## Introduction

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**Biographical notes:** Michael R. Bartolacci is a PhD in Industrial Engineering from Lehigh University. He is a Member of the INFORMS Telecommunication Section's Governing Council and specialises in the modelling of wireless networks.

This Special Issue includes select papers from the *14th International Conference on Telecommunication Systems Modelling and Analysis* that was held on at Penn State University in October 2006. These give a diverse range of contributions of contemporary relevance. Also included in this Special Issue are other noteworthy contributions from such top institutions as the Naval Postgraduate School and Southern Methodist University.

In the paper titled 'Neural modelling and analysis of the link occupancy distribution for wireless broadband transmissions', Lokshina et al. address modelling and analysis of the link occupancy distribution for wireless broadband transmission. Multiclass models of a single link transmission for rigid, adaptive and elastic traffic are developed, based on Markov rewards models. The link occupancy distribution is introduced as embedded, discrete time Markov chains researched with the use of vector quantification. Link occupancy performance is simulated as a combination of single queues with random distributions of arrival processes and holding time service phases. The density of occupancy probability is determined using learning vector quantification in a two-layered neural structure.

In the paper titled 'W-CDMA network design', W-CDMA network design problem is modelled as a discrete optimisation problem that maximises revenue net the cost of constructing base stations, mobile telephone switching offices and the backbone network to connect base stations through mobile telephone switching offices to the public switched telephone network. The formulation results in a very large scale integer programming problem with up to 18,000 integer variables and 20,000 constraints. To solve this large-scale integer programming problem. A pair of models are developed, one for the upper bound and one for the lower bound. The upper bound model relaxes integrality on some of the variables while the lower bound model uses a 5% optimality gap to achieve early termination. Additionally, a heuristic procedure is developed that can solve the largest problem instances very quickly with a small optimality gap. To demonstrate the efficiency of the proposed solution methods, problem instances were solved with five candidate mobile switching offices servicing some 11.000 simultaneous cellular phone sessions on a network with up to 160 base stations. In all instances, solutions are guaranteed to be within 5% of optimality were obtained in less than an hour of CPU time.

In the paper titled 'Extending the OSI model for wireless battlefield networks: a design approach to the 8th layer for tactical hyper-nodes', Bordetsky et al. introduce the architecture and functionality of a new 8th layer that extends the well-known 7-layer OSI model to implement adaptive networking by giving every critical node of a C4I network its own specialised Network Operation Centre (NOC) capability. Emerging networkcentric concepts such as FORCEnet and ubiquitous networking services such as the Global Information Grid will need to incorporate self-organising network clusters including semi-autonomous sensors, unmanned vehicles and human decision-makers. In these predominantly mesh networking architectures the behaviour of every node, its capability to form or to heal the network, depends on the node's awareness about networking status and capabilities of its neighbours. This trend towards meshing of more capable nodes will eventually evolve into a qualitatively new architecture, in which every significant node also acts as a small-scale NOC. It is illustrated that this trend by observations of recent SOCOM-NPS Tactical Network Topology experiments. The authors show how this can be thought of as the 8th level of the OSI stack, where the new layer adds intelligent adaptive self-control. The new layer requires a new protocol, which would include a new type of message, its semantics and syntax, as well as a new type of interpreter describing the behaviour of the 8th layer state machine.

The 8th layer interpreter must exhibit empirical adaptivity, improving with experience. It achieves goal-seeking behaviour by choosing how to satisfy or modify Service Level Agreement (SLA) constraints; it achieves sensing by way of polling higher-level SNMP MIB data describing overall NOC status; and it captures experience through a memory mechanism for learned network management actions. Bordetsky et al. call these intelligent modular subnetworks that adapt their behaviour and organisation through incorporation of this 8th layer *hyper-nodes*. The authors believe hyper-nodes are a fundamental building block of the kinds of open, extensible mesh networks required in

many military operations. A network of hyper-nodes is scalable, adaptive and robust, thus a required kind of infrastructure for enabling extensible growth and information.

In the paper titled 'A statistical viewpoint on the use of GPS information in wireless ad-hoc protocols', Guardiola et al. consider the impact of fast fading effects on the discovery and maintenance of routes in a mobile ad hoc network. The authors provide a statistical interpretation of link quality based on the instantaneously received power under a multipath fading model, for which associated types 1 and 2 errors are defined. Based on this viewpoint, we propose embedding GPS information into the AODV protocol to block the discovery of routes with unreliable links, and thereby enhance end-to-end performance of the system.

The paper titled 'An energy-efficient heterogeneous dual routing scheme for mobile ad hoc and sensor networks' by Dhar et al. introduces a new energy-efficient routing algorithm based on a generalisation of the k-SPR sets from earlier work by the authors. This generalisation provides a means for the automatic avoidance of certain nodes and links when messages are routed. Sensor networks are modelled as connected graphs with vertex costs and edge costs. These costs indicate the extent to which corresponding nodes and links should be avoided. The node costs depend inversely on the strengths of the batteries. Avoiding nodes with weak batteries tends to extend the lifetime of the network as a whole. In addition, the authors present a two-tiered routing system. The low level routing is used for local routing within k-hops, and is essentially (local) link-state routing. The high level routing depends on the 'routers' from a k-SPR set, in order to manage the global routing.

In the paper titled 'Dynamic structured routing in mobile networks', Peltsverger et al. describe dynamic structured routing schema for mobile users in a hostile, noisy environment. The suggested approach is based on the election of a head node for each cluster. The structured routing approach assumes that only some nodes are allowed to communicate with a base station or another cluster head. A cluster head is elected for each cluster

to maintain cluster membership information and the most up-to-date routing table. It is difficult to maintain a structured routing especially for large ad hoc networks due to dynamically changing configuration of the MANET. The paper describes a new approach to the cluster head election. The proposed method is based on the election of a head node for a cluster depending on the status of nodes and the cluster itself. The goal is to predict a location of the cluster head based on a guaranteed estimation of mobile users' current locations. Guaranteed estimation, known as bounded-error estimation, allows also construction of the information set of state or parameter vectors that are compatible with the measured data for dynamic systems with unknown, but bounded errors and system inputs. The new approach is based on polygonal approximations of systems' information sets.

A further contribution (Dressler et al.) comes from an extended paper presented at the 40th Hawaii International Conference on Systems Science, in the mini-track on Wireless Sensor Networks and Applications, co-chaired and co-organised by Dr. Edoardo Biagioni, University of Hawaii. The paper, titled 'Dynamic address allocation self-organized management and control for in sensor networks" has a data-centric approach. Several data-centric communication paradigms have been proposed in the domain of Wireless Sensor Networks (WSN). Therefore, the principles of operation and maintenance in such networks are changing in order to control massively distributed systems. Previous addressing schemes fail or produce too much overhead even if only locally unique addresses of sensor nodes are required. In this paper, Dressler et al. present a dynamic address allocation scheme for localised address assignments in WSN. A round-robin address assignment approach is developed with subsequent duplicate address detection that operates in a self-organised manner. It inherently allows busy-sleep periods and does not assume always awake nodes. In order to verify the approach, the authors implement the algorithm on Mica2 sensor motes and test it in a WSN maintenance scenario. The results demonstrate that our method works well for operation and maintenance of WSN without prior address assignments.