDs)

OLEDs: One of the most promising next-generation display device and lighting source with versatility in various form factors.
Recently, Hyunsu Cho and his colleagues investigated the possibility of multilayer transparent electrode consist of dielectric-metal-dielectric, and proved its usefulness in fabricating flexible OLEDs.
OPVs: In OPVs, efficiency improvement is the most important issue. Seungchan Han and his colleagues have worked on the performance improvement of OPVs using amorphous tungsten oxide as an interfacial buffer layer.

OTFT and MoxTFTs: OTFTs and MoxTFTs have been expected to overcome the limitations of a-Si and poly-Si TFTs to realize next coming products such as AMOLED, e-paper, RFID, smart card, etc. Bongjun Kim and his colleagues have worked on the CMOS employing OTFT as p-MOS and MoxTFT as n-MOS that is low cost and low power.

Key Achievements

[1] D. Gupta, N. Jeon, and S. Yoo, "Modeling the electrical characteristics of TIPS-pentacene thin-film transistors: Effect of contact barrier, field-dependent mobility, and traps," *Organic Electron.,* vol. 9, no. 6, pp. 1026-1031, Dec. 2008.
[2] S. Han, W. S. Shin, M. Seo, D. Gupta, and S. Yoo, "Improving performance of organic solar cells using amorphous tungsten oxides as an interfacial buffer layer on transparent anodes," *Organic Electron.,* vol. 10, no. 5, pp. 791-797, Aug. 2009.
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Achievements in 2009/2010

[1] H. Cho, C. Yun, and S. Yoo, "Multilayer transparent electrode for organic light-emitting diodes: Tuning its optical characteristics," *Optics Express,* vol. 18, no. 4, pp. 3404-3414, Feb. 2010.
[2] T. W. Koh, J. M. Choi, S. Lee, and S. Yoo, "Optical outcoupling enhancement in organic light-emitting diodes: Highly conductive polymer as a low-index layer on microstructured ITO electrodes," *Adv. Materials,* vol. 22, no. 16, pp. 1849-1853, Apr. 2010.

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Communication Electronics Laboratory

The Communication Electronics Laboratory explores a vision of multi-functional and intelligent devices, systems, and algorithms to provide more efficient and seamless information communications. Our research areas of interest include solid-state nano-scale devices, ultra-small intelligent RF devices and systems, and smart systems and algorithms for future wireless applications.

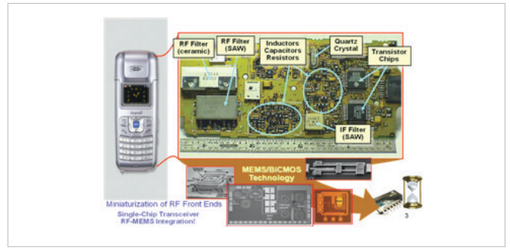

Fig. 1

Recently, our research efforts have been mainly focused on communication hardware and software technologies involving ultra-small RF devices and multi-input multi-output (MIMO) algorithms.
More efforts are expected to be made to develop nano-scale solid-state devices based on the modeling, designing and fabricating of novel structures.
In addition, we have a keen interest in the semiconductor technology-based RF devices and intelligent algorithms for smart wireless communications.

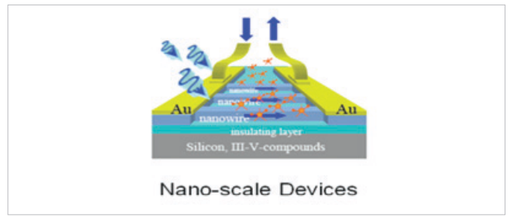

Fig. 2

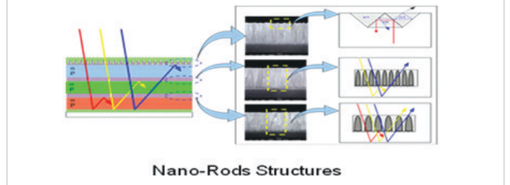

Fig. 3

Key Achievements

[1] M. T. Le, V. S. Pham, L. Mai, and G. W. Yoon, "Low-complexity maximum-likelihood decoder for four-transmit-antenna quasi-orthogonal space-time code," *IEEE Tr. Comm.,* vol. 53, no. 11, pp. 1817-1821, Nov. 2005.
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Achievements in 2009/2010

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[2] L. Mai, V. S. Pham, and G. W. Yoon, "ZnO-based film bulk acoustic resonator devices on a specially designed bragg reflector," *Appl. Phys. A,* vol. 95, no. 3, pp. 667-671, Mar. 2009.

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3D Micro-Nano Structures Laboratory

The 3D Micro-Nano Structures Laboratory has been focusing on micromachining technologies for 3D structures with micro to nano size, and applying these in Korea-strong fields such as display, memory, and wireless telecommunication.

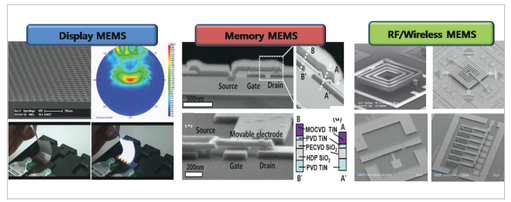

Fig. 1 Korea-strong MEMS/NEMS: display, memory and RF/wireless MEMS

In the display MEMS, we have researched novel backlight units (BLU) and flexible front light guide units (FLU) for display. Our light guides are based on microlens arrays made by 3D diffuser lithography. The significance of the proposed system is that the number of optical films can be reduced to just one sheet and improve not only their optical performance, but also the manufacturing cost efficiency. We have researched the digital mirror device (DMD) with unique and simpler structures than that of the Texas Instruments. The research on 16μmX16μm DMD was conducted for the high resolution and low cost projection display.
In the memory MEMS, we proposed the mechanical memory which was produced using MEMS/NEMS technology. Nano mechanical memory can overcome the physical limitation of the memory based on the CMOS technology. The nano-mechanical memory controls the current level using mechanical movements using electrostatic force instead of electric field same as CMOS devices. We developed a 3-terminal NEMS switch with 40nm-thick beam and 20nm-thick air-gap with NNFC for high density logic and memory applications in 2009.
In RF/microwave MEMS, passive components such as RF inductors, variable capacitors, and microwave antennas have been researched. Specially, we have gone deeper into modeling, design, and fabrication of MEMS inductors for a long time.

Key Achievements

[1] J.-B. Yoon, C.-H. Han, E. Yoon, and C.-K. Kim, "Surface micromachined solenoid on-Si and on-glass inductors for RF applications," *IEEE Electron Dev. Lett.,* vol. 20, no. 9, pp. 487-489, Sep. 1999.
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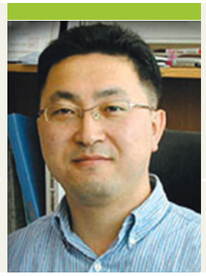
[3] W. W. Jang, J. O. Lee, J.-B. Yoon, M.-S. Kim, J.-M. Lee, S.-M. Kim, K.-H. Cho, D.-W. Kim, D. Park, and W.-S. Lee, "Fabrication and characterization of a nanoelectromechanical switch with 15-nm-thick suspension air gap," *Appl. Phys. Lett.,* vol. 92, no. 10, pp. 1-3, Mar. 2008.

Achievements in 2009/2010

[1] J. O. Lee, M.-W. Kim, S.-D. Ko, H.-O. Kang, W.-H. Bae, M.-H. Kang, K.-N. Kim, D.-E. Yoo, and J.-B. Yoon, "3-terminal nanoelectromechanical switching device in insulating liquid media for low voltage operation and reliability improvement," *IEEE Int. Electron Dev. Meeting,* Baltimore, USA, Dec. 2009.
[2] D.-H. Kim, M.-W. Kim, J.-W. Jeon, K.-S. Lim, and J.-B. Yoon, "Modeling, design, fabrication, and demonstration of a digital micromirror with interdigitated cantilevers," *IEEE J. Microelectrom. Syst.,* vol. 18, no. 6, pp. 1382-1395, Dec. 2009.



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Wireless Information Systems Research Laboratory

The Radio Frequency System Solution Laboratory (RFSS Lab) primarily focuses on making RF systems more optimal, reliable, and efficient for the future wireless environment. Currently, our main research areas include hybrid and integrated RF system, minimized and multiband antenna, applications using electromagnetic analysis, etc.
In the system area, six-port applications for RF system architecture which enable wide bandwidth, low cost, and low power are actively studied. We also investigate a simulation environment similar to a real condition for which the parameters of digital and RF components are controllable in tag-to-reader or reader-to-tag communication in the UHF band.
In the antenna area, researches in quadrifilar antenna which consists of four antennas winding up along the same direction, and minimized and multi-band antenna are ongoing.
In the field of electromagnetic analysis, electromagnetic imaging for breast cancer, and security applications based on electromagnetic characteristic such as RFID are studied.

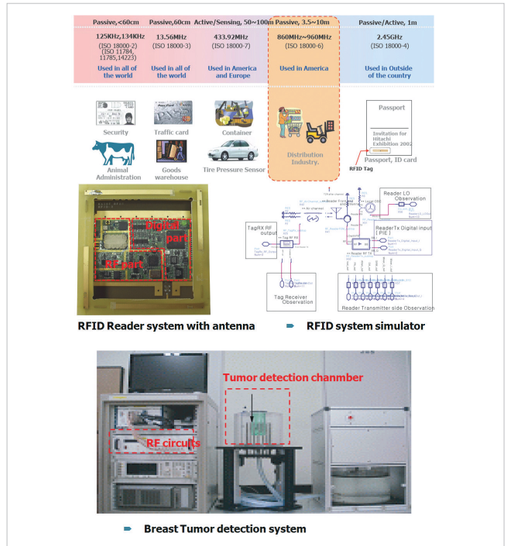

Fig. 1 RFID system development and RF breast tumor detection system

Key Achievements

[1] W.-S. Lee, D.-Z. Kim, K.-J. Kim, and J.-W. Yu, "Wideband planar monopole antenna with dual band-notched characteristic," *IEEE Tr. Microw. Theory, Techn.,* vol. 54, no. 6, pp. 2800-2806, June 2006.
[2] H.-S. Lim, W.-K. Kim, and J.-W. Yu, "Compact six-port transceiver for time-division duplexer systems," *IEEE Microw., Wireless Components Lett.,* vol. 17, no. 5, pp. 394-396, May 2007.
[3] W.-G. Lim, S.-Y. Park, W.-I. Son, M.-Q. Lee, and J.-W. Yu, "RFID reader front-end having robust Tx leakage canceller for load variation," *IEEE Tr. Microw. Theory, Techn.,* vol. 57, no. 5, pp. 1348-1355, May 2009.

Achievements in 2009/2010

[1] W.-G. Lim, S.-Y. Park, W.-I. Son, M.-Q. Lee, and J.-W. Yu, "RFID reader front-end having robust Tx leakage canceller for load variation," *IEEE Tr. Microw. Theory, Techn.,* vol. 57, no. 5, pp. 1348-1355, May 2009.
[2] S.-Y. Lee, D.-Z. Kim, M.-Q. Lee, and J.-W. Yu, "A new six-port receiver architecture using poly phase networks," *Microw. Optical Techn. Lett.*, vol. 52, no. 3, pp. 499-502, Jan. 2010.

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Integrated Nanophotonics Laboratory

The Integrated Nanophotonics Laboratory, led by Prof. Kyoungsik Yu, focuses on nano- and micro-scale optoelectronic devices and their integration techniques for photonic interconnects, bio/chemical sensing, and imaging applications.

Information processing and communication technologies have improved our perception of the world by supplying abundant information and computing power. However, because of power consumption and space constraints, it is becoming more difficult to build high-performance information processing and distribution systems only with electronics. In optical imaging and sensing systems, the engineering trade-off in resolution and throughput has limited our ability to probe small objects and fast phenomena in biology and nanotechnology.

Nanophotonics can provide unique solutions to such important problems by processing optical signals in combination with electrical and mechanical methods. Integrated nanophotonic devices offer exciting opportunities in the generation, control, and detection of photons, and their interaction with semiconductor and/or biochemical materials. The range of optical wavelengths useful for most communication and sensing applications is on the order of micrometers, therefore, nanofabrication technologies allow us to precisely fabricate features in subwavelength dimensions that can best interact with photons.

An example of our nanophotonic research is the subwavelength metal-optic cavities on active compound semiconductor materials to surpass the size limitation of conventional light sources. Conventional light sources are usually in the micrometer range due to the diffraction limit, whereas the length scale of electronic transistors is currently approaching 10nm with the advance of fabrication technology. Nanoscale light sources and their integration techniques will play important roles for future integration of electronic and photonic devices on a chip-scale platform.

Key Achievements

[1] K. Yu, J. Shin, and N. Park, "Wavelength-time spreading optical CDMA system using wavelength multiplexers and mirrored fiber delay lines," *IEEE Photon. Techn. Lett.,* vol. 12, no. 9, pp. 1278-1280, Sep. 2000.

[2] I. Keslassy, S.-T. Chuang, K. Yu, D. A. B. Miller, M. Horowitz, O. Solgaard, and N. McKeown, "Scaling internet routers using optics," *ACM Special Interest Group Data Comm.*, Karlsruhe, Germany, Aug. 2003.

[3] K. Yu and O. Solgaard, "Tunable optical transversal filters based on a Gires-Tournois interferometer with MEMS phase shifters," *IEEE J. Select. Topics Quantum Electron.,* vol. 10, no. 3, pp. 588-597, Mar. 2004.

Achievements in 2009/2010

[1] Z. Fan, H. Razavi, J. Do, A. Moriwaki, O. Ergen, Y.-L. Chueh, P. W. Leu, J. C. Ho, T. Takahashi, L. A. Reichertz, S. Neale, K. Yu, M. Wu, J. W. Ager, and A. Javey, "Three-dimensional nanopillar-array photovoltaics on low-cost and flexible substrates," *Nature Materials,* vol. 8, no. 8, pp. 648-653, Aug. 2009.

[2] K. Yu, A. Lakhani, and M. C. Wu, "Subwavelength metal-optic semiconductor nanopatch lasers," *Optics Express,* vol. 18, no. 9, pp. 8790-8799, Apr. 2010.

DEPARTMENT OF ELECTRICAL ENGINEERING

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Research Centers

Brain Science Research Center (BSRC)
Director: Prof. Soo-Young Lee
Sponsor: National Research Foundation, Ministry of Knowledge Economy

- BSRC has worked on the understanding and computational models of brain information processing mechanisms and their applications to brain-like intelligent systems (artificial brain and artificial cognitive systems). It also operates brain signal measurement facilities such as 3T fMRI, fMRI-compatible EEG, and NIRS.

Center for Advanced Flexible Display Convergence (CAFDC)
Director: Prof. Kyung Cheol Choi
Sponsor: National Research Foundation

- CAFDC conducts interdisciplinary convergence of basic research related to next generation flexible display devices, materials, and driving methods. CAFDC has set its aim high to develop display devices in the spirit of anywhere, any size, and anytime for the approaching ubiquitous era.

Center for Robot Intelligence Technology (RIT)
Director: Prof. Jong-Hwan Kim
Sponsor: Institute for Information Technology Advancement

- RIT center guides the leadership of technical innovation from 'information technology' (IT) to 'intelligence technology' (IT). The center proposes 6 types of robot intelligence (CI, SI, BI, AI, GI, SI) and realizes each of them through 5 core technologies (EC, FL, NN, DES, ML) and 5 detail technologies (cognitive architecture, voice recognition, HRI, task scheduling, learning).

Center for Robot Vision and Perception (CRVP)
Director: Prof. Myung Jin Chung
Sponsor: Ministry of Knowledge Economy

- CRVP consists of 4 professors and 42 students. CRVP is currently focusing on the development of 3D sensing and vision based human/object perception for intelligent robots.

Display Research Center (DRC)
Director: Prof. Gun-Woo Moon
Sponsor: Samsung Electronics

- DRC consists of 12 professors and 80 students who conduct research in the field of LCD and displays.

IC Design Education Center (IDEC)
Director: Prof. Chong-Min Kyung
Sponsor: Ministry of Knowledge Economy

- IDEC was founded by the Ministry of Commerce, Industry and Energy to cultivate design experts in the field of non-memory IC. IDEC provides each working group (WG) in each university with CAD tools, computing platforms, and related technologies. IDEC offers the lectures, CAD tool training classes and CD-ROMs of the open lectures, and books relevant to IC design.

Image Information Research Center (IIRC)
Director: Prof. Jong Beom Ra
Sponsor: Defense Acquisition Program Administration and Agency for Defense Development

- IIRC consists of 4 professors and 35 students conducting research in the field of image information.

Intelligent Radio Engineering Center (IREC)
Director: Prof. Chul Soon Park
Sponsor: National Research Foundation

- The mission of the IREC is to acquire the "Universal Radio Solution with Unlimited Connectivity" to cope with convergence among the mobile, WLAN, WPAN, broadcasting, and sensor networks. 14 professors and more than 100 students are engaged in the IREC.

Intelligent Robot Vision Systems (IRVS) Research Center
Director: Prof. In So Kweon
Sponsor: Samsung Techwin

- The main research direction of IRVS Research Center is a new development of self-localization for mobile surveillance robot through fusing multiple sensor systems.
  A typical task of a mobile surveillance robot usually takes a role in detecting and tracking people of interest. In order to accomplish such task, the robot requires a stable and accurate localization of the robot's surrounding environment. These environments can vary from indoor to outdoor with their own individual conditions. Outdoor environments usually have more difficult obstacles such as abrupt luminance changes and dynamic motions of numerous objects.
  The traditional approaches for self-localization will not improve the robot's performance, therefore we introduce a fusion system of local sensors such as cameras and laser with global sensors such as DGPS to obtain more accurate and stable information of the surrounding environment.
  To achieve a fine result in detecting and tracking the objects of interest, we adapt the traditional approaches and try to use not only color and texture information but also motion models of the objects. By modeling the motion of the objects, we can successfully predict and estimate the location of the object in successive frames.

Mobile Media Platform Center (MMPC)
Director: Prof. Hwang Soo Lee
Sponsor: Texas Instruments, Ministry of Information and Communication

- MMPC consists of 9 professors and 50 students. MMPC was established to develop mobile multimedia platform technology.

Mobile Multimedia Research Center (MMRC)

Director: Prof. Joong Soo Ma

Sponsor: Ministry of Knowledge Economy

- MMRC consists of 9 professors and 60 students. MMRC is developing fundamental technologies and prototypes for mobile tactical communication system (MOTACS) and ad hoc mesh network.

Next Image Systems (NIS) Research Center

Director: Prof. In So Kweon

Sponsor: Samsung Electronics

- Recent trend in information technology leans toward developing new ways of display technology with the most interest in moving from 2D to 3D display.
  The traditional cameras are designed to capture the scenes in front of it into 2D plane (CMOS), hence the video results do not have 3D information such as depths of each pixel in the array. In order to provide the audience with a better experience of 3D display, recent technologies cannot still achieve the satisfying result. NIS Research Center will be covering both software and hardware development of a novel approach for 3D display. The software system will mainly focus on reconstructing 3D information of depths and spatio-temporal relationships from original 2D video sequences along with the new hardware system.
  For CMOS imaging sensors, we introduce a new concept of 3D CMOS imaging sensors where both color and depths information will be stored in the pixel array.
  These new systems will allow us to strongly compete with the new 3D display industry by providing a new and better experience to the consumers.

Optical Internet Research Center (OIRC)

Director: Prof. Minho Kang

Sponsor: Korea Science and Engineering Foundation

- OIRC consists of 12 professors and 80 students. OIRC is first aimed to put the invention practice use and get core patents for GMPLS over AOBS. Second, it aims to investigate for the metro-access architectures and applications in AOBS, and finally conducts researches in the blue ocean of the optical internet.

Power Electronics Research Center (PERC)

Director: Prof. Gun-Woo Moon

Sponsor: Samsung Electro-Mechanics

- PERC consists of one professor and 18 students. PREC is working to develop the best products in the world in terms of both servers and adapters while collaborating with 12 experts from Samsung Electro-Mechanics.

Radio Education and Research Center (RERC)

Director: Prof. Hyuckjae Lee

Sponsor: Korea Communications Commission

- Funded by the Korea Communications Commission, RERC has been established to be a major educational center to cultivate students and professionals in the radio technology field and to boost the global competitiveness of radio technology industry through systematic development of new educational materials both online and offline.

Radiowave Detection Research Center (RDRC)

Director: Prof. Noh-Hoon Myung

Sponsor: Agency for Defense Development

- RDRC consists of 13 professors and 11 students. RDRC works to develop next generation mobile systems and digital television (DTV) broadcasting systems using the uniform geometric theory of diffraction (UGTD), finite difference time domain (FDTD) analysis, design of an RF head coil for 3T MRI, EMI/EMC, and related technologies.

Samsung Research Center (SRC)

Director: Prof. Youngnam Han

Sponsor: Samsung Electronics

- SRC consisted of 7 professors and 40 students who conduct research in the field of uHealth and 4G wireless communication systems. Currently, 2 professors and 6 students are invloved in Samsung sponsored research.

SoC Initiative for Ubiquity and Mobility (SoCium)

Director: Prof. Chong-Min Kyung

Sponsor: Samsung Electronics, LG Electronics, Core-Logic, Enter-Tech

- SoCium consists of 14 professors and 100 students. SoCium produces the experts in the field of SoC design and industry.

System Design Innovation and Application Research Center (SDIA)

Director: Prof. Hoi-Jun Yoo

Sponsor: Institute for Information Technology Advancement

- SDIA focuses on the research related to development of some platforms and application of intelligent robots, wearable computers, and bio systems.

Wireless Technology Center (WTC)

Director: Prof. Songcheol Hong

Sponsor: Samsung Electro-Mechanics

- WTC, consisting of 4 professors and 37 students, is working to develop next generation wireless technology. The center does researches on the RF front-end ICs and modules for future wireless system.

Undergraduate Courses

Classification	Subject No.	Subject Name	Lecture:Lab.: Credit (Homework)	Semester	Remark
Mandatory Major Course	EE201	Circuit Theory	3:1:3 (6)	Spring/Fall	
	EE202	Signals and Systems	3:1:3 (6)	Spring/Fall	
	EE204	Electromagnetics	3:0:3 (6)	Spring/Fall	
	EE209	Programming Structure for Electrical Engineering	3:0:3 (6)	Spring/Fall	
	EE305	Introduction to Electronics Design Lab.	1:6:3 (6)	Fall	
	EE405	Electronics Design Lab.	1:6:3 (6)	Spring	
Elective Major Course	EE205	Data Structures and Algorithms for Electrical Engineering	3:0:3 (6)	Fall	
	EE210	Probability and Introductory Random Processes	3:0:3 (6)	Spring/Fall	
	EE211	Introduction to Physical Electronics	3:0:3 (6)	Fall	
	EE303	Digital System Design	3:1:3 (6)	Spring/Fall	*CS211
	EE304	Electronic Circuits	3:1:3 (6)	Spring/Fall	
	EE311	Operating Systems and System Programming for Electrical Engineering	3:0:3 (6)	Spring	
	EE312	Introduction to Computer Architecture	3:1:3 (6)	Fall	*CS311
	EE321	Communication Engineering	3:0:3 (6)	Spring	
	EE323	Computer Network	3:0:3 (6)	Spring	
	EE324	Network Programming	3:1:3 (6)	Fall	
	EE326	Introduction to Information and Coding Theory	3:0:3 (6)	Fall	
	EE341	Electromagnetic Waves and Antennas	3:0:3 (6)	Spring	
	EE342	Radio Engineering	3:1:3 (6)	Fall	
	EE362	Semiconductor Devices	3:0:3 (6)	Fall	
	EE372	Digital Electronic Circuits	3:0:3 (6)	Fall	
	EE381	Control System Engneering	3:0:3 (6)	Spring	
	EE391	Electronic Control of Electric Machines	3:0:3 (6)	Spring	
	EE401	Communication Skills	2:0:2 (4)	Spring	
	EE402	Future Society and Electrical Engineering	2:0:2 (4)	Fall	
	EE403	Analog Electronic Circuits	3:0:3 (6)	Spring	
	EE406	Project Lab.	1:6:3 (6)	Fall	
	EE411	Switching and Automata Theory	3:0:3 (6)	Spring	
	EE414	Embedded Systems	3:1:3 (6)	Fall	
	EE421	Wireless Communication Systems	3:0:3 (6)	Spring	
	EE425	Wireless Network	3:0:3 (6)	Spring	
	EE432	Digital Signal Processing	3:0:3 (6)	Fall	
	EE441	Introduction to Fiber Optic Communication Systems	3:0:3 (6)	Spring	
	EE452	Fundamentals of Photonics	3:0:3 (6)	Fall	
	EE463	Semiconductor IC Technology	3:0:3 (6)	Spring	
	EE464	Electrical Engineering for Green Energy	3:0:3 (6)	Fall	
	EE466	Introduction to Biomedical Electronics	3:0:3 (6)	Fall	
	EE474	Introduction to Multimedia	3:0:3 (6)	Spring	
	EE476	Audio-Visual Perception Model	3:0:3 (6)	Fall	
	EE481	Intelligent Systems	3:0:3 (6)	Spring	
	EE485	Special Topics in Electronic Engineering Ⅰ	1:0:1	Spring/Fall	
	EE486	Special Topics in Electronic Engineering Ⅱ	2:0:2	Spring/Fall	
	EE488	Special Topics in Electrical Engineering	3:0:3 (6)	Spring/Fall	
Research	EE490	B.S. Thesis Research	0:6:3		
	EE495	Individual Study	0:6:1		
	EE496	Seminar	1:0:1	Spring	

Notes. i) 400 level course credits except EE405 and EE406 can be counted as master course credits.
ii) "*" mark represents a substitutive subject.

Graduate Courses

Classification	Subject No.	Subject Name	Lecture:Lab.: Credit (Homework)	Semester	Remark
	CC010	Special Lecture on Leadership	1:0:0	Fall	
	CC020	Ethics and Safety I	1AU	Spring/Fall	
General Course (Select 1 out of 8)	CC500	Scientific Writing	3:0:3 (4)	Spring/Fall	
	CC510	Introduction to Computer Application	2:3:3 (10)	Spring/Fall	
	CC511	Probability and Statistics	2:3:3 (6)	Spring/Fall	*EE528
	CC512	Introduction to Materials and Engineering	3:0:3 (3)	Spring/Fall	
	CC513	Engineering Economy and Cost Analysis	3:0:3 (6)	Fall	
	CC530	Enterpreneurship and Business Strategies	3:0:3 (6)	Fall	
	CC531	Patent Analysis and Invention Disclosure	3:0:3 (6)	Spring/Fall	
	CC532	Collaborative System Design and Engineering	4:0:4	Spring	
Mandatory Major Course	EE505	Electronics Design Lab.	1:6:3 (6)	Spring	
Elective Major Course	EE511	Computer Architecture	3:0:3 (6)	Spring	
	EE512	System Programming	3:0:3 (6)	Fall	
	EE513	Operating Systems for Networked Systems	3:0:3 (6)	Spring	
	EE515	Cryptography and Network Security	3:0:3 (6)	Fall	
	EE516	Embedded Software	1:6:3 (6)	Fall	
	EE520	Telecommunication Networks	3:0:3 (6)	Spring	
	EE522	Communication Theory	3:0:3 (6)	Spring	
	EE525	Networking Technology and Applications	1:6:3 (6)	Spring	
	EE527	Data Communication	3:0:3 (6)	Spring	
	EE528	Engineering Random Processes	3:0:3 (6)	Spring/Fall	
	EE531	Statistical Learning Theory	3:0:3 (6)	Fall	
	EE533	Digital Speech Processing	3:0:3 (6)	Spring	
	EE535	Digital Image Processing	3:0:3 (6)	Spring	
	EE538	Neural Networks	3:0:3 (6)	Fall	
	EE539	Nonlinear Statistical Signal Processing	3:0:3 (6)	Fall	
	EE541	Electromagnetic Theory	3:0:3 (6)	Spring	
	EE542	Microwave Engineering	3:1:3 (6)	Fall	
	EE543	Antenna Engineering	3:1:3 (6)	Spring	
	EE546	Fields and Waves	3:0:3 (6)	Fall	
	EE555	Optical Electronics	3:0:3 (6)	Spring	
	EE561	Introduction to VLSI Devices	3:0:3 (6)	Spring	
	EE563	Display Engineering	3:0:3 (6)	Spring	
	EE565	Modern Physics for Engineers	3:0:3 (6)	Spring	
	EE566	MEMS in EE Perspective	3:0:3 (6)	Fall	
	EE567	Photovoltaic Power Generation	3:0:3 (6)	Spring	
	EE568	Introduction to Organic Electronics	3:0:3 (6)	Fall	
	EE569	Nanobioelectronics	3:0:3 (6)	Spring	
	EE571	Advanced Electronic Circuits	3:0:3 (6)	Spring	
	EE572	Technology Futures and Management Strategies: Future New Media	3:0:3 (6)	Fall	
	EE573	Introduction to VLSI Systems	3:0:3 (6)	Spring	
	EE574	Computer Aided Design of VLSI Circuits and Systems	3:0:3 (6)	Fall	
	EE575	Entertainment Platform	3:0:3 (6)	Fall	
	EE581	Linear Systems	3:0:3 (6)	Spring	
	EE582	Digital Control	3:1:3 (6)	Spring	
	EE594	Power Electronics Systems	3:0:3 (6)	Fall	
	EE612	Discrete Event System Modeling and Simulation	3:0:3 (6)	Fall	*CS655
	EE613	Distributed Computing Systems	3:0:3 (6)	Spring	
	EE614	Service Oriented Computing Systems	3:0:3 (6)	Spring	

Classification	Subject No.	Subject Name	Lecture:Lab.: Credit (Homework)	Semester	Remark
Elective Major Course	EE615	Architecture of Systems Problem Solving	3:0:3 (6)	Spring	
	EE617	Parallel Computing Systems and Programming	3:0:3 (6)	Fall	
	EE621	Coding Theory	3:0:3 (6)	Spring	
	EE622	Signal Detection Theory	3:0:3 (6)	Fall	
	EE623	Information Theory	3:0:3 (6)	Fall	
	EE624	Mobile Communication Systems	3:0:3 (6)	Fall	
	EE625	Applied Detection and Estimation	3:0:3 (6)	Spring	
	EE626	Advanced Communication Theory	3:0:3 (6)	Fall	
	EE627	Performance Analysis of Communication Networks	3:0:3 (6)	Spring	
	EE628	Visual Communication Systems	3:0:3 (6)	Fall	
	EE629	Mobile Communication Engineering	3:0:3 (6)	Fall	
	EE631	Advanced Digital Signal Processing	3:0:3 (6)	Fall	
	EE634	Pattern Recognition	3:0:3 (6)	Fall	*CS676
	EE636	Digital Video Processing	3:0:3 (6)	Fall	
	EE637	Speech and Audio Coding Theory	3:0:3 (6)	Spring	
	EE641	Monolithic Microwave Integrated Circuits	3:0:3 (6)	Fall	
	EE643	MMIC Design	3:0:3 (6)	Spring	
	EE645	Wireless Transceiver Systems	3:0:3 (6)	Spring	
	EE647	Nano-Photonics	3:0:3 (6)	Spring	
	EE650	Optimization in Communication Network	3:0:3 (6)	Fall	
	EE651	Digital Switching Engineering	3:0:3 (6)	Spring	
	EE652	Optical Communication	3:0:3 (6)	Fall	
	EE653	Network Security	3:0:3 (6)	Spring	
	EE654	MIMO Wireless Communications	3:0:3 (6)	Fall	
	EE655	Economics in Communication Network	3:0:3 (6)	Spring	
	EE657	Local Area Network/Metropolitan Area Network	3:0:3 (6)	Spring	
	EE658	Queueing Theory with Applications	3:0:3 (6)	Fall	
	EE659	Wireless Communication Network	3:0:3 (6)	Spring	
	EE661	Solid State Physics	3:0:3 (6)	Spring	
	EE663	High Frequency Electronic Devices	3:0:3 (6)	Spring	
	EE665	CMOS Front-End Process Technology	3:0:3 (6)	Spring	
	EE666	Optoelectronic Semiconductor Devices and Their Applications	3:0:3 (6)	Fall	
	EE669	Experimental Methods in Biotechnology	3:0:3 (6)	Spring	
	EE676	Analog Integrated Circuits	3:0:3 (6)	Fall	
	EE678	Digital Integrated Circuits	3:0:3 (6)	Fall	
	EE679	Analog and Mixed Signal Circuits for Communication	3:0:3 (6)	Spring	
	EE681	Nonlinear Control	3:0:3 (6)	Fall	
	EE682	Intelligent Control Theory	3:0:3 (6)	Fall	
	EE683	Robot Control	3:0:3 (6)	Fall	
	EE684	Evolutionary Computation	3:0:3 (6)	Fall	
	EE686	Optimization Theory	3:0:3 (6)	Fall	
	EE687	Real-Time Control	3:0:3 (6)	Spring	
	EE690	Overlay Networking	3:0:3 (6)	Fall	
	EE691	Telecommunication Network Management	3:0:3 (6)	Spring	
	EE692	Parallel and Distributed Computation in Communication Network	3:0:3 (6)	Fall	
	EE694	Telephone and IP Telephony Network	3:0:3 (6)	Fall	
	EE696	Telecommunication Software Design	3:1:3 (6)	Fall	
	EE698	Multimedia Communication Middleware	3:0:3 (6)	Fall	
	EE722	Advanced Signal Detection	3:0:3 (6)	Fall	
	EE727	Broadband Network Design and Analysis	3:0:3 (6)	Fall	
Elective Major Course	EE731	Adaptive Signal Processing	3:0:3 (6)	Spring	
	EE733	Multirate Signal Processing	3:0:3 (6)	Spring	
	EE734	Image Understanding	3:0:3 (6)	Spring	
	EE735	Computer Vision	3:0:3 (6)	Fall	
	EE737	Medical Imaging Technology	3:0:3 (6)	Spring	
	EE738	Speech Recognition Systems	3:0:3 (6)	Fall	
	EE739	Cognitive Information Processing	3:0:3 (6)	Spring	
	EE741	Radiation and Diffraction of Waves	3:0:3 (6)	Spring	
	EE742	Ray Analysis for Electromagnetic Scattering Problems	3:0:3 (6)	Fall	
	EE745	EMI/EMC Design and Analysis	3:0:3 (6)	Spring	
	EE746	Radar System	3:0:3 (6)	Fall	
	EE748	High-Frequency Passive Devices	3:0:3 (6)	Fall	
	EE755	Advanced Coding Theory	3:0:3 (6)	Fall	
	EE756	Advanced Information Theory	3:0:3 (6)	Fall	
	EE757	Nonlinear Fiber Optics	3:0:3 (6)	Spring	
	EE758	Optical Networks	3:0:3 (6)	Fall	
	EE762	Advanced MOS Device Physics	3:0:3 (6)	Fall	
	EE764	Quantum Engineering for Nanoelectronic Devices	3:0:3 (6)	Fall	
	EE766	Plasma Electronics	3:0:3 (6)	Fall	
	EE772	Electronic Circuits for Green Energy	3:0:3 (6)	Fall	
	EE773	Bio-Medical CMOS IC Design	3:0:3 (6)	Spring	
	EE774	VLSI Design Methodology	3:0:3 (6)	Fall	
	EE775	Communication Core IP Design	3:0:3 (6)	Spring	
	EE783	Adaptive Control Theory	3:0:3 (6)	Spring	
	EE785	Robust Control Theory	3:0:3 (6)	Spring	
	EE786	Optimal Control Theory	3:0:3 (6)	Fall	
	EE788	Robot Cognition and Planning	3:0:3 (6)	Fall	
	EE791	Power Conversion Circuits and Systems	3:0:3 (6)	Spring	
	EE807	Special Topics in Electrical Engineering	3:0:3 (6)	Spring	
	EE808	Special Topics in Electronic Engineering Ⅰ	1:0:1	Spring/Fall	
	EE809	Special Topics in Electronic Engineering Ⅱ	2:0:2	Spring/Fall	
	EE817	Special Topics in Computer Engineering	3:0:3 (6)	Spring	
	EE827	Special Topics in Communication	3:0:3 (6)	Spring	
	EE837	Special Topics in Signal Processing	3:0:3 (6)	Spring/Fall	
	EE838	Special Topics in Image Engineering	3:0:3 (6)	Fall	
	EE847	Special Topics in Electromagnetics	3:0:3 (6)	Spring/Fall	
	EE857	Special Topics in Optical Engineering	3:0:3 (6)	Spring	
	EE867	Special Topics in Physical Electronics	3:0:3 (6)	Spring/Fall	
	EE868	Special Topics in Solid-State Physics	3:0:3 (6)	Fall	
	EE877	Special Topics in Integrated Circuits	3:0:3 (6)	Spring/Fall	
	EE878	Special Topics in VLSI	3:0:3 (6)	Fall	
	EE887	Special Topics in Robotics	3:0:3 (6)	Spring	
	EE888	Special Topics in Control Theory	3:0:3 (6)	Spring/Fall	
	EE897	Special Topics in Power Electronics	3:0:3 (6)	Spring	
	EE898	Special Topics in Intelligent Information Processing	3:0:3 (6)	Fall	
Research	EE960	M.S. Thesis			
	EE966	M.S. Seminar	1:0:1	Spring	
	EE968	Technical Writing	1:0:1 (2)	Fall	
	EE980	Ph.D. Thesis			
	EE986	Ph.D. Seminar	1:0:1	Spring	

Notes. i) 500 level course credits except EE505 and EE525 can be counted as bachelor course credits.
ii) "*" mark represents a substitutive subject.

Global Advisory Committee

Professor
Yongmin Kim
University of Washington

Professor
Karen Maex
Katholieke Universiteit Leuven

Professor
Jasprit Singh
University of Michigan

Special Programs

Government-Sponsored Program

Brain Korea 21 (BK21)
BK 21 Electronics and Communications Technology Division of KAIST aims to develop a world-class research-oriented graduate program. Specifically, our goal is to improve the graduate program so that its quality reaches a level comparable to that of the top level universities in the world. IT is widely expected to play an essential role in the information-oriented society of the 21st century, and the School of IT is committed to playing a pioneering role in conducting research and educating students who will become leaders in Korea. The Electronics and Communications Technology Division consists of 3 groups with 82 professors, 50 researchers, and 800 graduate students. The average annual budget for the Electronics and Communications Technology Division is about 28 million dollars which comes from the government, industry, and KAIST.

Industry-Sponsored Programs

Cooperative Telecommunication Education Program (CTEP)
CTEP was established to promote education in data transmission, networking, and network application. This program provides the participating students with a scholarship and appropriate facilities for IT education. CTEP students are industry-university cooperative scholarship students supported by the companies participating in CTEP such as Dacom, KTF, LG Electronics, and Hanaro Telecom. This program has been started in 1998 as a cooperative educational program in collaboration with the four departments/divisions; Electrical Engineering, Computer Science, Industrial Engineering, and Applied Mathematics.
Homepage: http://ktep.kaist.ac.kr

Educational Program for Samsung Semiconductor (EPSS)
EPSS was founded in August 2005 to cultivate human resources that will become the pioneers in the semiconductor technology through the world in the 21st century with joint efforts of the five departments (Electrical Engineering, Physics, Biological and Chemical Engineering, Material Engineering, Chemistry) at KAIST and the sponsor of Samsung Electronics. This program makes an effort to produce high quality and multidisciplinary human resources by offering the customized programs and to set a successfully collaborative model with both industry and university.
Homepage: http://epss.kaist.ac.kr

KAIST Education Program for Semiconductor Industry (KEPSI)
KEPSI was established in 1996 as a response to the demand of semiconductor industries to foster high qualified semiconductor engineers who can play a leading role in the area of semiconductors and integrated circuits for information technologies. This program is supported by the participating companies, especially Hynix Semiconductor.
Homepage: http://kepsi.kaist.ac.kr

Admission to Graduate Program

1. Scholarships for Graduate Students

Every graduate student at KAIST is eligible for one of the following scholarships:

A. Government Scholarship (sponsored by the government)
B. KAIST Scholarship (sponsored by the research fund of a faculty member or industry-funded education programs such as CTEP, KEPSI, EPSS, etc.)
C. General Scholarship (sponsored by outside organizations)

2. Advisor Assignment

A. A student with Government Scholarship shall be assigned a faculty member in the Department by the Head.
B. A student with KAIST Scholarship shall be assigned a faculty member who has in advance requested students under the special education programs. The field of the student's research may have been pre-determined if the student is supported by the research fund of a faculty member.
C. A student with General Scholarship shall be assigned a faculty member in the field of research specified by the sponsoring organization.

3. Admissions Process

Once an applicant submits the academic information together with English score (TOEFL, TOEIC, TEPS, IELTS), the Admissions Committee will review the application material and then interview the qualified applicants as necessary. For more information, please visit http://admission.kaist.ac.kr

대학원 입학 안내

1. 학생구분

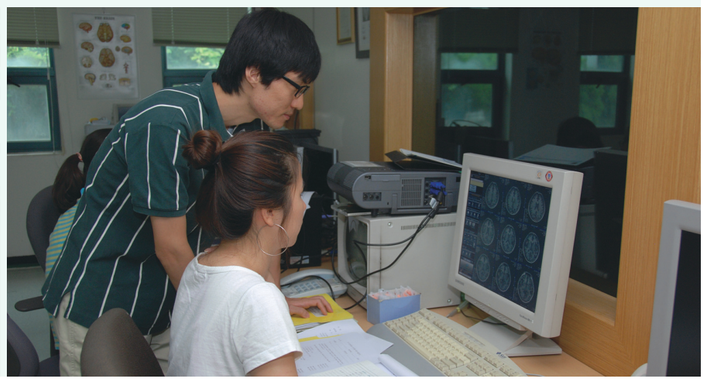
- 국비 장학생: 교육경비의 전부 또는 일부를 한국과학기술원이 확보한 정부예산으로 지원받는 학생.
- 과학기술원 장학생: 교육경비의 전부 또는 일부를 교육 프로그램 (CTEP, KEPSI, EPSS), 한국과학기술원에서 조성한 장학금, 외부출연기금, 교수 수탁과제 연구비, 또는 연구센터 운영비에서 지원받는 학생
  (교수 수탁과제 연구비에서 지원받는 과학기술원 장학생은 해당 과제에 따라 연구 분야가 제한될 수 있습니다.)
- 일반 장학생: 교육경비의 전부 또는 일부를 입학추천기관에서 지원받는 학생.
- 지원자는 입학 원서에 학생구분을 3지망까지 순위를 매겨 적어 낼 수 있습니다. 그 순위를 바탕으로 한국과학기술원이 학생구분을 정해 최종 합격자를 발표하며, 따라서 2지망이나 3지망으로 합격될 수 있음을 참고하시기 바랍니다.

2. 전형방법

- 1차 전형: 서류심사 (영어성적 포함)
- 2차 전형: 면접시험

※ 자세한 사항은 학교 누리집 http://admission.kaist.ac.kr에서 보실 수 있습니다.





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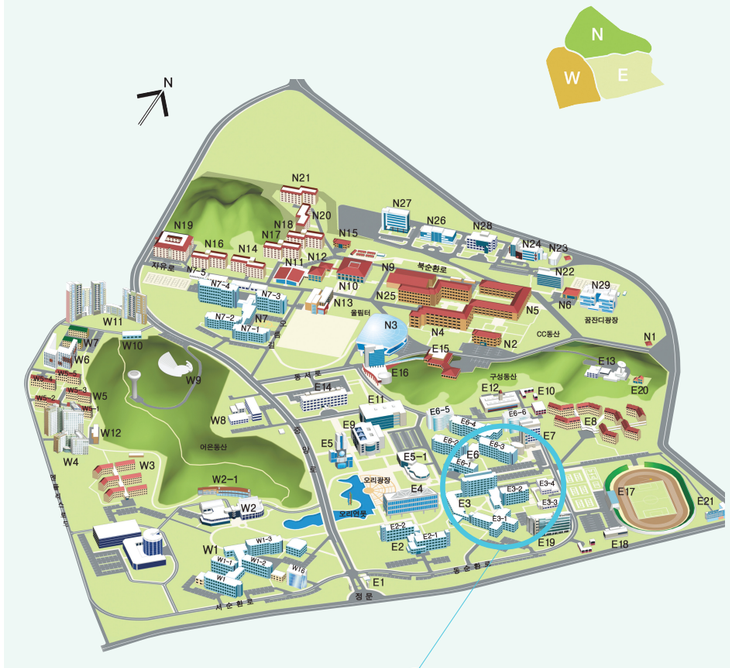
Location



East Campus Map
E1 • Main Gate
E2 • Industrial Engineering and Management
E3 • Information and Electronics
1 Department of Computer Science
2 Department of Electrical Engineering
3 Image Processing
4 Semiconductor
E4 • KAIST Institutes
E5 • Faculty Hall
E6 • Natural Science
E7 • Biomedical Research Center
E8 • Sejong Hall
E9 • KAIST Library
E10 • Storehouse
E11 • Creative Learning
E12 • Energy Plant
E13 • Satellite Technology Research Center
E14 • Main Adminstration
E15 • Auditorium
E16 • ChungMoonSoul
E17 • Stadium
E18 • Bio Model System Park
E19 • National Nano Fab Center
E20 • KyeRyong Hall
E21 • Medical Center

West Campus Map
W1 • Applied Engineering
W2 • Student Center-1
1- International Center
W3 • Galilei Hall
W4 • Heemang Hall, Dasom Hall
W5 • 1,2,3- Married Students Housing
4,5- International Village A/B
W6 • Student Dormitory
W7 • Nanum Hall
W8 • Educational Support
W9 • Outdoor Theater
W10 • Wind Tunnel Laboratory
W11 • KAIST Foreign Professor Residence
W12 • West Energy Plant
W16 • Geotechnical Centrifuge Center

North Campus Map
N1 • East Gate
N2 • Branch Administration
N3 • Sports Complex
N4 • School of Humanities and Social Science
N5 • Basic Experiement and Research
N6 • Faculty Club
N7 • Mechanical Engineering
N9 • Practice
N10 • KAIST Branch Library
N11 • Cafeteria
N12 • Student Center-2
N13 • Tae Wul Gwan
N14 • Sarang Hall
N15 • Bachelors Housing-2
N16 • Somang Hall
N17 • Seongsil Hall
N18 • Jilli Hall
N19 • Areum Hall
N20 • Silloe Hall
N21 • Jihye Hall
N22 • Alumni Venture Hall
N23 • f/MRI Center
N24 • LG Semicon Hall
N25 • Department of Industrial Design
N26 • CHIPS
N27 • Hi-Tech Venture Hall
N28 • Energy and Environment Research Center
N29 • Center for IT Convergence

한국과학기술원
전기 및 전자공학과
연차보고서 2009/2010

펴낸이_ 박현욱

엮은이_ 강경화, 김준모, 송익호, 윤준보, 최완

꾸민이_ 모인 (김성룡, 이애란)

펴낸때_ 2010년 8월