EIT Digital – Industrial PhD position proposal

PhD thesis information

PhD Thesis – Title		Predictive Anomaly Pattern Recognition in Complex Communication Networks
PhD Thesis – Short summary	Max 100 words	Today's communication networks are extremely complex systems consisting of hundreds of thousands network elements organized in cooperating, coexisting and overlapping technology layers. The network elements generate huge amounts of versatile data for performance monitoring, optimization and troubleshooting purposes. It is impossible to tackle these tasks thus there is a strong need for automated solutions that are capable to analyze the raw data and draw conclusions, generate actionable insights. One important area in this field is the predictive detection of anomaly patterns that appear in the data. The main theme of this thesis is to develop an effective solution for predictive anomaly pattern recognition that is general enough to be applied in various areas of communication networks.
Rationale/challenge – *describe the problem and why it is relevant*	Max 200 words	The main reason that anomaly pattern recognition is a challenging task is that it must be solved in an unsupervised way. In most cases there is no ground truth that would set a reference point except statistical probability. Another big challenge is the strong pressure from operators for predictive solutions that are capable to reliable detect early symptoms of failures and send notification before serious degradations occur. The third big challenge is that the analyzed systems are non-stationary thus solutions need to be capable to continuously learn new information contained in the data. The results need to be easily interpretable by domain experts without data science knowledge. The system needs to be scalable and easily deployable. Textbook solutions do not work.
Innovation – *describe what is the intended solution and the advance w.r.t. the state-of-the-art*	Max 250 words	The goal of this thesis is to develop a predictive, on-line anomaly pattern recognition system: - Predictive system state modelling solution; - Method to continuously updating the model; on-line learning; - Potentially develop new ML models or modify/upgrade existing ones; - System design;
Research focus/topics – *describe how you are going to solve the problem*	Max 200 words	First the state of the art should be reviewed along with understanding Nokia's current internal understanding and status of the problem. Then the new concepts should be formulated an implemented then verified with real network data (from several real networks and domains). Initially the machine learning part should be in focus, later the ideas need to be implemented as a scalable solution on decent hardware and with best in class big data technology. Cooperation with Nokia engineers, researcher and engineers of Nokia's customers is expected.

Deadlines/milestones (Gantt chart)	M6	Review state of the art, understanding Nokia's current internal understanding and status of the problem. Identify and design the solution including ML and infrastructure. Action plan for the remaining time.
	M12	One conference paper. Potential inventions. Implement a proof-of -concept prototype (focused on the ML level solution and not on the deployability/scalability) and apply it on the data provided by Nokia; share results with operator, gather feedback.
	M24	Extensive study of the solution on multiple datasets. Optimize algorithms. Design implementation for scalability and deployability using decent big data stack and ML/AI frameworks. One journal paper, one conference paper. Potential inventions.
	M36	Full prototype, verification, potential pilot in Nokia's customer network. One journal paper, on conference paper. Potential inventions.
	M48	Summarize the results and complete the PhD thesis.
Expected outcome – *describe the expected results of the PhD*	Max 100 words	The expected results of the PhD are new solutions to predictive anomaly pattern recognition. The results shall include: • Working, verified prototype of the new concepts; • Detailed analysis of the impact on network performance and deployment considerations; • Published papers describing the findings in high-quality academic journals; • Potential patents, working in close cooperation with Nokia Solution Networks Kft.

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

Action Line	AL	Digital Infrastructure
Alignment with Action Line – *statement from the Action Line Leader indicating the relevance for the AL from his perspective*	Max 150 words	The topic is definitely in line with the Action Line focus areas and it is indeed an important topic for network operators and vendors as it relates to performance monitoring, optimization , troubleshooting and cyberattacks. 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	We have currently some related Innovation activities applying machine learning to detect anomalies, attacks, data streams for routing. The IA Deep-Augur deals with pattern recognitions and attacks in networks and the IA Security Operations Center for protecting critical infrastructure deals with anomaly detection to prevent cyberattacks.

Partnership/financial information

Action Line Leader	Name	

Industrial partner		Nokia Solutions and Networks Kft.
Industry advisor – *name and short bio*	Max 100 words	Szabolcs Nováczki is a senior research engineer at Nokia Bell Labs. He received his M.Sc. degree in Electrical Engineering from the Budapest University of Technology and Economics (BME), Hungary, in 2006. He is currently focusing on developing applied statistics and machine learning solutions in various fields of telecommunication networks. His main research area is pattern recognition and prediction in multi-dimensional time series.
Academic/research partner		Budapest University of Technology and Economics (BME)
Academic/research supervisor – *name and short bio*	Max 100 words	Dr. Kristóf Csorba Works at BME AUT since 2008, now as associate professor since 2015. Also researcher at the Center for University-Industry Cooperation (FIEK) since 2017. MSc and PhD thesis topic was natural language processing and pattern recognition. Now research focus is on image processing in interdisciplinary applications like geology, material technology, and medical image processing. Teaching mainly software development and embedded system design classes. Since 2010., supervisor of 58 BSc and MSc theses.
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
Co-funding percentages: - Industry	[%]	20%
- Academia	[%]	30%
- EIT Digital	[%]	50%