Anticipatory Networking Techniques in 5G and Beyond

Reporting

Project Information

ACT5G

Grant agreement ID: 643002

Funded under
H2020-EU.1.3.1.

Project website

Overall budget
€ 1 043 441,28

EU contribution
€ 1 043 441,28

Start date
1 May 2015

End date
31 August 2019

Coordinated by
LINKOPINGS UNIVERSITET
Sweden

Periodic Reporting for period 2 - ACT5G (Anticipatory Networking Techniques in 5G and Beyond)

Reporting period: 2017-05-01 to 2019-08-31

Summary of the context and overall objectives of the project

The ever-growing demand on broadband mobile data calls for substantial capacity and performance improvement in the fifth generation (5G) networks. This evolution has huge impact on society, as virtually all of us are witnessing the importance of the availability of mobile high-speed Internet. Technological advancement in wireless communication systems and networks is also the enabler of the recent development smart cities.

The research and development for 5G have to address a number of challenges. Anticipation is a
promising approach that equips the network with intelligence to be able to predict events and performance, and thereby enable the optimization of resource usage and sharing of infrastructure that dynamically responds to the changes in the data demand, service requirements, and channel conditions.

The Horizon 2020 MSCA EID project ACT5G has the overall objective of developing models, methods, concepts, and algorithms for network anticipation and network reaction for 5G systems, to significantly improve the service quality as well as deployment cost in comparison to current networks. The project aims to

- investigate analytic methods to effectively and efficiently leverage the network data for performance evaluation, addressing the trade-off of accuracy versus complexity;
- develop prediction methods to assess network performance for a range of indicators, such as coverage, link status, interference, load, and user rate at various timescales;
- optimize resource management focusing on heterogeneity in access technology, cell size, and system level specifications, interference management;
- introduce comprehensive business and infrastructure/resource sharing models across operators, with guarantees for security and transparency to the end users.

The research topics of the project are addressed via advanced methods of machine learning, artificial intelligence, and mathematical modeling and optimization.

The ACT5G project also aims at training of early-stage researchers and promoting their career development in Information and Communication technologies (ICT), and hereby to foster human capital for the European Research Area.

Work performed from the beginning of the project to the end of the period covered by the report and main results achieved so far

The project has two technical work packages (WPs).

- WP 1: Network anticipation
- WP 2: Reaction techniques

The following progress has been made for WP 1:

- Literature survey of learning approaches for communications networks and mmWave systems.
- A study of anomaly detection for virtual network functions (VNFs), consisting of detecting critical nodes in the system in terms of network traffic and topology and cross domain network anticipation. In both cases, we had access to data gathered every minute from a Nokia testbed.
- The use of transfer learning as an anticipating tool for tilt-dependent radio map predictions, and channel quality and traffic predictions.
- Modeling and analysis of the throughput of a relay-assisted mmWave wireless network, taking into account the beamforming delay.
- Optimization methods for link scheduling in mmWave systems, and an application of learning using random forest classifier for predicting efficient scheduling of mmWave links with multi-connectivity.

The following progress has been made for WP 2:

- A literature survey of resource allocation aspects for a number of 5G-oriented transmission techniques (such as MIMO, mmWave, and flexible frame structure) and schemes for sharing of resource and infrastructure among network operators.
- Mathematical modeling, analysis, and solution approaches for scheduling with scalable transmission time interval (TTI), addressing scenarios with mixed types of service requirements (including deadlines), and a comparative study of the performance of scalable TTI and numerology in 5G for service differentiation.
- An end-to-end performance analysis of 1) VNFs from the network edge to the core, with a queueing model for the performance analysis of the system consisting of both processing and transmission flows, and 2) service chaining in a virtualized network.
- Proposal of a techno-economic model that enables dynamic short-term resource sharing as well as resource pricing, while simultaneously collecting revenue for network expansion; the proposed framework allows operators to meet their individual utility targets while optimizing their expenditures based on their respective budgets.
- Models and performance evaluation for network sharing accounting also for prediction errors.

The research outcome has been disseminated via a significant number of publications and presentations within the scientific community. The results are contributing to the evolution of 5G systems via the industrial partner.

Main conclusions of the project are: 1) combining anticipation and reaction technique is an important line of research and development for 5G, and 2) the Horizon 2020 MSCA ITN-EID scheme is effective in promoting knowledge and career development of young researchers.

Progress beyond the state of the art and expected potential impact (including the socio-economic impact and the wider societal implications of the project so far)

Wireless broadband communication is a driver for economic growth, social cohesion/inclusion, and for the improvement of welfare and well-being. The ACT5G project advocates the introduction of anticipation techniques in future mobile radio networks to boost their performance and reachability. The core concept of anticipatory networking is that, nowadays, tools exist to make reliable prediction about network status and performance. Moreover, information availability is increasing as human behavior is becoming more socially and digitally interconnected. In addition, data centers are available to provide services and tools to analyze huge amount of data.

The recent development in 5G evolution has confirmed anticipation as an enabling tool for approaching the service targets in 5G and beyond. Hence the scope of ACT5G is timely in terms of research as well as knowledge development.
As a consequence, not only can researchers tailor their solutions to specific places and users, but also they can anticipate the sequence of locations a user is going to visit or to forecast whether connectivity might be worsening, and to exploit the forecast information to take action before the event happens. This enables the possibility to take full advantage of prediction techniques. The ACT5G Early Stage Researchers are all tackling specific cutting-edge research challenges to make network anticipation effective and concretely applicable, with potential impact in several dimensions:

- Advanced Doctoral training approaches: The ACT5G training pattern tightly couples academic and industrial approaches to knowledge acquisition. We posit that the training approach used in ACT5G can constitute a good practice which can be exported to other research fields and educational institutions. Impacted entities: early stage researchers, educational institutions.

- Advancing the state of the art with tangible and concrete proposals: The ACT5G ESRs are highly committed to top-level research on 5G networks with a medium-short time to market, enabled by the presence in the consortium by one of the big players in the 5G arena.

- Creation of market opportunities: One of the ACT5G ESRs, namely ESR 4, is working on infrastructure sharing for future generation networks, to assess a brand new business approach to the ownership and management of 5G; the advocated approach decouples the ownership and the use of the network infrastructure, thus opening up to a new era of more flexible and agile mobile network operators.
Last update: 11 March 2020
Record number: 203542