Editorial: First Quarter 2016 IEEE COMMUNICATIONS SURVEYS AND TUTORIALS

I WELCOME you to the first issue of IEEE COMMUNICATIONS SURVEYS AND TUTORIALS (ComST) in 2016. This issue includes 35 papers covering different aspects of communication networks. In particular, these articles cover various issues in wireless and optical networks, network virtualization and management, vehicular networks and multimedia delivery, separation frameworks for control and data signaling in networks, positioning and localization techniques, wireless sensor networks, software-defined networks (SDNs), and green and cognitive radio networks. A brief account for each of these papers is given below.

I. WIRELESS AND OPTICAL NETWORKS

In information theory, turbo codes (TCs) are a class of high-performance forward error correction (FEC) codes developed around 1990–1991, which were the first practical codes to closely approach the channel capacity, a theoretical maximum for the code rate at which reliable communication is still possible given a specific noise level. TCs have many applications in third generation (3G) and fourth generation (4G) mobile communications as well as in (deep space) satellite communications. They also have other applications where designers seek to achieve reliable information transfer over bandwidth- or latency-constrained communication links in the presence of data-corrupting noise. In this context, the paper titled "20 Years of Turbo Coding and Energy-Aware Design Guidelines for Energy-Constrained Wireless Applications" by Matthew F. Brejza, Liang Li, Robert G. Maunder, Bashir M. Al-Hashimi, Claude Berrou, and Lajos Hanzo presents a tutorial on TCs. The paper starts by providing an introduction to turbo coding in detail highlighting the various parameters of TCs and characterizing their impacts on the encoded bit rate, radio frequency bandwidth requirement, transmission energy consumption, and bit error rate. Then the paper discusses energy-efficient application specific integrated circuit (ASIC) architecture designs for TC decoders and characterizes the processing energy consumption as a function of the TC parameters. Finally, the paper shows how to specify the TC parameters in order to minimize the sum of the processing and transmission energy consumption.

Due to the proliferation of various high-bandwidth wireless applications, low-frequency radio spectrum is becoming overcrowded. Therefore, it would be desirable to use higher frequency radio spectrum such as the millimeter-wave (mmwave) spectrum (e.g., spectrum in the 60 GHz band). This can potentially provide a very high data rate; however, transmissions in these spectrum bands suffer from a low wireless propagation range. Therefore, a large number of radio access points (RAPs) would be required to provide seamless coverage. One of the potential solutions for access networking for future high bandwidth wireless communication systems can be therefore based on optical fibers for transmission of radio signals between the base station (BS) and RAPs in both directions, which is generally referred to as a radio over fiber (ROF) solution. In an ROF system, radio frequency signals are converted into an optical signal in an electrical-to-optical (E-O) converter at the BS. The optical signal is transmitted through the fiber and detected at the RAP, where an optical-to-electrical (O-E) converter recovers the original RF signal, which is amplified and transmitted from the RAP antenna to the mobile stations. The paper titled "Millimeter-Wave Radio Over Fiber Optical Upconversion Techniques Relying on Link Nonlinearity" by Varghese Antony Thomas, Mohammed El-Hajjar, and Lajos Hanzo presents a survey on this topic. The paper starts by providing the basics of ROF communication including optical modulation and optical detection techniques. The paper then surveys the family of advanced optical upconversion techniques that exploit the nonlinearity of the ROF link. More specifically, the paper describes how optical up-conversion can be achieved by exploiting the Mach Zhender Modulator's (MZM's) nonlinearity, wavelength conversion techniques, or the photo-detector's nonlinearity. Finally, the paper provides some design guidelines.

The integration of sensing and embedded computing in consumer electronic devices at the edge of the Internet will result in the evolution of an embedded Internet or the Internet of Things (IoT). Typical IoT devices include physical items tagged/embedded with sensors (e.g., chemical containers with temperature sensors) and smart meters to remotely monitor energy consumption. An emerging category of edge devices that will result in the evolution of IoT is consumer-centric mobile sensing and computing devices which are connected to the Internet. These include smartphones (iPhone, Google Nexus), music players (iPods), sensor embedded gaming systems (Wii, XboX Kinect), and in-vehicle sensing devices (GPS, OBD-II). Recently, they have become extremely popular and are potentially important sources of sensor data. They are typically equipped with various sensing capabilities that allow them to produce data and upload the data to the Internet. They can serve either as a bridge to other everyday objects, or generate information about the environment themselves. In this context, the paper titled "Incentives for Mobile Crowd Sensing: A Survey" by Xinglin Zhang, Zheng Yang, Wei Sun, Yunhao Liu,

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Shaohua Tang, Kai Xing, and Xufei Mao presents a survey of diverse strategies that have been proposed in the literature to provide incentives for stimulating users to participate in mobile crowd sensing applications. The incentives are divided into three categories: entertainment, service, and money. The related research works for each type are comprehensively discussed and summarized. Also, the paper outlines the further challenges and promising future directions concerning incentive mechanism design.

In the same context of mobile sensing, the paper titled "Context-Awareness for Mobile Sensing: A Survey and Future Directions" by Özgür Yürür, Chi Harold Liu, Zhengguo Sheng, Victor C. M. Leung, Wilfrido Moreno, and Kin K. Leung presents a survey on context-awareness in mobile platforms by providing an up-to-date summary of related research and outlining future research directions. Moreover, it points out the challenges faced in this regard and proposes possible solutions.

Recently, RF fingerprinting has been proposed as a means of enhancing the security of wireless networks. When a radio transmitter is activated, the RF signal emitted from the transmitter shows a transient behavior with respect to instantaneous frequency and amplitude. Transient signal behavior is attributable to a variety of sources such as the acquisition characteristics of frequency synthesis systems, modulator subsystems, and RF amplifiers. The duration of the transient behavior may change depending on the type and model of the transmitter. Typically, differences are observable even for transmitters of the same type, mainly because of the manufacturing tolerances and the aging of the devices. The unique turn-ON transient signal behavior is called the RF fingerprint of a radio and can be used to identify the transmitter. In this context, the paper titled "Device Fingerprinting in Wireless Networks: Challenges and Opportunities" by Qiang Xu, Rong Zheng, Walid Saad, and Zhu Han presents a survey on wireless device fingerprinting for security applications. The paper aims at providing a detailed treatment on developing novel wireless security solutions using device fingerprinting techniques. The paper then introduces a comprehensive taxonomy of wireless features that can be used in fingerprinting. Subsequently, it provides a systematic review on fingerprint algorithms including both white-list based and unsupervised learning approaches. Finally, it identifies the key open research problems in the area of device fingerprinting and feature extraction as applied to wireless security.

A mobile network measurement platform is an infrastructure of dedicated probes that periodically runs network measurement tests on the network. These platforms have been deployed to satisfy specific use-case requirements. For instance, a number of early measurement studies utilized these platforms to understand the network-level macroscopic topology of mobile networks. Several years of research efforts have matured this area and led to a number of algorithms for topology mapping with reduced complexity. Recently, we have seen a shift toward the deployment of performance measurement platforms that provide network operational support and measure fixed-line and mobile access networks. This has been motivated by the emerging need to not only assess the broadband quality but also to verify service offers against contractual agreements. In this context, the paper titled "Survey of End-to-End Mobile Network Measurement Testbeds, Tools, and Services" by Utkarsh Goel, Mike P. Wittie, Kimberly C. Claffy, and Andrew Le presents a survey that examines the current approaches to end-to-end mobile network performance measurement, diagnosis, and application prototyping. The paper compares the available tools and their shortcomings with respect to the needs of developers, researchers, network operators, and regulators. Finally, the paper outlines possible future research directions.

Mobile communication is pervasive and it allows people to be connected even in the most remote places of the world. Since 2005, it has initiated the decline of landline use both in the developing and the developed world. Due to their ubiquity, mobile phones have stimulated the creativity of scientists to use them as millions of potential sensors of their environment. Mobile phones have been used as distributed seismographs, motorway traffic sensors, transmitters of medical imagery, or as communication hubs for high-level data such as the reporting of invading species. In this context, the paper titled "Large-Scale Mobile Traffic Analysis: A Survey" by Diala Naboulsi, Marco Fiore, Stephane Ribot, Razvan Stanica presents a survey on analyses of mobile traffic collected by operators within their network infrastructure. More specifically, the paper provides a thorough review of the multidisciplinary activities that rely on mobile traffic datasets and identifies major categories and subcategories in the literature, so as to outline a hierarchical classification of research lines.

Wireless local area networks (WLANs) based on the IEEE 802.11 standards have become an integral part of our network infrastructure. The IEEE 802.11 WLAN physical layer (PHY) standard supports multiple data rates by using different modulation and channel coding schemes. For instance, the IEEE 802.11a networks have eight different modes with varying data rates from 6 to 54 Mb/s. However, due to the packet headers from higher layers as well as the various overheads in the medium access control (MAC) layer, there is a significant reduction in effective throughput. The effective throughput (or goodput) is defined as the ratio of the expected delivered data payload and the expected transmission time. Moreover, most voice and video applications tend to use very small payload sizes to ensure reliable and low-delay delivery. This results in significant loss in effective throughput. In this context, the paper titled "MU-MIMO MAC Protocols for Wireless Local Area Networks: A Survey" by Ruizhi Liao, Boris Bellalta, Miquel Oliver, and Zhisheng Niu presents a survey on random access based MAC protocols for multiuser multiple-input multiple-output (MU-MIMO)-enabled WLANs. It first provides background information about the evolution and the fundamental MAC schemes of the IEEE 802.11 Standards and Amendments. Then, it identifies the key requirements of designing MU-MIMO MAC protocols for WLANs. Subsequently, the most representative MU-MIMO MAC proposals in the literature are overviewed by examining their key components (e.g., for channel state information acquisition, de/pre-coding and scheduling schemes). Based on the surveyed MAC protocols, the research challenges for designing effective MU-MIMO MAC protocols as well as their roles in the future heterogeneous networks are highlighted.

For WLANs, to provide security equivalent to that available with wired networks, IEEE focussed on the creation of security protocols that would co-work with the WLAN

standards. Toward this direction, wireless intrusion detection systems can assist to proactively and reactively protect the network. In this context, the paper titled "Intrusion Detection in 802.11 Networks: Empirical Evaluation of Threats and a Public Dataset" by Constantinos Kolias, Georgios Kambourakis, Angelos Stavrou, and Stefanos Gritzalis presents a survey. The paper starts by gathering, categorizing, thoroughly evaluating the most popular attacks on 802.11, and analyzing their signatures. Then, it offers a publicly available dataset containing a rich blend of normal and attack traffic against 802.11 networks. An extensive first-hand evaluation of this dataset is also provided using several machine learning algorithms and data features.

In communication and information theory, FEC or channel coding is a technique used for controlling errors in data transmission over unreliable or noisy communication channels. The central idea is that the sender encodes the message in a redundant way by using an error-correcting code (ECC). The redundancy allows the receiver to detect a limited number of errors that may occur anywhere in the message, and correct these errors without retransmission. FEC gives the receiver the ability to correct errors without needing a reverse channel to request retransmission of data, but at the cost of a forward channel bandwidth. In this context, the paper titled "A Survey on FEC Codes for 100G and Beyond Optical Networks" by Georgios Tzimpragos, Christoforos Kachris, Ivan B. Djordjevic, Milorad Cvijetic, Dimitrios Soudris, and Ioannis Tomkos presents a survey of third generation FEC codes suitable for 100G and beyond optical networks. Furthermore, the paper discusses the major advantages and drawbacks of each scheme and provides a qualitative categorization and comparison among the proposed schemes based on their main features such as net coding gain, bit error rate, and complexity.

II. Network Virtualization and Management, Vehicular Networks, and Multimedia Delivery

The information and communication technologies (ICT) are responsible, on average, for 2% of the carbon emissions worldwide. The communication networks are responsible for a great part of this amount. The network service providers (NSPs) usually over-provision bandwidth in order to ensure service level agreements (SLAs). Nonetheless, the links are usually underutilized. Therefore, there is an opportunity to reduce the energy consumption by managing networks in a more sustainable way. Policy-based network management (PBNM) is one of the key approaches to manage communication networks. A policy is a set of rules used to manage and control access to a set of ICT resources and services in order to be able to handle quality of service, security, and sustainability issues. In this context, the paper titled "A Survey of Policy Refinement Methods as a Support for Sustainable Networks" by Ana Carolina Riekstin, Guilherme Carvalho Januário, Bruno Bastos Rodrigues, Viviane Tavares Nascimento, Tereza Cristina Melo de Brito Carvalho, and Catalin Meirosu presents a survey. The paper starts by identifying the major characteristics of sustainability-oriented policies as well as the requirements for policy refinement methods for such type of policies. The paper then analyzes the existing policy refinement techniques and discusses the challenges related to their applications to sustainability-oriented policies.

Network functions virtualization (NFV) has recently been proposed to improve the flexibility of network service provisioning and reduce the time to market new services. By leveraging virtualization technologies and commercial off-the-shelf programmable hardware such as general purpose servers, storage and switches, NFV decouples the software implementation of network functions from the underlying hardware. As an emerging technology, NFV brings several challenges to network operators. In this context, the paper titled "Network Function Virtualization: State-of-the-Art and Research Challenges" by Rashid Mijumbi, Joan Serrat, Juan-Luis Gorricho, Niels Bouten, Filip De Turck, and Raouf Boutaba presents a survey. The paper starts by discussing NFV and its relationship with complementary fields of software-defined networking (SDN) and cloud computing. Subsequently, the paper surveys the state-of-the-art in NFV and identifies promising research directions in this area. Finally, the paper overviews key NFV projects, standardization efforts, early implementations, use cases, and commercial products.

Vehicle platooning is an important innovation in the automotive industry that aims at improving the safety, mileage, efficiency, and the time needed to travel. Autonomous vehicles in tightly spaced computer controlled platoons will lead to savings in fuel, increased highway capacity, and increased passenger comfort. The introduction of automation into road traffic can provide essential solutions to the mainstream issues of accidents, traffic congestion, pollution, and energy consumption. Under cooperative driving, automated vehicles drive like the migration of birds or a group of dolphins; the formation of birds in the migration is aerodynamically efficient, and the dolphins swim without collision while communicating with each other. Cooperative driving, simulating the formation of birds or dolphins, will contribute to the increased road capacity as well as traffic safety. In this context, the paper titled "A Survey on Platoon-Based Vehicular Cyber-Physical Systems" by Dongyao Jia, Kejie Lu, Jianping Wang, Xiang Zhang, and Xuemin (Sherman) Shen presents a survey on platoon-based vehicular cyber-physical systems (VCPS). The paper starts by reviewing the related work on platoon-based VCPS and introduces two elementary techniques involved in platoon-based VCPS. Then, it discusses the fundamental issues in platoon-based VCPS including vehicle platooning/clustering, cooperative adaptive cruise control (CACC), and platoon-based vehicular communications. It gives an overview of VCPS simulation tools. Finally, the paper highlights some open research issues.

We are currently in the midst of a networking revolution. The Internet now connects millions of computers, smartphones, and tablets. In parallel with the ever increasing network sizes, there has been a concomitant increase in the collection of network measurement data for proper management of networks and services. Understanding this data is of crucial importance as we move to a modern information-rich society. Unfortunately, tools for analyzing the network data have not kept pace with the data volumes. Traditional network analysis software and graphs cannot cope with the size of today's networks and their

data collection capabilities. In this context, the paper titled "A Survey on Information Visualization for Network and Service Management" by Vinícius Tavares Guimarães, Carla Maria Dal Sasso Freitas, Ramin Sadre, Liane Margarida Rockenbach Tarouco, and Lisandro Zambenedetti Granville presents a survey on the use of information visualization techniques as a tool to support the network and service management process. The paper also points out future research directions and opportunities regarding the use of information visualization in network and service management.

The end-to-end congestion control mechanism of transmission control protocol (TCP) is critical for the robustness of Internet. However, the Internet is no longer a small closely knit user community, and it is no longer practical to rely on all end-nodes to use end-to-end congestion control for best-effort traffic. The network itself must now participate in controlling its own resource utilization. Router-based queue management schemes driven by fairness objectives have become an inescapable necessity for sharing the network resources in a fair manner. In this context, the paper titled "Fairness-Driven Queue Management: A Survey and Taxonomy" by Ghulam Abbas, Zahid Halim, and Ziaul Haq Abbas presents a survey on the different fairness-driven queue management schemes from the inception of the concept and preliminary research works to the most recent research works. The paper presents a new taxonomy of categorizing the fairness-driven queue management schemes. Moreover, the paper discusses the design approaches and key attributes of these schemes and provides a comparison among them. Based on the outcomes of this survey, the paper discusses a number of open issues and outlines some generic design guidelines and future directions for the research in this field.

The Moving Picture Experts Group (MPEG) is a working group of ISO/IEC with the mission of developing standards for coded representation of digital audio and video and related data. The paper titled "Understanding Timelines Within MPEG Standards" by Lourdes Beloqui Yuste, Fernando Boronat, Mario Montagud, and Hugh Melvin presents a survey and a review of how clock references (timing) and timestamps (time) are conveyed and interpreted when using the most widespread delivery technologies, such as DVB, RTP/RTCP and MPEG standards (e.g., MPEG-2, MPEG-4, MPEG-DASH and MMT). It particularly focusses on the format, resolution, frequency, and the position within the bitstream of the fields conveying timing information, as well as on the involved components and packetization aspects. Finally, it provides a survey of the proof-of-concepts making use of these synchronization related mechanisms.

The ever growing bandwidth in access networks in combination with video on demand (VoD) offerings, opens up unlimited possibilities to the users. The operators can no longer compete solely on the number of channels or content. Instead, quality of experience (QoE) is considered as a major service differentiator. Currently, the most reliable way of assessing and measuring QoE is conducting subjective experiments, where human observers evaluate a series of short video sequences using one of the international standardized subjective quality assessment methodologies. Unfortunately, these subjective experiments need to be conducted in controlled environments, and therefore, pose limitations on the sequences and overall experiment duration. Hence, they cannot be used for real-life QoE assessment of VoD services. In this context, the paper titled "Measurement of Quality of Experience of Video-on-Demand Services: A Survey" by Parikshit Juluri, Venkatesh Tamarapalli, and Deep Medhi presents a survey. The paper starts by providing a tutorial overview of the popular video streaming techniques deployed for stored videos, followed by identifying various metrics that could be used to quantify the QoE for video streaming services. Moreover, the paper presents a comprehensive survey of the literature on various tools and measurement methodologies that have been proposed to measure or predict the QoE of online video streaming services.

III. Separation Frameworks, Positioning, and Localization Techniques

In traditional voice-oriented wireless networks, the signaling designed for network access (denoted as control signaling) and that for dedicated data transmission (denoted as data signaling) are tightly coupled. However, with the traffic explosion and the paradigm shift from voice-oriented services to data-oriented services, traditional homogeneous architecture no longer maintains its optimality. Instead, a heterogeneous deployment with flexible network control capability becomes a promising evolution direction. In this context, the paper titled "Separation Framework: An Enabler for Cooperative and D2D Communication for Future 5G Networks" by Hafiz Atta Ul Mustafa, Muhammad Ali Imran, Muhammad Zeeshan Shakir, Ali Imran, and Rahim Tafazolli presents a survey, where it reviews various proposals that have been presented in the literature to enable separation architecture (SARC). The paper outlines to what extent the various SARC proposals are capable of addressing the four main challenges in network densification, namely, energy efficiency, system level capacity maximization, interference management, and mobility management. The paper then focusses on two candidate technologies for future cellular networks, which are coordinated multipoint (CoMP), and device-to-device (D2D) communications, and how SARC can act as an enabler for CoMP and D2D in the context of fifth generation (5G) networks. Finally, the paper highlights some possible future research directions.

In the same context of separation frameworks for cellular networks, the paper titled "Control-Data Separation Architecture for Cellular Radio Access Networks: A Survey and Outlook" by Abdelrahim Mohamed, Oluwakayode Onireti, Muhammad Ali Imran, Ali Imran, and Rahim Tafazolli presents a survey of existing literature on control-data separation architecture (CDSA) for cellular radio access networks. The paper starts by discussing the fundamental concepts and general structure of the CDSA. The paper then outlines the shortcomings of the conventional architecture in futuristic deployment scenarios. Moreover, the paper reviews the research works that have been done to investigate potential benefits of the CDSA as well as its technical challenges and enabling technologies. Finally, an overview of standardization proposals related to this research vision is provided.

The proliferation of mobile computing devices and local-area wireless networks has fostered a growing interest in location-aware systems and services. A key distinguishing feature of such systems is that the application information and/or interface presented to the user is, in general, a function of his or her physical location. The granularity of location information needed could vary from one application to another. While many research works have focussed on developing service architectures for location-aware systems, less attention has been paid to the fundamental and challenging problem of locating and tracking mobile users, especially in in-building environments. The few efforts, which have addressed this problem, have typically done so in the context of infrared (IR) wireless networks. The limited range of an IR network is a handicap in providing ubiquitous coverage. Also, the IR network is often deployed for the sole purpose of locating people and does not provide traditional data networking services. To avoid these limitations, RF WLANs with accurate user location and tracking capabilities have been used. This complements the data networking capabilities of RF wireless LANs, and thereby, enhances the value of such networks. In this context, the paper titled "Wi-Fi Fingerprint-Based Indoor Positioning: Recent Advances and Comparisons" by Suining He and S.-H. Gary Chan presents a survey. The paper overviews the recent advances in two major areas of Wi-Fi fingerprint localization: advanced localization techniques and efficient system deployment. Moreover, the paper studies and compares the approaches through deployment experiences, and discusses some future directions.

In the same context of positioning and localization techniques, the paper titled "A Survey of Fingerprint Based Outdoor Localization" by Quoc Duy Vo and Pradipta De presents another survey where it classifies the existing fingerprint-based localization approaches, which intelligently sense and match different clues from the environment for outdoor location identification. The paper then describes how each fingerprinting technique works, followed by a review of the merits and demerits of the systems built based on these techniques. The paper concludes by identifying several improvements and application domains for fingerprinting-based localization.

IV. Wireless Sensor Networks and SDNs

Due to recent technological advances, manufacturing of small and low-cost sensors has become technically and economically feasible. These sensors measure ambient conditions in their surrounding environment and then transform these measurements into signals that can be processed to reveal some characteristics about phenomena located in the area around these sensors. In many applications, a large number of these sensors can be networked to form a wireless sensor network (WSN) that require unattended operations. The applications of WSNs are quite numerous. For example, WSNs have profound effects on military and civil applications such as target field imaging, intrusion detection, weather monitoring, security and tactical surveillance, distributed computing, and detecting ambient conditions such as temperature, movement, sound, and light. In this context, the paper titled "The Evolution of Sink Mobility Management in Wireless Sensor Networks: A Survey" by Yu Gu, Fuji Ren, Yusheng Ji, and Jie Li presents a survey on the sink mobility issue. Its main contribution is an extensive review of the mobility management schemes from an evolutionary point of view. The related schemes are divided into four categories: uncontrollable mobility (UMM), path-restricted mobility (PRM), location-restricted mobility (LRM), and unrestricted mobility (URM). Several representative solutions are described following a proposed taxonomy.

In the same context of WSNs, the paper titled "A Survey on Cross-Layer Quality-of-Service Approaches in WSNs for Delay and Reliability-Aware Applications" by Irfan Al-Anbagi, Melike Erol-Kantarci, and Hussein T. Mouftah presents a survey on the state- of-the-art cross-layer QoS approaches in wireless terrestrial sensor networks to achieve delay and reliability bounds in critical applications. Furthermore, the paper highlights the main challenges of implementing QoS protocols in WSNs and presents an overview of QoS-aware WSN applications.

Again in the context of WSNs, the paper titled "Wireless Sensor Network Virtualization: A Survey" by Imran Khan, Fatna Belqasmi, Roch Glitho, Noel Crespi, Monique Morrow, and Paul Polakos presents a comprehensive review and an in-depth discussion of the state-of-the-art virtualization techniques in WSNs. The paper starts by introducing the basics of WSN virtualization and motivates its pertinence with carefully selected scenarios. Then, it surveys the existing works in detail and critically evaluates them using a set of requirements for the considered scenarios.

The availability of inexpensive radio transceivers has enabled new types of applications and created new research challenges. Applications range from WSNs that can be used for health monitoring, industrial control, and building automation to smart cards that enable seamless user authentication and signing of digital documents. Depending on the application, these devices may not only exchange information locally with peers, but also globally with entities in the Internet. They are expected to be deployable in large quantities and in environments where they may be exposed to tampering, eavesdropping, and attempts to modify transmitted data and insert unauthorized messages into the network. To counter such threats, flexible and effective mechanisms for secure communication are essential. In this context, the paper titled "A Survey of Public-Key Cryptographic Primitives in Wireless Sensor Networks" by Kyung-Ah Shim presents a survey of the use of public-key cryptographic techniques in WSNs including identity-based cryptography. The paper then discusses their main directions and some open research issues that can be further pursued. Moreover, it investigates the state-of-the-art software implementation results of public-key cryptographic primitives in terms of execution time, energy consumption, and resource occupation on constrained wireless devices choosing popular IEEE 802.15.4-compliant WSN hardware platforms.

Conventional networks utilize special algorithms and rules implemented on dedicated devices (hardware components) to control and monitor the data flow in the network, managing routing paths and determining how different devices are interconnected in the network. A problem posed by this methodology is the limitation of the current network devices under high network traffic, which poses severe limitations on network performance. Due to the ever increasing network traffic, issues

such as increasing demand for scalability, security, reliability, and network speed can severely hinder the performance of the current network devices. One possible solution to this problem is the implementation of data handling rules as software modules rather than embedding them in hardware. This method enables the network administrators to have more control over the network traffic, and therefore, has a great potential to improve network performance in terms of efficient use of network resources. Such an idea is defined in an innovative technology called software-defined networking (SDN). On the other hand, distributed denial of service (DDoS) flooding attacks have become one of the major security concerns. Typically, the DDoS flooding attacks are explicit attempts to disrupt legitimate users' access to services. Attackers usually gain access to a large number of computers by exploiting their vulnerabilities to set up attack armies (i.e., Botnets). Once an attack army has been set up, an attacker can invoke a coordinated large-scale attack against one or more targets. Developing a comprehensive defense mechanism against identified and anticipated DDoS flooding attacks is a desired goal for the research community working on intrusion detection and prevention. In this context, the paper titled "Software-Defined Networking (SDN) and Distributed Denial of Service (DDoS) Attacks in Cloud Computing Environments: A Survey, Some Research Issues, and Challenges" by Qiao Yan, F. Richard Yu, Qingxiang Gong, and Jianqiang Li presents a survey. The paper discusses the new trends and characteristics of DDoS attacks in cloud computing and provides a comprehensive survey of defense mechanisms against DDoS attacks using SDN. In addition, the paper reviews the studies on launching DDoS attacks on SDN as well as the defense methods against DDoS attacks in SDN.

In the same context of SDN, the paper titled "A Survey of Security in Software Defined Networks" by Sandra Scott-Hayward, Sriram Natarajan, and Sakir Sezer presents a survey where it studies security in SDN presenting advances in this area both from the academic research community and industry. The paper discusses challenges to securing the network from a persistent attacker as well as designing an holistic security architecture for SDN. Finally, the paper highlights some possible future research directions.

In the context of SDN, the paper titled "Survey on Network Virtualization Hypervisors for Software Defined Networking" by Andreas Blenk, Arsany Basta, Martin Reisslein, and Wolfgang Kellerer presents a survey on hypervisors for SDN networks. The paper categorizes the SDN hypervisors into centralized and distributed hypervisors according to their architectures. The paper offers a further classification of the hypervisors according to their execution platform, namely, hypervisors running exclusively on general-purpose compute platforms, or on a combination of general-purpose computing platforms with general or special-purpose network elements. Finally, the paper outlines the development of a performance evaluation framework for SDN hypervisors.

V. Green Networks

Efficient use of energy in wireless networks has become a key research agenda for both academia and industry. Various solution approaches have been proposed to enable efficient usage of energy in wireless networks, and these approaches are referred to as green wireless communications and networking approaches. In this context, the paper titled "Energy Efficiency Tradeoff Mechanism Towards Wireless Green Communication: A Survey" by Rajarshi Mahapatra, Yogesh Nijsure, Georges Kaddoum, Naveed Ul Hassan, and Chau Yuen presents a survey of different tradeoff mechanisms proposed in the literature for using energy efficiently in each protocol layer, as well as in the infrastructure. Moreover, the paper discusses different QoS parameters related to spectral efficiency, deployment, delay, routing, scheduling, bandwidth, and coding. Finally, the paper highlights some possible future research directions.

In the same context of green telecommunication networks, the paper titled "A Quantitative Survey of the Power Saving Potential in IP-Over-WDM Backbone Networks" by Ward Van Heddeghem, Bart Lannoo, Didier Colle, Mario Pickavet, and Piet Demeester presents a survey on the reported power saving potential in IP-over-WDM backbone telecommunication networks across the existing body of research in this area. More specifically, the paper maps more than ten different approaches to a concise analytical model and estimates the combined power reduction potential.

Reduction of power consumption in data centers (DCNs) has attracted major research efforts in the past decade. Traditionally, the main functionality of a DCN has been hosting multiple types of web services (e.g., HTTP, FTP, mail, etc.), storing large volume of contents, and processing various types of web requests. Modern data centers are typically composed of server clusters, networking elements such as switches, and site infrastructure, e.g., cooling and power delivery systems. Sizes of the server clusters can vary from tens of servers to thousands of servers depending on the service capability of the DCN, which process requests and deliver service to end-users or store large volumes of contents. In this context, the paper titled "Data Center Energy Consumption Modeling: A Survey" by Miyuru Dayarathna, Yonggang Wen, and Rui Fan presents a survey of the state-of-the-art techniques used for modeling and prediction of energy consumption in DCNs and their components. The paper organizes these models into a hierarchical structure with two main branches focussing on hardware-centric and software-centric power models. The paper concludes the survey by describing the key challenges for constructing effective and accurate data center power models.

VI. Cognitive Radio Networks

Studies on spectrum utilization have revealed that actual spectrum usage varies from 15% to 85% with wide variance in time and space. This implies that one root cause of current spectrum scarcity is the fixed (or rigid) spectrum allocation. Cognitive radio (CR) thus has emerged as a promising solution to mitigate the spectrum efficiency problem by exploiting the under-utilized spectrum wherein unlicensed (secondary) users are allowed to opportunistically access the un-used licensed spectrum without interfering the primary users (PUs) with legacy rights to access that spectrum. The key component of CR technology is the ability to sense and ultimately adapt to

the continuously varying radio environment. The most crucial task of CR in this regard is to track the PU activity in the spectrum of interest with an aim to reliably identifying the currently un-occupied frequency bands, popularly known as spectrum hole(s). These spectrum holes can exist across multiple dimensions such as time, space, frequency, angle, and code. In this context, the paper titled "Channel Assignment Algorithms in Cognitive Radio Networks: Taxonomy, Open Issues, and Challenges" by Ejaz Ahmed, Abdullah Gani, Saeid Abolfazli, Liu Jie Yao, and Samee U. Khan presents a survey on the state-of-the-art channel assignment algorithms in CR networks. The paper classifies the algorithms by presenting a thematic taxonomy of the current channel assignment algorithms in CR networks. Moreover, the critical aspects of the current channel assignment algorithms in CR networks are analyzed to determine the strengths and weaknesses of such algorithms. The paper also discusses open research issues and challenges related to channel assignment in CR networks.

In the same context of CR networks, the paper titled "Radio Resource Allocation Techniques for Efficient Spectrum Access in Cognitive Radio Networks" by Georgios I. Tsiropoulos, Octavia A. Dobre, Mohamed Hossam Ahmed, and Kareem E. Baddour presents a survey and an overview of CR networks with focus on the recent advances in resource allocation techniques and architectural design. The paper starts by offering a systematic way to study the resource allocation problem while introducing various design approaches. Then the paper studies different CR optimization methods accompanied by a comprehensive study of the resource allocation problem formulations. Finally, the paper discusses some challenges in spectrum assignment.

Again, in the context of CR networks, the paper titled "A Survey of Measurement-Based Spectrum Occupancy Modeling for Cognitive Radios" by Yunfei Chen and Hee-Seok Oh presents a survey on different spectrum occupancy models from measurement campaigns taken around the world. In addition, the paper discusses spectrum occupancy prediction, where the auto-regressive and/or moving-average models are used to predict the channel status at future time instants. Finally, the paper outlines some challenges that need to be tackled in future research in this area.

The centrally controlled electrical grid today is a large interconnected network that delivers electricity from suppliers to consumers. New challenges such as rising energy demand, aging infrastructure, renewable energy sources, reliability, and security are emerging in the traditional power grid. These challenges have become a global concern that necessitates the traditional electrical grid to evolve toward a smart grid (SG) with intelligence, autonomy, improved efficiency, easy control, and high security. The smart power grid is considered to be the next generation electricity grid. To significantly improve the efficiency, sustainability, security, and stability of the electrical grid, a smart power grid will be integrated with a variety of state-of-the-art enabling ICT covering the areas of embedded sensing, broadband wireless communication, pervasive computing, and adaptive control. One example of such an enabling technology is the CR technology. The paper titled "Cognitive Radio for Smart Grids: Survey of Architectures, Spectrum Sensing Mechanisms, and Networking Protocols" by Athar Ali Khan, Mubashir Husain Rehmani, and Martin Reisslein presents a survey on the CR-based communication paradigm for SGs, including the system architecture, communication network compositions, applications, and CR-based communication technologies. The paper highlights potential applications of CR-based SG systems. In addition, the paper surveys CR-based spectrum sensing approaches with their major classifications. It also studies CR-based routing and MAC protocols and describes different interference mitigation schemes. Finally, the paper sheds light on some open issues and research challenges faced by CR-based SG networks.

I hope that you enjoy reading this issue and find the articles useful. Last, but not the least, I highly encourage you to submit your work which fit within the scope of ComST. For detailed instructions on the preparation and submissions of papers to ComST, please check the URL below: http://dl.comsoc.org/livepubs/surveys/. I will be happy to receive your comment and feedback on our journal.

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