NETWORK TESTING


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In the world of communications, testing is usually applied to verify an implementation, in terms of functionality, conformance, interoperability, performance, robustness, and stability. The implementation under test could be a black-box or white-box device, a piece of software, or scaled up to a system of hardware and software. This September issue received nine submissions in December 2013. We accepted three of them, with two from academia and one from a hybrid team of universities and a startup company. The other six submissions were not included, mainly due to not enough focus or interesting materials on test methodologies and results, or not enough technical contributions. Again, the due dates for this series are June 1 and December 1 each year, with publication in the March and September issues of the following year. The turn-around time of the review process is being kept within three months, usually with two rounds of review. We continue to solicit submissions with a focus on test methodologies and results in communications and networking systems.

In this issue, of the three articles, two are on testbed design, and one is on device testing. The first article constructs an IEEE 802.11 mesh network testbed with Android smartphones and tablets. By observing and configuring cross-layer protocol parameters and non-protocol parameters on Android devices, the testbed serves as a tool to evaluate various techniques for cognitive networking. The source code of the tool is made available as an open source package. The second article constructs a testbed for vehicular networks in a harbor area with trucks, boats, and vessels attached with onboard units (OBUs), plus roadside units (RSUs) and cloud-based data and control systems. Through various forms of testing, it is demonstrated that this mesh is adequate to support daily harbor operations. The third article implements and tests a cross-protect (XP) router with flow-aware networking (FAN) and quality of service (QoS) capabilities. Both XP routers and traditional IP routers are tested to evaluate how well they provide QoS to streaming flows and other elastic flows.

The article on cognitive networking testbed ("CARMEN: A Cognitive Networking Testbed on Android OS Devices") first differentiates cognitive networking (CN) from cognitive radio (CR). The latter involves physical (PHY) layer design adaptive to changing radio conditions, while the former learns the relationship between the network's behavior and its performance, and jointly optimizes different layers of the protocol stack. In short, the scope of CN is wider than that of CR. CN should be done on real devices instead of a simulator like ns-3, which cannot simulate all the factors of real network devices. The Cognitive Android Mesh Network (CARMEN) testbed is based on inexpensive commercial Android devices that allow direct observation and modification of their cross-layer in-stack parameters (e.g., TCP congestion window, number of outstanding packets, round-trip time, retransmission timeout, transmission channel, transmission power, RSSI, interframe spacing) and indirect access of out-of-stack parameters (e.g., acceleration, orientation, position) through other sensors (e.g., accelerometer, gyroscope, GPS). Several cognitive networking techniques are demonstrated by setting a bound on TCP congestion window (CWND) to maximize the throughput for a particular mesh network, comparing three mesh routing strategies in terms of their average TCP throughput, and observing TCP throughput variation in the presence of mobility events.

In the second article, on a vehicular network testbed ("Harbornet: A Real-World Testbed for Vehicular Networks"), Harbornet, a vehicular mesh networking testbed consisting of OBUs installed in trucks, tow boats, and patrol vessels, RSUs connected to the optical fiber backhaul of the seaport, and cloud-based data and control systems, is presented. The OBU operates mainly a dedicated short-range communication (DSRC) interface (IEEE 802.11p) up to 900 m on an unlicensed band with the 3G cellular interface as the backup. In their experiment with 25 trucks, two boats, two vessels, one harbor administration vehicle, and five RSUs 300–500 m apart, they observe that 70 percent of the time vehicles are disconnected, without a network path from their location to an RSU, for less than 1 min. Nearly 95 percent of the time vehicles are able to reconnect in less than 5 min. That is, cellular backup is not necessary for applications that can tolerate a 5-min delay. Handovers between RSUs are also performed in less than 100 ms, which enables seamless mobile communication in the harbor.

In the third article, on cross-protect routers ("The Cross-Protect Router: Implementation Tests and Opportunities"), the concepts of FAN and XP routers are reviewed first. FAN is an alternative QoS architecture to the well-known but failed integrated services (IntServ) and differentiated services (DiffServ). It does not require complicated signaling. It implicitly classifies packets into two kinds of flows, streaming and elastic, with the former being prioritized as they are more vulnerable to sudden transmission rate change. An XP router implements FAN by adding two modules, measurement-based admission control and fair queuing with priority, to a standard IP router. The name, cross-protect, comes from the congestion feedback from fair queuing to admission control. No new flows will be established to the protected flow list (PFL) if an outgoing link is congested. Thus, admitted flows are protected with QoS. Compared to traditional IP routers, XP routers enforce balanced bandwidth to each flow, while IP routers serve flows proportionally to incoming packets. Also, the impact of elastic flows on streaming flows is minimal in XP routers, which is not the case in IP routers.

BIOGRAPHIES

YING-DAR LIN [F'13] (ydlin@cs.nctu.edu.tw) is a Distinguished Professor of Computer Science at National Chiao Tung University, Taiwan. He received his Ph.D. in computer science from the University of California, Los Angeles in 1993. He served as the CEO of Telecom Technology Center during 2010–2011 and a visiting scholar at Cisco Systems in San Jose during 2007–2008. Since 2002, he has been the founder and director of the Network Benchmarking Lab (NBL, www.nbl.org.tw), which reviews network products with real traffic. NBL recently became an approved test lab of the Open Networking Foundation (ONF). He also cofounded L7 Networks Inc. in 2002, which was later acquired by D-Link Corp. His research interests include design, analysis, implementation, and benchmarking of network protocols and algorithms, quality of services, network security, deep packet inspection, wireless communications, embedded hardware/software co-design, and recently software defined networking. His work on multihop cellular was the first along this line, and has been cited over 600 times, and standardized into IEEE 802.11s, IEEE 802.15.5, WiMAX IEEE 802.16j, and 3GPP LTE-Advanced. He is an IEEE Distinguished Lecturer (2014 and 2015), and a research associate of ONF. He is currently on the Editorial Boards of *IEEE Transactions on Computers*, *IEEE Computer*, *IEEE Network*, *IEEE Communications Magazine* (Network Testing Series), *IEEE Wireless Communications*, *IEEE Communications Surveys and Tutorials*, *IEEE Communications Letters*, *Computer Communications*, *Computer Networks*, *Journal of Network and Computer Applications*, and *IEICE Transactions on Information and Systems*. He has guest edited several Special Issues in IEEE journals and magazines, and co-chaired symposia at IEEE GLOBECOM '13 and will do so at IEEE ICC '15. He published a textbook, *Computer Networks: An Open Source Approach* (www.mhhe.com/lin), with Ren-Hung Hwang and Fred Baker (McGraw-Hill, 2011). It is the first text that interleaves open source implementation examples with protocol design descriptions to bridge the gap between design and implementation.

ERICA JOHNSON (erica.johnson@iol.unh.edu) combines business acumen and an in-depth understanding of complex networking technology to direct the University of New Hampshire InterOperability Laboratory (UNH-IOL). In this capacity, she oversees all aspects of the testing services the UNH-IOL offers for more than 20 unique data networking and storage technologies. Her strategic management of these services includes relationships with industry fora, high-profile test events, and UNH-IOL operations. In recognition of her ability to drive technical innovation, Fierce Telecom named her to the publication's 2011 Women in Wireline. Furthermore, in 2010, UNH awarded her the UNH Women's Commission Stephanie Thomas Staff Award in honor of her achievements in promoting and embodying the advancement of women in the sciences. Widely recognized as an industry leader, she was appointed co-editor of the Network Testing Series for *IEEE Communications Magazine* in 2010. In addition, she serves as an IPv6 Ready Logo Regional Officer, IPv6 Forum Fellow, and USGv6 Test Program lead. In her role within the University of New Hampshire, she engages daily with industry leaders, members of the local community, faculty, and students. She is an advisor for the UNH Broadband Center of Excellence (BCoE), a Director of the College of Engineering and Physical Sciences (CEPS) Alumni Society Board, and participates on the Electrical and Computer Engineering and Computer Science Advisory Boards. She takes great pride in using her entrepreneurial and technical skills to train the workforce's next generation of engineers, and often supports university researchers with grant proposals. She received her Master of Business Administration degree from the University of New Hampshire in 2011, and her Bachelor of Science in computer science, also from the University of New Hampshire, in 2001. She joined the UNH-IOL in 1999 as an undergraduate student in computer science.