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MMTC Communications – Review

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Message from the Review Board Directors

Welcome to the February 2017 issue of the IEEE ComSoc MMTC Communications – Review.

This issue comprises four reviews that cover multiple facets of multimedia communication research including confidential cloud-based image processing, correlated image transmission within cloud, QoE enhancement in 5G networks, and secure multimedia transmission in wireless sensor networks. These reviews are briefly introduced below.

The first paper, published in IEEE Transactions on Information Forensics and Security and edited by Pradeep K. Atrey, investigated image scaling and cropping in encrypted domains within a cloud environment.

The second paper is published in IEEE Wireless Communications and edited by Wei Wang. It proposed a data-driven architecture for personalized QoE management in 5G networks. The work is different from existing works in that it focused on the personalized QoE rather than generic QoE management.

The third paper, published in IEEE Transactions on Multimedia and edited by Haoqi Ren, presents an innovative scheme in sharing mobile image within a cloud. The proposed solution considers the correlations between mobile images to reduce the amount of data transmitted.

The fourth paper is published in IEEE Transactions on Multimedia and edited by Qing Yang. The paper solves the issue of efficient multimedia transmission, at the same, guaranteeing the security of transmitted data.

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

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Towards Confidential Cloud-Based Image Processing

A short review for "2DCrypt: Image Scaling and Cropping in Encrypted Domains"

Edited by Pradeep K. Atrey

M. Mohanty, M. R. Asghar, and G. Russello, "2DCrypt: Image Scaling and Cropping in Encrypted Domains", IEEE Transactions on Information Forensics and Security, vol. 11, Issue 11, Nov. 2016.

Cloud computing provides a cost effective solution to store and process a large amount of images, such as histopathological images. Due to its pay-as-you-go model, individuals and organizations those typically cannot invest a lot of money in owning computer infrastructures, e.g., hospitals, are outsourcing the storage and processing of images to cloud servers. An image, however, can be sensitive and private. For example, the histopathological image available to a hospital can contain disease information of patients. Sending such sensitive image to third-party cloud servers presents data confidentiality issue, as the image can be subject to unauthorized access at the cloud server-end. Leakage of the confidential information can lead to privacy loss. Due the confidentiality and privacy threats, laws such as the HIPPA act in USA, the PIPED act in Canada, and the Data Protection Act in European countries have been enacted to protect the images of citizens.

A common approach to address the data confidentiality (and privacy) issue in cloud-based imaging is storing and processing encrypted images in the cloud servers. A number of encryption-based solutions are available for cloud-based image storage. There are, however, a very few works supporting encrypted domain image processing (i.e., processing the encrypted images without decrypting them) [1, 2]. Ideally, the fully homomorphic encryption [3] scheme can be used to perform any type of computations over encrypted images. However, fully homomorphic encryption schemes are not computationally practical [4]. An alternate approach is using partial homomorphic encryption, which can allow certain computationally efficient operations in the encrypted domain. Using partial homomorphic Shamir's secret sharing, Mohanty et al. proposed an encrypted domain image scaling and cropping scheme [1]. Their scheme, however, is prone to collision attack.

In this paper, the authors proposed a cloud-based, computationally efficient, collision attack-free, confidential image scaling and cropping framework. The proposed scheme uses modified Paillier encryption [5], which is homomorphic to addition and scalar multiplication operations. In the proposed approach, only one cloud server is required, which is assumed to be an honest but curious entity. That is the cloud server is trusted to honestly perform requested operations, but can know the content of the image in an unauthorized manner. An image outsourcer (i.e., the hospital), who is responsible to the security and privacy issues attached to image outsourcing, encrypts the image before sending it to the cloud server. An image user, who is authorized by the image outsourcer to view the image in plaintext, requests image scaling and cropping operations to the cloud server. The cloud server scales and crops the encrypted image and sends encrypted output to the image user. Finally, the user decrypts the images and views the scaled/cropped image in plaintext.

However, Paillier encryption scheme incurs significant computational and storage overhead when applied to images. An eight-bit color value is represented using a b-bit number (where the current recommended value of b is at least 1024) in the encrypted domain. To overcome this overhead, the authors proposed a novel tile-based image scaling and cropping scheme. The main idea of this scheme was to smartly pack more than one colors in a tile, represent the tile using a big number that is less than b bits, and encrypt the tile instead of encrypting the colors individually.

The proposed tiling scheme was designed for bilinear scaling, although similar tiling schemes can be designed for other image scaling algorithms. Bilinear scaling interpolates four colors of four neighboring pixels. Therefore, the pixels were distributed among four different tiles. Since a pixel is never operated with neighbor's neighbor, the pixel was put with neighbor's

neighbor pixel in one tile. For scaling an 8*8 image block with any scaling factor, nine different 4*4 tiles were required (each 8*8 image block was represented using a different set of nine tiles). Each tile was then unrolled into a vector of *16* pixels (e.g., in raster scan order). The color *C* of (*m+1*)-th pixel in the vector was multiplied by 10^m, and all the C*10^ms were added so that the color of all the pixels can be packed in a big number without losing any information. This big number was then encrypted instead of encrypting *16* different colors. Based on the scaling factor, encrypted tiles were selected, and image scaling was obtained by interpolating the selected tiles. Note that some of the tiles may not be required when scaling by for a particular scaling factor. For example, only four tiles are sufficient for scaling by a factor of two.

Furthermore, the proposed work is a full-fledged multi-user scheme where users can view and process images without requiring any key sharing. In the proposed approach, an image is encrypted using two keys and decrypted using two keys. A decryption key associated with a user is stored at the cloud server, and another decryption key is with the user. For obtaining the plaintext image, the cloud server must perform first round of decryption using the stored key. Then, the user can perform second round of decryption. When a user loses authorization to view and process the image, the cloud server can stop decrypting her images. In that way, the user's key will be useless. The proposed approach suits the need of organizations having a dynamic workforce where managing shared keys is challenging.

2DCrypt is a promising scheme for secure cloud-based image streaming. The proposed solution is IND-CPA secure, and incurs acceptable overhead. In future, this work can be extended for other scaling algorithms. Also, possible application of this scheme on compressed images can be explored.

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

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Managing QoE in 5G Wireless Networking with Personalized Data

A short review for "A Data-Driven Architecture for Personalized QoE Management in 5G Wireless Networks"

Edited by Wei Wang

Y. Wang, P. Li, L. Jiao, Z. Su, N. Cheng, X. Shen, and P. Zhang, "A Data-Driven Architecture for Personalized QoE Management in 5G Wireless Networks," IEEE Wireless Communications, vol. PP, no. 99, November 2016.

With the popularity of diverse, autonomous, and interactive user applications across modern 5G wireless networks, managing user's perspective QoE becomes a critical and essential issue in future generations of wireless technology. As the traffic of mobile internet grows exponentially at an enormous rate and the proliferation of smart mobile devices, accommodating multimedia traffic over 5G wireless systems is the essential focus of both academia and industry. By the year of 2019, around 80 percent of the internet traffic will be multimedia.

Unlike traditional wireless network systems, 5G put significant emphasis on providing a wide range of Quality of Service (QoS) guarantee [1] [2]. In fact, video-based service over 5G is one of the most critical applications for mobile users with smart devices such as modern smart phones and wearable healthcare devices. It has been realized in this community that it is more crucial to assess the Quality of Experience (QoE) in addition to QoS. However, QoE is more subjective and QoS is more objective, making the QoE evaluation and assessment hard. In 5G systems, QoE is expected to be autonomously managed for each user and each service [3]. QoE is also highly related to user acceptability, referring to the interaction between the user and the application, typically across the unreliable networks and communication channels.

The authors started this article with a brief review of state of the art QoE research works, focusing on 1) the definition of QoE, 2) the influential factors to determine the QoE, 3) the assessment method to evaluate QoE, 4) the mathematics to numerically model the QoE, and 5) the approaches to control the QoE in wireless communication networks.

As an essential contribution of this article, the authors proposed a data-driven architecture to enhance personalized QoE in 5G network systems. They specifically presented a two-step model to quantify QoE in order to capture the strength of the relationship between the users and the services. In their model, user's preference was introduced as a subjective factor to represent this user's subjectivity towards a specific service.

For example, they used a soccer game video and two users, Bob and Lin, to show the importance of users' preference in QoE assessment. Bob is a soccer fan, but Lin is not. Thus Bob and Lin have very different QoE requirement for this piece of soccer game video – Bob has much higher requirement of QoE than Lin. When the 5G wireless resources are limited, Bob should be allocated with more resources than Lin, such as having higher bandwidth allocation, more time slots of communications, various resource blocks with lower interferences or higher Signal to Noise Ratio (SNR), etc.

Various QoE models have been recommended by different organizations and research teams. The IQX hypothesis model was introduced in [4]. In this IQX model, the changes of QoE depend on the both QoS and the existing level of QoE. Thus the QoS and QoE models are correlated. The authors obtained a negative exponential function to present QoE in terms of QoS factors of packet loss or network delay. In short, the IQX model correlated the QoE with QoS impairment.

In many situations the QoS influencing factors such as bandwidth and delay and the QoE correlation cannot be mathematically expressed, or at least or in a close form. Thus modern machine learning and crowdsourcing approaches were utilized to model the QoE. For example, a Support Vector Machine (SVM) based model

was adopted in [5], considering factors of page loading time, memory effect, and type of score. In a different research work [6], a crowdsourcing-based QoE model was developed using factors of freezes and blocks.

The authors also discussed the QoE control issues, emerging applications and big data challenges in 5G systems. With the higher bandwidth availability of 5G systems, traffic hungry and latency sensitive applications such as virtual reality devices, 3D video services, and interactive video games will bring enormous challenges to QoE. These applications need new QoE models. Various smart multimedia devices provide diverse application patterns. In addition, huge amount of data will be generated in communications, such as users' mood, attention, expectation, and many other factors related not only to Computer Science but also Social Psychology and Cognitive Science. The online viewing time, total number of clicks of videos, daily access of certain contents, etc, could be valuable resource to evaluate, control and manage QoE from big data analytics. Finally the authors provided a case study to validate the data-driven QoE management architecture.

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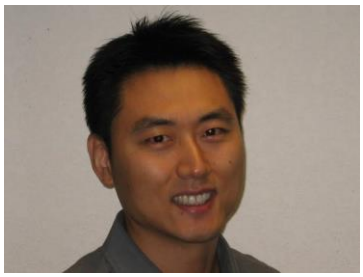

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Data-Assisted Communications of Mobile Images with Cloud Computing Support

A short review for "DAC-Mobi: Data-Assisted Communications of Mobile Images with Cloud Computing Support"

Edited by Haoqi Ren

J. Wu, J. Wu, H. Cui, C. Luo, X. Sun and F. Wu, "DAC-Mobi: Data-Assisted Communications of Mobile Images with Cloud Computing Support," IEEE Transactions on Multimedia, vol. 18, no. 5, pp. 893 – 904, May 2016.

With the development of social network, the explosive increasing data such as mobile images presents a great challenge to the wireless communications. To address this problem, lots of researches have been made on the physical layer, such as massive MIMO, full duplex, and non-orthogonal transmission. However, the throughput improvement is still inadequate for the challenges of explosive data increase. Specific to the mobile images shared by people with smart phones, there exists a large amount of highly correlated images in the cloud. If there is a good solution to retrieve and utilize the correlated information, the data needed to be transmitted over the wireless channel will be dramatically reduced. Although the correlated images have been used to solve many image processing problems, there does not exist a concrete scheme to utilize the correlated information to improve the transmission efficiency.

In traditional digital transmission system, the impairment caused during transmission cannot be cured by the correlated images in the cloud, because the transmitted image is represented by 0/1 bits, and bit errors cannot be mapped to any specific type of image impairments after digital source coding. The recently proposed analog visual communication paradigms, such as SoftCast [1] and Cactus [2], are basically joint source-channel designs, and change the network stack to act like a linear transform. The linear transformation of the pixel values is directly transmitted over the channel, so that the perturbation of channel noise translates into the approximation in the original pixel values, which makes it possible to utilize the correlated image information in the cloud. However, the existing denoising algorithm, such as BM3D [3], may achieve limited quality improvement when the channel condition is poor. In addition, none of the existing analog visual communication schemes has considered utilizing the external correlated information (outside of the transmitted signal) in the cloud.

Therefore, the authors develop a data-assisted communication of mobile image (DAC-Mobi) scheme based on the analog visual communication technology, to tackle the communication problem. Contrast to the traditional digital image coding and transmission paradigm which cannot realize the full potential of data-assisted image transmission in the cloud, the proposed DAC-Mobi scheme utilizes the correlated information retrieved from the cloud to reconstruct the images. As a result, DAC-Mobi can significantly decrease the transmitted data and improve the power efficiency.

The authors' primary contribution is to propose a novel data-assisted image transmission framework, which utilizes a large amount of correlated images stored in the cloud to improve the spectrum efficiency and visual quality. Distributed source coding (DSC) is explored to utilize the retrieved correlated information in the cloud. To reduce the power and increase signal to noise power ratio (SNR), a two-layer Coset coding is proposed for the DCT coefficients transmission. The most significant bits (MSBs) for a small portion of low frequency DCT coefficients are kept and digitally transmitted to receiver. The least significant bits (LSBs) are transmitted using analog modulation. The remaining MSBs and the middle bits are discarded. At receiver, the digitally decoded MSBs and the received analog LSBs are used to reconstruct a down-sampled small image. Based on the small image, a lot of correlated images can be retrieved from the cloud, to recover the discarded middle bits, and then reconstruct the whole image.

Under the framework, the authors present the detailed Coset design, and investigate how to select the parameters of the Coset coding. Then the authors discuss the internal and external denoising design and propose a piecewise operation to obtain super performance: at low SNR, no power allocation is at transmitter and Wiener filtering based external denoising is

applied at receiver; at middle to high SNR, both power allocation at transmitter and linear least square estimator (LLSE) at receiver are applied. The Coset coding is always applied to get additional gain. The switch point can be calculated beforehand for each given image based on their energy distribution, and the meta data can be used to send the variance of chunks, thus power scaling factors can be derived at the receiver.

To evaluate the performance of the proposed scheme, DAC-Mobi is implemented with proper parameters and the simulation results demonstrate that DAC-Mobi outperforms the state-of-the-art reference schemes: the proposed scheme achieves 4.5 dB gain over Omni-JPEG, 3.5 dB gain over SoftCast, 3.2 dB gain over SoftCast+BM3D and 2 dB gain over Cactus. Furthermore, the experiment results show that addition gain can be achieved with the decreasing of SNR.

The proposed DAC-Mobi scheme is a promising solution for mobile image transmission with the support of the cloud. DAC-Mobi has shown its super performance and feasibility in the wide range of channel SNR, especially more remarkable at low SNR. This work is a valuable exploration in the field of joint source channel coding for Data-Assisted Communications.

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Secure Multimedia Transmission in Wireless Sensor Networks

A short review for "Index-Based Selective Audio Encryption for Wireless Multimedia Sensor Networks"

Edited by Qing Yang

H. Wang, M. Hempel, D. Peng, W. Wang, H. Sharif and H. H. Chen, "Index-Based Selective Audio Encryption for Wireless Multimedia Sensor Networks," in IEEE Transactions on Multimedia, vol. 12, no. 3, pp. 215-223, April 2010.

The advancements in wireless multimedia sensor networks (WMSNs) enable a large number of sensor-based audio applications, including acoustic surveillance, animal tracking, and health monitoring. There are several major challenges in deploying acoustic sensors in a wireless multimedia sensor network. Small sensors have resource constraints in terms of limited memory, computation capability, bandwidth availability, and battery power. A good strategy is to reduce the amount of streaming audio data with the help of efficient audio coding schemes. Several audio codecs (such as MP3, MPEG2 AAC, MPEG4 AAC, TwinVQ, and Dolby AC3) have widely been used for digital audio encoding, and most of them are based on modified discrete cosine transform (MDCT). However, none of those traditional audio codecs takes into account the requirements of WMSNs applications: security and resource efficiency. In this paper, the authors propose an audio encoding scheme that addresses these concerns by identifying and encrypting the most important portions of the audio stream during compression using a resource-efficient cross-layer design approach [1].

The selective encryption scheme presented in this paper encrypts only the most important audio data in order to achieve both real-time performance and energy efficient transmission in WMSNs. This work was motivated mainly by the following observations. First, it is not necessary to protect unimportant audio data in a resource-limited WMSN, due to the fact that audio information could not be recovered completely, even if the non-encrypted portion were intercepted by a third party. Second, most traditional encryption algorithms, such as advanced encryption standard (AES) algorithm, are too complex to be used, inducing a severe delay in small sensor nodes. For example, the encryption time of each 128-bit block using the AES algorithm is about 1.8 ms on a MicaZ platform, according to a recent study reported in [2]. In contrast, the proposed selective encryption approach encrypts only the data containing the most important information to significantly reduce the processing delay and energy consumption on a sensor node. Because the encrypted data represent the most important portion of the transmitted audio stream, it deserves additional protection in wireless transmission by employing an unequal resource allocation scheme. It is also noted that traditional information security schemes, e.g., encryption, are designed at the application layer, and the quality-of-service (QoS) issues were handled at the link layer. To overcome the problems (such as excessive delay) associated with this separation in functionalities, the approach proposed in this paper merges the information security and QoS scheduling into one unified algorithm, offering a cross-layer solution for secure audio transmission over WMSNs.

The paper presented several contributions in the design of an energy-efficient selective encryption scheme for audio data transmission over WMSNs. Firstly, it establishes an optimization model for the selective audio encryption with unequal network resource allocation. Secondly, the proposed approach can achieve high energy efficiency, quality and security. The authors also conducted comprehensive simulations and compared their work with some existing approaches. The simulation results demonstrate the performance gain for wireless audio transmissions.

As an essential contribution of this article, the authors proposed an index-based selective audio encryption scheme for WMSNs. The scheme can protect data transmissions by combining resource allocation and selective encryption, based on modified discrete cosine transform (MDCT). In this proposed scheme, the audio data's importance is leveraged using the MDCT audio index, and wireless audio data transmission proceeds with energy efficient selective encryption. Simulation results show that the proposed approach offers a significant

gain in terms of energy efficiency, encryption performance and audio transmission quality.

In summary, the authors presented a selective encryption approach with unequal network resource allocation for audio streaming in WMSNs. The proposed approach identifies and then encrypts important portions of the MDCT coefficient data, and it allocates more network resources to protect the encrypted audio data transmission to optimize energy efficiency, audio transmission quality and security performance jointly. The major contribution of this article is two-fold. First, it proposed a selective encryption scheme that differentiates important audio information from less significant audio information. The important information is encrypted so that the audio security is protected against intercepters or eavesdroppers in the network. Second, with the utilization of unequal network resource allocation, encrypted important MDCT audio information is well protected from packet losses.

The proposed selective encryption approach not only improves the network real-time performance and computational efficiency, but also reduces the energy consumption under the same audio transmission quality. The paper could be a reference for the readers in the area of wireless multimedia sensor networks and security.

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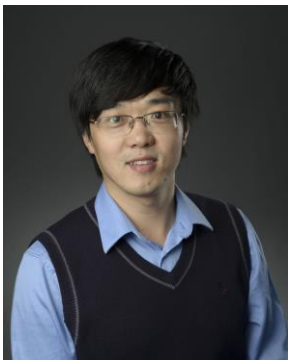

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Paper Nomination Policy

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/.

MMTC Communications – Review Editorial Board

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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.