Guest Editorial

Design, Implementation, and Analysis of Communication Protocols

Communication protocols are the foundation of modern communication networks, including the Internet, intelligent networks and wireless networks. The availability of reliable and high performance communication protocols has become indispensable in our daily life for us to conduct business and to exchange information more than ever before. This makes the correctness, robustness, and performance of protocols crucial for communications as that of algorithms for computer sciences. This issue of the Journal on Selected Areas in Communications (JSAC) is devoted to a study of communication protocol design, implementation, analysis and testing with a focus on new concepts, advances, approaches, and experiences.

Eight articles cover a range of aspects of protocol design and implementations.

Routing protocol design is essential for reliable and efficient information and data transmission. “Multipath Routing for Video Delivery over Bandwidth-Limited Networks” addresses the need of end-to-end bandwidth requirement for video data transmission and proposes multipath routing, where the video takes multiple paths to reach its destination(s), thereby increasing the aggregate throughput. The design of border gateway protocol (BGP), an important Internet protocol, is studied in “Improved BGP Convergence via Ghost Flushing,” where a minor modification of BGP is proposed to reduce the time for route convergence and stability after a node failure, and BGP is also discussed in “Advertising Interdomain QoS Routing Information,” where the authors propose an extension of BGP for efficiently advertising the available bandwidth and the delay information of routes. Over the years, a large number of papers have been published on improving BGP performance. While appreciating the scientific merits of these two new improvements one might ask: given the growth and needs of Internet, is it time to design a new, more scalable and secure protocol to replace BGP?

As usual, control is an important aspect of protocol design for its reliability and performance. “On Designing Self-Tuning Controllers for AQM Routers Supporting TCP Flows Based on Pole Placement” explores the simple pole placement technique in the classical control theory for the controllers for active queue management in Internet protocol (IP) routers to support transmission control protocol (TCP) flows. It proposes two self-tuning controllers with a good active queue management (AQM) performance reacting very quickly to changing system loads. “Leveraging Single Rate Schemes in Multiple Rate Multicast Congestion Control Design” proposes a new approach to multiple rate congestion control for layered multicast sessions, combining the benefits of single rate congestion control with the scalability of multiple rates. Efficient scheduling is another channel for improving network throughput and reliability. With the demand from its increasing applications and wide deployment, “Improving Protocol Capacity for UDP/TCP Traffic with Model-based Frame Scheduling in IEEE 802.11-operated WLANs” develops a model-based frame scheduling scheme to enhance the capacity of IEEE 802.11-operated wireless local area networks (LANs) for both TCP and user datagram protocol (UDP) traffic, while reducing the delay.

Aside from the main stream of activities on routing and control, protocol design has to address the requirements from other network application needs, such as efficient and robust data collection as in “A Coordinated Data Collection Approach: Design, Evaluation, and Comparison,” where the authors propose coordinated data collection of a large amount of data from several different hosts to a single destination in a wide-area network, and also network resource reservation and provisioning as in “A Scalable Model for Interbandwidth Broker Resource Reservation and Provisioning,” where a scalable model for interbandwidth broker resource reservation and provisioning is proposed for reducing admission control time and for coping with scalability problems.

Network protocol design has as a long history as network itself with enormous achievements in engineering and applications. However, there is little scientific foundation of protocol design; it has been mostly an engineering effort. Recently, there is a call for science of design (SoD), appealing for a scientific foundation of system designs: http://www.nsf.gov/pubs/2004/nsf04552/nsf04552.htm. While there is no doubt of its necessity it apparently requires a breakthrough advancement to lay a scientific foundation for protocol design.

No matter how novel and elegant a protocol design is, it cannot provide a desirable network system unless it is verified by a rigorous analysis for its correctness and performance and unless it is tested for conformance and interoperability of its implementation.

“SeSFJava Harness: Service and Assertion Checking for Protocol Implementations” formally verifies and tests the implementation of a network protocol for its conformance to the required services based on an assertion checking. Rather than testing general protocols, “A Framework for Systematic Evaluation of Multicast Congestion Control Protocols” is focused on multicast congestion control protocol testing, based on an

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appropriate model from protocol specifications and correctness conditions, and devises an automated search engine to generate error scenarios for an evaluation. Different than testing for conformance of a protocol to its specification, interoperability testing is on the interfaces of integrated protocol system components. “Interoperability Test Generation and Minimization for Communication Protocols Based on the Multiple Stimuli Principle” presents an automatic test generation and minimization method for testing interoperability of communications protocols, based on a technique of composing finite-state machines, minimizing the number of increased test cases due to the multiple stimuli without jeopardizing transition coverage.

“A Cryptographically Sound Security Proof of the Needham–Schroeder–Lowe Public-Key Protocol” verifies the security property of the well-known Needham–Schroeder–Lowe public-key protocol for entity authentication against arbitrary active attacks if it is implemented using standard provably secure cryptographic primitives. It differs from traditional formal methods based security proofs in that the results are not restricted to properties in terms of an abstract (Dolev–Yao) model, but in fact carry over to the actual cryptographic algorithms used. Moreover, the proof techniques used are well-suited for a machine-assisted formal proof, e.g., using a theorem-prover.

With the advancement of networking technologies, performance analysis remains important for estimating a designed protocol and for improving its performances. “An Improved Packet Collision Analysis for Multi-Bluetooth Piconets Considering Frequency-Hopping Guard Time Effect” analyzes the interference problem of Bluetooth piconet to predict the packet collision effect in a multipiconet environment, taking into account the frequency-hopping guard time effect in Bluetooth baseband. “Performance Analysis of IEEE 802.11e Contention-Based Channel Access” examines another wireless protocol: IEEE 802.11e, for supporting quality-of-service (QoS) in wireless LAN with a study of the performance of enhanced distributed channel access (EDCA) and the fundamental medium access control (MAC).

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