MMTC Communications – Review

Vol. 7, No. 5, December 2016

IEEE COMMUNICATIONS SOCIETY

TABLE OF CONTENTS

Message from the Review Board Directors

Welcome to the December 2016 issue of the IEEE ComSoc MMTC Communications – Review.

This issue comprises six reviews that cover multiple facets of multimedia communication research including social event analysis, wireless networks, cloud security, and quality of experience. These reviews are briefly introduced below.

The first paper, published in IEEE Transactions on Multimedia and edited by Pradeep K. Atrey, assimilates multimodality into social event tracking.

The second and third papers are related to wireless multimedia area. The second paper is published in IEEE Journal of Selected Areas in Communications and edited by Cong Shen. It looks into interference management policies for heterogeneous small cell networks. Similarly, the third paper, published in IEEE Transactions on Vehicular Technology and edited by Xiaoli Chu, presents a subchannel grouping scheme simplifying the multichannel optimization problem to a multitarget single channel optimization problem.

The fourth and fifth papers, both published in IEEE Transactions on Multimedia, focus on cloud computing from video streaming and video deduplication perspectives, respectively. The fourth paper, edited by Xiaohu Ge, resolves video management issues in cloud-based crowdsourced live streaming; whereas the fifth paper, edited by

Pradeep K. Atrey, presents a secure data deduplication protocol for H.264 videos.

Finally, the sixth paper is published in IEEE Transactions on Multimedia and edited by Wei Wang. This paper assesses quality of experience in multimedia services integrating audiovisual quality and user interest.

All the authors, nominators, reviewers, editors, and others who contribute to the release of this issue deserve appreciation with thanks.

IEEE ComSoc MMTC Communications – Review Directors

Pradeep K. Atrey
State University of New York at Albany, USA
Email: patrey@albany.edu

Qing Yang
Montana State University, USA
Email: qing.yang@montana.edu

Wei Wang
San Diego State University, USA
Email: wwang@mail.sdsu.edu

Jun Wu
Tongji University, China
Email: wujun@tongji.edu.cn

Multi-Modal Event Topic Model for Social Event Analysis

A short review for "Multi-Modal Event Topic Model for Social Event Analysis"
Edited by Pradeep K. Atrey

Nowadays, more and more social media sites are popping up and rich social multimedia content have been generated and shared conveniently on these sites. Therefore, when a popular event is happening around us, it can spread very fast and will have substantial amounts of event content information with multi-modality (e.g., images, videos, and text) in Internet. However, it is very time-consuming for people to manually identify or cluster their interesting information from massive social media data in real-world scenarios. If there is a good solution which can automatically get the evolutionary trends of social events and visualize the theme pattern over time, it will be very beneficial for people or other governments to obtain their useful information over the event evolution process. Therefore, the purpose of this paper aims to propose a novel social event tracking and evolution method to find and organize the interesting events from massive social media data automatically, and track event evolution process over time.

In this paper, the authors tackle this problem by exploring a new multi-modal event tracking and evolution framework for multi-modal time-series data. In contrast with traditional event tracking and evolution problems generally involving a single modality such as textual information, the event data in social media platform include a lot of unstructured metadata in multiple modalities. This article thinks about multi-modal data can complement each other, and multi-modal feature fusion in social media is useful for social event analysis [1, 2]. Some methods have been proposed to exploit multi-modal data for event analysis, but they only focus on feature designing rather than modeling the textual and visual information jointly and ignoring the semantic relationship among multiple modalities of social events. Thus, this is a challenge for this paper to explore an effective multi-modal fusion strategy for social event tracking and evolution analysis.

The authors of the original paper tackle multi-modal data by using a novel topic model method (multi-modal Event Topic Model, mmETM).

Compared with other multi-modal models which only focus short text and images, such as Corr-LDA [3] and mm-LDA [4], this model can effectively fuse multi-modality information and consider visual-representative topics and non-visual-representative topics together, and can be applied to long text and images. In particular, in this model, the authors introduce the switch variable to obtain two types of topics by separating the non-visual-representative topics and visual-representative topics in the multi-modal documents.

Furthermore, based on the proposed mmETM model, the authors propose a novel multi-modal social event tracking and evolution framework to obtain the evolutionary trends of social events and generate effective event summary details over time. There are several steps: (1) The input is multi-modal time-series documents downloaded from Google News. (2) The mmETM model is to effectively model multi-modal social event documents, which can conduct multi-modal event topic visualization. (3) For event tracking and evolution, the authors adopt an incremental learning strategy to update the mmETM model over time, which can be applied to event tracking and evolution. Thus, the authors' primary contribution is to propose a novel topic model for multi-modal event data, especially for long text and images, and then apply their proposed model to event tracking and evolution by using an incremental learning method.

The authors evaluate their solution on a large-scale multi-modal time-series event dataset. Their experiment results and analysis include the parameter analysis, the qualitative evaluation of the mined visual and textual topics, and the quantitative results compared with the existing methods. In the qualitative evaluation, the mined visual-representative and non-visual-representative topics are meaningful and show high consistency between semantic concepts and visual content. In the quantitative evaluation, the authors first conduct related experiments to

measure performance of online topic model by the comparison of the soft clustering quality and text/image perplexity, and the experiment results verify the effectiveness of the proposed multi-modal model. Then, the authors also conduct the time efficiency analysis, which shows that the incremental strategy is effective fairly in an online mode with the time-series event. Moreover, the authors also evaluate the event tracking results with the comparison of different models, and the results show that the proposed multi-modal event tracking and evolution framework achieves better performance than other methods.

In the future, it would be worthwhile to explore whether the proposed model can be applied to other multi-modal event summarization and event attribute mining in social media. In order to obtain better performance, the authors will consider different domains, such as Flickr, Google News, YouTube, to boost event tracking performance by using cross-domain learning method.

Acknowledgement

The editor would like to thank the authors for providing a preliminary draft of this review.

References

[1] X. Chen, A. O. Hero III, and S. Savarese, "Multimodal video indexing and retrieval using directed information," IEEE Trans.Multimedia, vol. 14, no. 1, pp. 3–16, Feb. 2012.

[2] W. Liu, T. Mei, and Y. Zhang, "Instant mobile video search with layered audio-video indexing and progressive transmission," IEEE Trans.Multimedia, vol. 16, no. 8, pp. 2242–2255, Dec. 2014.

[3] D. M. Blei and M. I. Jordan, "Modeling annotated data," in Proc.SIGIR, 2003, pp. 127–134.

[4] K. Barnard et al., "Matching words and pictures," J. Mach. Learn. Res., vol. 3, pp. 1107–1135, 2003.

Pradeep K. Atrey is an Associate Professor of Computer Science and Co-director of Albany Lab for Privacy and Security (ALPS) at the State University of New York, Albany, NY, USA. He received his Ph.D. in Computer Science from the National University of Singapore. He was a Postdoctoral Researcher at the Multimedia Communications Research Laboratory, University of Ottawa, Canada. His current research interests are in the area of Security and Privacy with a focus on multimedia surveillance and privacy, multimedia security, secure-domain cloud-based large-scale multimedia analytics, and social media. He has authored/co-authored over 100 research articles at reputed ACM, IEEE, and Springer journals and conferences. Dr. Atrey is on the editorial board of several journals including ACM Trans. on Multimedia Computing, Communications and Applications (TOMM), Elsevier Signal Processing: Image Communication Journal and ETRI Journal. Dr. Atrey has received numerous awards including the ACM TOMM Associate Editor of the Year (2015), the IEEE Comm. Soc. MMTC Best R-Letter Editor Award (2015) and the Erica and Arnold Rogers Award for Excellence in Research and Scholarship (2014). He was also recognized as the ACM Multimedia Rising Star (2015).

Distributed Interference Management for Next Generation Wireless Networks

A short review for "Distributed Interference Management Policies for Heterogeneous Small Cell Networks"

Edited by Cong Shen

Heterogeneous wireless networks (integrated deployment of femtocells, picocells, and macrocells) have been envisioned by many as the future of wireless networks [1]. These networks present a useful paradigm for the improvement of network capacity especially needed to sustain the growing demand for multimedia content on mobile devices (smartphones, tablets, etc.). The successful deployment of these networks requires a framework for interference management that can overcome the following challenges: a) efficient solution enabling co-existence with macro layer, b) distributed implementation, i.e. the small cells self-coordinate in the absence of a central coordinator thus making it useful for large scale deployments, and c) scalable policies, i.e. the gains achieved should be sustainable in networks with large number of users.

The existing literature on interference management falls short of fulfilling the above challenges. The works on distributed interference management can be categorized as: a) power control [2], b) spatial-reuse [3], and c) joint power control and spatial-reuse [4]. In distributed power control all the users in the network transmit at the same time and control their power levels in such a way that the network throughput is maximized. These policies fail to cope up with interference especially when the network is dense owing to the simultaneous transmission of the users. In distributed spatial reuse based policies, maximal independent sets (MISs) are constructed based on the interference graph representation of the users and a scheduling policy is arrived at by the users in a distributed manner. These spatial-reuse based policies are designed considering the users to be homogenous and thus cannot take heterogeneity in users' throughput requirement into account. In joint distributed spatial-reuse and power control based policies, spatial reuse is not carried out efficiently as the MISs of users are not selected thus the minimum throughput guarantees for all the users can be difficult to sustain.

In this paper, the authors develop a new framework that is built on two new tools: a) an efficient distributed method to construct sets of MISs of users from an interference graph (that spans all users), b) an approximation approach to reduce the problem of joint power control and scheduling problem to power control and scheduling of the MISs and combine it with state-of-the-art distributed alternating direction method of multipliers (ADMM) [5]. The development of the above two tools allows the authors to overcome the limitations of the existing work significantly.

The framework of the authors has three main steps. i) Each user identifies its interfering neighbors and informs the neighbor that it belongs to its set of interfering neighbors. Thus each user develops a local view of the interference graph. ii) The users compute a set of MISs that span all the users in a distributed manner as follows. This step has two phases. Phase one is comprised of a distributed randomized algorithm for computing a coloring of the graph. In every iteration of the algorithm, each user randomly selects a color from the list of colors available and fixes its choice if the color is not chosen by its neighbors and exits this phase. Otherwise, it continues the same process in the next iteration. At the end of this phase, each user has selected a color that is not chosen by its neighbors. Thus all the users with the same color form an independent set. In the second phase, each independent set represented by one color is extended to a maximal independent set by using a randomized algorithm that is similar to the one used for selecting the colors. At the end of this step, each user will know the set of MISs it belongs to. iii) In the third step, the general problem of joint power control and scheduling is approximated by the problem of power control and scheduling of the MISs computed as described above. The approximation is reduced to a form that can be solved using a distributed ADMM based procedure introduced in [5].

Next, the authors prove the efficiency properties of their framework. First, the authors prove that their framework is computationally efficient, i.e. the computation of the MISs (in the second step) and the computation of the power control and scheduling (in the third step) does not require a long computational time as the number of users in the network grows. The authors also prove that under a wide range of conditions the proposed framework is scalable, i.e. the throughput achieved by the proposed policy is a constant factor approximation of the highest throughput that can be achieved by any centralized policy while satisfying the minimum throughput guarantees of all the users.

Under extensive simulations, the proposed framework is shown to outperform the counterpart state-of-the-art methods for different performance objectives such as total throughput achieved, minimum throughput achieved significantly with gains ranging from 150-700 %. The proposed framework is also extended to dynamic settings with user arrivals and exits and is shown to have robust performance under such dynamic conditions.

The scheme proposed by the authors is very promising as it has been shown to perform significantly better than its counterparts in many settings. The key idea of developing a distributed method for scheduling maximal independent sets in an optimal manner is very useful and has the potential of being a part of the interference management protocols adopted in the future generation of heterogeneous wireless networks. Also, the new tools built in this work can be applied to other problems in the area of network-based optimization.

References

[1] A. Ghosh, N. Mangalvedhe, R. Ratasuk, B. Mondal, M. Cudak, E. Visotsky, T. A. Thomas, J. G. Andrews, P. Xia, H. S. Jo et al., "Heterogeneous cellular networks: From theory to practice," IEEE Communications Magazine, vol. 50, no. 6, pp. 54–64, 2012.

[2] J. Huang, R. A. Berry, and M. L. Honig, "Distributed interference compensation for wireless networks," IEEE Journal on Selected Areas in Communications, vol. 24, no. 5, pp. 1074–1084, 2006.

[3] A. Ephremides and T. V. Truong, "Scheduling broadcasts in multihop radio networks," IEEE Transactions on Communications, vol. 38, no. 4, pp. 456–460, 1990.

[4] S. G. Kiani and D. Gesbert, "Optimal and distributed scheduling for multicell capacity maximization," IEEE Transactions on Wireless Communications, vol. 7, no. 1, pp. 288–297, 2008.

[5] E. Wei and A. Ozdaglar, "On the o (1/k) convergence of asynchronous distributed alternating direction method of multipliers," arXiv preprint, arXiv:1307.8254, 2013.

Cong Shen received his B.S. and M.S. degrees, in 2002 and 2004 respectively, from the Department of Electronic Engineering, Tsinghua University, China. He obtained the Ph.D. degree from the Electrical Engineering Department, UCLA, in 2009. From 2009 to 2014, He worked for Qualcomm Research in San Diego, CA. In 2015, he returned to academia and joined University of Science and Technology of China (USTC) as the 100 Talents Program Professor in the School of Information Science and Technology. His general research interests are in the area of communication theory, wireless networks, and information theory. He is a Senior Member of IEEE and serves as an editor for the IEEE Transactions on Wireless Communications.

Optimization of Energy Efficiency for MIMO-OFDM Mobile Multimedia Communications

A short review for "Energy Efficiency Optimization for MIMO-OFDM Mobile Multimedia Communication Systems with QoS Constraints"

Edited by Xiaoli Chu

Multiple-input multiple-output (MIMO) technologies can create independent parallel channels to transmit data streams in wireless communication systems, which improves spectral efficiency and system capacity without increasing the bandwidth requirement [1]. Orthogonal frequency-division multiplexing (OFDM) technologies eliminate the multipath effect by transforming frequency-selective channels into flat channels [2]. As a combination of MIMO and OFDM technologies, the MIMO-OFDM technologies are widely used in the fourth generation (4G) mobile multimedia communication systems [3]. As various wireless multimedia applications are getting more and more popular, the demand for wireless traffic is increasing rapidly in 4G mobile multimedia communication systems. Therefore, the energy consumed for mobile multimedia communication systems is quickly increased [4]. Therefore, it is an important issue for improving the energy efficiency of mobile multimedia communication systems. Different from the conventional energy efficiency optimization methods used for wireless communication systems, the quality of service (QoS) requirement is an additional constraint for the energy efficiency optimization of mobile multimedia communication systems. How to improve energy efficiency with QoS constraints is an indispensable challenge in MIMO-OFDM mobile multimedia communication systems.

In general, the QoS of multimedia communication is affected by multiply metrics, such as transmission rate, delay and jitter. To evaluate the QoS constraint on the energy efficiency of MIMO-OFDM multimedia communication systems, the authors adopt the statistical QoS constraint as a uniformly QoS metric, which uses a statistical exponent to measure the queue characteristics of data transmission in mobile communication systems [5]. Moreover, the effect capacity and channel gain of each subchannel is depended on the

statistical QoS exponent. Based on the definition of energy efficiency, the energy efficiency of MIMO-OFDM mobile multimedia communication systems depends on transmission power-allocation results over multiply subchannels. In this case, the energy efficiency optimization problem is a multichannel optimization problem, which is intractable to obtain a closed-form solution in mathematics.

The authors' primary contribution is to propose a novel subchannel grouping scheme for allocating the corresponding transmission power to each of the subchannels in different groups, which simplifies the multichannel optimization problem to a multi-target single channel optimization problem. Considering the MIMO-OFDM transmission technologies, all subchannels in mobile multimedia communication systems are classified by their channel characteristics which is employed by the channel-matrix singular value decomposition (SVD) method. After subchannels at each subcarrier are sorted by subchannel gains, subchannels with the same order position at different orthogonal subcarriers have the identical marginal probability density function (MPDF). Per this property, a subchannel grouping scheme is proposed to classify subchannels with the identical MPDF into the same group. Based on the proposed subchannel grouping scheme, author can optimize the effective capacity of each grouped subchannels per their MPDFs. In this process, the multichannel joint optimization problem is transformed into a multi-target single-channel optimization problem, which significantly reduces the complexity of energy efficiency optimization. Furthermore, an optimized transmission power allocation solution is derived for each grouped subchannels.

Based on the closed-form solution of transmission power allocation, a novel algorithm, i.e., the EEOPA algorithm is designed to improve

the energy efficiency of MIMO-OFDM mobile multimedia communication systems with statistical QoS constraints. The core idea of EEOPA algorithm is presented as follows: first, the SVD method is applied for the channel matrix at each orthogonal subcarrier to obtain parallel space-frequency subchannels. Second, subchannels at each subcarrier are pushed into a subchannel gain set, where subchannels are sorted by the subchannel gain which depends on the statistical QoS exponent and wireless channel fading. Moreover, the subchannels with the same order position in the subchannel gain set are selected into the same group. Since the subchannels within the same group have the identical MPDF, the transmission power allocation threshold for the subchannels within the same group is identical. Therefore, the optimized transmission power allocation for the grouped subchannels is implemented to improve the energy efficiency of MIMO-OFDM mobile multimedia communication systems.

To evaluate the energy efficiency and the effect capacity of the proposed EEOPA algorithm in MIMO-OFDM mobile multimedia communication systems, three typical scenarios with different antenna number are configured for simulations. Moreover, the proposed EEOPA algorithm is compared with the average power allocation (APA) algorithm, a state-of-the-art power allocation scheme for MIMO-OFDM communication systems. Simulation results indicate that the energy efficiency and the effect capacity of EEOPA algorithm always higher than the energy efficiency and the effect capacity of APA algorithm when the statistical QoS constraints are configured.

This paper is one of pioneer studies to optimize the energy efficiency of MIMO-OFDM mobile multimedia communication systems with QoS constraints. By cleverly transforming the multichannel optimization problem into a multi-target single channel optimization problem, an energy efficiency optimization solution is derived for MIMO-OFDM mobile multimedia communication systems. Moreover, a novel algorithm is designed to enhance both the energy efficiency and the effect capacity for MIMO-OFDM mobile multimedia communication systems with QoS constraints. In summary, this work is an excellent study to improve the energy

efficiency and the effect capacity for 4G mobile multimedia communication systems with QoS constraints. It is a foregone conclusion that this paper has been selected as an Essential Science Indicator (ESI) highly cited paper (*the citation number of paper is ordered in top 1% in the last 10 years of the computer science topic*) by Thomson Reuters.

References

[1] C.-X. Wang, X. Hong, X. Ge, X. Cheng, G. Zhang, and J. Thompson, "Cooperative MIMO channel models: a survey," *IEEE Communications* Magazine, vol.48, no.2, pp.80-87, Feb, 2010.

[2] T. Hwang, C. Yang, G. Wu, S. Li and G. Li, "OFDM and its wireless applications: a survey," *IEEE Transactions on Vehicular Technology,* vol. 58, no. 4, pp. 1673 - 1694, May 2009.

[3] M. Jiang and L. Hanzo, "Multiuser MIMO-OFDM for next-generation wireless systems," *Proceedings of the IEEE,* vol. 95, no. 7, pp.1430-1469, July, 2007.

[4] L. Xiang, X. Ge, C.-X. Wang, Frank Y. Li and Frank Reichert, "Energy efficiency evaluation of cellular networks based on spatial distributions of traffic load and power consumption," *IEEE Transactions on Wireless Communications*, vol. 12, no. 3, pp.961-973, March. 2013.

[5] J. Tang and X. Zhang, "Quality-of-service driven power and rate adaptation over wireless links," *IEEE Transactions on Wireless Communications*, vol. 6, no. 8, pp. 3058–3068, Aug. 2007.

Xiaoli Chu is a Senior Lecturer at the University of Sheffield. She received her Ph.D. degree from Hong Kong University of Science and Technology in 2005. From 2005 to 2012, she was with King's College London. She has published more than 100 peer-reviewed journal and conference papers. She is lead editor/author of Heterogeneous Cellular Networks (Cambridge University Press, 2013). She was Co-Chair of the Wireless Communications Symposium at IEEE ICC 2015, and Guest Editor for IEEE Transactions on Vehicular Technology.

Cloud-based Crowdsourced Live Streaming

A short review for "Coping With Heterogeneous Video Contributors and Viewers in Crowdsourced Live Streaming: A Cloud-Based Approach"

Edited by Xiaohu Ge

With the content contributed from end-users, crowdsourced live streaming systems have been emerged as one of mainly applications in Internet, for example, a series of real-world platforms being available in the market, such as YouTube Live, Azubu.tv and Twitch.tv. Compared to professional video producers and distributors, the new generation broadcasters are geo-distributed globally and highly heterogeneous in terms of the generated video quality and the network/system configurations. Moreover, the crowdsourced live streaming systems present an extremely dynamic over time for both the overall population and the distribution of reviewers in each region. To meet the challenges from heterogeneity and dynamics of networks and end-users, the adaptive bitrate (ABR) stream and dynamic adaptive streaming over HTTP (DASH) have been developed and applied by YouTube and Netflix [1]. Based on above schemes, heterogeneous viewers can select among multiple quality versions of the same video, but have to require intensive computational resources for transcoding these video quality versions [2]. The cloud computing with elastic resource provisioning is an accelerator of great potentials for the new generation of crowdsourced live streaming systems. In this literature, some exiting works studied the resource allocation and optimization in streaming systems [3-5]. However, most of them have generally assumed the workload is fixed, e.g., the video representation set for transcoding is pre-determined. Moreover, the geo-distributed workload assignment and video delivery in the crowdsourced context with cloud computing has not been addressed.

In this paper, the authors identify the benefits and challenges when deploying cloud-based systems for crowdsourced live streaming, which involves with two problems, i.e., the resource allocation problem of assigning geo-distributed cloud service to broadcasters for video transcoding and delivery and the decision problem of choosing video representation set for every individual broadcaster to enable ABR/DASH. These two problems are coupled with each other: different video representation sets result in different computation workload for the cloud assignment, while the pricing and performance of cloud services in different regions also affect the decision of video representation sets. How to address these two problems and optimize the resource allocation in a uniform framework is an important challenge for the crowdsourced live streaming system with cloud-based.

Thus, the authors' primary contribution is to propose a new generic framework with an optimal scheduler to allocate cloud instances for crowdsourced live streaming systems. Based on the cloud computing framework, the general Purpose cloud instances are used to collect source stream and Compute Optimized instances are used as master server for decision making in the cloud level 1. Moreover, Compute Optimized instances are utilized for video transcoding and delivering in the cloud level 2.

The cloud optimal scheduler is to match one or more cloud servers to one broadcaster to maximize the reward and minimize the overall cost. However, there exist some inherent conflicts to realize all objectives, e.g., providing more video representation leads to higher viewer satisfaction level but increases the rental cost. To solve this issue, a comprehensive cost model, i.e., a sum of viewer satisfaction and the rental cost with different weights, has been established in this paper. Furthermore, the Greedy Rental Scheduler (GRS) algorithm is developed to optimize the comprehensive cost, where the channels are ranked in decreasing order of popularity and the cloud instances are sorted in ascending order of the rental cost. And then, the more popular broadcasters will be considered first and cloud servers with cheaper unit cost will be selected first. Based on above scheme, the least comprehensive cost is expected to be achieved.

The GRS works optimally with sufficient cloud service provided in every region. However, most existing cloud service providers indeed have imposed strict usage constraints. A dynamic programming based algorithm, i.e., Scheduling With Limited Cloud Service Supply (SLCS), is developed for the real world case with limitation on cloud service supply. For larger scale, a faster implementation, i.e., SLCS* is developed, which simplifies SLCS by using a heuristic to rank cloud instances ahead of time, and then chooses the generally most preferred instance first when assigning the rental schedule.

To validate the performance of GRS, SLCS and SLCS* algorithms, the trace data captured by the Twitch's API is used for large scale simulation. Moreover, the Top-N algorithm, which is currently adopted in Twitch TV, is simulated for comparing with other three proposed algorithms. Considering the constraint on cloud service supply, simulation results show that Twitch's default Top-N algorithm has the highest cost, followed by the GRS algorithm. The SLCS and SLCS* algorithms have lower total costs. Furthermore, a prototype of proposed system is implemented with 223 PlanetLab nodes, where ten nodes are broadcasters and 213 nodes are viewers. Experiments imply that the proposed algorithms still have the better performance than the performance of Top-N algorithm.

A cloud-based approach is a promising solution for crowdsourced streaming systems. To trade off the contradictions between the viewer satisfaction and the rental cost, a comprehensive cost model has been proposed for optimizing the cloud instances allocation. Three novel algorithms, i.e., GRS, SLCS and SLCS* algorithms are developed to improve the cost efficiency of crowdsourced streaming systems. The trace-driven simulations and the Planetlab-based experiments validate the superiority of proposed algorithms. The success deployment of cloud-based approaches, e.g., GRS, SLCS and SLCS* algorithms will promote the application of crowdsourced streaming systems.

Acknowledgement

References

[1] B. Li *et al.*, "Two decades of internet video streaming: A retrospective view," *ACM Trans. Multimedia Comput., Commun., Appl.*, vol. 9, no. 1s, 2013, Art. ID. 33.

[2] C. Liu, I. Bouazizi, and M. Gabbouj, "Rate adaptation for adaptive http streaming," in *Proc. 2nd ACM Conf. Multimedia Syst.*, 2011, pp. 169–174.

[3] Y. Wu *et al.*, "Scaling social media applications into geo-distributed clouds," in *Proc. IEEE INFOCOM*, Mar. 2012, pp. 684–692.

[4] F. Wang, J. Liu, and M. Chen, "CALMS:Cloud-assisted live media streaming for globalized demands with time/region diversities," in *Proc. IEEE INFOCOM*, Mar. 2012, pp. 199–207.

[5] Z. Huang, C. Mei, L. E. Li, and T. Woo, "CloudStream: Delivering highquality streaming videos through a cloud-based SVC proxy," in *Proc. IEEE INFOCOM*, Apr. 2011, pp. 201–205.

Xiaohu Ge received the Ph.D. degree in communication and information engineering from Huazhong University of Science and Technology (HUST), Wuhan, China, in 2003. He is currently a Full Professor with the School of Electronic Information and Communications, HUST. He is an Adjunct Professor with the Faculty of Engineering and Information Technology, The University of Technology Sydney (UTS), Sydney, N.S.W., Australia. He is the founding director of China International Joint Research Center of Green Communications and networking. He has authored more than 120 papers in refereed journals and conference proceedings and has been granted about 15 patents in China. His research interests include mobile communications, traffic modeling in wireless networks and green communications.

Toward Deduplicated Encrypted Cloud Media Center

A short review for "Toward Encrypted Cloud Media Center With Secure Deduplication"
Edited by Pradeep K. Atrey

The explosion in growth of multimedia contents, especially videos, is pushing forward the paradigm of cloud-based media hosting today. Toward such a trend, various kinds of emerging media applications, such as media live streaming and media coding, are being increasingly deployed at the cloud for the well-understood service benefits [1]. While the benefits of cloud media center are quite appealing, the wide attacking surface of the public cloud and the growing security awareness from the society are both calling for data encryption before data outsourcing.

Although effective in protecting data confidentiality, directly applying encryption to multimedia data would explicitly invalidate many functionalities of cloud-based media applications. Accordingly, there have been recent efforts in the literature on investigating how to support various desirable functionalities over encrypted multimedia data at the cloud media center, such as encrypted feature extraction [2] and encrypted social discovery [3]. Under the circumstance of encrypted videos, how to still preserve all the service benefits of cloud media center remains to be fully explored.

In this paper, the authors show a secure system design along this direction, with goal of bringing together the advancements of video coding techniques and secure deduplication. They target the crucial deduplication functionality at cloud, which can eliminate the burdensome storage and bandwidth overhead when storing encrypted videos from different entities. The proposed design is also fully tailored to the scalable video coding (SVC) techniques from the very beginning, and supports the ubiquitous adaptive video delivery in the context of heterogeneous networks and devices.

For deduplication over encrypted data, a plausible approach is message-locked encryption (MLE) [4], which is known as the state-of-the-art approach. In general, MLE uses keys derived deterministically from the data (e.g., the hash value) to generate tags for duplicate checking in the encrypted domain. Nevertheless, directly applying MLE over videos would not be necessarily suitable, as MLE is known to be vulnerable to offline brute-force guessing attacks for target plaintext from a small space or considered as predictable [5]. In video applications, popular videos, trending searches, and near-duplicate videos, might all fall into this predictable space category, and could be the easy breach point of such offline guessing attacks, threatening video confidentiality. Besides, for proper video dissemination, the encrypted deduplication design must also prevent malicious users from illegitimately accessing unauthorized videos by simply using the checking tags [6].

Thus, the authors' primary contribution is to propose a secure deduplication framework that addresses the above problems completely and well suit the needs of cloud-based video applications. Specifically, the proposed framework supports secure deduplication with resistance to bounded data leakage, and with defense against offline brute-force attacks over predictable videos, respectively. Besides, the authors provide designs in both the centralized and decentralized settings, where the decentralized setting provides stronger security strength. Their secure deduplication designs provide the encrypted cloud media center with comprehensive protection that prior arts do not afford.

Under the encrypted secure deduplication framework, the authors investigate how to facilitate the fast-growing demand of adaptively disseminating videos to heterogeneous networks and devices. They bridge the gap between video coding and secure deduplication, enabling the encrypted cloud media center with efficient adaptive dissemination and structure-aware secure deduplication. In particular, the authors resort to SVC techniques for adaptive delivery and storage efficiency. They carefully tailor the proposed secure deduplication design to be compatible with the inherent characteristics of

SVC videos, devising structure-aware layer-level deduplication strategies. The authors also provide insightful discussion on supporting secure deduplication over other media types with scalable structures, i.e., scalable media.

In order to deliver a full-fledged security system implementation, the authors further present structure-aware encryption mechanisms and structure-aware storage strategies for SVC videos. They provide thorough security analysis to show that the proposed system design achieves strong protection of video confidentiality. Extensive experiments are also conducted via an implemented end-to-end prototype deployed at the Microsoft Azure cloud platform. The authors adopt various performance measures to justify the effectiveness and efficiency of the proposed system.

In summary, the key contribution of this work is a secure system framework enabling encrypted cloud media center with secure deduplication. The framework is highly customized by taking into account the property of media data structures for performance optimization. This work is a nice effort toward bridging the gap between video coding techniques and secure deduplication in the context of cloud-based media hosting.

Acknowledgement

References

[1] W. Zhu, C. Luo, J. Wang and S, Li, "Multimedia cloud computing," *IEEE Signal Process. Mag.*, vol. 28, no. 3, pp. 59-69, 2011.
[2] Z. Qin, J. Yan, K. Ren, C. W. Chen, and C. Wang, "Towards efficient privacy-preserving image feature extraction in cloud computing," in *ACM MM* '14, 2014, pp. 497-506.
[3] X. Yuan, X. Wang, C. Wang, A. Squicciarini, and K. Ren, "Enabling privacy-preserving image-centric social discovery," in *IEEE ICDCS* '14, 2014, pp. 198-207.
[4] M. Bellare, S. Keelveedhi, and T. Ristenpart, "Message-locked encryption and secure deduplication," in *EUROCRYPT* '13, 2013, pp. 296-312.
[5] M. Bellare, S. Keelveedhi, and T. Ristenpart, "Dupless: Server-aided encryption for deduplicated storage," in *USENIX Security* '13, 2013, pp. 179-194.
[6] J. Xu, E. Chang, and J. Zhou, "Weak leakage-resilient client-side deduplication of encrypted data in cloud storage," in *ACM AISACCS* '13, 2013, pp. 195-206.

Pradeep K. Atrey is an Associate Professor of Computer Science and Co-director of Albany Lab for Privacy and Security (ALPS) at the State University of New York, Albany, NY, USA. He received his Ph.D. in Computer Science from the National University of Singapore. He was a Postdoctoral Researcher at the Multimedia Communications Research Laboratory, University of Ottawa, Canada. His current research interests are in the area of Security and Privacy with a focus on multimedia surveillance and privacy, multimedia security, secure-domain cloud-based large-scale multimedia analytics, and social media. He has authored/co-authored over 100 research articles at reputed ACM, IEEE, and Springer journals and conferences. Dr. Atrey is on the editorial board of several journals including ACM Trans. on Multimedia Computing, Communications and Applications (TOMM), Elsevier Signal Processing: Image Communication Journal and ETRI Journal. Dr. Atrey has received numerous awards including the ACM TOMM Associate Editor of the Year (2015), the IEEE Comm. Soc. MMTC Best R-Letter Editor Award (2015) and the Erica and Arnold Rogers Award for Excellence in Research and Scholarship (2014). He was also recognized as the ACM Multimedia Rising Star (2015).

Assessment of User's QoE for Audiovisual Services

A short review for: "QoE Evaluation of Multimedia Services Based on Audiovisual Quality and User Interest"

Edited by Wei Wang

In the past two decades, the QoE studies of the multimedia services mainly focused on the technology-centric quality measurements, such as the quality of service (QoS), video quality, audio quality, and audiovisual quality [2]. These quality metrics were mainly used to improve the service quality with respect to network- and application-level technical parameters, lacking sufficient consideration of user's perceptions and feelings. Recently, QoE was examined as a "central concept" or rather a central theme for analysis of the entire communications ecosystem [3], where various factors of technology, contents, business/economy, and human behavior domains are all playing a part. Despite considerable research efforts invested in QoE analysis [4], it remains nontrivial to provide a practical solution to estimate quantitatively the QoE, due to the fact that multiple interactive factors are involved in the complicated service context. In this paper, the authors revisited the challenges of evaluating the user's QoE for audiovisual services and analyzed the user's QoE from a unitary perspective in the context of a communication ecosystem.

To establish and clarify the relationships between the influential factors, user's perceptions and QoE, the authors proposed a user-centric framework for the objective QoE assessment model. Different from the traditional framework which directly maps the influential factors to the QoE, where the factors are considered to be independent of each other, the proposed framework adopts a user-centric approach and the influential factors from the technology and content domains are interactive with the human domain. Additionally, this framework focuses on the actual generation process of user perception in audiovisual services. Finally, two fundamental perceptions which affect QoE for almost all audiovisual services are considered in the proposed QoE framework, namely, the perception of audiovisual quality and user interest in audiovisual content and/or story.

Different from the traditional (i.e., strictly controlled) test environment, the authors established a living lab that provided familiar surroundings of daily life for users, where the users could choose a comfortable way to enjoy audiovisual services as they prefer without any restriction with regard to viewing distance, posture or order of viewing audiovisual clips.

The authors designed two experiments to record the user's perceptions on the audiovisual services. The first experiment was carried out in the living lab to obtain the user's rating scores in terms of their interest in the video content and the QoE, during which the user's viewing behaviors such as the blinks and eye movement were also recorded. For the second experiment, the perceived audiovisual quality was recorded. The information of viewing behaviors and the rating scores of perceived video quality, user interest and QoE were all used to devise the QoE evaluation model.

As a performance metric in technology domain, audiovisual quality is one of the most essential of multimedia services. Using the data obtained by the subjective test, the relationship between the audiovisual quality and the QoE was analyzed firstly from the quantitative point of view. According to the distribution of the QoE values and audiovisual quality for each user in different groups, it was found that the QoE values gradually increased with the increment of the audiovisual quality in each group, which indicated that the audiovisual quality generally had a positive impact on the QoE. However, it was also obvious that the audiovisual quality values were concentrated in a small range with a consistent level, while the QoE values were quite distinct for different clips. This difference indicated that the audiovisual quality itself was not sufficient for accurately estimating the user's QoE.

Content is another basic attribute of audiovisual services. It also decisively influences the user's

QoE from the hedonic point of view [5]. To further check the diversity of the QoE as mentioned above, the authors then analyzed the relationship between the user's interest in content and the QoE. According to the average values and standard deviations of all user interest and QoE values for each audiovisual clip, it was found that the change of QoE values was in good accordance with that of user interest when the audiovisual quality was at a uniform level. Moreover, for a given audiovisual clip, the user interest and QoE rating values usually varied significantly for different users, reflecting diversity of their background and experience. Thus, it was quite necessary to evaluate the individual user interest and QoE considering these properties.

However, as one of human internal states, user interest is usually difficult to measure quantitatively. Considering that the eyes play an essential role in daily life communications and convey the person's attentions and emotions. The authors analyzed a number of common viewing behaviors such as blink, fixation, and saccade. It was found that the fixation and saccade were closely related to the motion activity of a video, which was not suitable to indicate the user's interest. In contrast, the total long blink interval and the average blink frequency were identified to be closely related with the user interest. Using the ordered logit regression, the relationships between user interest, total long blink interval and the average blink frequency were determined.

Finally, the authors proposed a user-centric objective QoE evaluation model (QAVIC) taking account of both perceptual audiovisual quality and user interest in audiovisual content. The validation test results indicated that the average values of subjective QoE and objective QoE were quite similar and the standard deviations of these two QoE values for most audiovisual clips were in good agreement with each other, which demonstrated that the model had a satisfactory performance.

The contribution of this article is to propose a feasible way to evaluate the user's actual perception, and at the current stage only the limited influential factors are considered to formulate the model. It would be beneficial that the user perceptions in other dimensions are considered in formulation of the QoE model, including more users' general explicit responses in the behavior and physiology, such as physiological responses, expression behaviors, and commercial behaviors and so on.

Acknowledgement

References

[1] K. U. R. Laghari, N. Crespi, and K. Connelly, "Toward total quality of experience: a QoE model in a communication ecosystem," *IEEE Commun. Mag.*, vol.50, no.4, pp.58-65, 2012

[2] F. Yang and S. Wan, "Bitstream-based quality assessment for networked video: a review," *IEEE Commun. Mag.*, vol. 50, no. 11, pp. 203-209, 2012.

[3] K. Kilkki, "Quality of Experience in Communications Ecosystem," *J. UCS*, vol.14, no.5, pp.615-624, 2008.

[4] K. Brunnström, S. Beker, K. De Moor, and A. Dooms, et al., "Qualinet white paper on definitions of quality of experience," 2013.

[5] D. W. Hansen, and Q. Ji. "In the eye of the beholder: A survey of models for eyes and gaze," *IEEE Trans. Pattern Anal. Mach. Intell.*, vol.32, no.3, pp.478-500, 2010.
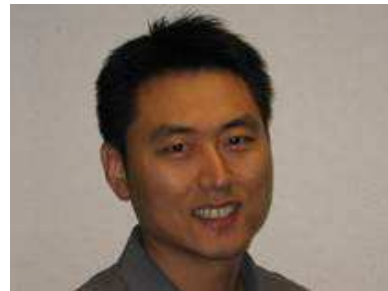
Wei Wang is an Assistant Professor of Computer Science at San Diego State University. He received his Ph.D. degree in Computer Engineering with Significant Computer Science Emphasis from University of Nebraska - Lincoln, NE, USA. His research interests include wireless multimedia communications, QoE-QoS issues in network economics, cyber physical system healthcare, and breast cancer imaging. He serves as an Associate Editor of Wiley Security and Communication Networks Journal (SCIE-Index), the Guest Editor of several journals and special issues such as IEEE ACCESS, Springer MONET, IJDSN, etc, the web co-chair of IEEE INFOCOM 2016-17, the program chair of ACM RACS 2014-16, the track-chair of ACM SAC 2014-16, workshop co-chair of ICST BodyNets 2013, the chair of IEEE CIT-MMC track 2012, the vice-chair of IEEE ICCT-NGN track 2011, and the program chair of the ICST IWMMN 2010, a Technical Program Committee (TPC) member for many international conferences such as IEEE INFOCOM, GLOBECOM and ICC.

Paper Nomination Policy

Following the direction of MMTC, the Communications – Review platform aims at providing research exchange, which includes examining systems, applications, services and techniques where multiple media are used to deliver results. Multimedia includes, but is not restricted to, voice, video, image, music, data and executable code. The scope covers not only the underlying networking systems, but also visual, gesture, signal and other aspects of communication. Any HIGH QUALITY paper published in Communications Society journals/magazine, MMTC sponsored conferences, IEEE proceedings, or other distinguished journals/conferences within the last two years is eligible for nomination.

Nomination Procedure

Paper nominations have to be emailed to Review Board Directors: Pradeep K. Atrey (patrey@ albany.edu), Qing Yang (qing.yang@montana. edu), Wei Wang (wwang@mail.sdsu.edu), and Jun Wu (wujun@tongji.edu.cn). The nomination should include the complete reference of the paper, author information, a brief supporting statement (maximum one page) highlighting the contribution, the nominator information, and an electronic copy of the paper, when possible.

Review Process

Members of the IEEE MMTC Review Board will review each nominated paper. In order to avoid potential conflict of interest, guest editors external to the Board will review nominated papers co-authored by a Review Board member. The reviewers' names will be kept confidential. If two reviewers agree that the paper is of Review quality, a board editor will be assigned to complete the review (partially based on the nomination supporting document) for publication. The review result will be final (no multiple nomination of the same paper). Nominators external to the board will be acknowledged in the review.

Best Paper Award

Accepted papers in the Communications – Review are eligible for the Best Paper Award competition if they meet the election criteria (set by the MMTC Award Board). For more details, please refer to http://mmc.committees.comsoc. org/.

Multimedia Communications Technical Committee Officers

MMTC examines systems, applications , services and techniques in which two or more media are used in the same session. These media include, but are not restricted to, voice, video, image, music, data, and executable code. The scope of the committee includes conversational, presentational, and transactional applications and the underlying networking systems to support them.