NTU GICE Newsletter
Graduate Institute of Communication Engineering, National Taiwan University

Vol. 5, No.4 November 2014 http://www.comm.ntu.edu.tw gicenewsletter@ntu.edu.tw

In this issue

Technology Developed in GICE

Development and Applications of High-Accuracy Multi-domain Legendre Pseudospectral Methods for Computational Electromagnetics

from Electromagnetics Group

Introduction

This work concerns a high-accuracy method for computational electromagnetics and its applications in the micro-meter wavelength regime of the electromagnetic-wave spectrum. In this spectral regime, nanophotonics and plasmonics have been active research areas in recent years with many potential applications. In nanophotonics, relevant structures and devices have the characteristic of nanometer-scale dimensions (several hundreds of nanometers or smaller) or sub-wavelength size. As for plasmonics, it relates to structures involving interfaces between conducting and dielectric materials and excitations of electromagnetic surface-wave propagation or resonance in such structures via the collective oscillations of the electromagnetic fields and the electrons in the conductor, leading to the so-called propagating or localized surface plasmon polaritons (SPPs), which have the characteristic of field confinement in the sub-wavelength scale and more importantly the phenomenon of enhanced electric field near the metal-dielectric interface.

In the study of the interaction of the electromagnetic fields with structures in nanophotonics and plasmonics, and associated wave propagations and resonances, direct solution of Maxwell's equations is often conducted. One popular numerical analysis and simulation method adopted is the finite-difference time-domain (FDTD) method using Yee mesh. One advantage of the time-domain solution lies in that the Fourier transform of one solution provides the frequency response. The related finite-difference frequency-domain (FDFD) method has also been developed for solving frequency-domain problems such as determination of waveguide Eigen modes. However, traditional Yee mesh is composed of rectangular grids and its so-called stair-casing approximation of the often occurring curved material interface makes the FDTD calculation of the electromagnetic field near the curved interface difficult to offer high precision. This is particularly severe for obtaining high-accuracy field profiles

(Continued on page 2)

GICE Honors

Prof.Wan-jiun Liao
2014 The 21st Teco Award

Prof. Kwang-Cheng Chen
2014 IEEE Jack Neubauer Memorial Award

Prof. Tzong-Lin Wu
2014 Outstanding Teaching Award of National Taiwan University

Message from the Director

Tzong-Lin Wu

Professor & GICE Director

With the weather getting colder and colder, we keep sharing distinguished researches, good news and some prominent activities with our GICE friends hoping that GICE Newsletter just like a warm current coursing through your body.

This periodical published two researches developed by Professor Hung-chun Chang and Professor Hung-Yu Wei, wishing you has great benefits in this reading. We also published about GICE professor won honors recently including Teco Award, IEEE jack Neubauer Memorial Award and Outstanding Teaching Award of National Taiwan University which is a great glory to announce and congratulate.

Please enjoy the latest Newsletter and we look forward your feedbacks.
We wish you a Merry Christmas and Happy New

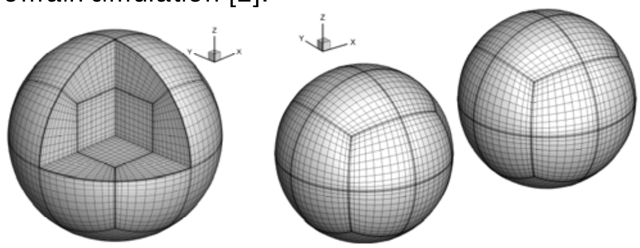
Technology

(Continued from page 1)

near material interfaces demanded in understanding the behavior of a plasmonic or nanophotonic structure and relevant applications. One basic example is the interaction between closely spaced metallic nanoparticles, such as silver or gold ones, under optical wave incidence. Plasmon resonance induced strong field enhancement in the gap between the particles may occur, which provides applications such as the surface enhanced Raman scattering (SERS) technique for biomedical detection. For high numerical-accuracy purposes, a multi-domain Legendre pseudospectral time-domain (PSTD) method has been developed [1], which can be used to study the three-dimensional (3-D) problem of light scattering by coupled metallic nanospheres and associated plasmonic resonances.

The Pseudospectral Time-Domain (PSTD) Method and Applications

In the PSTD formulation, with the multi-domain technique, the simulation environment is partitioned into curvilinear hexahedral subdomains that well match the geometrical profile and material interfaces, which is an essential treatment to assure numerical accuracy, in particular, in near-field calculations. The mesh division, subdomains, and coordinates for one-sphere problem, for example, are depicted in Fig. 1(a), where one eighth of the sphere is removed for illustrating the meshing inside, and those for the two-sphere structure are shown in Fig. 1(b). Legendre polynomials are used as interpolation bases, and the penalty scheme is utilized to handle boundary conditions between adjacent subdomains. Also, each subdomain has its own collocation grid points which are defined by the Legendre-Gauss-Lobatto quadrature (LGL) grid points. Based on these distinct collocation points, a set of global degree-*N* Lagrange interpolation polynomials can be further established to approximate a function and its spatial derivatives. And the temporal derivatives (time-marching) are managed by the fourth-order Runge-Kutta scheme [1]. In plasmonics, metal is a highly dispersive material and its dispersive characteristic of the metal in the visible light frequency range is approximated here by the Drude-Lorentz model. And the auxiliary differential equation technique is employed to include the material model in the time-domain simulation [2].



(a) (b)

Fig. 1. The mesh division, subdomains, and coordinates for (a) the one-sphere problem and (b) the two-sphere structure.

The cross sections of a single silver sphere have been computed by the PSTD method [3]. The calculated extinction cross sections for three different radii, 25 nm, 50 nm, and 100 nm, are compared, respectively, with the analytic Mie theory results, as shown in Fig. 2. With the maximum values of the Mie theory normalized to 1.0, the maximum absolute errors corresponding to these three radii are found to be 0.012, 0.002, and 0.006, respectively, for grid resolution N = 12 (i.e., $N + 1$ points for each direction of the subdomain). Such accuracy is good enough for plasmonic studies. The obtained cross sections in Fig. 2 indicate that larger sphere possesses more resonant peaks, i.e., higher order modes.

The field coupling between two closely placed silver spheres with radii 50 nm has then been studied. The spheres are placed along the x-axis with three different spaces, 10 nm, 25 nm, and 50 nm. Here we show the results when the incident wave propagates along the y-direction with Ex polarization. The calculated extinction cross sections are shown in Fig. 3 for the three different spaces. When the incident wave propagates toward the spheres, the incident electric field would lead the electrons in the metallic spheres to oscillate and then radiate energy outward. It is seen that the resonant spectral shift in Fig. 3 is related to the spacing between the two spheres. There exists quite strong field enhancement in the gap as revealed in the |Ex| and |Ey| profiles in the x-y plane in Fig. 4 for the 10-nm spacing and the main spectral peak at the wavelength λ = 481

(Continued on page 3)

Technology *(Continued from page 2)*

nm. The |Ex| field is about 28 times larger than the incident field.

The PSTD method has also been applied to the study of optical behaviors of 2-D dielectric and plasmonic waveguide-coupled ring resonators [2]. It was demonstrated to provide better numerical handling upon circular or even more complicated ring structures.

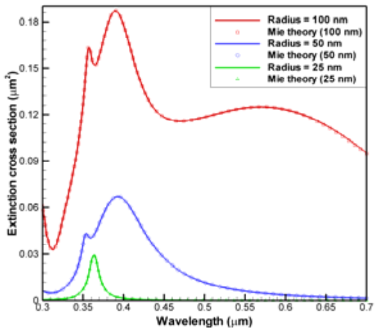


Fig. 2. PSTD calculated and analytical (Mie theory) extinction cross sections for three silver spheres with different radii, 100 nm, 50 nm, and 25 nm.

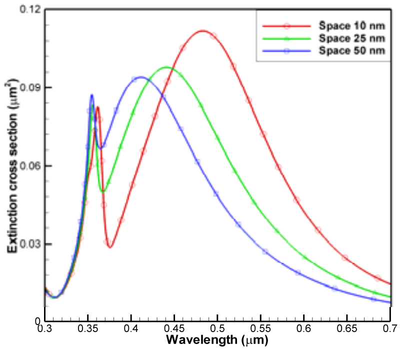


Fig 3. Extinction cross sections of two silver spheres with 50-nm radius for different spaces, 10 nm, 25 nm, and 50 nm. The incident wave propagates along the y-direction with Ex polarization.

The Pseudospectral Frequency-Domain (PSFD) Method and Applications

We have also formulated a new PSFD method for scattering problems using the similar scheme of the multi-domain Legendre PSTD method with the final form of a linear matrix equation which can be easily solved by iterative algorithms [4]. Using this PSFD method, we have shown that numerical accuracy on the order of 10^{-9} can be achieved in the scattered-field calculation of a circular metallic cylinder, as compared with known analytical results and that it provides exponentially convergent rate in numerical accuracy with respect to grid resolution. The scattering problem of a system of two square silver cylinders, each having 100-nm edge width, with 10-nm spacing, is presented as an example [4]. There is no analytical solution for such scattering problem, even for a single square cylinder. Since our PSFD method has been proved a high-order accurate one, its analysis results for the square-cylinder structures should carry high numerical accuracy and would serve as a very useful reference for other analysis methods to compare with. Figure 5(a) shows the $|E_x|$ distribution when the wave is incident from left at λ = 0.627 μm, which reveals two spots of field enhancement at the upper and lower corners in the gap, with the field enhancement being as high as up to 30 times. If we change the incident wave direction to bottom-up at λ = 0.613 μm, the strong $|E_x|$ enhancement appears in the gap near the bottom corner, as shown in Fig. 5(b), with the enhancement being up to 13 times. Note that extremely high fields can occur at the sharp corner points.

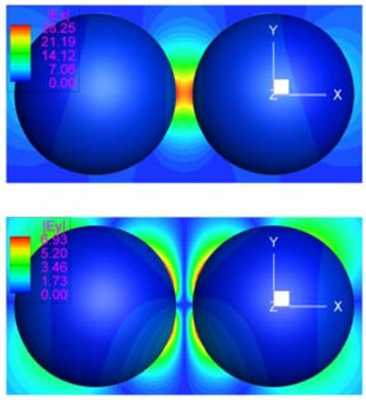
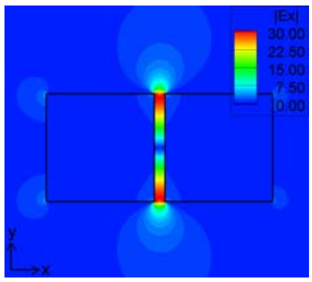
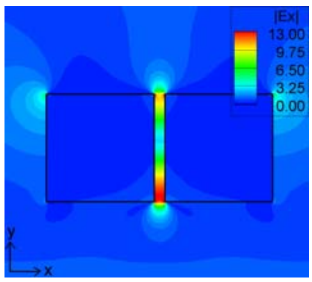


Fig. 4. Electric field component magnitude distributions at the main peak wavelength of the extinction cross section for 10-nm spacing in Fig.3 at = 481 nm.



(a)



(b)

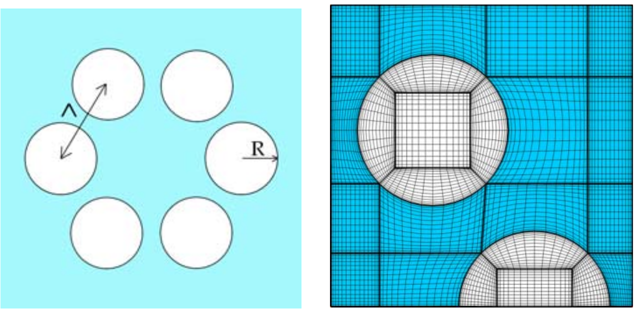
Fig. 5. $|E_x|$ distributions of two 10-nm spaced silver square cylinders of 100-nm edge width with plane light wave incidence. (a) Wave incident from left at = 0.627 m. (b) Wave incident from bottom at = 0.613m.

A related PSFD method development is the implementation of a waveguide Eigen mode solver incorporated with stretched coordinate perfectly matched layers so that effective indexes of leaky modes can be determined with very high accuracy [5]. One example is the analysis of a leaky six-air-hole fiber, as shown in Fig. 5(a), for which the six holes are hexagonally arranged, the center-to-center distance

(Continued on page 4)

Technology (Continued from page 3)

of adjacent holes is 6.75 μm, the radius of each hole is 2.5 μm, the refractive indexes for the fiber and the hole are 1.45 and 1.0, respectively, and the wavelength is 1.45 μm. Figure 5(b) shows the sub-domain arrangement and grid mesh for one quarter of the fiber cross-section. The PSFD computed complex effective indexes for the *p* = 1 and *p* = 3 modes are listed in Table I for different *N*s. Accuracy of self-convergence on the order of 10^{-14} is observed for this complicated structure.



(a) (b)

Fig. 6. (a) Cross-section of a six-air-hole fiber. (b) Sub-domain arrangement and grid mesh for one quarter of (a).

N	$Re[n_{eff}]$ ($p = 1$)	$Im[n_{eff}]$ ($p = 1$)	$Re[n_{eff}]$ ($p = 3$)	$Im[n_{eff}]$ ($p = 3$)
4	1.438367658633584	0.000001321295554	1.445395882102650	0.000000042017309
6	1.438364943632872	0.000001432990316	1.445395236589104	0.000000031910666
8	1.438364934410756	0.000001416728792	1.445395232274384	0.000000031944327
10	1.438364934183757	0.000001416477217	1.445395232151004	0.000000031945254
12	1.438364934178938	0.000001416475936	1.445395232149312	0.000000031945250
14	1.438364934178881	0.000001416475992	1.445395232149294	0.000000031945250
16	1.438364934178884	0.000001416475997	1.445395232149295	0.000000031945250

Table I: PSFD Computed Effective Indexes for the p = 1 and p = 3 Modes of the Six-Air-Hole Waveguide

Conclusion

The multi-domain Legendre PSTD method numerical model has been successfully applied to the study of problems in plasmonics and nanophotonics, such as calculation of cross sections of coupled plasmonic nanospheres and modeling of dielectric and plasmonic waveguide-coupled ring resonators. With the multi-domain technique, the simulation environment is partitioned into curvilinear subdomains that well match the geometrical profile and material interfaces, which is an essential treatment to assure numerical accuracy, in particular, in near-field calculations. Similar schemes and techniques have been employed to develop high-accuracy PSFD methods for treating 2-D scattering problems and solving leaky waveguide modes.

References

[1] C. H. Teng, B. Y. Lin, H. C. Chang, H. C. Hsu, C. N. Lin, and K. A. Feng, "A Legendre Pseudospectral Penalty Scheme for Solving Time-Domain Maxwell's Equations," Journal of Scientific Computing, Vol. 36, No. 3, pp. 351–390, September 2008.

[2] S. Y. Chung, C. Y. Wang, C. H. Teng, C. P. Chen, and H. C. Chang, "Simulations of Dielectric and Plasmonic Waveguide-Coupled Ring Resonators Using the Legendre Pseudospectral Time-Domain Method," IEEE/OSA Journal of Lightwave Technology, Vol. 30, No. 11, pp. 1733–1742, June 1, 2012.

[3] S. Y. Chung, C. Y. Wang, C. H. Teng, C. P. Chen, and H. C. Chang, "Numerical Investigation of Light Scattering by Coupled Plasmonic Nanospheres Using a High-Accuracy Multidomain Legendre Pseudospectral Time-Domain Method," in XXXth General Assembly and Scientific Symposium of International Union of Radio Science (URSI-GASS 2011) Proceedings, paper DP3.4, Istanbul, Turkey, August 13–20, 2011.

[4] C. Y. Wang, S. Y. Chung, C. H. Teng, J. K. Wang, C. P. Chen, and H. C. Chang, "A High-Accuracy Multidomain Legendre Pseudospectral Frequency-Domain Method with Penalty Scheme for Solving Scattering and Coupling Problems of Nano-Cylinders," IEEE/OSA Journal of Lightwave Technology, Vol. 31, No. 5, pp. 768–778, March 1, 2013.

[5] C. Y. Wang, H. H. Liu, S. Y. Chung, C. H. Teng, C. P. Chen, and H. C. Chang, "High-Accuracy Waveguide Leaky-Mode Analysis Using a Multidomain Pseudospectral Frequency-Domain Method Incorporated with Stretched Coordinate PML," IEEE/OSA Journal of Lightwave Technology, Vol. 31, No. 14, pp. 2347–2360, July 15, 2013.

For more information please contact:
Professor: Hung-chun Chang
Email: huncghun@ntu.edu.tw

Energy-Efficient Protocol Design for Energy-Harvesting Machine-to-Machine Communications

from Communication and Signal Processing Group

Introduction

In Machine-to-Machine (M2M) communications, thousands of devices wirelessly communicate with each other or with a central controller autonomously without human intervention. The applications include water/gas metering system, aquatic environmental monitoring, healthcare, etc., where M2M traffic is uplink-dominated. Since M2M devices can be deployed in places arduous to access (e.g. the desolate plain or desert), it is promising to power those devices with energy harvesting technology. Energy harvesting technology enables the devices to harvest and convert the ambient energy, such as solar energy, vibration, heat, etc. to usable electricity so as to reach sustainability. In this scenario, it is significant to design appropriate wireless communication protocols to satisfy the requirements and properties of energy-harvesting M2M communications. In our research, we propose (1) DeepSleep scheme to enhance IEEE 802.11 wireless local area network [1], and (2) Energy-Aware scheme for LTE-A cellular system [2].

DeepSleep for IEEE 802.11 Enhancement

To enhance IEEE 802.11 wireless local area network for uplink-oriented energy-harvesting M2M communication, we propose DeepSleep scheme [1], including Energy-Aware Deep Sleeping and DeepSleep with Controlled Access. In Energy-Aware Deep Sleeping, when the energy level of a device is

(Continued on page 5)

Technology *(Continued from page 4)*

below a certain operational threshold, the device is forced to sleep longer in low power-consuming mode, whereas guaranteed higher priority for data transmission after waking up. In this way, the device focuses on energy harvesting and power saving. With the growing number of M2M devices, DeepSleep with Controlled Access can be activated, where the device supposed to wake up can either actually wake up for high priority data transmission with probability p, or continue on deep sleeping with probability $1-p$. This probability is decided by the AP (access point) and announced to the network.

Compared to the original IEEE 802.11, results show that DeepSleep improves the energy efficiency (i.e. energy consumption per successful transmission) in Fig. 1 and decreases the application layer loss rate due to buffer overflow in Fig. 2. In addition, DeepSleep co-exists well with the original IEEE 802.11 as shown in Fig. 3. If some energy-harvesting M2M devices adopt DeepSleep, the energy efficiency of the network is improved not only for devices with DeepSleep but also for devices with original IEEE 802.11.

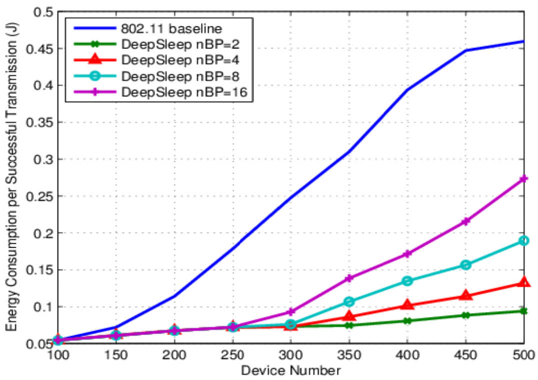


Fig. 1 Energy consumption per successful transmission of 802.11 baseline and DeepSleep with Energy-Aware Deep Sleeping only.

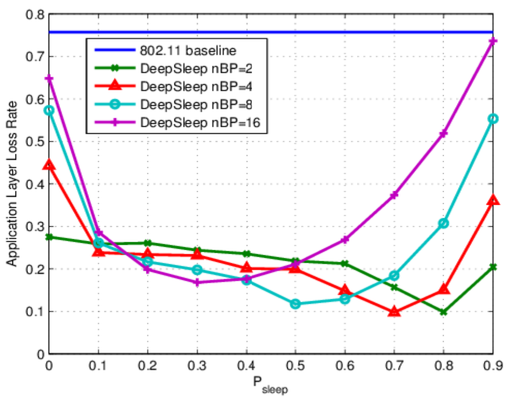


Fig. 2 Application layer loss rate under a 600-device network

Energy-Aware Scheme in LTE-A Cellular System

As the worldwide 4G cellular network standard, LTE-A (Long Term Evolution Advanced) has put M2M into its scope to cope with the overload problem [3] due to the large number of M2M devices. We further propose Energy-Aware scheme as the energy control and admission control for LTE-A cellular system. Traditionally, the device, aiming at uplink data transmission, wakes up from the idle mode and performs the network entry procedure to contend for dedicated uplink resources. If the device succeeds in the network entry procedure, it then enters the connected mode for dedicate uplink data transmission. Energy-Aware scheme allows the M2M device to perform the network entry procedure based on the data arrival rate and energy arrival rate, so that the device is guaranteed of data transmission with sufficient energy and less delay. As shown in Fig. 4, the preamble transmission success probability in Energy-Aware LTE-A system outperforms that in naïve LTE-A system. The energy efficiency in terms of the number of successful transmitted packets per Joule is enhanced as well, as shown in Fig. 5.

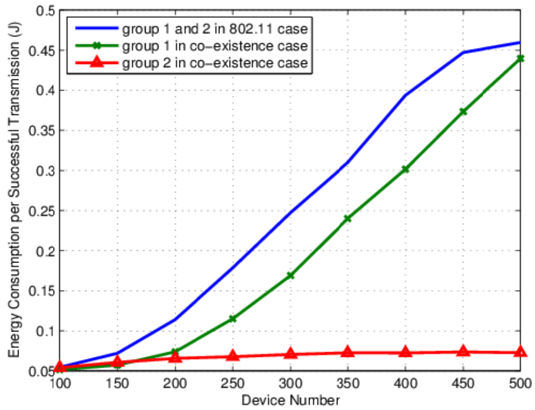


Fig. 3 Energy consumption per successful transmission (In co-existence case, group 1 adopts 802.11 baseline, and group 2 uses 0.5 as the value of channel congestion control p).

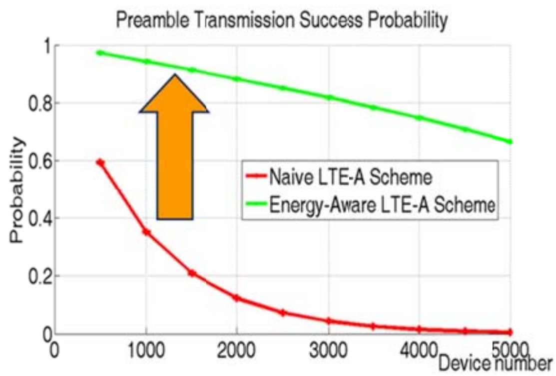


Fig. 4 Enhanced preamble transmission success probability in the network entry procedure

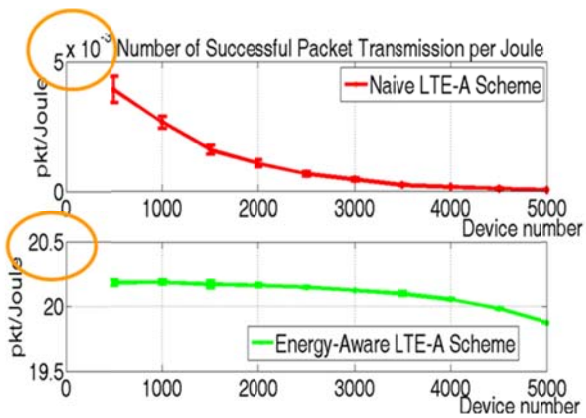


Fig. 5 Improved energy efficiency in Energy-Aware LTE-A scheme

(Continued on page 6)

Technology *(Continued from page 5)*

Conclusion

Energy harvesting technology is promising to enhance the energy efficiency of M2M communications so as to achieve the sustainability. We propose DeepSleep for IEEE 802.11 enhancement and Energy-Aware scheme for LTE-A cellular system. The two schemes provide energy-efficient solutions for energy-harvesting M2M communications in wireless local area network and in wide-coverage cellular network.

REFERENCES

[1] H.-H. Lin, M.-J. Shih, H.-Y. Wei, and R. Vannithamby, "DeepSleep: IEEE 802.11 Enhancement for Energy- Harvesting Machine-to-Machine Communications," ACM/Springer Wireless Networks, Aug. 2014

[2] M.-J. Shih, Y.-C. Pang, G.-Y. Lin, H.-Y. Wei, and R. Vannithamby, "Performance Evaluation for Energy-Harvesting Machine-Type Communication in LTE-A System," The 2nd International Workshop on 5G Mobile and Wireless Communication System for 2020 and Beyond (MWC2020 '14), May 2014

[3] M.-Y. Cheng, G.-Y. Lin, H.-Y. Wei, and Alex C.-C. Hsu, "Overload Control for Machine-Type-Communications in LTE-Advanced System," IEEE Communications Magazine, Volume 50 , Issue 6, Page 38 - 45, Jun. 2012

For more information please contact:
PHD. Student: Mei-Ju Shih
Adviser: Professor Hung-Yu Wei
Email: hywei@ntu.edu.tw

Activities

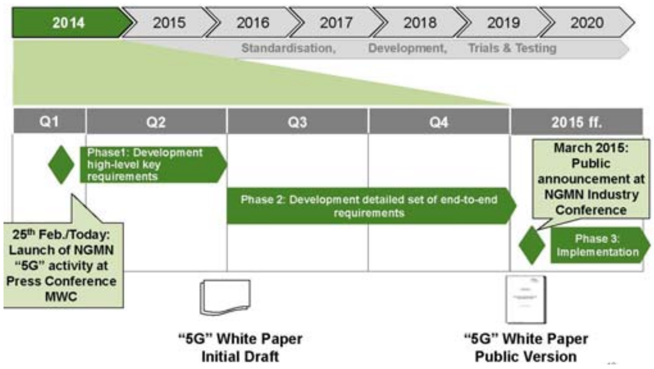
NGMN Taiwan Team for 5G Mobile Communications

In July 2014, Taiwan has officially become one of many countries that embrace 4G wireless communication. Although various 4G services are just about to kick off in Taiwan, 5G technologies has been the focus of IT industries and academic societies worldwide. According to the conclusions of Taiwan Executive Yuan's 5G strategy meeting, two key strategies are defined including (1) establishing efficient cooperation between industries and academic societies so as to harvest on the advanced academic researches and (2) defining effective intellectual properties and patents strategy so as to ensure global market development of our IT industries.

As one of the main driving forces for communication technologies, Graduate Institute of Communication Engineering (GICE) in National Taiwan University (NTU) has participated in different international organization and research project to enable 5G communication. Among these 5G research and development efforts, Next Generation Mobile Networking (NGMN) Alliance has been a main arena for GICE. NGMN Alliance is one of the most important broadband mobile alliances worldwide. Unlike other international standard bodies such as 3GPP, NGMN Alliance focuses on defining and integrating the requirements of telecommunication operators so that end users' needs and expectation for broadband mobile communication can be satisfied. NGMN Alliance is composed of more than 60 members including major international telecommunication operators (such as AT&T, China Mobile, DoCoMo), equipment manufacturers (such NSN, Ericsson, Huawei, and MTK) and academic advisors as shown in Figure 1. Through the large member base and their influences on IT industries, end-to-end end user requirements defined by NGMN Alliance will be adopted by different standardization bodies to define the next generation standards. More importantly, the massive deployment and operation verification via NGMN members will help expedite the realization of the next generation mobile communications.

Figure 1: Organization and Cooperation Model of NGMN Strategic Partners.

In Mobile World Congress (MWC) 2014, NGMN Alliance starts its 5G Initiatives and reveals its plans for 5G development. One of the main objectives in NGMN 5G Initiatives is to issue the white paper of 5G communication systems in March 2015 to ensure that 5G mobile communication systems and their services can be successfully deployed by 2020. NTU GICE, represented by Prof Chun-Ting Chou, was invited by NGMN Alliance Chief Operation Officer Peter Meissner during MWC 2014 to serve as the academic advisory partner. Through such participation and cooperation, Taiwan industries and academic societies will have early access to the development of global 5G solutions.



Schedule and Milestone of NGMN 5G Initiative

(Continued on page 7)

Activities

(Continued from page 6)

GICE together with the faculty from National Chiao-Tung University, III, and NTU CSIE Department have also formed a so-called "Taiwan Team" to participate in various NGMN activities and international coalition organizations in 2014. For example, the Taiwan Team has been involved in NGMN Advisory Forum, NGMN Industry Conference, Horizon 2020 and IEEE 802 to leverage our efforts in 5G. In addition, the Taiwan Team, with the support from Ministry of Education, has also held the first "NGMN and 5G Technology Trends Forum" in July 2014 to orchestrate the research and development efforts in Taiwan. Such efforts will only increase for the coming years and the impacts of our research in 5G are expected to be significant.

NGMN and 5G Technology Trends Forum, NTU, Taiwan, July 2014

2014 Bridge-to-the-future Electromagnetics Workshop

This report summarizes the 2014 Bridge-to-the-future Electromagnetics Workshop that was partially contributed by the IEEE Taipei Chapter in the first quarter of 2014.

IEEE EMC Taipei Chapter, as one of the co-organizers of the Bridge-to-the-future Electromagnetics Workshop, has helped arrange experts to deliver lectures. This program offering several presentations, workshops, and exhibitions, was held at Prince Hotel, a very famous amusement park in Taiwan. Sponsored by National Chung Cheng University, Microwave Society of the ROC, and Taiwan Electromagnetic Industry-Academia Consortium (TEMIAC), this program was mainly organized by the Department of Electrical Engineering, the Department of Communications Engineering, and the Center for Telecommunication Research of National Chung Cheng University. Besides IEEE EMC Taipei Chapter, this event was also co-organized by IEEE MTT Tainan and Taipei Chapters and IEEE APS Tainan Chapter. More than 200 people enrolled in this event. In addition to the presenters (scholars, PhD candidates, post doctors, and industrial practitioners), the attendees include juniors, seniors, graduate students, and professors from many universities in Taiwan.

The lectures delivered by scholars and industry experts are listed below.

1. “From small cell to B4G” by Dr. Cheng-Chung Chen, a manager of the Information and Communications Research Lab., Industrial Technology Research Institute of Taiwan.
2. “Introduction to high-way electronic toll collection systems in Taiwan” by Chung-Jay Chang, a manager of Far Eastern Electronic Toll Collection Company.
3. “WIN compound semiconductor (GaAs/GaN/InP) technology for microwave and millimeter wave” by Dr. Cheng-Kuo Lin, a manager of WIN Semiconductors Corp.
4. “Scattering parameters and its applications” by Prof. Chie-In Lee, the Department of Electrical Engineering, National Sun Yat-sen University.
5. “Broadband high performance microwave circuits using monolithic HBT-HEMT technology” by Prof. Hong-Yeh Chang, the Department of Electrical Engineering, National Central University.
6. “Microwave technologies in wearable systems” by Prof. Chin-Lung Yang, the Department of Electrical Engineering, National Cheng-Kung University.
7. “Antenna miniaturization techniques and the limitation” by Prof. Shih-Yuan Chen, the Department of Electrical Engineering, National Taiwan University.

The presentations given by some PhD candidates and a post doctor, who are regarded as stars of the future in the area of electromagnetic applications, are given as follows.

1. “Design of ring-resonator bandpass filter with tunable center frequency and bandwidth” by Dr. Yi-Ming Chen, the Department of Communications Engineering, National Chung Cheng University.
2. “Modeling and analysis of Power delivery network in three-dimensional integrated circuit” by Chi-Shian Cheng, a PhD candidate of the Department of Electrical Engineering, National Taiwan University.
3. “Low power FSF receiver using an oscillator-based injection-locked frequency divider” by Zyun-Fu Yeh, a PhD candidate of the Department of Electrical Engineering, National Sun Yat-sen University.
4. “All polarization receiving rectenna with harmonic rejection property for wireless power transmission” by Ray-Hung Chou, a PhD candidate of the Department of Electrical Engineering, National Taiwan University.
5. “The insight of Darlington-pair topology and its applications in low-power MMW COMOS circuit designs” by Hung-Ting Chou, a PhD candidate of the Department of Electrical Engineering, National Central University.
6. “Millimeter-wave CMOS power amplifiers with

(Continued on page 8)

Activities

(Continued from page 7)

high output power and wideband performances" by Yuan-Hung Hsiao, a PhD candidate of the Department of Electrical Engineering, National Taiwan University.
7. "Low-profile, small-size inverted-F LRD/WWAN tablet device antenna" by Li-Yu Lee, a PhD candidate of the Department of Electrical Engineering, National Sun Yat-sen University.
8. "The current status and future prospects of the antenna design group at Chun-Shan Institute of Science and Technology" by Tsai-Wen Hsiao, a PhD candidate of the Department of Communications Engineering, Yuan Ze University.
9. "Recent research topics and achievements at National Taiwan University of Science and Technology" by Ming-Yu Yang, a PhD candidate of the Department of Electrical Engineering, National Taiwan University of Science and Technology.

In addition to the above lectures and presentations, several workshops were also held in the three-day program. They include "Component characterization at mm-wave frequencies" offered by Taiwan Agilent corp., "GHz to THz calibration in vector network analyzer" by Anritsu Corp, "testing and application of satellite navigation systems" by Taiwan Rohde & Schwarz Corp., "VHF-to-THz EM Test solutions" by Taiwan EMtrek Technologies Corp., and "Solutions to high-frequency high-speed circuit design" by Taiwan National Instruments Corp.

The keynote speech was delivered as the last lecture in the three-day program by Prof. Richard Cameron, who is now an IEEE distinguished lecturer. The topic of his speech is "Coupling matrix synthesis techniques for microwave filter circuits."
Before closing the three-day program, Prof. Ruey-Beei Wu (the Department of Electrical Engineering, National Taiwan University), Chief Executive Officer of Institute For Information Industry (III) and Chief Executive Officer of TEMIAC, awarded the 2013 TEMIAC Distinguished Chair Professorship to four professors in Taiwan for their efforts in delivering exciting state-of-the-art EM lectures to corporation members of TEMIAC; they are Prof. Tzong-Lin Wu (the Department of Electrical Engineering, National Taiwan University), Chairman of IEEE EMC Taipei Chapter, Prof. Hsi-Tseng Chou (the Department of Communications Engineering, Yuan Ze University), Chief Officer of the Research and Development Center at Yuan Ze University, Prof. Tzyy-Sheng Horng (the Department of Electrical Engineering, National Sun Yat-sen University), and Prof. Cheng-Fa Yang (the Department of Electrical Engineering, National Taiwan University of Science and Technology). The newly elected TEMIAC distinguished chair professors for 2014 were also announced to be Prof. Yi-Cheng Lin (the Department of Electrical Engineering, National Taiwan University), Prof. Ding-Bing Lin (the Department of Electronics Engineering, National Taipei University of Technology), and Prof. Sheng-Fuh Chang (the Department of Communications Engineering, National Chung Cheng University), who have the same responsibility of sharing their research outcomes to corporation members of TEIMAC by delivering lectures in 2014.

The 2013 TEMIAC Distinguished Chair Professorship recipients with Chief Executive Officer of TEMIAC. From left to right: Prof. Tzong-Lin Wu (National Taiwan University), Prof. Prof. Hsi-Tseng Chou (National Yuan Ze University), Prof. Ruey-Beei Wu (National Taiwan University), Prof. Tzyy-Sheng Horng (National Sun Yat-sen University), and Prof. Chang-Fa Yang (National Taiwan University of Science and Technology).

Chung-Jay Chang, a manager of Far Eastern Electronic Toll Collection Company. delivering a lecture, titled "Introduction to high-way electronic toll collection systems in Taiwan."

National Taiwan University Graduate Institute of Communication Engineering

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

Phone
+886-2-3366-3075

Fax
+886-2-2368-3824

E-mail
gicenewsletter@ntu.edu.tw

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

Editor in Chief
Prof. Hung-Yu Wei

Editor
Chiao Yun Kang