5G Monitor[1] : Hungary

***Vilmos Németh**, March 2015*

MTA-BME Future Internet Research Group

Budapest University of Technology and Economics

The current state in the evolution of Internet is the "wireless Internet" in which Internet access has become available for anybody, anywhere at any time through mobile devices. As a direct consequence, if the network operators win the trust of costumers by running the Internet without any degradation or interruption in their services, the era of the Internet as "critical infrastructure for society" will begin.

Based on this vision, the goal of our research group is to seek high impact, short- and long-term solutions in access and backbone networks providing the next level of reliability with which the Internet will become an ever-operating fast communication system for the whole society. While this concept conflicts with the current industrial trends where high reliability and large bandwidth are associated with premium services, our mission is to push the research community and operators in this direction by scientific publications, prototype demonstrations and patents.

The group was established in 2012 by János Tapolcai as part of the Momentum Program (LENDÜLET) by the Hungarian Academy of Sciences (MTA), at the Department of Telecommunications and Media Informatics of the Budapest University of Technology and Economics (BME). Our main focus is on the following research topics:

- Packet processing: compressing routing tables without compromising look-up and update performance.
- Survivable optical network design: ultra-fast localization of failures in optical networks and network coding in backbone networks.
- Internet routing: reliable and scalable network design for IP Fast Reroute, for multicast addressing, and for compressible, non-traditional routing policies.
- Software defined networking: data center architecture prototyping with network function virtualization.

Following the Internet of Things vision the number of mobile and wireless devices will increase by one or even two orders of magnitude from today's numbers reaching 500 billion devices by 2020, resulting in a dramatic bandwidth request for the overall communication system. Furthermore 5G is on the horizon introducing the tactile Internet which imposes massive requirements also on security, safety, resilience, throughput, and delay. Software defined networking and virtualization can be a promising

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way to cope with upcoming issues as these technologies enable flexible and automated deployment of service chains containing also software middle-boxes or Virtualized Network Functions.

The group has been involved in **UNIFY** (FP7) [http://www.fp7-unify.eu], a European-funded project that focuses on the issue of unifying cloud and carrier networks in a common framework. The framework supports automated, flexible service creation based on a dynamic fine-granular service chaining model leveraging cloud virtualization techniques and software defined networking, focusing on programmability and orchestration.

In order to fulfill the above demands a revolutionary change to code centric networks is needed: suitable routers will perform compute and forward using random linear network coding. This enables efficient multi path communication over channels with loss while providing inherent algebraic security as hackers would need to tap all involved communication systems. The use of network coding is also enabling another important feature which is a dynamic allocation of distributed clouds on top of each router, placing the cloud in close proximity of the user, which enables low latencies for the tactile Internet.

The group is also involved in **GN3Plus Open Call Minerva** (FP7) [http://www.geant.net/opencall/SDN/Pages/MINERVA.aspx], in which our goal was to minimize the number of network coding nodes, as well as the complexity of the coding operations which have to be performed to provide capacity-efficient protection with instantaneous recovery. The benefits of the resulting resilient network architecture were demonstrated on two application scenarios, namely distributed storage, e.g., XoR codes and single storage node failures, and video streaming.

Finally, the group is part of a consortium that successfully proposed 5GEx (H2020). The **5G Exchange (5GEx)** project aims to bootstrap a systematic collaboration among telecommunications operators regarding 5G infrastructure services. Ideally, a customer would expect a one-stop shop, where such services could be purchased from a single operator, who would in turn sub-contract other operators if it lacks the necessary footprint, capacity or other capabilities to provide the entire service. Such services and associated resources will play a crucial role in making 5G happen as they provide the foundation of all cloud and networking services apart from the radio interface itself. The 5G Exchange will enable operators to buy, sell, and integrate infrastructure services, enabling one-stop shopping for their customers. It will provide the ability to automatically trade resources, verify requested services, and it will lead to clear billing and charging. The MTA-BME Future Internet Research Group will contribute to both the economic (business framework, subcontracting, SLAs) and technical aspects (architecture design, implementation, integration and testing) of 5GEx.

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In the beginning of his carrier he worked as a physicist in a research institute of the MTA. Then he dealt with science policy affairs and managed innovation programmes of the public sector. Later he was employed in a leading telecom company as an innovation manager. Then he headed the ICT technology transfer centre of ELTE and BME. He is the member of the EU's Future Internet Forum, and he works for the National Innovation Office as a counsellor responsible for the activities related to the Future Internet.

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The ceFIMS-CONNECT Monitor is an ongoing tool for Member States and Associated Countries to publish and share their national best practices, success stories and developments in the area of Future Internet and 5G, as well for European initiatives to share their news with national stakeholders, on a regular basis.

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