

Computer Networks

Ivan Stanimirović, Ph.D.



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Computer Networks



About the Editor

Ivan Stanimirović, Ph.D.

Ivan Stanimirović gained his PhD from University of Niš, Serbia in 2013. His work spans from multi-objective optimization methods to applications of generalized matrix inverses in areas such as image processing and computer graphics and visualisations. He is currently working as an Assistant professor at Faculty of Sciences and Mathematics at University of Niš on computing generalized matrix inverses and its applications.

List of Contributors

Khalid Kh. Sharaf

Computer Science, Alaqsa University, Gaza, Palestine

AbuBaker Elhussein

Computer Engineering, Africa University, Khartoum, Sudan

Changwang Zhang

School of Computer Science, National University of Defense Technology, Changsha, China
Department of Computer Science, University College London, Gower Street, London WC1E 6BT, United Kingdom

Zhiping Cai

School of Computer Science, National University of Defense Technology, Changsha, China

Weifeng Chen

Department of Math & Computer Science, California University of Pennsylvania, USA

Xiapu Luo

Computing Department, Hong Kong Polytechnic University, China

Jianping Yin

School of Computer Science, National University of Defense Technology, Changsha, China

Chao Zhou

Institute of Computer Science & Technology, Peking University, Beijing 100871, PR China

Xinggong Zhang

Institute of Computer Science & Technology, Peking University, Beijing 100871, PR China

Zongming Guo

Institute of Computer Science & Technology, Peking University, Beijing 100871, PR China

Keerti Tiwari

Department of Electronics and Communication Engineering, Jaypee University of Information Technology, Waknaghat, Solan 173234, India

Davinder S. Saini

Department of Electronics and Communication Engineering, Chandigarh College of Engineering and Technology, Chandigarh 160019, India

Sunil V. Bhooshan

Department of Electronics and Communication Engineering, Jaypee University of Information Technology, Waknaghat, Solan 173234, India

Eduardo da Silva

Department of Informatics, Federal University of Parana (UFPR), 81531970 Curitiba, Brazil
Department of Informatics, Catarinense Federal Institute (IFC), 89245000 Araquari, Brazil

Luiz Carlos Pessoa Albini

Department of Informatics, Federal University of Parana (UFPR), 81531970 Curitiba, Brazil

Niranjana Kumar Ray

Department of Computer Science & Engineering, Silicon Institute of Technology, Bhubaneswar 751024, India

Ashok Kumar Turuk

Department of Computer Science & Engineering, National Institute of Technology, Rourkela 769008, India

Shahrukh Khalid

Telecommunication Engineering, Hamdard University, Sharae Madinat Al-Hikmah, Muhammad Bin Qasim Avenue, Karachi 74600, Pakistan

Athar Mahboob

Khawaja Fareed University of Engineering & Information Technology, Rahim Yar Khan 64200, Pakistan

Choudhry Fahad Azim

Faculty of Engineering Sciences and Technology, Hamdard University, Sharae Madinat Al-Hikmah, Muhammad Bin Qasim Avenue, Karachi 74600, Pakistan

Aqeel Ur Rehman

Department Computer Science, Hamdard University, Sharae Madinat Al-Hikmah, Muhammad Bin Qasim Avenue, Karachi 74600, Pakistan

Shin-ichi Kuribayashi

Department of Computer and Information Science, Seikei University, Japan

Christopher Köhnen

¹City University London, Department of Electrical and Electronic Engineering, London EC1V 0HB, UK

Christian Überall

City University London, Department of Electrical and Electronic Engineering, London EC1V 0HB, UK

Muttukrishnan Rajarajan

City University London, Department of Electrical and Electronic Engineering, London EC1V 0HB, UK

Rudolf Jäger

Department for Information Technology, Electrical Engineering & Mechatronics, Technische Hochschule Mittelhessen-University of Applied Sciences, Wilhelm-Leuschner-Straße 13, 61169 Friedberg, Germany

Veselin Rakočević

City University London, Department of Electrical and Electronic Engineering, London EC1V 0HB, UK

Christian Köbel

Departamento de Telecomunicaciones y Telemática, Instituto Superior Politécnico José Antonio Echeverría ISPJAE, Calle 114, No. 11901, e/Ciclovía y Rotonda, Marianao 19390, La Habana, Cuba

Walter Baluja García

Departamento de Telecomunicaciones y Telemática, Instituto Superior Politécnico José Antonio Echeverría ISPJAE, Calle 114, No. 11901, e/Ciclovía y Rotonda, Marianao 19390, La Habana, Cuba

Joachim Habermann

Department for ICT, Electrical Engineering & Mechatronics, THM University of Applied Sciences, Wilhelm-Leuschner Straße 13, 61169 Friedberg, Germany

Rakesh Matam

Indian Institute of Information Technology, Guwahati, Assam 781001, India

Somanath Tripathy

Indian Institute of Technology Patna, Patna, Bihar 800013, India

Martin Ellis

School of Computing Science, University of Glasgow, Glasgow G12 8QQ, UK

Dimitrios P. Pezaros

School of Computing Science, University of Glasgow, Glasgow G12 8QQ, UK

Theodore Kypraios

School of Mathematical Sciences, University of Nottingham, Nottingham NG7 2RD, UK

Colin Perkins

School of Computing Science, University of Glasgow, Glasgow G12 8QQ, UK

Fan Wang

School of Computer Science and Technology, Dalian University of Technology, Dalian, China

Yan Yang

School of Computer and Information Technology, Liaoning Normal University, Dalian, China

Kunpeng Wang

School of Computer Science and Technology, Dalian University of Technology, Dalian, China

Xiaopeng Hu

School of Computer Science and Technology, Dalian University of Technology, Dalian, China

Ning Zhang

School of Computer Science and Technology, Dalian University of Technology, Dalian, China

Adewale Adeyinka A

Covenant University, Canaanland, Ota, Nigeria

Adagunodo Emmanuel R

Obafemi Awolowo University, Ile-Ife, Nigeria

John Samuel N

Covenant University, Canaanland, Ota, Nigeria

Ndujiuba Charles

Covenant University, Canaanland, Ota, Nigeria

Yu Nakata

Graduate School of Information, Science and Technology, Osaka University, 1-5, Yamadaoka, Suita, Osaka 565-0871, Japan

Shin'ichi Arakawa

Graduate School of Information, Science and Technology, Osaka University, 1-5, Yamadaoka, Suita, Osaka 565-0871, Japan

Masayuki Murata

Graduate School of Information, Science and Technology, Osaka University, 1-5, Yamadaoka, Suita, Osaka 565-0871, Japan

Omar Said

IT/ College of Computers and Information Technology Taif University Taif, Saudi Arabia.

Mehedi Masud

CS/ College of Computers and Information Technology Taif University Taif, Saudi Arabia.

Preface

Computer networks represent a main component of the economy of information. Their appliance spans from WiFi to cellular networks, enabling the foundations of the Web. Some fundamental problems of computer networking, from performing distributed applications to multiple-access and bandwidth allocation, are being investigated. For each problem, various design strategies are developed to assess its performance in practical applications. Many interconnections are considered in computer networking, and various aspects of computer system analysis using queueing network models are illustrated by particular case studies. A number of important modelling techniques are summarized in the algorithmic form, for all main widely-used networking technologies. Network Management is the process of controlling a complex data network so as to maximize its efficiency and productivity. An architecture for dynamic network reconfiguration is presented in the first section of the book, giving the auto reconfiguration using the directory server, which is used to store and maintain configuration information.

The following seven chapters of the book present various techniques to improve Ad hoc networks and appliance of technologies such as Low-rate Distributed Denial-of-Service (LDDoS) and multiple-input and multiple-output (MIMO) technology. The remaining content of this book focuses on the advances of specific methods and algorithms in the field of QoS framework and Internet. The specific advances discussed in this book include the use of ordered successive interference cancellation, new QoS frameworks, as well as the advances in Internet of things.

The recently proposed TCP-targeted LDDoS attacks send fewer packets to attack legitimate flows by exploiting the vulnerability in TCP's congestion control mechanism. Congestion Participation Rate (CPR) metric is presented as well as a CPR-based approach to detect and filter LDDoS attacks by their intention to congest the network. The major innovation of the CPR-base approach is its ability to identify LDDoS flows. The effectiveness of CPR is analysed theoretically by quantifying the average CPR difference between normal TCP flows and LDDoS flows and showing that CPR can differentiate them.

In computer networks systems, multiple-input and multiple-output, (MIMO) technology can be employed because of the enormous benefits it offers. It is the technique of using multiple antennas at the transmitter to propagate signal through multiple propagation paths to multiple antennas at the receiver. This can be used to significantly increase communication performance, measured by data throughput, and link reliability without additional bandwidth or increased transmit power. It achieves this goal by spreading the same total transmit power over the antennas to achieve an array gain that improves the spectral efficiency, channel capacity and link reliability. These benefits are not without setbacks due to mutual coupling of the antennas, correlation of the signals and the degree of matching between the receiver and the load. Some general expressions are formulated showing the impact, on the capacity of the MIMO channel, by both antenna coupling and spatial correlation due to the propagation environment. Due to heterogeneous channel conditions in MIMO wireless networks, it is challenging for video broadcasting to map scalable video layers to proper MIMO transmit antennas to minimize the average overall video transmission distortion. Channel scheduling problem for broadcasting scalable video content over MIMO wireless networks is investigated. An adaptive channel scheduling based unequal error protection (UEP) video broadcasting scheme is proposed. In the scheme, video layers are protected unequally by being mapped to appropriate antennas, and the average overall distortion of all receivers is minimized. This scheme is formulated into a non-linear combinatorial optimization problem.

Ordered successive interference cancellation (OSIC) is adopted with minimum mean square error (MMSE) detection to enhance the multiple-input multiple-output (MIMO) system performance. The optimum detection technique improves the error rate performance but increases system complexity. Therefore, MMSE-OSIC detection is used which reduces error rate compared to traditional MMSE with low complexity. The system performance is analyzed in composite fading environment that includes multipath and shadowing effects known as Weibull-Gamma (WG) fading. Along with the composite fading, a generalized noise that is additive white generalized Gaussian noise (AWGGN) is considered to show the impact of wireless scenario. This noise model includes various forms of noise as special cases such as impulsive, Gamma, Laplacian, Gaussian, and uniform. Consequently, generalized function is used to model noise. The average symbol error probability (ASEP) of MIMO system is computed for 16-quadrature amplitude modulation (16-QAM) using MMSE-OSIC detection in WG fading perturbed by AWGGN.

Multicast is an indispensable communication technique in wireless mesh network (WMN). Many applications in WMN including multicast TV, audio and video conferencing, and multiplayer social gaming use multicast transmission. An algorithm called SEMRAW (SEcure Multicast Routing Algorithm for Wireless mesh network) is developed to be resistant against all known active threats including wormhole attack. SEMRAW employs digital signatures to prevent a malicious node from gaining illegitimate access to the message contents.

802.11-based wireless mesh networks (WMNs) as last mile solutions frequently become bottlenecks in the overall Internet communication structure. The lack of end-to-end capacity on routes also affects vertical traffic coming from or flowing towards external networks, such as the Internet. The presented approach aims to increase the overall network performance by exploiting channel diversity and to additionally favor vertical traffic. To achieve this, first a general system that modifies an existing mesh

node architecture is proposed, in order to prepare a more efficient resource management and to enhance the restricted transmission capacity in standard WMNs. Quality-of-Service parameters were improved, and more efficient use of multiple radios could be reached.

The high increase of bandwidth-intensive applications like high definition video streaming in home and small office environments leads to QoS challenges in hybrid wired/wireless local area networks. These networks are often not QoS aware and may contain bottlenecks in their topology. A novel autonomous system for hybrid QoS in local area networks is investigated, called QoSILAN, which does not rely on network infrastructure support but on host cooperation and works independently of the access technology. Also, a new QoS Signalling Protocol, policing and admission control algorithms are presented, as well as a new lightweight statistical bandwidth prediction algorithm for autonomous resource management in LANs. This new QoS framework enables link based, access-medium independent bandwidth management without network support.

Ad hoc networks lack support of infrastructure and operate in a shared bandwidth wireless environment. Presently, such networks have been realized by various adaptations in Internet Protocol (IP) architecture which was developed for infrastructure oriented hierarchical networks. Ad hoc networks suffer from additional problems like IP address autoconfiguration, service provisioning, efficient bandwidth utilization, and node identification. IDHOCNET is a novel implementation of service provisioning and application development framework in the ad hoc context. Moreover how identifiers can completely replace the IP addresses to run the IP based applications is shown.

Secure Middleware for Ad Hoc Networks (SEMAN), which provides a set of basic and secure services to MANETs is presented, aiming to facilitate the development of distributed, complex, and flexible applications. SEMAN considers the context of applications and organizes nodes into groups, also based on these contexts. The middleware includes three modules: service, processing, and security.

An energy conservation technique, called Location Based Topology Control with Sleep Scheduling for ad hoc networks is developed. It uses the feature of both topology control approach and power management approach. Like the topology control approach, it attempts to reduce the transmission power of a node, which is determined from its neighborhood location information. A node goes to sleep state based on the traffic condition as that of power management approach.

In the Internet, Autonomous Systems exchange traffic through interconnected links. As traffic demand increases, more traffic becomes concentrated on such links. A method to identify the hierarchical nature of traffic aggregation on the Internet topology is developed and used to discuss the long-term changes in traffic flow. A new evolution process that attempts to reduce this traffic concentration is investigated. It increases the number of links in the deeper level in the hierarchy, thus relaxing the traffic concentration.

Internet of things is a promising research due to its importance in many commerce, industry, and education applications. Recently, new applications and research challenges in numerous areas of Internet of things are fired. Different proposed architectures of Internet of things, research challenges and open problems are discussed. The concept of Internet of things database is introduced and it is discussed about the future vision of Internet of things.

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