Computer Communications Laboratory

Anh T. Pham
Associate Professor

Cong-Thang Truong
Assistant Professor

Tongiun Huang
Assistant Lecturer

Ha Duyen Trung
Visiting Researcher

In the AY2012, the Computer Communications Laboratory (CCL) has three faculty members, three visiting scholars and 14 research students. Our research and education focus on the areas of computer networks, multimedia communications and networks, optical communications and networking technologies, communication engineering, and ubiquitous computing & its applications. Especially, we encompass following topics:

1. Multimedia communications and networks: Visual media, video streaming, Image/video processing, video streaming, content adaptation, MPEG/JVT/ITU-T Standardization.

2. Computer networks: Internet of Things, smart town, smart grid; Internetworking technologies for security & reliability sensitive applications e.g. medical and healthcare networks.

3. Optical communications and networks: Optical fiber, optical wireless comm., systems design and performance analysis; Enabling technologies and techniques for broadband Fiber to the Home (FTTH), Fiber in the Home (FITH) networks; Optical network architecture, network protection, survivable and green optical networks.

4. Communication engineering: System modeling and performance analysis, Modulation techniques and channel coding, Code acquisition and synchronization techniques in spread spectrum systems, Cognitive radio, cooperative communications

5. E-Learning, distributed algorithms and ubiquitous computing

We always welcome undergraduate and graduate students who are interested in the above mentioned research. For further information, visit our website at `http://www.u-aizu.ac.jp/labs/ce-cc/`.

Refereed Journal Papers

[pham-01:2012] Ngoc T. Dang and Anh T. Pham. Performance analysis of 2-D OCDMA systems using novel multi-code pulse-position modulation. *IET Communications*, 6(15):2425–2431, 10 2012.

Previous works show that pulse-position modulation (PPM) is an effective signalling method for mitigating multipleaccess interference, and hence is able to increase the number of users in two-dimensional (2-D) optical code-division multipleaccess (OCDMA) systems. However, in order to achieve high bit-rates, 2-D OCDMA systems using PPM signalling require very high transmitted power because of the negative impact of dispersion. In this study, the authors propose a novel modulation technique of multi-code PPM (MCPPM), which is the combination of the PPM and multi-code modulation (MCM). As the proposed technique inherits advantages from both MCM (in mitigating the dispersion) and PPM, 2-D OCDMA systems using MCPPM signalling are able to support higher user bit-rates for a larger number of users at low transmitted powers. Numerical results show that 2-D OCDMA systems using 4-4-MCPPM can support 60 users with 5 Gbps per user at the transmitted power of -27 dBm. The power gain in this case is 11 dB compared to 2-D OCDMA systems using 4-PPM signalling. The proposed systems using 4-2-MCPPM can support as many as 36 users with the bit-rate of 10 Gbps per user and transmitted power is -22 dBm

[pham-02:2012] Ngoc T. Dang and Anh T. Pham. Performance Improvement of FSO/CDMA Systems over Dispersive Turbulence Channel using Multi-wavelength PPM Signaling. *OSA's Optics Express*, 20(24):26786–26797, 11 2012.

Previous studies show that, compared to on-off keying (OOK) signaling, pulse-position modulation (PPM) is favorable in FSO/CDMA systems thanks to its energy efciency and simple detection. Nevertheless, when the system bit rate increases and the transmission distance is far, the FSO/CDMA systems using PPM signaling critically suffer from the impact of pulse broadening caused by dispersion, especially when the modulation level is high. In this paper, we therefore propose to use multi-wavelength PPM (MWPPM) signaling to overcome the limitation of PPM. To further improve the system performance, avalanche photodiode (APD) is also used. The performance of the proposed system is theoretically analyzed using a realistic model of Gaussian pulse propagation. To model the impact of intensity uctuation caused by the at-

mospheric turbulence, the log-normal channel is used. We nd that, by using MWPPM, the effects of both intensity uctuation and pulse broadening are mitigated, the BER is therefore signicantly improved. Additionally, we quantitatively show that the system performance is further improved by using APD, especially when the average APD gain is chosen properly.

[pham-03:2012] Truong Cong Thang, Jung Won Kang, Nam Pham Ngoc, and Anh T. Pham. Standard-Compliant Content Adaptation in IPTV Systems. *REV Journal on Electronics and Communications*, pages 26–32, 2012.

IPTV, which is based on the universal IP infrastructure, has the inherent nature of heterogeneity in terms of content, networks, terminals, and users. An important solution to cope with such heterogeneity is content adaptation. This paper reviews the standardization issues related to content adaptation in IPTV standards. We rst describe the basic architecture of content adaptation and its integration into the ITU-T IPTV architecture. Then typical methods of content adaptation in practical IPTV systems are discussed in detail. Especially, we highlight the standard metadata tools that are potential to support adaptation methods within ITU-T IPTV architecture. Some recent developments in other standard bodies are also discussed.

[thang-01:2012] N. Pham-Ngoc A. T. Pham T. C. Thang, J. W. Kang. Standard-Compliant Content Adaptation in IPTV Systems (invited paper). *REV Journal on Electronics and Communications*, 2(2):26–32, 2012.

IPTV, which is based on the universal IP infrastructure, has the inherent nature of heterogeneity in terms of content, networks, terminals, and users. An important solution to cope with such heterogeneity is content adaptation. This paper reviews the standardization issues related to content adaptation in IPTV standards. We first describe the basic architecture of content adaptation and its integration into the ITU-T IPTV architecture. Then typical methods of content adaptation in practical IPTV systems are discussed in detail. Especially, we highlight the standard metadata tools that are potential to support adaptation methods within ITU-T IPTV architecture. Some recent developments in other standard bodies are also discussed.

Refereed Proceeding Papers

[pham-04:2012] Truong Cong Thang, Hoc X. Nguyen, Anh T. Pham, and

Nam Pham Ngoc. Perceptual Difference Evaluation of Video Alternatives in Adaptive Streaming. In *Proc. of the 4th International Conference on Communications and Electronics (ICCE'12)*, pages 322–326, 2012.

Adaptivity, which is the most important requirement for any video streaming systems, is usually supported by creating multiple versions of video content at the server. A practical question in this context would be: Which versions should be generated to support adaptivity? For this purpose, we investigate, through subjective tests, the number of JND (Just Noticeable Difference) levels existing in the practical quality range of streaming video content. It is found that the typical number of video versions is 4 to 7, among which most versions are located in low bitrate range. The results of this study give useful insights for streaming content providers to prepare a reasonable set of video versions.

[pham-05:2012] Ngoc T. Dang, Vuong V. Mai, Hien T. T. Pham, and Anh T. Pham. A Novel Scheme of Optical Code-based Header Processing for OBS Networks using JIT Signaling. In *Proc. of the 4th International Conference on Communications and Electronics (ICCE'12)*, pages 25–30, 2012.

In Optical Burst Switching (OBS) networks, Just-in-Time (JIT) is a simple resource reservation scheme, which does not involve complex scheduling and is amenable to hardware implementation. However, in OBS networks using JIT, the header processing time is a main factor that affects the network performance since it is included in resource reservation time. In this paper, we propose a novel optical code (OC)-based header processing with header compression, which is able to reduce the header processing time hence improve the network performance. The numerical results show that OC-based header processing helps to increase the utilization efficiency, reduce the minimum burst length and burst drop probability in comparison with conventional electronic header processing. In addition, we modify the signaling scheme to avoid header swapping at intermediate nodes. Therefore, the complexity of switch nodes can be reduced.

[pham-06:2012] Duy A. Luong, C-T. Truong, and Anh T. Pham. Effect of APD and Thermal Noises on the Performance of SC-BPSK/FSO Systems over Turbulence Channels. In *Proc. of the 18th Asia-Pacific Conference on Communications (APCC 2012)*, pages 344–349, 2012.

In this paper, we comprehensively study the performance of direct-detection free-space optical (FSO) communication systems using subcarrier binary phase-shift keying (SC-BPSK) modulation and avalanche photodiode (APD). The system bit-error rate is theoretically derived in case of two atmospheric turbulence channel models: the log-normal and gamma-gamma ones for the weak-to-moderate and moderate-to-strong turbulence conditions, respectively. We quantitatively discuss the optimal values of the average APD's gain, required received optical powers and operating bit-rates considering various turbulence conditions, APD shot noise and thermal noise. It is seen that the effect of temperature on the value of optimal gain is stronger than that of the turbulence. We also find that the impact of turbulence is severe; however using APD receiver with optimal average gain can significantly improve the system performance in both cases of turbulence channels.

[pham-07:2012] Bui T. Ninh, Ngoc T. Dang, and Anh T. Pham. The Effects of EDFA Noise on the Performance of Multi-wavelength OCDM-based Long-Reach Passive Optical Networks. In *Proc. of the IEEE Region 10 Technical Conference (TENCON 2012)*, page 10.1109/TENCON.2012.6412257, 2012.

In this paper, we propose a model of Long-reach Passive Optical Network (LR-PON) using multi-wavelength optical code-division multiplexing (OCDM) and Erbium-doped fiber amplifier (EDFA). In addition, we analyze the effects of EDFA noise on the performance of OCDM-based LR-PON. Other noise and interference such as shot noise, thermal noise, beat noise, and multiple-access interference (MAI) are included in our theoretical analysis and simulation. We found that the location of EDFA on the link between OLT and ONUs plays an important role in network design since it affects network performance. According to the simulation results, to achieve low bit error rate, the EDFA should be located around 15 to 25 km from OLT when total link distance of 90 km.

[pham-08:2012] Bach T. Vu, Ngoc T. Dang, C-T. Truong, and Anh T. Pham. Performance of Rectangular QAM/FSO Systems using APD Receiver over Atmospheric Turbulence Channels. In *Proc. of the IEEE Region 10 Technical Conference (TENCON 2012)*, page 10.1109/TENCON.2012.6412187, 2012.

We theoretically analyze the performance of free-space optical (FSO) communication systems using rectangular quadrature amplitude modulation

(QAM) and avalanche photodiode (APD) over atmospheric turbulence channels. The log-normal fading channel is used in the analysis. We derive the system's average symbol error rate (SER) taking into account the APD shot noise and thermal noise, turbulence strengths, channel distances and various system parameters.We find that using APD can greatly benefit the performance of the system in comparison with that of using PIN photodiode. However the selection of APD gain is critical to the system performance. In addition, the optimal value of APD gain also significantly depends on various conditions of the atmospheric turbulence channels.

[pham-09:2012] Ngoc T. Dang, Hien T. T. Pham, and Anh T. Pham. Reducing Atmospheric Turbulence Effects in FSO/CDMA Systems by Using Multi-wavelength PPM Signaling. In *Proc. of the 18th Asia-Pacific Conference on Communications (APCC 2012)*, pages 338–343, 2012.

In this paper, we present a comprehensive study of the effects of atmospheric turbulence, including intensity fluctuation and pulse broadening, on the performance of FSO/CDMA systems. A realistic model of Gaussian pulse propagation is used for analyzing the bit error rate (BER). The numerical results show that pulse position modulation (PPM) with high modulation level should not be used for FSO/CDMA systems as it requires to send high chip rate (i.e., short pulse), which is significantly affected by pulse broadening effect. To overcome the limitation of PPM, we propose to use multi-wavelength PPM (MWPPM), which achieves high modulation level by combining PPM and wavelength shift keying. By using MWPPM, the effects of both intensity fluctuation and pulse broadening are mitigated thus the BER is reduced. In addition, we found that the performance of FSO/CDMA systems using MWPPM can be further improved and lower BER can be achieved by using avalanche photodiode with the gain around 80 to 100.

[pham-10:2012] Hien T. T. Pham, Phuc V. Trinh, Ngoc T. Dang, and Anh T. Pham. A Comprehensive Performance Analysis of PPM-based FSO Systems with APD Receiver in Atmospheric Turbulence. In *Proc. of the 5th International Conference on Advanced Technologies for Communications (ATC 2012)*, pages 357–361, 2012.

In this paper, a model of Gaussian pulse propagation over atmospheric turbulence channel is used to comprehensively analyze the performance of PPM-based free-space optical communication (FSO) systems with APD receiver. This model simultaneously takes into account all effects of atmospheric turbulence including intensity fluctuation and pulse broadening,

which has not been considered in previous works. In addition, the impacts of APD shot noise, background noise, and thermal noise are included in our analysis. The numerical results show that, when $M \leq 128$, the main factor that limits the system performance is intensity fluctuation. However, when $M \geq 128$, optical pulse is so short that the effect of pulse broadening becomes dominant. Moreover, we found that APD gain of 60 is the optimum value that helps to achieve the lowest bit-error rate. Finally, based on channel capacity, we are able to determine the maximum transmission length of the system.

[pham-11:2012] Ha Duyen Trung, Anh T. Pham, and Kiyomichi Araki. Information Capacity of Practical MIMO Channel. In *Proc. of the 9th IEEE Vehicular Technology Society Asia Pacific Wireless Communications Symposium (APWCS 2012)*, page NA, 2012.

In this paper, we consider perfect case and worst case practical conditions, i.e., spatially uncorrelated and correlated Rayleigh fading channels with impact of estimation errors and will investigate the information capacity performance of multiple-input multiple-output (MIMO) channels that uses a zero-forcing (ZF) estimation under these two conditions. Investigating on the correlation and Rayleigh fading channel, lower bound on the information channel capacity of spatially correlated MIMO links with ZF receiver will be derived. Numerical results show that spatial correlation reduces slightly some information capacity from the uncorrelated scenarios, whereas the capacity for imperfect channel estimation at the receiver saturates at the high SNR region. Channel estimation error, on the other hand, results in a minor SNR degradation for very low SNR values.

[pham-12:2012] P. H. Binh, V. D. Trong, C. T. Anh, X. Marie P. Renucci, C.T. Truong, and Anh T. Pham. Novel LEDfs Driver Circuit for Broadband Short-Range Optical Fiber Communication Systems. In *Proc. of the 4th International Conference on Communications and Electronics (ICCE'12)*, pages 35–39, 2012.

Compared to laser diode, LED offers advantages such as lower cost, better temperature stability and longer service life. LED is therefore the preferred choice for optical communication systems when environmental conditions are uncontrolled. However, modulation rate of LED and RC-LED at 100 Mbps and 200 Mbps, respectively, is much lower than that of tens of Gbps in LD and VCSEL. Our newly proposed driver circuit uses carrier sweep-out effect in the active region when electrical pulse is turned off and peaking

effect when electrical pulse is turned on in order to reduce influence of the LED's diffusion capacitance. As the result, it is possible to transmit on-off keying (OOK) signal with speed up to 500 Mbps.

[pham-13:2012] V. D. Trong, C. T. Anh, N. D. Cuong, P. H. Binh, T. C. Thang, and Anh T. Pham. Frequency Dependence of Negative Capacitance in Light-Emitting Devices. In *Proc. of the 4th International Conference on Communications and Electronics (ICCE'12)*, pages 44–47, 2012.

In this paper, we present a systematic experimental study of negative capacitance (NC) effect in p-i-n and p-n junctions of light-emitting devices. The focus is the dependence of NC on injected current mixed with a small ac signal (1 kHz - 13 MHz) at variable temperature in forward-biased light-emitting diode (LED) and laser diode (LD). The NC effect is shown by our measurement results to be strong in low frequency region (100 kHz - 1 MHz) and weaker in high frequency one (¿ 1 MHz). In addition, the NC in LD changes suddenly at its lasing threshold. These properties of the NC effect, combined with its dependence on temperature, can lead to understanding of impacts of p-n junction capacitance on high frequency modulation in optical communication systems.

[pham-14:2012] Truong Cong Thang, Anh T. Pham, Hoc X. Nguyen, and Phan Lac Cuong. Video Streaming over HTTP with Dynamic Resource Prediction (Best Paper Award). In *Proc. of the 4th International Conference on Communications and Electronics (ICCE'12)*, pages 130–135, 2012.

Adaptive HTTP streaming has become a new trend to support adaptivity in video delivery. A HTTP streaming client needs to estimate exactly resource availability and resource demand. In this paper, we focus on the most important resource which is bandwidth. To this end, our proposed streaming approach consists of 1) throughput prediction and 2) content bitrate prediction. The experiments show that our approach can effectively cope with large fluctuations in connection throughput and video bitrate.

[pham-15:2012] Dieu Linh Truong, Phan Thuan Do, Quang Huy Duong, and Anh T. Pham. A local improvement approach for survivable long-reach hybrid WDM-TDM PON design. In *Proc. of the 4th International Conference on Communications and Electronics (ICCE'12)*, pages 7–12, 2012.

Long-reach hybrid WDM-TDM PONs connect far away service areas to center offices of service providers. Typically, multiples fiber cables run from the center office side to each service area in order to feed the service area with data flows. We believe that mesh topology in service areas allows AWGs feeding each other and consequently less fiber cables need to be run between center offices and service areas. In this paper, we show some typical cases where mesh connections between AWGs are useful. We propose also an efficient algorithm based on Local improvement approach for designing survivable long-reach hybrid WDM-TDM PONs where mesh topology between AWGs is allowed. The experimental results show that a large percentage of PONs should use mesh topology in service areas in order to minimize the total PON deployment cost.

[t-huang-01:2012] Hui-Huang Hsu, Kang-Chun Tsai, Zixue Cheng, and Tongjun Huang. Posture Recognition with G-Sensors on Smart Phones. In *Proc. of NBiS2012 (15th International Conference on Network-Based Information Systems)*, pages 588–591. IEEE Computer Society Press, Sept. 2012.

With the popularity of smart phones in recent years, various sensors on smart phones can be utilized to detect the movement or intention of the smart phone users. In this research, we aim at using the signals collected from the G-sensor in the smart phone to recognize the posture of the user. Signals for sit, stand, walk and run are collected to train an offline neural network as the classifier. After the neural network learns the four postures, we then implement a neural network with the learned connection weights in a smart phone app. The app can record the postures of the user for the whole day and estimate the burned calories accordingly. This app can replace the pedometer to have a more accurate estimate of calorie consumption. Details of the app are presented in this paper. The accuracy of neural networks on posture recognition with G-sensor signals is also verified by five-fold cross-validation.

[thang-02:2012] A. T. Pham T. C. Thang, H. X. Nguyen and N. Pham-Ngoc. Perceptual Difference Evaluation of Video Alternatives in Adaptive Streaming. In *Proc. of the 4th International Conference on Communications and Electronics (ICCE'12)*, pages 1–5, 2012.

Adaptivity, which is the most important requirement for any video streaming systems, is usually supported by creating multiple versions of video content at the server. A practical question in this context would be which versions

should be generated to support adaptivity?For this purpose, we investigate, through subjective tests, the number of JND (Just Noticeable Difference) levels existing in the practical quality range of streaming video content. It is found that the typical number of video versions is 4 to 7, among which most versions are located in low bitrate range. The results of this study give useful insights for streaming content providers to prepare a reasonable set of video versions.

[thang-03:2012] H. X. Nguyen P. L. Cuong J. W. Kang T. C. Thang, A. T. Pham. Video Streaming over HTTP with Dynamic Resource Prediction. In *Proc. of the 4th International Conference on Communications and Electronics (ICCE'12)*, pages 1–6, 2012.

Adaptive HTTP streaming has become a new trend to support adaptivity in video delivery. A HTTP streaming client needs to estimate exactly resource availability and resource demand. In this paper, we focus on the most important resource which is bandwidth. To this end, our proposed streaming approach consists of 1) throughput prediction and 2) content bitrate prediction. The experiments show that our approach can effectively cope with large fluctuations in connection throughput and video bitrate.

Unrefereed Papers

[pham-16:2012] Bach T. Vu and Anh T. Pham. FSO/MIMO System using QAM over Gamma-gamma channels. In *IEICE General Conference*, Mar. 2013.

[pham-17:2012] Vuong V. Mai and Anh T. Pham. Modeling TCP Throughput with ARQ-SR over FSO Turbulence Channels. In *IEICE General Conference*, Mar. 2013.

[pham-18:2012] Duy A. Luong and Anh T. Pham. Average Capacity of MIMO/FSO Log-normal Channel. In *IEICE General Conference*, Mar. 2013.

Grants

[pham-19:2012] Anh T. Pham (PI). Enabling Technologies and Architecture for Future Broadband Home Networks, 2012.

Total budget: 1,447,000 Yen

[pham-20:2012] Anh T. Pham (main researcher). Cross layer optimization for Adhoc and Multihop networks, 2012.

Total budget: 577,000,000 VND 2,300,000 JPY. PI: Dr. Ha Duyen Trung (Hanoi University of Science and Technology)

[pham-21:2012] Anh T. Pham (main researcher). A Safe and Secure Situation-ware IoT system for Support of the Elderly Living Along, 2012.

Total budget: 3,000,000 Yen PI: Prof. S. Tei (Univ. of Aizu)

[pham-22:2012] with Prof. CT. Truong/CCL) Anh T. Pham (Co-PI. A study on video coding and adaptive streaming technology to support HEVC scalable extension, 2012.

approx. 9,000,000 Yen

[thang-04:2012] T. C. Thang. A study on 3D video multiplexing and transmission for MMT, 2012.

[thang-05:2012] T. C. Thang. A study on video coding and adaptive streaming technology to support HEVC scalable extension, 2012.

Academic Activities

[pham-23:2012] Anh T. Pham, 2002-2012.

Member

[pham-24:2012] Anh T. Pham, 2012.

Member of TPC

[pham-25:2012] Anh T. Pham, 2012.

Senior member

[pham-26:2012] Anh T. Pham, 2012.

Member

[pham-27:2012] Anh T. Pham, 2012.

Member of the International Steering Committee, Chair of the Optical Communications and Network Session

[pham-28:2012] Anh T. Pham, 2012.

Member of TPC

[pham-29:2012] Anh T. Pham, 2012.

Member of TPC

[pham-30:2012] Anh T. Pham, 2012.

Member of TPC

[pham-31:2012] Anh T. Pham, 2012.

Member of TPC

[pham-32:2012] Anh T. Pham, 2011-2012.

Technical reviewer for various IEEE, OSA and IEICE journals, transactions and international conferences.

Patents

[t-huang-02:2012] Shengguo Sun Tongjun Huang Zixue Cheng (Shigaku Tei), Mizuo Kansen. 自動支援システムおよび自動支援方法, Sep. 2011.

Ph.D and Others Theses

[pham-33:2012] Luong Anh Duy. Graduation thesis: Performance Analysis of SC-BPSK/FSO Systems using APD Receiver over Atmospheric Turbulence Channel, School of Computer Science and Engineering, March 2013.

Thesis Advisor: Anh T. Pham

[pham-34:2012] Nguyen Tat Thang. Graduation thesis: Implementation of simulation models for SAE/OCDM Systems over Optical Channels, School of Computer Science and Engineering, March 2013.

Thesis Advisor: Anh T. Pham

[pham-35:2012] Vu Trong Bach. Graduation thesis: BER Analysis of QAM/FSO Systems Over Atmospheric Turbulence Channels, School of Computer Science and Engineering, March 2013.

Thesis Advisor: Anh T. Pham

[t-huang-03:2012] Masataka Watanabe. Graduation thesis, School of Computer Science and Engineering, 2013.

Thesis Advisor: T. Huang

[t-huang-04:2012] Keita Yamaguchi. Graduation thesis, School of Computer Science and Engineering, 2013.

Thesis Advisor: T. Huang

[t-huang-05:2012] Yuta Era. Graduation thesis, School of Computer Science and Engineering, 2013.

Thesis Advisor: T. Huang