Computer Communications Laboratory

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In the AY2014, the Computer Communications Laboratory (CCL) has three faculty members, two visiting scholars (Dr. Hoa Le-Minh from Northumbria University in UK and Dr. Nguyen Thanh Chuyen from Hanoi University of Science and Technology in Vietnam). Dr. Ngoc T. Dang of Posts and Telecommunications Institute of Technology, Vietnam continues to work as researcher associate under the Nafosted project #102.02-2013.02. We have fourteen research students, including two PhD candidates, seven master's students and five GT students. Also in this year, Prof. Cong-Thang Truong is promoted to the rank of Senior Associate Professor.

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

The AY2014 is a successful year of CCL with many notable achievements. We have published totally 24 refereed academic papers, including 6 journal articles and 18 international conference papers. Our students also won several prizes and awards

1. Phuc Trinh, master's student, won the 2014 IEEE Sendai Section Student Award by IEEE Sendai Section for the paper entitled "OAF Serial Relay-Assisted FSO Systems using EDFA combined with Optical Hard-Limiter" presented at 2014 Tohoku-Section Joint Convention of Institutes of Electrical and Information Engineers, Japan.

2. Duc Nguyen, master's student, won the "ICCE Young Scientist Paper Award" by the IEEE Consumer Electronics Society East Joint Japan Chapter and the 3rd place prize of "Best Student Papers", at IEEE Conference on Consumer Electronics, Las Vegas, 2015.

3. Phuc Trinh, master's student, won the "University of Aizu's President award" for the best master student at the AY2014 graduation ceremony.

4. Sally Yamaguchi, master's student, won the "Aizu Area Foundation for the Promotion of Education and Science award" (the only one for graduate school students).

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-01:2014] Ha Duyen Trung, Do Trong Tuan, and Anh T. Pham. Pointing Error Effects on Performance of Free-Space Optical Communication System using SC-QAM Signals over Atmospheric Turbulence Channels. *Elsevier's Intl. Journal of Electronics and Communications*, 68(9):869–876, 2014.

In this paper, we theoretically analyze pointing error effects on performance of free-space optical (FSO) communication systems using subcarrier intensity quadrature amplitude modulation (SC-QAM) signals over atmospheric turbulence channels. Unlike previous studies, we take into account both atmospheric turbulence channels and the pointing error effect. In order to model atmospheric turbulence channels, we employ a log-normal distribution for weak-to-moderate turbulent condition and a gammagamma distribution for strong turbulent condition. Moreover, we study the pointing error effect by taking into account the influence of beamwidth, aperture size and jitter variance. In addition, we use a combination of these models to analyze the combined effect of atmospheric turbulence and pointing error to FSO/SC-QAM systems. Finally, we derive analytical expressions to evaluate the average symbol error rate (ASER) performance of such systems. Numerical results present the impact of pointing error on the performance of FSO/SC-QAM systems and how we use proper values of aperture size and beamwidth to improve the performance of such systems. In addition, simulation results of FSO/SC-QAM performance over strong atmospheric turbulence and pointing errors show that the closed-form expression can provide a precision for evaluating ASER of such systems

[pham-02:2014] Vuong V. Mai and Anh T. Pham. Performance Analysis of Cooperative-ARQ Schemes in Free-Space Optical Communications. *IEICE Trans. Communications*, E97-B(8):1614–1622, 2014.

We theoretically analyze the performance of free-space optical (FSO) systems using cooperative-ARQ (C- ARQ), a joint scheme of automatic-repeat-request (ARQ) and cooperative diversity, over atmospheric turbulence channels. We also propose a modified C-ARQ (M-C-ARQ) scheme that allows relay nodes to store a copy of frames for the more efficient response to transmission failure so that both transmission delay and energy consumption can be improved. Using Markov chain- based analytical models for both schemes, the system performance is analytically studied in terms of frame-error rate, good- put

and energy efficiency, which directly reflect the transmission delay and energy consumption. Numerical results confirm that the proposed schemes outperform conventional ones. In addition, we discuss cross-layer design strategies for selecting parameters in both physical and link layers in order to optimize the performance of FSO systems over different atmospheric turbulence conditions and channel distances

[pham-03:2014] Hien T. T. Pham, Ngoc T. Dang, and Anh T. Pham. Effects of atmospheric turbulence and misalignment fading on performance of serial relaying M-ary PPM FSO systems with partially coherent Gaussian beam. *IET Communications*, 8(10):1762–1768, 2014.

A novel method is presented to analyse the effects of atmospheric turbulence and misalignment fading (or pointing error) on performance of serial-relaying M-ary pulse-position modulation (PPM) free-space optical (FSO) systems. This study is more comprehensive than previous ones, since the effect of beam size variation due to turbulence by using the partially coherent Gaussian beam model is taken into account. In addition, a closed-form expression is formulated for bit error rate of serial-relaying M-ary PPM FSO systems over Gamma-Gamma atmospheric turbulence channel, taking into account the effects of atmospheric attenuation, extinction ratio and signal-dependent noise. The authors find that the laser source's coherent parameter, which governs the beam size at the receiver, plays an important role in the system design. If this parameter is not chosen properly, the system impairment will be either dominated by pointing error or geometric spreading loss. Thanks to the use of serial-relaying and M-ary PPM, the effects of atmospheric turbulence and misalignment fading is mitigated; hence the ability of combating atmospheric turbulence and the transmission distance of FSO systems are significantly improved. In addition, useful information for system design, such as the required number of relays for a specific turbulence strength and transmission distance, could be obtained from the numerical results.

[pham-04:2014] Vuong V. Mai, Ngoc-Anh Tran, Truong C. Thang, and Anh T. Pham. Performance Analysis of TCP over Visible Light Communication Networks with ARQ-SR Protocol. *Wiley's Transactions on Emerging Telecommunications Technologies*, 25(6):600–608, 2014.

This paper theoretically studies the performance of transmission control protocol (TCP) over visible light communications (VLC) networks when the automatic-repeat request, selective repeat (ARQ-SR) protocol is employed in

the link layer. We analytically derive TCP throughput considering the impact of ARQ-SR parameters and different VLC physical factors, including inter-symbol interference (ISI), signal reflection and light power distribution. Numerical results show that TCP throughput is strongly dependent on the location of VLC user due to impacts of ISI and signal reflection. It is also seen that the use of ARQ-SR could significantly improve both the maximum value and the distribution of TCP throughput in the VLC network. Especially, with a proper selection of the number of re-transmissions by the ARQ-SR protocol, the dependence of TCP throughput on user location caused by ISI, light signal reflection and distribution could be effectively remedied

[pham-05:2014] Thanh V. Pham and Anh T. Pham. Performance analysis of amplify-decode-and-forward multihop binary phase-shift keying/free-space optical systems using avalanche photodiode receivers over atmospheric turbulence channels. *IET Communications*, 8(9):15181526, 2014.

This paper studies the performance of multihop free-space optical systems using the subcarrier binary phase-shift keying modulation over atmospheric turbulence channels. The authors propose a modified relaying strategy, termed 'amplify-decode-and-forward', realised by using avalanche photodiode (APD) receivers. The outage probability of the proposed system is analytically derived considering the atmospheric turbulence and the receiver noise, including APD shot noise and thermal noise. The analytical results are verified by Monte Carlo simulations, and a good agreement between the analytical and simulation results is confirmed. In the authors' analysis, they quantitatively discuss the impact of turbulence strength, number of relay nodes, relaying configuration, system bit rate and receiver parameters on the system outage probability. In addition, the optimal value of APD gain for achieving the lowest outage probability in different cases of relaying configuration, number of relays and receiver parameters is also discussed

[t-huang-01:2014] Yinghui Zhou, Zixue Cheng, Lei Jing, Junbo Wang, and Tongjun Huang. Pre-classification based hidden Markov model for quick and accurate gesture recognition using a finger-worn device. *Applied Intelligence*, 40(4):613–622, 2014.

Hidden Markov Model (HMM)-based recognition methods are very commonly used for some applications and can be highly accurate. However, they have a high computational complexity that creates problems when they are used for gesture recognition on resource-constrained wearable devices. In this paper,

we propose a pre-classification method to reduce recognition complexity by dividing gesture vocabularies into groups, and maintain, even improve, the recognition accuracy by adaptively adjusting the HMMs for different groups. The technique consists of three tasks: gesture grouping, group modeling, and gesture modeling. Gesture grouping is performed using a K-means++ algorithm; the groups are modeled using a table-based method; and the gestures are modeled using an HMM-based approach. We evaluated the pre-classification method using real data collected by a tiny finger-worn device called a Magic Ring. The complexity of our method is much less than the standard Hidden Markov Model, without any loss of accuracy.

[t-huang-02:2014] Zixue Cheng, Junbo Wang, Neil Y. Yen, Joseph C. Tsai, and Tongjun Huang. A Context-Aware IoT Middleware for Management of Conflicts Using a Priority Scheme Based on Diagram of Situation State Transition. *JIT Journal of Internet Technology*, 16(1):151–162, Jan 2015.

Context-aware service is an extremely important research issue for users to collaborate with multiple smart objects embedded with various sensors in a local ubiquitous computing environment. And it is showing more important position in Internet of Things (shortly IoT) environment, when considering more complex situations happening in different locations. There is a need for IoT middleware to well organize the situations, e.g., creation and deletion of a situation, state transmission of the situation, in order to effectively provide services adaptive to various situations in IoT environment. Meanwhile conflict requests for situation-aware services are really hard to be solved, since many situations happen in the same time period need common resources for the services. In order to tackle the problem, we first propose an IoT middleware based on diagram of situation state transition (DSST), to specify and manage states of a situation. And then a priority scheme based on DSST for resolving conflicts is also presented by considering different states of situations. Experiment results demonstrate the feasibility of proposed method and the performance of situation-aware services based on the conflict resolution scheme.

[thang-01:2014] T. C. Thang, H. T. Le, D. V. Nguyen, and A. T. Pham. A Metadata-enabled Approach for Scalable Video Streaming in Heterogeneous Networks. *Journal of Multimedia and Information Systems*, 2(1):153–162, Mar. 2015.

In today's pervasive computing environments, multimedia content should be

adapted to meet various conditions of network connections, terminals, and user characteristics. Scalable Video Coding (SVC) is a key solution for video communication over heterogeneous networks, where user terminals have different capabilities. This paper presents a standard-compliant approach that adapts an SVC bitstream to support multiple users. The adaptation problem is formulated as an optimization problem, focusing on the tradeoff between qualities of different spatial layers of an SVC video. Then the adaptation process is represented by standard metadata of MPEG-21, which can be solved by universal processing to enable interoperable and automatic operation. Our approach provides the users with optimal quality, a wide flexibility, and seamless adaptation. To the best of our knowledge, this is the first study that shows the adaptation tradeoff between spatial layers of a conforming SVC bitstream.

[thang-02:2014] T. C. Thang, H. T. Le, A. T. Pham, and Y. M. Ro. An Evaluation of Bitrate Adaption Methods for HTTP Live Streaming. *IEEE Journal on Selected Areas in Communications*, 32(4):693–705, Apr. 2014.

HTTP streaming has become a cost effective means for multimedia delivery nowadays. For adaptivity to networks and terminals, a provider should generate multiple representations of an original video as well as the related metadata. Recently, there have been various adaptation methods to support adaptive HTTP streaming. In this paper, we investigate typical adaptation methods in the context of live video streaming. We first discuss the trade-off among typical adaptation methods. The evaluation and comparison are then carried out not only in terms of bitrate and buffer behaviors but also in terms of the perceptual impact to end users. It is found that the perceptual impact depends not only on adaptation method but also on the content itself. We also show that the preparation of representation sets may affect the behaviors of some adaptation methods.

Refereed Proceeding Papers

[pham-06:2014] Bach V. Trong, Truong C. Thang, and Anh T. Pham. Selection Decode-and-Forward Cooperative FSO Systems with Adaptive Rate Strategy over Gamma-Gamma Fading Channels. In *2014 IEEE Global Communications Conference (GLOBECOM)*, page 35853590, Austin, TX, December 2014. IEEE, IEEEXplore.

This paper analytically studies the performance of selection decode-and-forward (DF) cooperative free-space optical communication (FSO) sys-

tems, employing adaptive subcarrier quadrature amplitude modulation (SC-QAM) and taking into account the fading effect caused by atmospheric turbulence. Closed-form expressions of outage probability, spectral efficiency and bit-error rate (BER) are derived, using a novel accurate series approximation method. Numerical results highlight the improvement of the proposed system compared with all-active relaying and non-adaptive FSO systems. The validity of the analytical method is also confirmed by Monte-Carlo simulations

[pham-07:2014] Vuong V. Mai and Anh T. Pham. Adaptive Multi-Rate Designs for Hybrid FSO/RF Systems over Fading Channels. In *2014 Globecom Workshops (GC Wkshps)*, pages 469–474, Austin, TX, December 2014. IEEE, IEEEXplore.

This paper proposes a concept of adaptive multi-rate (AMR), which jointly employs switching between two links and adaptive rate on each link, for hybrid free-space optical/radio-frequency (FSO/RF) systems. Moreover, to support the operation of AMR, we propose the cross-layer design of AMR switching, which is based on both the physical and link layers with automatic-repeat request (ARQ) scheme. System performance metrics, including frame-error rate, goodput and outage probability, are analytically studied under the presence of atmospheric turbulence and Rician fading in FSO and RF links, respectively. Numerical results quantitatively show how the proposed systems significantly outperform conventional ones with physical layer-based design and/or fixed-rate switching operation

[pham-08:2014] Hoa Le-Minh, Anh T. Pham, Zabih Ghassemlooy, and Andrew Burton. Secured Communications-Zone Multiple Input Multiple Output Visible Light Communications. In *2014 Globecom Workshops (GC Wkshps)*, pages 505–511, Austin, TX, December 2014. IEEE, IEEEXplore.

Secured data broadcasting is an importantly emerging area in visible light communications (VLC). In this paper we introduce a novel approach for secured communications that is based on data beam-forming and secret channel for multiple-input-multiple-output (MIMO) VLC. Using a scrambling matrix based on either target transmission position or secret channel, it is possible to define the data-recoverable zone within the original illumination area. The paper provides theoretical development, the demonstration and evaluation of the proposed system for a MIMO VLC operating in a standard room scale

[pham-09:2014] Nhan Nguyen-Thanh, Philippe Ciblat, Anh T. Pham, and Van-Tam Nguyen. Attack and Surveillance Strategies for Selfish Primary User Emulator in Cognitive Radio Network. In *2014 IEEE Global Conference on Signal and Information Processing (GlobalSIP)*, pages 1199–1203, Atlanta, Georgia, December 2014. IEEE, IEEEXplore.

Primary user emulation (PUE) attack is a serious security problem in cognitive radio (CR) networks. In PUE attack, attacker transmits an emulated primary signal during a spectrum sensing interval to fool the CR system causing a prohibition in the secondary access on the attacked channel. An attacker is called selfish attacker if it performs the PUE attack for its selfish own purpose. Since it is obligate to reveal the user's identification in any communication link, a channel surveillance process can help to identify the selfish PUE attacker. In this paper, we formulate a non-zero-sum game with incomplete information for analyzing and modeling the selfish PUE attack and surveillance strategies simultaneously. Nash Equilibrium (NE) is figured out in closed form. The results show that the network demand and the penalty factor strongly influence the NE. Numerical simulations confirm our claims based on our analytic results

[pham-10:2014] Anh T. Pham and Duy A. Luong. Optical Wireless Communications over Fading Channels: Spatial Diversity or Multihop Relaying? (Invited Paper). In *2014 International Conference on Advanced Technologies for Communications (ATC)*, pages 760–765, Hanoi, Vietnam, October 2014. IEEE, IEEEXplore.

It has been well-known in optical wireless communications (OWC) that both spatial and cooperative diversities are effective methods for mitigating the impact of fading channels. Cooperative diversity based on multihop relaying could significantly improve the system performance, especially over long distances, its cost is nevertheless increased proportionally with the increase of the number of hops. On the other hand, spatial diversity is could reduce fading variance, its effectiveness, however, is diminished when the fading among sub-channels are correlated. The purpose of this study is to investigate the fundamental performance limits of spatial diversity suffering from correlated atmospheric fading in multihop relaying OWC systems. The negative effects of channel correlation are comprehensively analyzed by quantifying the correlation coefficient as a function of link range, turbulence strength and aperture separation. By showing that there is a substantial reduction in power penalty caused by fading correlation when relays are

employed, we comprehensively analyze the performance trade-offs between spatial diversity and multihop relaying

[pham-11:2014] Thanh V. Pham, Ngoc T. Dang, and Anh T. Pham. APD-based Amplify-and-Forward Serial Relaying FSO Systems over Gamma-Gamma Channels. In *2014 IEEE Fifth International Conference on Communications and Electronics (ICCE)*, pages 48–53, Danang, Vietnam, July-August 2014. IEEE, IEEEXplore.

This paper analytically study the performance of amply-and-forward (AF) serial relaying free-space optical (FSO) systems employing avalanche photo-diodes (APD) in atmospheric turbulence modelled by the Gamma-Gamma distribution. The subcarrier binary phase-shift keying (SC-BPSK) signalling is assumed and at each relay node, an APD is used for signal detection and amplification. Closed-form expressions of outage probability and average bit error rate (BER) are analytically derived taking into account the impact of atmospheric turbulence and APD receiver noise by using the moment matching method. The analysis is verified by Monte-Carlo simulation and a good agreement between the analytical and simulation results is confirmed

[pham-12:2014] Sari Yamaguchi, Vuong V. Mai, Truong C. Thang, and Anh T. Pham. Design and Performance Evaluation of VLC Indoor Positioning System using Optical Orthogonal Codes. In *2014 IEEE Fifth International Conference on Communications and Electronics (ICCE)*, pages 54–59, Danang, Vietnam, July-August 2014. IEEE, IEEEXplore.

In this paper, a VLC indoor positioning system utilizing optical orthogonal codes (OOCs) is proposed. The use of OOC is to distinguish different transmitted signals at the receiver, the trilateration method then calculate the position of receiver based on these distinguished signals. To expand the scale of system and use efficiently OOC resource, a strategy of reusing/combining codeword is proposed. We also create a combination of simulation and mathematical modeling to investigate the performance of proposed system. Numerical results confirm that the proposed system can achieve a good positioning accuracy level in average

[pham-13:2014] Duy B. Chu, Hien T. T. Pham, Ngoc T. Dang, and Anh T. Pham. Performance Analysis of Indoor MIMO Visible Light Communication Systems. In *2014 9th International Symposium on Communi-*

cation Systems, Networks & Digital Signal Processing (CSNDSP), pages 330–335, Manchester, UK, July 2014. IEEE, IEEEXplore.

In this paper, we propose to use relay transmission as a powerful technique for performance improvement of free-space optical code-division multiple-access (FSO/CDMA) systems. Relay nodes are based on chip detect-and-forward to avoid decoding process that makes the relay nodes more complex. We formulate a closed-form expression for bit-error rate (BER) of proposed FSO/CDMA systems over log-normal atmospheric turbulence channels taking into account channel loss due to attenuation and beam divergence. Multiple-access interference and background noise are also considered in our analysis. The numerical results show that the relay transmission is an efficient solution to improve the system performance. Thanks to this solution, FSO systems can achieve low BER, long distance, and high data rate. In addition, the advantages of using two-dimensional (2-D) prime code over 1-D one are also investigated in this paper

[pham-14:2014] Vuong V. Mai, Truong C. Thang, and Anh T. Pham. Cross-Layer Design and Analysis for FSO Links Using Automatic Repeat Request and Adaptive Modulation/Coding Schemes. In *2014 9th International Symposium on Communication Systems, Networks & Digital Signal Processing (CSNDSP)*, pages 1176–1180, Manchester, UK, July 2014. IEEE, IEEEXplore.

This paper introduces a framework for cross-layer management of data transmissions in free-space optical (FSO) systems over atmospheric turbulence channels, in which link layer automatic repeat request (ARQ) and physical layer adaptive modulation and coding (AMC) are integrated to improve the system's spectral efficiency. The system performance is analytically studied in terms of average frame-error rate and average spectral efficiency, for which we derive closed-form expressions. In numerical results, we show how the proposed scheme outperforms a conventional one, and discuss cross-layer designs for parameters' selection in both physical and link layers to optimise the system performance over different atmospheric turbulence conditions

[pham-15:2014] Hoa Le Minh, Rayana Boubezari, Zabih Ghassemlooy, Ahmed Bouridane, and Anh T. Pham. Data Detection for Smartphone Visible Light Communications. In *2014 9th International Symposium on Communication Systems, Networks & Digital Signal Processing*

(CSNDSP), pages 1034–1038, Manchester, UK, July 2014. IEEE, IEEEXplore.

In this paper we present the experimental work on object detection in the Smartphone visible light communications (SVLC) system. In SVLC, the Smartphone emits encoded images using its panel light under different conditions (link range and angles) and the transmitted data is captured by a receiving phone. The captured image is processed using the Speeded Up Robust Features (SURF) technique, which enables the frame detection and subsequently bit stream recovery. The success rate of the bit stream transmission is measured for the above test conditions. The obtained results show that 93% of successful data recovery is achieved under the normal user's working environment. In addition tests carried out also show the possibility of fast data rate communications

[pham-16:2014] Bach T. Vu, Truong C. Thang, and Anh T. Pham. Selective Relay Decode-and-Forward QAM/FSO Systems Over Atmospheric Turbulence Channels. In *2014 9th International Symposium on Communication Systems, Networks & Digital Signal Processing (CSNDSP)*, pages 407–410, Manchester, UK, July 2014. IEEE, IEEEXplore.

In this paper, we analytically investigate the performance of selective relay free-space optical (FSO) systems employing decode-and-forward scheme (DF) and sub-carrier quadrature amplitude modulation (SC-QAM) taking into account of the fading effect caused by the atmospheric turbulence. The log-normal distribution is used to model the fading channel. The closed-form of system symbol-error rate (SER) is analytically derived, and the numerical results quantitatively highlight the impact of the number of relays, turbulence strengths and QAM signaling on the average SER improvement of the selective relay FSO systems. We also verify the theoretical analysis by Monte-Carlo simulation and a good agreement between the analytical and simulation results is confirmed

[pham-17:2014] Phuc V. Trinh, Ngoc T. Dang, and Anh T. Pham. Optical Amplify-and-Forward Multihop WDM/FSO for All-Optical Access Networks. In *2014 9th International Symposium on Communication Systems, Networks & Digital Signal Processing (CSNDSP)*, pages 1106–1111, Manchester, UK, July 2014. IEEE, IEEEXplore.

Multihop free space optical (FSO) system using optical amplify-and-forward (OAF) relaying technique combined with wavelength division multiplexing

(WDM) is proposed for all-optical access networks. The proposed system can provide a low cost, flexible, and high-bandwidth access network for multiple users. To investigate the system performance, we consider a special case of dual-hop WDM-FSO system taking into account the effects of all noises, interchannel crosstalk, as well as path loss and geometric spreading of optical beam over atmospheric turbulence channels. In addition, pulse position modulation (PPM) is employed for improving the overall performance. Our results show that OAF technique combined with PPM scheme can be a good solution for mitigating the effect of atmospheric turbulence. Moreover, the required amplifier gain corresponding to a specific value of BER, transmission distance, and turbulence strength is quantitatively discussed. Finally, the adverse effect of interchannel crosstalk in the upstream transmission is also evaluated

[pham-18:2014] Duy A. Luong and Anh T. Pham. Average Capacity of MIMO Free-Space Optical Communications. In *2014 IEEE International Conference on Communications (ICC)*, pages 3354–3358, Sydney, Australia, June 2014. IEEE, IEEEXplore.

Atmospheric turbulence is one of the main impairments degrading the performance of free-space optical (FSO) systems. Similar to radio-frequency communications, the use of spatial diversity techniques in FSO can significantly mitigate the fading effect caused by atmospheric turbulence. In this paper, closed-form expressions for the average capacity of multiple-input-multiple-output FSO systems over strong atmospheric turbulence using Gamma-Gamma fading channel model are presented. Our analysis is carried out for both equal gain combining and maximal ratio combining diversity techniques. Numerical examples compare analytical and simulation results, quantitatively verifying the advantages of spatial diversity techniques

[pham-19:2014] Ngoc-Anh Tran, Duy A. Luong, Truong C. Thang, and Anh T. Pham. Performance Analysis of Indoor MIMO Visible Light Communication Systems. In *2014 IEEE Fifth International Conference on Communications and Electronics (ICCE)*, page 6064, Danang, Vietnam, July-August 2014. IEEE, IEEEXplore.

In this paper, we study the performance of Repetition Code (RC) and Spatial Multiplexing (SMP) applied to Visible Light Communication (VLC) in indoor scenarios with non-direct line-of-sight (LOS) characteristics. Considering a VLC MIMO system with 4 transmitters within a typical 5 m

× 5 m × 3 m room, by means of simulation, we investigate the distribution of Bit-error-rate (BER) when the receiver moves around the room. For various transmitter separations, the normalized area at which the system performance does not satisfy a required BER level is illustrated. The optimal values of transmitter separation for RC and SMP are 1.5 m and 3.5 m, respectively. Comparing between RC and SMP, the results show that RC outperforms SMP at low spectral efficiency. However, at relatively high spectral efficiency RC does not perform well since it requires a very high constellation size, while SMP with its spatial multiplexing gain can offer a much better performance

[thang-03:2014] H.T. Le, N.P. Ngoc, A.T. Pham, and T.C. Thang. Adaptive video streaming with smooth advertisement insertion. In *in Proc. IEEE Int'l Communications and Electronics (ICCE)*, pages 1–6, Danang, Vietnam, July 2014.

Advertisement has contributed a significant part of video streaming revenue nowadays. So far, advertisement insertion is mostly done at a streaming server or a proxy server inside the networks. However, this approach faces problems such as complexity and scalability issues. To this end, this paper presents a client-based approach in HTTP streaming which has becomes a cost effective means in multimedia delivery. In addition, a novel method is proposed for supporting smooth advertisement insertion. The experiment results show that our method can provide smooth transitions under different network conditions.

[thang-04:2014] D.V. Nguyen, H.T. Le, P.N. Nam, A.T. Pham, and T.C. Thang. Bandwidth management for multiple HTTP streaming clients. In *in Proc. IEEE Vehicular Networking Conference (VNC)*, pages 1–2, Paderborn, Germany, Dec. 2014.

In this paper, we propose a solution for sharing bandwidth among multiple HTTP streaming clients running on different devices in a vehicular network. Our solution consists of two main aspects: a manager that can determine bandwidth allocated for each client and a client-based throughput control mechanism that can regulate throughput of each client

[thang-05:2014] Duc V. Nguyen, D. M. Nguyen, H. Tran, N. P. Ngoc, A. T. Pham, and T. C. Thang. Quality-Delay Tradeoff Optimization in Multi-Bitrate Adaptive Streaming. In *in the Proc. IEEE Conference on*

Consumer Electronics (ICCE2015), pages 1–2, Las Vegas, US, Dec. 2015.

This paper studies the delay-quality tradeoff of variable bitrate (VBR) videos in multi-bitrate adaptive streaming. A novel method is presented that provides an adapted video with the best possible quality while still meeting the constraints of bandwidth and delay. (3rd prize of best student paper)

[thang-06:2014] T.C. Thang and et al. Design and Implementation of an e-Health System for Depression Detection. In *in the Proc. IEEE Conference on Consumer Electronics (ICCE2015)*, pages 1–2, Las Vegas, US, Dec. 2015.

We present the design and implementation of a cost-effective e-Health system for automatic depression detection. The system is based on a client-server architecture, where clients are popular mobile devices. For practical deployment, various factors that affect the accuracy and speed of depression detection are discussed and evaluated with extensive experiments.

[thang-07:2014] H.T. Le, N.P. Ngoc, T.A. Vu, A.T. Pham, and T.C. Thang. Smooth-bitrate adaptation method for HTTP streaming in vehicular environments. In *in Proc. IEEE Vehicular Networking Conference (VNC)*, pages 1–2, Paderborn, Germany, Dec. 2014.

Recent years have seen a fast growth of video on- demand (VOD) services over HTTP. In order to improve service quality, video services are required to support different network conditions. For vehicular environments, this study proposes a novel adaptation method that improves quality of experience (QoE) by 1) reducing the number of bitrate switches and 2) avoiding sudden quality changes. The experiment shows that proposed method can provide a smooth video even under highly fluctuating network conditions.

Unrefereed Papers

[pham-20:2014] Bach T. Vu and Anh T. Pham. Selective Relay DF/FSO Systems over Atmospheric Fading Channels. In *2014 Tohoku-Section Joint Convention of Institutes of Electrical and Information Engineers*, Yamagata, August 2014.

[pham-21:2014] Vuong V. Mai and Anh T. Pham. Performance of Adaptive Multiple-Rate Hybrid FSO/RF System over Fading Channels. In *2014 Tohoku-Section Joint Convention of Institutes of Electrical and Information Engineers*, Yamagata, August 2014.

[pham-22:2014] Duy A. Luong anh Anh T. Pham. Spatial Diversity in Multi-hop FSO System over Gamma-Gamma Correlated Fading Channels. In *2014 Tohoku-Section Joint Convention of Institutes of Electrical and Information Engineers*, Yamagata, August 2014.

[pham-23:2014] Phuc V. Trinh and Anh T. Pham. OAF Serial Relay-Assisted FSO Systems using EDFA combined with Optical Hard-Limiter. In *2014 Tohoku-Section Joint Convention of Institutes of Electrical and Information Engineers*, Yamagata, August 2014.

Grants

[pham-24:2014] Anh T. Pham. Performance Evaluation and Improvement Methods For Relay-Assisted Free-Space Optical Communication Systems, 2014–2015.

[pham-25:2014] Anh T. Pham. Toward the Paradigm of Ultra-wideband MIMO-OFDM Optical-Wireless Communications, 2014.

Academic Activities

[pham-26:2014] Anh T. Pham, 2014.

Member of TPC for many other international conferences, including ATC'14, IEEE ICCE'14, CSNDSP'14 etc.

[pham-27:2014] Anh T. Pham, 2014.

Member of IEICE: Communications, Engineering societies

[pham-28:2014] Anh T. Pham, 2014.

Guest Editor Optoelectronics for the Special Issue on Optical Wireless Communications, IET, UK

[pham-29:2014] Anh T. Pham, 2014.

> Member of TPC for many other international conferences, including ATC '14, IEEE ICCE '14, CSNDSP '14 etc.

[pham-30:2014] Anh T. Pham, 2014.

> Organising Committee Co-Chair for the 2nd International Workshop on Optical-Wireless LED Communication Networks (OWLED 2014), 8th - 11th July 2014, Shanghai, China

[pham-31:2014] Anh T. Pham, 2014.

> Organising Committee Co-Chair for the 4th Colloquium on Optical Wireless Communications, co-located with the 9th IEEE/IET International Symposium on Communication Systems, Networks and Digital Signal Processing CSNDSP 2014, July 23-25, Manchester, UK

[pham-32:2014] Anh T. Pham, 2014.

> Guest Editor Optoelectronics for the Special Issue on Optical Wireless Communications, IET, UK

[pham-33:2014] Anh T. Pham, 2014.

> Guest Editor Optoelectronics for the Special Issue on Optical Wireless Communications, IET, UK

[pham-34:2014] Anh T. Pham, 2014.

> Member of TPC for many other international conferences, including ATC '14, IEEE ICCE '14, CSNDSP '14 etc.

[pham-35:2014] Anh T. Pham, 2014.

> Peer Reviewer for many Transactions and Journals of IEEE, OSA and IEICE, including IEEE Transactions on Communications, IEEE/OSA Journal of lightwave Technology, IEEE/OSA Journal of Optical Communications and Networks, OSA Optics Express, IEEE Communications Letters etc.

[pham-36:2014] Anh T. Pham, 2014.

> Senior member of IEEE: Communications, Photonics and Vehicular Technology societies

[pham-37:2014] Anh T. Pham, 2014.

> Member of Optical Society of America (OSA)

[pham-38:2014] Anh T. Pham, 2014.

> Guest Editor Optoelectronics for the Special Issue on Optical Wireless Communications, IET, UK

Ph.D and Others Theses

[pham-39:2014] Trinh Viet Phuc. Master's thesis: Performance analysis of OAF relaying FSO systems using EDFA combined with OHL over atmospheric turbulence channels, Graduate School of Computer Science and Engineering, March 2015.

> Thesis Advisor: Anh T. Pham

[pham-40:2014] Sari Yamaguchi. Master's thesis: Design, Analysis and Simple Implementation for VLC Indoor Positioning System using Optical Orthogonal Codes, Graduate School of Computer Science and Engineering, March 2015.

> Thesis Advisor: Anh T. Pham

[t-huang-03:2014] Miho Suzuki. Graduation thesis, School of Computer Science and Engineering, 2015.

> Thesis Advisor: T. Huang

[t-huang-04:2014] Takahiro Kenmotsu. Graduation thesis, School of Computer Science and Engineering, 2015.

> Thesis Advisor: T. Huang

[t-huang-05:2014] Shoichi Hara. Graduation thesis, School of Computer Science and Engineering, 2015.

> Thesis Advisor: T. Huang