

EDITORIAL

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The rapid advances in telecommunications networks and technologies, as well as their applications, have given rise to a massive number of design and optimisation problems which are difficult to be solved by traditional methods. The newly emerging field of nature-inspired computational heuristics are an appealing alternative, as it has provided very good results to tackling these problems. Observing the great need for an in-depth investigation of these approaches to the design of high-quality and cost-effective telecommunications networks, this special issue of the *International Journal of Computational Intelligence and Applications (IJCIA)* is devoted to the application of nature-inspired approaches to telecommunications and networking problems. It aims at providing both scientists and engineers a new perspective into the design and optimisation of telecommunications networks and a promising area for the application of computational intelligent techniques.

This special issue received 21 submissions from all over the world. All papers went through strict peer reviews in order to ensure originality, technical correctness, significance, and relevance to this issue. Although most of them were of high quality, many of them could not be included in this issue due to space constraints. In the end, only nine papers that best fit the theme were selected. These papers encompass a variety of topics that focus on the use of nature-inspired approaches to such areas as routing, multicast and multiuser, traffic engineering, physical topology optimisation, etc., in wired networks, wireless networks, ad-hoc networks, and WDM optical networks. A brief summary of each paper classified according to topic is provided below.

1. Routing in Telecommunications Networks

Routing is probably the most important topic in telecommunications networks. A very competitive nature-inspired approach to this problem is the ant colony algorithm and other similar ones. In this special issue three papers cover different aspects of this subject.

In ‘A novel mechanism based on artificial logical spider web for rerouting in MPLS networks’, Yang and Shi present an interesting and novel approach based on artificial spiders to the rerouting problem in MPLS networks, aiming to deliver reliable services. An artificial logical spider web is defined, constructed, modelled, built and maintained in the MPLS network to dynamically explore recovery paths in the rerouting area. A novel rerouting algorithm, the DDRAAS, is proposed and implemented to calculate and establish recovery paths when faults occur. Simulation results show that this algorithm is efficient in reducing packet loss and disorder, and runs faster than existing ones, which helps to minimise the effects of link failure and/or congestion.

In ‘QColony: A multi-pheromone best-fit QoS routing algorithm as an alternative to shortest-path routing algorithms’, a real-time routing algorithm known as QColony, based on the ant colony algorithm for QoS routing in packet-switched communications networks, is proposed by Tadrus and Li. A new breed of ants, the soldier ants, and a new routing table structure, the multi-pheromone tables, are introduced in this paper to integrate the best-fit path-selection scheme in QoS routing. Compared to other routing algorithms, QColony exhibits good routing performance despite heavy traffic, unusual circumstances, and other unreported errors.

Another algorithm based on ant colony optimisation for routing in mobile ad-hoc networks, the AntHocNet, is proposed by Ducatelle *et al.* in the paper ‘Using ant agents to combine reactive and proactive strategies for routing in mobile ad-hoc networks’. To combine the reactive path finding and repairing with proactive path maintenance and improvement, the authors utilise the reactive forward ants to find the destination of a session and the proactive forward ants to search for new and better paths. Simulation results show that the AntHocNet algorithm outperforms AODV in terms of delivery ratio, average delay and jitter, and scales better with the increase of the number of nodes in the networks.

2. Multicast and Multiuser Systems

Multicasting has been an intensive research topic for both wired and wireless networks. It allows a message to be simultaneously transmitted to selected multiple recipients. Due to frequent topology changes, limited network resources and transmission errors, multicasting in a mobile ad-hoc network (MANET) environment faces more challenges than in wired networks. In ‘An ant-based multicasting protocol in mobile ad-hoc networks’, a new multicast routing protocol, the RISP

(receiver-initiated soft-state probabilistic multicasting protocol), is proposed by Zhang *et al.* for MANETs based on an ant colony's route-seeking mechanism. In this protocol, the authors introduce probabilistic forwarding and the soft-state for making relay decisions that are automatically adaptive to node mobility in MANETs. The effectiveness of the proposed scheme in reducing delivery redundancy, control overheads, and the average delay of all data packets and in improving delivery ratio, is demonstrated through comparison with other multicast routing protocols.

Multiuser detection (MUD) is another topic in this category which is important in CDMA systems since each user shares the same frequency band and time interval. In order to support multimedia communications in the future, a high-performance CDMA receiver with high data-rate transmission in high-mobility environments is desired. In 'Novel low-complexity ant colony based multiuser detector for direct sequence code division multiple access', Hijazi and Natarajan present a DS-CDMA multiuser detector based on ant colony optimisation. In their algorithm, every ant builds a solution vector in each iteration. Pheromones are then deposited and evaporated based on the path traversed by the ants. The final solution is the trail with the highest pheromone concentration. Simulation results show that the proposed algorithm is able to achieve the optimal bit-error rate with lower complexity than an exhaustive search and a GA-based method.

3. Traffic Engineering

Traffic engineering (TE) is the process to control traffic flows in the network in order to optimise resource use and network performance. There are two major performance objectives in TE: the traffic-oriented, which includes minimisation of the number of packets lost, maximisation of network throughput, and QoS-related issues; and the resource-oriented, which deals with the efficient use of network resources. This subject includes two papers which deal with the distribution of the interdomain traffic in the internet and traffic grooming in WDM optical networks, respectively.

In 'A multiple objectives evolutionary perspective to interdomain traffic engineering', Ullig first shows that the interdomain traffic engineering problem is intrinsically a multiple-objectives one where different objectives often conflict with each other. He then presents a multiobjective evolutionary approach to optimising the distribution of the interdomain traffic in the internet. Two instances of the problem with different objectives, viz. the daily volume-based billing and the daily percentile-based billing versus the short-term traffic balancing, the long-term versus the short-term traffic balancing, and the outbound traffic balancing versus IGP cost, are discussed and compared in this paper.

In 'Metaheuristic approaches to traffic grooming in WDM optical networks', Xu *et al.* present a comprehensive, thorough, and up-to-date review of the metaheuristic approaches to the grooming of both static and dynamic traffic in WDM optical networks. The pros and cons of each metaheuristic approach in solving the

traffic grooming problems are analysed in detail. Future directions concerning the application of the metaheuristic approach in designing algorithms directly operating on traffic matrices, in the grooming of traffic in mesh and other topology networks, in the grooming of dynamic traffic, and in traffic grooming with QoS considerations, are also discussed in this paper.

4. Physical Topology Optimisation

Physical topology optimisation has always been a big issue in the design of modern telecommunications networks. The purpose of design is to minimise the total cost and to maximise reliability. Two papers are included in this subject.

In ‘Reliable communication network design with evolutionary algorithms’, Reichelt and Rothlauf explore the use of evolutionary algorithms for the design of reliable communications networks. Two new evolutionary approaches, the LaBOR-Net and the BaBORNet, are presented in this paper to solve this problem. Both approaches use repair strategies to ensure that the all-terminal reliability of the resulting network is higher than the predefined threshold. Simulation shows that the new approaches significantly outperform the existing EA approaches that use penalties for infeasible solutions.

In ‘A genetic algorithm for the design of minimum-cost two-connected networks with bounded rings’, Ventresca and Ombuki address the problem of designing two-connected networks with bounded rings with an improved GA approach such that the shortest cycle to which each edge belongs to does not exceed a given length. A flexible and simple crossover operator is introduced to ensure that all the solutions are feasible. Comparisons of the cost lengths with GA and other approaches, including branch and bound, the stingy approach, and tabu search approach, are made extensively. Simulations show that the proposed GA approach achieves better results than others in most of the cases.

We hope that the collaborative endeavour of the authors, the reviewers, and the editors in this special issue will serve the researchers in both telecommunications and nature-inspired computation communities well from the interesting research work provided in this issue. We also hope that these selected papers will inspire researchers in the area to disseminate their innovative research ideas in their future research work and help to draw more attention to these promising areas.

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