Talk Abstracts
Algorithmic and combinatorial methods on discrete structures

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<u>KEYNOTE 1</u>. 5G Networks: Planning, Design and Optimization

Brigitte Jaumard, Concordia University, Canada

We will first give an overview of some of the key challenges of 5G networks, in terms of planning, design or optimization problems. We will next present different optimization methods (large-scale optimization, nested decomposition, graph algorithms) and algorithms for solving those problems, covering issues ranging from network provisioning to network defragmentation and to how Machine Learning and Big Data Analytics can be used in network design optimization and proactive failure detection.

<u>KEYNOTE 2</u>. A generalization of a descent set reversing bijection from permutations to words and some consequences

Vincent Vajnovszki, Université de Bourbogne

For a length n permutation π, $\mathsf{Des}\,\pi$ (respectively, $\mathsf{Desrc}\,\pi$) denotes the descent set of π (respectively, the set $\{n - i \,|\, i \in \mathsf{Des}\,\pi\}$, i.e, the descent set of the reverse-complement of π), and $\mathsf{Ides}\,\pi$ denotes the descent set of π^{-1}; and Des, Desrc and Ides become set valued statistics. In 1976 Foata and Schützenberger showed that the bistatistics $(\mathsf{Des}, \mathsf{Ides})$ and $(\mathsf{Desrc}, \mathsf{Ides})$ have the same distribution on the set of same-length permutations. Extending Ides to words we show that $(\mathsf{Des}, \mathsf{Ides})$ and $(\mathsf{Desrc}, \mathsf{Ides})$ have the same distribution on the set of *rearrangements of the symbols of a word*.

As a consequence, we show the joint equidistribution on the rearrangements of the symbols of a word of stat, maj and Ides, and of maj, stat and Ides, together

with other statistics; here maj is the celebrated major index statistic, and stat is the generalization given by Kitaev and the present author (2016) of a Mahonian statistic which is defined originally on permutations in terms of vincular patterns by Babson and Steingrímsson (2000). This equidistribution is a generalization from permutations to words of a result of Burnstein (2010), and on which our construction is also based, and it refines a result stated in the above mentioned 2016 paper.

TALK 1. Efficient Make Before Break Capacity Defragmentation

Duong Quang Huy, Concordia University, Canada

The focus of this paper is on Layer 2, *i.e.*, on capacity defragmentation at the optical transport network (OTN) layer when routes (e.g., LSPs in MPLS networks) are making unnecessarily long detours to evade congestion. Reconfiguration into optimized routes can be achieved by re-defining the routes, one at a time, so that they use the vacant resources generated by the disappearance of services using part of a path that transits the congested section. For the Quality of Service, it is desirable to operate under Make Before Break (MBB) paradigm, with the minimum number of rerouting. The challenge is to determine the best rerouting order while minimizing the bandwidth requirement.

There are two strategies are applying under MBB paradigm. The first strategy is comprised of two phases, i) the first phase computes the optimal provisioning of the current demands, ii) while the second phase offers the reconfiguration order to transform the current network as close as possible to the optimal provisioning. With more efficient, the second strategy offers the exact rerouting order by which we achieve the best configuration under MBB condition.

We propose exact and scalable optimization models for these strategies . Numerical results show that we can successfully apply it on networks with up to 30 nodes, a very significant improvement with respect to the state of the art. We also provide some defragmentation analysis in terms of the bandwidth requirement vs. the number of reroutings.

TALK 2. Optimization of Free Space Optical Network

Truong Thi Dieu Linh, Hanoi University of Science and Technology

Free-space optics (FSO) refers to an optical communication technology that transmits data using a laser beam in free space between a pair of transceivers. FSO transceivers are now widely available in the market, and an FSO link can be set up quickly in several minutes to hours. In contrast to the fiber-optic

networks, FSO net- works can be deployed without having to lay out physical cable. Therefore, FSO networks are a promising candidate for densely populated urban areas, where the deployment of fiber optic infrastructure is impractical due to high costs or difficulty of physical deployment. In the recent research, we design and optimize free- space optics (FSO) mesh networks.

TALK 3. Towards a Smart SDN-based CDN architecture

Tran Hai Anh, Hanoi University of Science and Technology

A Content Delivery Network (CDN) is able to handle high traffic and offer reliable services by geographically bringing content data to the edge network, where replica servers are installed closer to end-users. Traditional CDN architecture lacks a global view of the whole network and thus cannot dynamically and optimally perform the server selection task. In this work, we propose to integrate Software Defined Network (SDN) into CDN architecture. Our intuitive motivation is to decouple the control plane from the forwarding plane in order to offer flexibility and programmability in using the centralized controller. This work also develops a novel server selection algorithm that is based on the so-called Multi-armed Bandit problem.

TALK 4. Online Load Balancing for Network Functions Virtualization

Pham Tuan Minh, Ngo Hong Son, Phenikaa University

Network service providers have to cope with the growing on-demand need from end-users as well as the diversity of usage. The softwarization and cloudication of the network components offer an interesting solution to achieve the agility necessary to dynamically match the requirement with the level of resource consumption. This materializes with the deployment of Network Functions Virtualization (NFV) where Virtual Network Functions (VNFs) may be chained together to create network services. This talk explores important design and architectural issues related to this approach. We first discuss several NFV-based network use cases, and then list key questions to answer in optimizing the performance of NFV services. Then we analyze and solve the load balancing problem using multipath routing in NFV to optimize network performance in response to the dynamic changes of user demands. We formalize the problem in a comprehensive manner taking into account a broad set of relevant parameters. The static (offline) and dynamic (online) cases are considered. The experiment results on real-world datasets show that our solutions performs very well for for

distributing traffic of each service demand across multipaths without knowledge of future demands, especially under high-load conditions.

TALK 5.   Combinatorial optimization in transportation and logistics: practical challenges

Pham Quang Dung, Hanoi University of Science and Technology
Nguyen Van Son, Academy of Cryptography Techniques

Transportations and logistics plays an important role in the industry. Solving combinatorial optimization problems in this field can help to reduce operation cost, thus bring value to our real-life. This is still an active research topic. In this presentation, we describe some combinatorial optimization problems in the context of Vietnamese logistics and discuss its complexity compared to existing research problems in the fields.

TALK 6.   To minimize energy consumption in heterogeneous wireless communication

Nguyen Duc Toan, Hanoi University of Science and Technology

In the next generation of wireless networks such as the fifth generation (5G), different radio access technologies (RATs) will be integrated into each mobile device as a fundamental feature, aiming to connect any person using any device at anytime, anywhere. To allow the users to enjoy the ubiquitous connectivity, RATs are generally activated simultaneously. Therefore, the mobile device must consume higher energy for the simultaneous activation of multiple wireless interfaces as well as the continuous connectivity. Although RATs co-exist in the same environment, they are designed heterogeneously. The technologies that offer high data rate are generally energy-consuming ones while low-energy technologies commonly provide low data rate. When the services run on the device do not always require high data rate, it is not an energy efficient way to keep using high-speed technology. In this work, the continuity of real time services as well as energy saving for mobile devices has been considered. Experimental and simulation results have confirmed that proposed method saves energy for the wireless communication with a small number of packet loss.

TALK 7. Some enumeration problems on pattern avoiding permutations and on words

Tran Thi Thu Huong, Vietnamese-German University

This talk is to discuss on open problems relating to known statistics on the set of permutations like Inverse, major, bak, etc. We would like to generalize concepts of these statistics, and their properties to the set of permutations avoiding a pattern set and to the set of words. Combinatorial bijections which preserve given statistics are our priority in this discussion.

TALK 8. Gray Code order relation and exhaustive generation for bounded restricted growth functions

Ahmad Sabri, Gunadarma University

A Gray code for a combinatorial class is a method for listing the objects in the class so that successive objects differ in some prespecified, small way, typically expressed as a bounded Hamming distance. In our previous work, we showed that the m-ary Reflected Gray Code Order yields a Gray code for the set of restricted growth functions. Here we investigate variations of this order relation and give the first Gray codes and efficient generating algorithms for bounded restricted growth functions. Further we show that RGC order also induces a Gray code for 1212-avoiding restricted growth functions and give an efficient generating algorithm for this class.

TALK 9. Generation of Gray Codes for Some Pattern-Avoiding Permutations Using Combinatorial Isomorphisms Techniques

Asep Juarna, Gunadarma University

In 1985, R. Simion and F.W. Schmidt established, among others, a constructive bijection between two classes of combinatorial objects, namely Fibonacci strings of length (n-1) and permutations of length n that avoid three patterns of length three. In this paper we extend the Simion-Schmidt bijection such that we establish five new bijections, each of them between certain class of binary strings of length (n-1) and certain pattern-avoiding permutations of length n. Furthermore, we show that each of the five bijection is combinatorial isomorphism, i.e. closeness-preserving bijections, by which we establish Gray codes for the corresponded classes of permutations; three of the codes are optimal: two successive permutations differ in two adjacent positions, and for the last two the number of positions where two successive permutations are differ are bounded by 4 and by min(n; (p-1)), respectively, where (p-1) is the order of Fibonacci class. The context of this paper is in the field of pattern-avoiding permutations studied from the combinatorial point of view. Our contribution is two-fold.

Firstly, we extend the most important problem in the field – the enumeration problem – to the corresponding generation problem. Secondly, we introduce the concept of combinatorial isomorphism, which is a closeness-preserving bijection, and apply it for obtaining the five Gray codes.

Keywords: pattern-avoiding permutations, combinatorial class, cardinality, Wilf class, bijection, enumeration, Gray code.

TALK 10. Some recent algorithms on special graphs

Do Phan Thuan, Pham Ba Thai, Than Viet Cuong, Hanoi University of Science and Technology

Many optimization problems such as Maximum Independent Set, Maximum Matching, Maximum Clique, Minimum Clique Cover and Maximum Induced Matching are NP-hard on general graphs. However they could be P when restricted on some special graph classes such as perfect graphs, comparability graphs and co-comparability graphs. In this talk, we will introduce these graph problems and their optimized algorithms on co-compatibility classes, especially on interval graphs, permutation graphs and trapezoid graphs.

TALK 11. Hurwitz numbers, counting maps and constellations

Nguyen Viet Anh, Hanoi University of Science and Technology

Among many equivalent definitions, Hurwitz numbers count maps embedded in Riemann surfaces and tuples of permutations satisfying certain natural conditions. Surprisingly, they are also connected to seemingly unrelated subjects which are very important in contemporary mathematics such that enumerative algebraic geometry, integrable equations and the recently discovered topological recursion. I will describe some results and open problems, in particular concerning the fact that their generating functions satisfy a host of surprising equations which arised in mathematical physics.