IEEE Communications Society Technical Committee on
Transmission, Access and Optical Systems (TAOS)

IEEE
IEEE COMMUNICATIONS SOCIETY

TAOS Newsletter – Issue 7, May 2017

Autonomous Cooperative Routing for Mission-Critical Applications

We are entering an era where three previously decoupled domains of technology are rapidly converging together: computer vision, robotics, and wireless communications. We have seen giant leaps and improvements in computational efficiency of vision processing and sensing circuitry coupled with continuously miniaturized form factors. As a result, a new wave of mission-critical systems has been unleashed in fields like emergency response, public safety, law enforcement, search & rescue, as well as industrial asset mapping.

There is growing evidence showing that the efficacy of team-based mission-critical systems is substantially improved when situational awareness data, such as real-time video, is disseminated within the network. Field commanders or operation managers can make great use of live vision feeds to make educated decisions in the face of unfolding circumstances or events. In the likely absence of adequate cellular service, this translates into the need for a mobile ad hoc networking technology (MANET) that supports high throughput but more importantly low end-to-end latency. However, classical MANET technologies fall short in terms of scalability, bandwidth and latency; all three metrics being quite essential for mission-critical applications. The real bottleneck has always been in how fast packets can be routed through the network.

To that end, autonomous cooperative routing (ACR) has gained traction as the most viable MANET routing proposition. Compared to classical MANET routing schemes, ACR is poised to offer up to 2X better throughput, more than 4X reduction in end-to-end latency, while observing a given target of transport rate normalized to energy consumption. Nonetheless, ACR is also associated with a few practical implementation challenges. If these go unaddressed, it will deem ACR practically infeasible. In recent work performed at KAUST, efficient and low-complexity remedies to those issues are presented, analyzed, and validated [1,2]. The validation is based on field experiments carried out using software-defined radio (SDR) platforms. This chapter sheds light on the underlying networking challenges and practical remedies for ACR to fulfill its promise.

[1] A. Bader and M.S. Alouini, "Mobile Ad Hoc Networks in Bandwidth-Demanding Mission-Critical Applications: Practical Implementation Insights," *IEEE Access*, vol. 5, pp. 891-910, 2017.

[2] KAUST, 'Real-Time Video Streaming for Mobile Field Networks', youtube, March 2016.

Small Antenna Arrays with Massive Performance for 5G

The future generation of mobile communication systems, commonly known as 5G, is required to address the exponential increase in traffic volumes. Towards this, the unutilized millimeter wave (mm-wave) band appears to be a promising candidate. Moreover, the shrinking of antenna elements at these frequencies enables the integration of a large number of antennas at the user end devices. However, 5G mm-wave systems face critical challenges such as high path loss, extremely high interference levels and multipath fading effects bringing beamforming to the fore as ever before. A majority of the mm-wave beamforming solutions propose the strategy of hybrid beamforming that compromise the steering accuracy at the cost of reduced complexity and power burden. In contrast to this, a team at Imperial College London proposes the utilization of spatiotemporal beamformers with "small" arrays, which exploit integrated space-and-time manifolds, resulting in gains and interference cancellation capabilities equivalent to a "massive" array.

The solution includes a family of spatiotemporal beamformers, comprising of a channel estimator and weight design block, that exploits additional degrees-of-freedom, combines multipath and suppresses cochannel interference to obtain extremely high array gains, similar to that of massive MIMO, albeit with a much smaller number of antennas. The solution utilizes a parametric channel model that enables powerful blind channel estimation that is not possible with traditional MIMO channel models. Simulation results indicate that the estimation and reception processes are highly tolerant to the near-far problem and the proposed spatiotemporal beamformer, for example a beamformer of 9 antennas outperforms the traditional MIMO system of 500 antennas by 15 dB, exhibiting very high array gain and selectivity in space and time.

[1] V. Sridhar, T. Gabillard and A. Manikas, "Spatiotemporal-MIMO channel estimator and beamformer for 5G", *IEEE Transactions on Wireless Communications*, vol. 15, no. 12, pp. 8025-8038, Dec. 2016.

Backscatter Communications Over Ambient OFDM Signals

Ambient backscatter communications (AmBC) enables radio-frequency (RF) powered devices (e.g., tags, sensors) to modulate their information bits over ambient RF carriers in an over-the-air manner. This system, called "modulation in the air", has emerged as a promising technology for green communications and future Internet-of-Things. A team at the University of Electronic Science and Technology of China has proposed an AmBC system over ambient orthogonal frequency division multiplexing (OFDM) carriers in the air. The system model for such AmBC system is established from spread-spectrum perspective, from which a novel joint design for tag waveform and reader detector is proposed. The test statistics are constructed that cancel out the direct-link interference by exploiting the repeating structure of the ambient OFDM signals due to the use of cyclic prefix. A maximum-likelihood detector recovers the tag bits, for which the optimal threshold is obtained with closed-form expression. After analyzing the effect of various system parameters on the transmission rate and detection performance, and extensive numerical results, it is concluded that the proposed transceiver design outperforms the conventional design.

[1] G. Yang, and Y-C-Liang, 'Backscatter Communications Over Ambient OFDM Signals: Transceiver Design and Performance Analysis,' *Proceedings of IEEE Global Communications Conference (Globecom)*, December 2016. The article received the best paper award.

Real-time Demonstration of PHY Processing on CPU for Programmable Optical Access Systems

Virtualization of optical access systems is being pursued to speedup service deployment and reduce CAPEX/OPEX. Several passive optical network (PON) specifications have been standardized and the applicability of virtualization to access networks is being considered. A research team at Nippon Telegraph and Telephone (NTT) has proposed a programmable optical line terminal (OLT) that performs OLT functions by software processing on general-purpose hardware. Unfortunately, general-purpose hardware struggles to achieve the 10 Gbps throughput demanded of access systems. Their work solves this problem by introducing software implementation techniques for PHY processing, a key component of computation complexity.

They propose a 2-stage parallel pipeline based on data parallelism, and details its implementation with the use of look up table (LUT) for the Galois-field multiplier for implementing the standard OLT functions of forward error correction (FEC) and encryption. The proposal is implemented on a general-purpose server with optical transmitter. Evaluation results show that the proposal drastically accelerates algorithm performance and attains the throughputs of 10 Gbps with RS(255,239), 5.1 Gbps with RS(255,223), 2.5 Gbps with CTR-AES-128 and 1.2 Gbps with GCM-AES-128.

[1] T. Suzuki, S.-Y. Kim, J.-I. Kani, K.-I.- Suzuki, and A. Otaka, 'Real-time Demonstration of PHY Processing on CPU for Programmable Optical Access Systems,' *Proceedings of IEEE Global Communications Conference (Globecom)*, December 2016. The article received the best paper award.

Jochen Maes
Editor

IEEE Communications Society
Technical Committee on Transmission, Access and Optical Systems (TAOS)
http://committees.comsoc.org/taos/

Contributors: M.S. Alouini; and V. Sridhar.

Template and Other Contributions by: Walter Cerroni