

Computer Communications Laboratory



Anh T. Pham
Senior Associate Professor



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In the AY2013, the Computer Communications Laboratory (CCL) has three faculty members, two visiting scholars (Dr. Dang The Ngoc from PTIT, Vietnam and Prof. Nguyen Van Tam from Paris Telecom, France) and 13 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; Inter-networking 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-01:2013] Truong C. Thang Vuong V. Mai and Anh T. Pham. Performance of TCP over Free-Space Optical Atmospheric Turbulence Channels. *IEEE/OSA Journal of Optical Communications and Networking*, 5(11):1168–1177, 2013.

This paper presents an analytical study of the performance of transmission control protocol (TCP) over free-space optical (FSO) turbulence channels when the automatic-repeat request, selective-repeat (ARQ-SR) scheme is employed. Different TCP versions, including Tahoe, Reno, and selective acknowledgement, are considered. In the TCP throughput analysis, a three-dimensional Markov model is used. In addition, to analyze the joint effect of ARQ-SR and FSO turbulence channels in terms of both TCP throughput and energy consumption, a newly defined joint throughput?energy-efficiency parameter is analytically derived. In the numerical results, we discuss cross-layer design strategies for the selection of FSO system parameters and the ARQ-SR scheme in order to maximize the TCP throughput and to achieve the trade-off between the energy consumption and the throughput under various conditions of the FSO turbulence channel.

- [pham-02:2013] Anh T. Pham Nhan Nguyen-Thanh and Van-Tam Nguyen. Medium Access Control Design for Cognitive Radio Networks: A Survey. *IEICE Trans. Communications*, E97-B(2):359–374, Feb. 2014.

Designing a medium access control (MAC) protocol is a key for implementing any practical wireless network. In general, a MAC protocol is responsible for coordinating users in accessing spectrum resources. Given that a user in cognitive radio(CR) networks do not have priority in accessing spectrum resources, MAC protocols have to perform dynamic spectrum access (DSA) functions, including spectrum sensing, spectrum access, spectrum allocation, spectrum sharing and spectrum mobility, beside conventional control procedure. As a result, designing MAC protocols for CR networks requires more complicated consideration than that needed for conventional/primary wireless network. In this paper, we focus on two major perspectives related to the design of a CR-MAC protocol: dynamic spectrum access functions and network infrastructure. Five DSA functions are reviewed from the point of view of MAC protocol design. In addition, some important factors related

to the infrastructure of a CR network including network architecture, control channel management, the number of radios in the CR device and the number of transmission data channels are also discussed. The remaining challenges and open research issues are addressed for future research to aim at obtaining practical CR-MAC protocols.

- [pham-03:2013] Phan Thuan Do Dieu Linh Truong and Anh T. Pham. Optimization of Survivable Mesh Long-Reach Hybrid WDM-TDM PONs. *IEEE/OSA Journal of Optical Communications and Networking*, 6(1):62–76, Jan. 2014.

Long-reach hybrid wavelength-division multiplexing (WDM) and time-division multiplexing (TDM) passive optical networks (PONs) allow deploying access networks for remote service areas with thousands of customers. Typically, several long fiber cables are run between the central office (CO) of the service provider and each service area in order to feed the service area with data flows. In the service area, array waveguide gratings (AWGs) multiplex and demultiplex wavelengths; then, splitters split wavelengths in order to serve multiple optical network units. This paper proposes use of a mesh topology in service areas, i.e., AWGs can feed each other. This architecture has two main advantages. First, mesh linkages between AWGs make the network structure more robust with a high possibility of integrating survivable schemes. Second, fewer fibers are required between the CO and service areas, leading to a reduction of total length of fiber deployment, with a corresponding reduction of fiber installation and maintenance costs. We support this proposal by showing that i) the proposed architecture is feasible with some modification/combination of conventional PON devices, and ii) while using our optimal and heuristic algorithms for designing survivable long-reach hybrid WDM-TDM PONs, most of these PONs should use the mesh topology in order to minimize the total length of fiber deployment.

- [pham-04:2013] H. D. Trung and Anh T. Pham. Performance Analysis of MIMO/FSO Systems using SC-QAM Over Atmospheric Turbulence Channels. *IEICE Transactions on Fundamentals*, E97-A(1):49–56, Jan. 2014.

We theoretically study the performance of multiple-input multiple-output (MIMO) free-space optical (FSO) systems using subcarrier quadrature modulation (SC-QAM) signaling. The system average symbol-error rate (ASER) is derived taking into account the atmo-

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spheric turbulence effects on the MIMO/FSO channel, which is modeled by log-normal and the gamma-gamma distributions for weak and moderate-to-strong turbulence conditions. We quantitatively discuss the influence of index of refraction structure parameter, link distance, and different MIMO configurations on the system ASER. We also analytically derive and discuss the MIMO/FSO average (ergodic) channel capacity (ACC), which is expressed in terms of average spectral efficiency (ASE), under the impact of various channel conditions. Monte Carlo simulations are also performed to validate the mathematical analysis, and a good agreement between numerical and simulation results is confirmed.

- [pham-05:2013] Truong C. Thang Vuong V. Mai and Anh T. Pham. Performance of TCP over Free-Space Optical Atmospheric Turbulence Channels. *IEEE/OSA Journal of Optical Communications and Networking*, 5(11):1168–1177, Nov. 2013.

This paper presents an analytical study of the performance of transmission control protocol (TCP) over free-space optical (FSO) turbulence channels when the automatic-repeat request, selective-repeat (ARQ-SR) scheme is employed. Different TCP versions, including Tahoe, Reno, and selective acknowledgement, are considered. In the TCP throughput analysis, a three-dimensional Markov model is used. In addition, to analyze the joint effect of ARQ-SR and FSO turbulence channels in terms of both TCP throughput and energy consumption, a newly defined joint throughput?energy-efficiency parameter is analytically derived. In the numerical results, we discuss cross-layer design strategies for the selection of FSO system parameters and the ARQ-SR scheme in order to maximize the TCP throughput and to achieve the trade-off between the energy consumption and the throughput under various conditions of the FSO turbulence channel.

- [pham-06:2013] T.C. Thang Bach T. Vu, Ngoc T. Dang and Anh T. Pham. Bit-Error Rate Analysis of Rectangular QAM/FSO Systems using APD Receiver Over Atmospheric Turbulence Channels. *IEEE/OSA Journal of Optical Communications and Networking*, 5(5):437–446, May 2013.

We theoretically analyze the performance of free-space optical (FSO) systems using rectangular quadrature-amplitude modulation (QAM) and an avalanche photodiode (APD) receiver over atmospheric turbulence channels. Both log-normal and gamma-gamma channel models

are used in the analysis for the cases of weak/moderate and strong atmospheric turbulence. The system bit error rate, when Gray code mapping is employed, is theoretically derived taking into account various link conditions and system parameters, including the APD shot noise, thermal noise, channel attenuation and geometrical loss, atmospheric turbulence strengths, and link distances. The numerical results show that using APD with a proper selection of the average gain could greatly benefit the performance of the system; as a matter of fact, in the case of optimal gain, the system using an APD receiver could provide 7 dB gain in comparison with the one with a positive-intrinsic-negative receiver. We also quantitatively discuss the impact of link conditions and system parameters on the selection of optimal APD gain.

- [pham-07:2013] T.C. Thang Duy A. Luong and Anh T. Pham. Effect of avalanche photodiode and thermal noises on the performance of binary phase-shift keying subcarrier-intensity modulation/free-space optical systems over turbulence channels. *IET Communications*, 7(8):738–744, May 2013.

In this study, the authors theoretically study the performance of direct-detection free-space optical communication systems using binary phase-shift keying subcarrier-intensity modulation and avalanche photodiode (APD). The system bit-error rate and channel capacity are theoretically derived in cases of log-normal and gamma-gamma channel models for weak-to-moderate and moderate-to-strong atmospheric turbulence conditions, respectively. The authors quantitatively discuss the optimal values of the APD average gain, required transmitted optical power, and operating bit-rate considering various turbulence conditions, APD shot noise and thermal noise. It is seen that, although the impact of turbulence is severe, a proper selection of APD average gain could significantly improve the system performance in both cases of turbulence channels. The optimal value of APD average gain remains almost the same for different levels of turbulence; nevertheless it varies significantly in accordance to the change of receiver noise temperature.

- [thang-01:2013] H. X. Nguyen A. T. Pham J. W. Kang T. C. Thang, H. T. Le and Y. M. Ro. Adaptive Video Streaming over HTTP with Dynamic Resource Estimation. *IEEE/KICS Journal of Communications and Networks*, 15(6):635–644, 2013.

Adaptive HTTP streaming has become a new trend to support adaptivity in video delivery. An HTTP streaming client needs to estimate

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exactly resource availability and resource demand. In this paper, we focus on the most important resource which is bandwidth. A new and general formulation for throughput estimation is presented taking into account previous values of instant throughput and round trip time. Besides, we introduce for the first time the use of bitrate estimation in HTTP streaming. The experiments show that our approach can effectively cope with drastic changes in connection throughput and video bitrate.

Refereed Proceeding Papers

- [pham-08:2013] Thanh V. Pham and Anh T. Pham. Performance of APD-based Amplify-and-Forward Multihop FSO Systems over Turbulence Channels. In *Prof. of the IEEE Globecom 2013 Workshop - Optical Wireless Communications*, Atlanta, USA, December 2013.
IEEEXplore
- [pham-09:2013] Truong C. Thang Ngoc-Anh Tran, Vuong V. Mai and Anh T. Pham. Impact of Reflections and ISI on the Throughput of TCP over VLC Networks with ARQ-SR Protocol. In *Proc. of the 4th IEEE International Conference on Photonics 2013 - ICP2013*, Melaka, Malaysia, October 2013.
IEEEXplore
- [pham-10:2013] Truong C. Thang Thanh V. Pham and Anh T. Pham. Performance Analysis of Multihop FSO Systems using APD Receivers over Log-Normal Channels. In *Proc. of the 2nd IEEE/CIC International Conference on Communications in China (ICCC 2013)*, Xian, China, August 2013.
IEEEXplore
- [pham-11:2013] Hien T. T. Pham Ngoc T. Dang and Anh T. Pham. Average BER Analysis of Multihop FSO Systems over Strong Turbulence and Misalignment Fading Channels. In *Proc. of the 2nd IEEE/CIC International Conference on Communications in China (ICCC 2013)*, Xian, China, August 2013.
IEEEXplore
- [pham-12:2013] Truong C. Thang Vuong V. Mai and Anh T. Pham. Performance Analysis of TCP Over Free-Space Optical Links with

ARQ-SR. In *Proc. of the 18th European Conference on Networks and Optical Communications (NOC 2013)*, Graz, Austria, July 2013.

IEEEXplore

[pham-13:2013] Truong C. Thang Vuong V. Mai and Anh T. Pham. Throughput Analysis of TCP over Visible Light Communication Indoor Networks. In *Proc. of the The Fifth International Conference on Ubiquitous and Future Networks (ICUFN 2013)*, Danang, Vietnam, July 2013.

IEEEXplore, (Invited paper)

[pham-14:2013] Truong C. Thang Bach T. Vu and Anh T. Pham. BER Analysis of MIMO/FSO Systems Using Rectangular QAM Over Gamma-Gamma Channels. In *Proc. of the The Fifth International Conference on Ubiquitous and Future Networks (ICUFN 2013)*, Danang, Vietnam, July 2013.

IEEEXplore

[pham-15:2013] Truong C. Thang Duy A. Luong and Anh T. Pham. Average Capacity of MIMO/FSO Systems with Equal Gain Combining over Log-Normal Channels. In *Proc. of the The Fifth International Conference on Ubiquitous and Future Networks (ICUFN 2013)*, Danang, Vietnam, July 2013.

IEEEXplore

[pham-16:2013] Bach T. Vu H. D. Trung and Anh T. Pham. Performance of Free-Space Optical MIMO Systems Using SC-QAM Over Atmospheric Turbulence Channels. In *Proc. of the IEEE ICC 2013*, Budapest, Hungary, June 2013.

IEEEXplore

[pham-17:2013] Hien T. T. Pham Phuc V. Trinh, Anh T. Pham and Ngoc T. Dang. BER Analysis of All-Optical AF Dual-Hop FSO Systems over Gamma-Gamma Channels. In *Proc. of the 4th IEEE International Conference on Photonics 2013 - ICP2013*, Melaka, Malaysia, October 2013.

IEEEXplore

[t-huang-01:2013] T. Huang P. Li N. Yen J. Tsai Y. Zhou L. Jing Z. Cheng, J. Wang. A Situation-Oriented IoT Middleware for Resolution of Conflict Contexts Based on Combination of Priorities. In

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Proc. of EMC-13(The 8th International Conference on Embedded and Multimedia Computing), pages 1–5, Aug. 2013.

Situation-aware service is recognized as an emerging research issue in ubiquitous computing. It becomes more important and significant with the recent progress in IoT, since the situations considered in IoT are more complex, become global, and cause more conflict. In this paper, a middle-ware for management conflict situations was designed, to prompt the development of context-aware services. It is characterized by its ability of situation-oriented, paying attention to relations among users (and situations as well) and smart objects around. Eventually, following issues were solved: (a) a method for detecting (i.e., being aware of) a specific situation, and triggering corresponding service; and (b) an algorithm for conflict situations/contexts management. A diagram of situation state transition (DSST) was proposed to specify states of a situation. A set of situation-oriented ECA rules are presented to reason the situations' states based on sensed data. Policies based on DSST for resolving conflicts were also given. The experiment results demonstrate the feasibility of proposed method, and the performance of proposed situation-oriented policies.

[thang-02:2013] A. T. Pham T. C. Thang J. Y. Lee K. J. Yun D. V. Nguyen, H. T. Le. Adaptive Home Surveillance System using HTTP Streaming. In *in the Proc. UMEDIA2013*, pages 1–5, 2013.

In this paper, we investigate the use of HTTP streaming in home surveillance system. First, we propose a dynamic resource allocation framework among the cameras. Under a set of constraints, e.g. link bandwidth and delay, our resource allocation solution decides which video versions will be requested from which cameras in order to maximize the weighted sum of utility for all cameras. The optimization, which is performed at the client, is based on a utility model for each video stream that takes into account not only perceptual quality but also the delay of a video stream. Video content is obtained through HTTP request/response transaction between the client and the cameras. The experiment results show that the proposed method is able to effectively improve the overall utility while still supporting low end-to-end delay and good perceptual quality for important cameras.

[thang-03:2013] A. T. Pham T. C. Thang H. T. Le, D. V. Nguyen. Buffer-based bitrate adaptation for adaptive HTTP streaming. In *in*

the Proc. Int'l Conf. on Advanced Technologies for Communications (ATC 2013), pages 1–6, 2013.

Live and on-demand video streaming has recently contributed a significant part of the Internet traffic. In order to guarantee the best possible user experience, multimedia service is required to support large fluctuations in different network conditions. One of the cost effective means for multimedia delivery nowadays is HTTP streaming. The key challenge of this technology is how to change adaptively video bitrates according to network variation and client buffer while bestowing upon users the best possible video quality. In this paper, we propose a novel rate-adaptation method on client side, which allows clients to estimate buffer level in the future, and thus achieving a balance between the need for high video quality and buffer stability. The experiments show that our method performs well under varying network conditions.

- [thang-04:2013] A. T. Pham H. T. Le and T. C. Thang. Client-based Ad Insertion for Adaptive Video Streaming. In *in the Prof. the 11th Annual IEEE CCNC, Las Vegas*, pages 1–2, 2014.

Advertisement is a crucial factor in business models of Internet video streaming. So far, most methods for advertisement video insertion are of server-based type. In this paper, we present an approach for client-based advertisement insertion in HTTP streaming, which has become a cost effective means for multimedia delivery. The advantages of our approach include client's unawareness of advertisement and smooth transition between content and advertisement.

Unrefereed Papers

- [pham-18:2013] Truong C. Thang Ngoc-Anh Tran, Vuong V. Mai and Anh T. Pham. TCP Throughput over VLC Local Networks with ARQ-SR. In *2013 Tohoku-Section Joint Convention of Institutes of Electrical and Information Engineers, Japan, Aizuwakamatsu, Japan, August 2013. IEICE*.
- [pham-19:2013] Thanh V. Pham and Anh T. Pham. Outage Analysis of Serial Relaying BPSK/FSO Systems using Avalanche Photodiode over Lognormal Turbulence Channels. In *2013 Tohoku-Section*

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Joint Convention of Institutes of Electrical and Information Engineers, Japan, Aizuwakamatsu, Japan, August 2013. IEICE.

- [pham-20:2013] Vuong V. Mai and Anh T. Pham. Performance of Cooperative-ARQ Relaying FSO Systems. In *2013 Tohoku-Section Joint Convention of Institutes of Electrical and Information Engineers, Japan, Aizuwakamatsu, Japan, August 2013. IEICE.*

Grants

- [pham-21:2013] Anh T. Pham. Performance Evaluation and Improvement Methods For Relay-Assisted Free-Space Optical Communication Systems, 2014-2015.
- [pham-22:2013] Anh T. Pham. Toward the Paradigm of Ultra-wideband MIMO-OFDM Optical-Wireless Communications, 2013–2014.
- [pham-23:2013] Anh T. Pham. Toward the Paradigm of Ultra-wideband MIMO-OFDM Optical-Wireless Communications, 2013.
- [pham-24:2013] Anh T. Pham. Cross-layer Design of Visible Light Communication based Indoor Multimedia Networks, 2013.
- [pham-25:2013] Anh T. Pham. Toward green wireless radio network using spectrum and energy efficient multi-band cognitive radios, 2012–2013.
- [thang-05:2013] T. C. Thang. A study on multilayer based 3D video transmission, 2013.
- [thang-06:2013] T. C. Thang. A study on SHVC bitstream characteristics, layer referencing structure and adaptive streaming technology to support SHVC, 2013.

Academic Activities

- [pham-26:2013] Anh T. Pham, 2013.
Senior member
- [pham-27:2013] Anh T. Pham, 2013.
Member

- [pham-28:2013] Anh T. Pham, 2013.
Member
- [pham-29:2013] Anh T. Pham, 2013.
“ Organising Committee Co-Chair ”
- [pham-30:2013] Anh T. Pham, 2014 ” ,.
“ Organising Committee Co-Chair ”
- [pham-31:2013] Anh T. Pham, 2013.
“ Member of TPC ”
- [pham-32:2013] Anh T. Pham, 2013 ” ,.
“ Member of TPC ”
- [pham-33:2013] Anh T. Pham, 2014 ” ,.
“ Member of TPC ”
- [pham-34:2013] Anh T. Pham, 2013 ” ,.
Member of TPC
- [pham-35:2013] Anh T. Pham, 2013.
Technical reviewer for various IEEE, OSA, IET and IEICE journals,
transactions and international conferences.

Patents

- [t-huang-02:2013] Shengguo Sun Tongjun Huang Zixue Cheng (Shigaku Tei),
Mizuo Kansan. 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-36:2013] Sari Yamaguchi. Graduation thesis, School of Computer
Science and Engineering, March 2014.
Thesis Advisor: Anh T. Pham
- [pham-37:2013] Mai Viet Vuong. Maser thesis, Graduate School of Computer
Science and Engineering, March 2014.
Thesis Advisor: Anh T. Pham
- [pham-38:2013] Tran Ngoc Anh. Graduation thesis, School of Computer
Science and Engineering, March 2014.
Thesis Advisor: Anh T. Pham

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[pham-39:2013] Pham Van Thanh. Graduation thesis, School of Computer Science and Engineering, March 2014.

Thesis Advisor: Anh T. Pham

[t-huang-03:2013] Takuya Hasegawa. Graduation thesis, School of Computer Science and Engineering, 2014.

Thesis Advisor: T. Huang

[t-huang-04:2013] Suguru Takagi. Graduation thesis, School of Computer Science and Engineering, 2014.

Thesis Advisor: T. Huang