EIT Digital – Industrial PhD position proposal

PhD thesis information

PhD Thesis – Title		Novel techniques for modeling, programming and provisioning network services
PhD Thesis – Short summary	Max 100 words	Future network services and applications envisioned in 5G pose serious challenges on the underlying networks and clouds. The recent paradigm shift in networking driven by SDN, NFV, and the evolution of cloud technologies enable a novel way of service creation, development and provisioning. However, several essential components are still missing. This thesis aims to propose novel application models and techniques, fostering service development and providing portability across cloud platforms, together with the orchestration methods responsible for deploying the service components on-the-fly even in multi-provider environments. By these means, emerging services with strict SLA requirements can be provisioned in cloud/edge environments.
Rationale/challenge – *describe the problem and why it is relevant*	Max 200 words	Future networked systems, encompassing cloud and fog infrastructures, IoT devices and wired/wireless networks connecting them, and envisioned 5G applications, such as remote surgery based on Tactile Internet or Industry 4.0 use-cases, pose serious challenges on the operators. A diverse set of cloud and network resources owned by cooperating or competing providers should be orchestrated by the means of technical and business level interactions. Current cloud platforms accelerate the development of new services and SW vendors are outsourcing application functionality, such as resiliency or scalability, into cloud platforms, however, in most cases this approach results in cloud provider lock-in. Technical building blocks are provided by Network Function Virtualization (NFV) and Software Defined Networking (SDN) in collaboration with evolved cloud platforms. However, creating and provisioning services spanning across multiple technology and administrative domains is not a trivial task, and several novel methods are needed. Moreover, today's Software as a Service solutions do not take the networking related requirements (e.g., latency, bandwidth) into consideration which can be crucial in MTC (Machine Type Communications) applications. Therefore, a novel way of service description is essential in order to enable flexible service creation and on-demand deployment together with the resources orchestration mechanisms considering strict SLA requirements.
Innovation – *describe what is the intended solution and the advance w.r.t. the state-of-the-art*	Max 250 words	The goal of the thesis is to provide enhanced and generally applicable solutions for service development, creation and orchestration exploiting emerging networking and cloud technologies and concepts, such as SDN, NFV, IaaS (Infrastructure as a Service), and FaaS (Function as a Service). To provide solutions for multi-operator scenarios is also an important part of the research work. More exactly, the inter-operation among

		different compute- and network virtualization technologies needs technology-agnostic service and resource models which can be the glue between the main components of the new integrated system. Different cloud platforms can be connected to the system via dedicated adapters mitigating the problem of cloud provider lock-in. In this thesis, we address the service and orchestration layers of the architecture. The main goals are the following: • Propose novel service/application models including network-related requirements such as latency, bandwidth, end-to-end path characteristics (e.g. redundancy), and supporting composition of 3rd party and own software modules • Implement software components which can foster/simplify service development and provide a model based development environment including the compiler/translator which is able to generate low-level codes from the high-level service models; implement adapters to different cloud/FaaS platforms (e.g. Kubeless/Kubernetes, Microsoft Azure) • Design and implement novel orchestration algorithms which are responsible for deploying the software components (VNFs and network configuration) of the services/applications on-the-fly even in multi-provider environments and fulfilling strict SLA requirements in cloud/edge environments including IoT infrastructures while utilizing underlying resources efficiently • Propose reusable "service patterns" (similar to design patterns) taking advantage of the previous models and methods
Research focus/topics – *describe how you are going to solve the problem*	Max 200 words	The following tasks will be addressed in consecutive phases: • A detailed survey on the state-of-the-art models and tools for application/service modeling is to be provided. This includes available theoretical results and the investigation of available open-source and proprietary products, such as Kubeless/Kubernetes, Amazon AWS, Microsoft Azure, Google Cloud Platform. The available models will be compared and evaluated from different aspects. • The specific requirements of the future services and their impact on the models, orchestration systems and underlying platforms will be investigated. • Based on the identified requirements, an abstract model and an enhanced service programming language will be proposed for describing the application logic and SLA parameters of given services. • A compiler / translator component will be proposed and implemented which is capable of generating low-level codes from high-level service models and adapters to available cloud/FaaS platforms will also be implemented. Formal proofs will support the correctness.

		• Novel orchestration algorithms are also addressed which can leverage the new models and provide optimal (or close to optimal) deployment. The new concepts will be implemented as open-source prototypes and evaluated in details based on comprehensive simulations and sandbox experiments. These tasks will require close cooperation with Ericsson and possibly with other European universities.
Deadlines/milestones (Gantt chart)	M6	Report on the state-of-the-art and preliminary tests on the existing open-source and proprietary solutions. Best practices and terse hands on based on the tests are provided. Requirements on the application/service models are identified and clarified.
	M12	First version of the service/application model and the description language are defined. Implementation options for the compiler and for a first, simple version of the orchestrator are investigated. The time plan of the implementation is provided.
	M18	First version of the proof-of-concept (PoC) compiler and the simple orchestrator are ready. A test environment is established. Publishing a concept paper at an international conference or workshop and gathering feedbacks from the community. A demo paper is submitted to an international conference.
	M24	Refined version of the PoC compiler and an advanced orchestration system are available. Report on the comprehensive evaluation of the prototype. Formal proofs on correctness. A journal paper summarizing the concept, the proof-of-concept prototype and the experiments with the prototype is submitted.
	M36	Refined concept, advanced requirements and new added values are incorporated in an extended model and in the prototype. New formal proofs are provided on the correctness of the operation. Improved, extended test environments are available. A research paper is submitted to an international conference.
	M48	Novel results are summarized in a submitted journal paper. All results are summarized, PhD theses are collected and formalized. PhD dissertation is ready for review.
Expected outcome – *describe the expected results of the PhD*	Max 100 words	The results of the PhD include approaches that offer portability across cloud platforms eliminating the problem of cloud platform provider lock-in, and software tools fostering service development. More specifically the expected results are the following: • Application/service models with advanced capabilities • Compiler/translator providing automation for developers • Orchestration algorithms • Working and verified proof-of-concept prototypes and novel SW modules into Ericsson products • Formal proofs on the correctness of the operation • Published papers at top conferences/journals • Demos with prototypes at industry events • Potential patents

Relevance for the Action Line (section to be filled out by the Action Line Leader)

Action Line	AL	Digital Infrastructure – Henrik Abramowicz
Alignment with Action Line – *statement from the Action Line Leader indicating the relevance for the AL from his perspective*	Max 150 words	This topic is indeed in line with the Action Line Digital infrastructure and the focus areas Devising a service programming language and compiler should improve the performance but it would be nice to see some comparison with existing methods to understand the performance gain. IT is indeed in addition important to provide models and solutions applicable for multi-operator cases. It would be very nice if the PhD student would participate in potential future IAs with investigations, workshops and similar.
Relevant IA – *List any relevant Innovation Activity (if applicable)*	Max 100 words	Currently we have no Innovation Activities in this area.

Partnership/financial information

Action Line Leader	Name	Henrik Abramowicz
Industrial partner		Ericsson Hungary Ltd.
Industry advisor – *name and short bio*	Max 100 words	Balázs Péter Gerő has received his MSc in Computer Science from Budapest University of Technology and Economics (BME) in 1998. He joined Ericsson Research in 2000. His research included a variety of fields such as traffic modeling of mobile networks, network management, transport network protocols and services, Software defined networks and data centers. Currently, he is active in orchestration system design of large scale distributed/edge cloud systems in a multi provider environment.
Academic/research partner		Budapest University of Technology and Economics (BME)
Academic/research supervisor – *name and short bio*	Max 100 words	Balázs Sonkoly is an Associate Professor at the Department of Telecommunications and Media Informatics, Budapest University of Technology and Economics (BME). He is the head of MTA-BME Network Softwarization Research Group supported by Hungarian Academy of Sciences and Ericsson. He received his PhD (2010) and MSc (2002) degrees in Computer Science from BME. He has participated in several national (IKTA, NKFP-HeHOK, OTKA-KTIA) and EU-funded research projects (FP7 OpenLab, FP7 UNIFY, H2020 5G Exchange) and also worked in bilateral cooperation projects with Ericsson. His research activity focuses on network softwarization, NFV, SDN, cloud/fog computing, 5G and novel orchestration algorithms.
HEI granting the title		Budapest University of Technology and Economics (BME)
DTC location	Node	Budapest
Geographical mobility plan		
No. of PhD positions	[#]	1
PhD duration	[#years]	4 years (the official duration of the Hungarian PhD scholarship)
Co-funding percentages:		20%

- Industry	[%]	
- Academia	[%]	30%
- EIT Digital	[%]	50%