Descriptions of project laboratory and thesis topics at the Faculty of Electrical Engineering and Informatics

Introduction – please read carefully

Dear Exchange Student!

Thank you for your interest to attend a Project Laboratory course or to prepare your BSc or MSc thesis work at the Faculty of Electrical Engineering and Informatics (VIK) of the Budapest University of Technology and Economics (BME) as an exchange student.

Bellow you find a list of topic descriptions available for exchange students at the VIK. If otherwise not stated, the working language is English. Students are strongly advised to contact the supervisor of the topic they are interested in as early as possible to get their permission to work on the topic. Please check the prerequisites carefully if such requirements are stated in the description.

All students working on a Project Laboratory class or preparing a thesis work must enroll to a course depending on the degree program (Electrical Engineering or Software Engineering). The credit values (using ECTS) of such courses are also depending on the degree program.

Both projects and thesis works are prepared under the supervision of a faculty staff member such that students are expected to regularly meet and report their progress to their supervisor during the semester. A written report has to be submitted by the end of the semester in order to get mark and credit. The supervisor has the right to grant no credit and a "fail" mark if he or she is strongly dissatisfied with the work, its progress and/or with presence or attitude of the student. Any topic or supervisor change is strongly discouraged during the study period at the BME and no such change is permitted as a general rule. In case of any kind of "force majeure" or personal conflict, please contact the course director.

No appeal is possible against the mark granted by the supervisor. No late submission of the written report is tolerated.

If the thesis work task comes with laboratory work (e.g. measurements, tests, manufacturing) requiring the use of dedicated equipment, the student is expected to strictly observe all regulations (opening hours, security measures, schedules, etc.) of the laboratory in question, otherwise he or she can be denied the use of the equipment which may result in the failure of completing the task specified by the topic description.

As a general rule, please notice that a successful study period abroad requires a careful preparation and this list is here to help you in that process.

On behalf of my colleagues, I am looking forward to welcome you at the VIK as an exchange student and wish you a successful semester at the BME.

Sincerely yours,

Dr. Bálint KISS
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BSc course director
BME VIK

Links to web pages of the departments at the faculty:
Automation and Applied Informatics - http://www.aut.bme.hu
Electronics Technology - http://www.ett.bme.hu/
Electron Devices - http://www.eet.bme.hu/new/index.php?lang=en
Telecommunications - http://www.hit.bme.hu/
Control Engineering and Information Technology - http://www.iit.bme.hu/eng/
Measurement and Information Systems - http://www.mit.bme.hu/eng/
Computer Science and Information Theory - http://www.cs.bme.hu/
Broadband Infocommunications and Electromagnetic Theory - http://hvt.bme.hu/index.php?lang=en
Telecommunications and Media Informatics - http://www.tmit.bme.hu/?bl=y
Electric Power Engineering - http://www.vet.bme.hu/indexe.html

Design Space Exploration using Modern Modeling Frameworks

The paradigm of model-driven design (MDD) uses models as primary artifacts for data representation. Furthermore, MDD often includes additional structural constraints, design goals and implementation parameters. Therefore, it is important to have methods for constructing models (also called design alternatives) that satisfy constraints and goals, while parameters are close to optimal (such as from cost, quality, reliability or performance). There are various algorithms using deterministic (e.g. constraint satisfaction) and random choice, that can be used for this purpose (Search-based Software Engineering).

The Eclipse Modeling Framework (EMF) is a framework, which allows the creation of domain-specific models using generic tools. There are also tools available (e.g. EMF IncQuery) usable for describing constraints and goals. Furthermore, the VIATRA2 model transformation framework supports the exploration and evaluation of design alternatives.

The student should get familiar with EMF and IncQuery technologies and extend the design-space exploration component of the VIATRA2 framework to support EMF models.

Requirements: Java programming, UML
Acquirable skills: Eclipse programming, EMF, model-driven development

Supervisor**:** Mr. Ábel Hegedüs, hegedusa@mit.bme.hu
Department: Measurement and Information Systems - http://www.mit.bme.hu/eng/

Proactive mobility management schemes for heterogeneous mobile networks

Several different mobility management schemes working in different layers of the TCP/IP hierarchy exist in the literature but their optimization for heterogeneous access architectures just have been started. 802.21 MIH (Media Independent Handovers), OMA-DM (OMA Device Management), ANDSF (Access Network Discovery and Selection Function) are emerging methods for proactive handover control in heterogeneous architectures, but their ways of application in mobile environments and integration with different mobility execution mechanisms has not yet defined precisely. Integration of 802.21 MIH, OMA-DM and ANDSF and similar standards with existing mobility management schemes (e.g., Dual-Stack Mobile IP, Proxy Mobile IP, Host Identity Protocol, etc.) in order to reduce or even totally eliminate deteriorations during mobility events are still hot topics. Also evaluation of mobility management schemes strongly relying on multiple existing host interfaces (i.e., multihoming) and integrate them with handover preparation and prediction mechanisms in order optimize access to heterogeneous access architectures and benefit from overlapping coverages is an important research activity nowadays.

Student(s) can analyze the existing methods with analytical/simulational performance evaluation and also can work on extensions and/or special deployment scenarios for the existing schemes.

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Department: Telecommunications - http://www.hit.bme.hu/

Analysis of incentive methods in Ad-hoc networks

The nodes of Ad-hoc networks are interested in transmitting their own packets. To ensure a network wide communication the nodes have to transmit the packets of other nodes as well. Various incentive methods are proposed in the literature for motivating the nodes for cooperation. The specific task is to analyze the performance of a particular incentive method (A queuing model-based incentive scheme for optimal data transmission in wireless networks with selfish nodes) which requires analytical and simulation based evaluation of the node behaviour.

Supervisor: Mr. Miklós Telek, telek@hit.bme.hu,
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Internet traffic analysis

The service quality of communication services are crucially affected by the users' behaviour. The dimensioning and the proper operation of communication equipments are based on stochastic traffic models which describe the dominant properties of the users' behaviour. The specific task is to implement programs for the statistical analysis of measured data set and to perform the statistical analysis using the developed programs.

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Implementation of traffic analysis programs in R language

R is a freely available language and environment for statistical computing" (http://cran.r-project.org/). The task is to implement a set of functions for various computations with simple Markov chains in R. The functions to implement are similar to the ones in the BuTools package. (see http://webspn.hit.bme.hu/~telek/tools/butoolshonlap/butools.html).

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Using quantum information processing in classical and space communications

Quantum information processing and quantum communications is a future and emergency technology which changes the current used information science to the “classical” one by classical bits and classical algorithms. Quantum computing is based on various quantum effects in physics and offers revolutionary solutions for different problems e.g. prime factorization, searching in unsorted database, key distribution and information coding. The power of quantum parallelism allows us to solve classically complex problems, and the quantum entanglement leads to quantum communication algorithms like teleportation (transmitting a quantum bit by sending only two classical bit over the channel) and superdense coding (sending two classical bits using only one quantum bit). The quantum cryptography provides new ways to transmit information with unconditional security by using different quantum key distribution protocols.

During the project work, students learn about the quantum computing from the engineering point of view. They will work to create and analyze efficient quantum communication algorithms.

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Speculative domain registrations

Domain names (ex: google.com) are the fundamental element of Internet communication. Yet, it is unclear even today, why people register domain names, what is their goal? It is also not sure what the value of domain names is. It is an urban legend that most domain names registered today are of speculative nature: malicious domains for phishing and spam; typosquatting and domain parking and resale. The goal of this project is to shed light to the purpose of domain registrations trying to separate these speculative registrations.

The project requires the use of scripting skills and data mining techniques. This project runs in collaboration with UC Berkeley and UC San Diego.

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Work for your spam

Spam has been around for a long time and there are various techniques to stop it. Most of them work pretty efficiently, but there is still a lot of room for improvement. As the Internet infrastructure becomes more dynamic, content-based filtering becomes more prevalent. The goal of the project is to involve the users in the spam verification without putting a high burden on them. We want to design "proof-of-will" schemes where the system sends an email digest to the user who subsequently decides if the email is worth reading. Thus, unimportant messages get filtered out from the flow. Such techniques can be part of a framework to establish trust between communicating parties.

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Traffic analysis attacks in wireless sensor networks

The objective of this project is to propose and analyze models and methods for traffic analysis attacks in heterogeneous sensor networks. In such networks, the aggregated traffic observed at the sink is composed of multiple flows with different characteristics dependent on the type of the sensors. The task of the attacker is to separate these flows from each other and determine the type of the sensors present in the network. The project requires the application of signal processing methods and the usage of network simulation tools (e.g., OMNeT++). The proposed traffic analysis models and methods should be evaluated in terms of their accuracy and performance by means of simulations.

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Privacy preserving communications in pocket switched networks

Pocket switched networks consists of mobile devices with short range wireless communication capabilities. Communication in such network is based on the store-carry-and-forward principle: a device can receive messages from its local neighbors, it stores those messages, carries them while moving on, and forwards them later on in a different location and neighborhood. Thus messages propagate from device to device until they reach their destinations. Such a network inherently provides a certain level of privacy by making it difficult for an attacker to observe who is communicating with whom. The objective of this project is to quantitatively measure this privacy. This requires development of privacy models and metrics for pocket switched networks, and running network simulations to estimate the privacy level. A follow-up task is to design privacy aware communication protocols for pocket switched networks and study their performance by means of simulations.

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Development of application-level multicast software

The multicasting means a great advantage of the Internet-based media communication. Investigate the most important technical literature in the field of Application-Level Multicast (ALM) routing and the P2P overlays. Classify the known ALM routing protocols according to the network environments and density of participating hosts. Design and implement a simple chat or other multiparty media-application for comparative testing the performance of the most important multicast functionality. Make some example runs and test its properties to show their right operations.

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Comparison of different file sharing methods

The P2P computing means a great advantage of in the Internet-based media communication. Investigate the most important technical literature in the field of application-level networking. Classify the known application-level multicast methods and other peer-to-peer (P2P) systems, as LimeWire, Gnutella, Freenet, FastTrack, Kazaa, according to the network environments and their performance. Design and implement a simple chat or other multiparty media-application for comparative testing the performance of the most important P2P functionality. Compare the measured results to the data gained from the literature.

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Development of web application for graphical presentation of statistical data

Investigate the relevant scientific literature in the field of designing web interfaces. Study the freeware database management systems and the related web interfaces. Choose an optimal software tool for the development. Design an application for data processing and presenting in a graphical manner, e.g. in a world or country map. Use the language Java or the Delphi for programming.

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Development of an interactive game system

Review the available software tools for developing interactive game software for different platforms. Based on this comparison, choose the appropriate programming language for generating the necessary codes. Develop the model description method of an interactive quiz application. Design the functional structure of the software based on the developed structure. Make some example runs and test its properties to show their right operations.

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Developing host multicast encyclopedia with web interface

Learn the basics of the PHP web language and the MySQL database management system. Create an application, which have a web interface and a background database. The MySQL database and the web server extended with PHP interpreter are run in a server of the department.
Review the most important scientific literature in the field of host level multicast algorithms, protocols, and applications. Create a necessary methodology to compare them and a database oriented description. Develop a necessary database structure to store this knowledge.
Generate the user and the administrator interfaces of the information centre using the PHP scripting language. Test the ready web-based encyclopedia software to demonstrate its proper operation.

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Development of Web-based group communication software

Survey the relevant scientific literature of the web-based group communication softwares. Based on the collected information develop a new, special designed system, which can improve of the group communication and common working for people.
Investigate the fundamentals of the PHP language and the MySQL database management system. Create software for accessing a MySQL database management system with an appropriate web interface. The MySQL database and the web server extended with PHP interpreter are run in a server of the department.
Generate the user and the administrator interfaces of the software using the PHP scripting language. Test the completed parts of the system to demonstrate its proper operation.

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Modeling a Sensor Network Element in VHDL

Review the VHDL hardware modeling language and its use for describing microprocessors.

- Study the fundamental routing algorithms, which can be applied in the sensor networks.
- Based on the scientific results of the literature, define the system specification of a sensor element with simple routing functionality.
- Develop the digital hardware part of the sensor element in VHDL language.
- Verify the right operation of the designed VHDL model with test simulations.

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Efficient algorithms

Most of the algorithmic problems are NP hard but even for the ones with polynomial time solutions a natural question is whether there exist faster method then the usual one if we introduce some restrictions or relaxations. The goal is to look at problems related to graphs from this point of view. For example, lately lots of work are done on huge graphs when a cubic or a quadratic algorithm might be infeasible but there is a chance to obtain an efficiently solvable variants of the problems.

One possibility is to look for useful special cases that can be solved more efficiently than the general problem. Another approach is to consider the average case complexity of the problem, where the expectation is that the algorithm is efficient for a random input. To consider a relaxation of the problem also might help. We can look for a good approximate solution instead of the optimum or a randomized algorithm when a small probability of error can be tolerated, if these improve the performance significantly. Furthermore, a more and more popular tool is parameterized complexity theory, where a new parameter is introduced (for example maximum degree or other graph parameter) in such a way that the problem is efficiently solvable when the value of the parameter is small (for example, in the case of graphs with small degrees).

The goal is that for some selected problems related to graphs investigate the possibilities to apply these or similar approaches to obtain efficient algorithms.

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Optimization algorithms for increasing the efficiency of computer systems

The complexity of today's computer systems makes their design an extremely challenging optimization problem. Tackling these challenges is very important, as this would lead to more efficient computer systems. On the other hand, solving these problems optimally is unimaginable without appropriate computer support; in fact, because of the size of the solution space or the difficulty of assessing the objective function, in many cases, it is quite hard even with today's computing power. Some current important optimization problems include:

- CPU-GPU optimization aims at finding the optimal workload distribution between a general-purpose central processing unit (CPU) and a graphical processing unit (GPU) that is also capable of general-purpose computation. The optimization must take into account that some operations can be computed more efficiently by the CPU, while some others are more appropriate for the GPU. Furthermore, the time penalty incurred by the data transfer between the CPU and the GPU must also be considered.
- Multicore scheduling is the problem of assigning parts of a program (e.g., threads, objects, instructions) to the available cores of a multicore processor. The aim is to minimize the total execution time as well as the total power consumption of the system. Dependencies between the program parts as well as communication between cores must be taken into account, as they constrain the speedup achievable through parallelization.
- Memory optimization arises as a distinct optimization problem because memory accesses have an increasing relative contribution to overall system performance and energy efficiency. In the hardware architecture community, different techniques have been developed to decrease the average cost of memory accesses, e.g. by caching. In the software and compiler community, techniques have been developed to decrease the number of memory accesses and improve their locality. The aim of this research is to combine these methods in a multicore, distributed cache environment.

In any of these cases, the student's task will be to define an appropriate mathematical model of the problem, to analyze its computational complexity, and to devise efficient algorithms for it. Since these problems are typically NP-hard, not only exact algorithms, but also approximation algorithms and heuristics should be investigated. Special attention should be given to the empirical evaluation of the algorithms on both real and random problem instances. This way, the practical applicability of the algorithms can be validated. Moreover, this will provide insight into what makes a problem instance easy or hard; such insight can then be leveraged to improve the efficiency of the algorithm, or to devise completely new algorithms.

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Combinatorial Optimization and its Engineering Applications

Discrete mathematics (or combinatorics) has a history of several centuries. In the last 60 years computers raised the importance of studying algorithmic questions. In case of large scale problems the number of steps would exponentially increase if an algorithm examined every possibility in an exhaustive search. Instead, such algorithms are required where the number of steps can be bounded from above by a polynomial function of the size of the input.

In order to develop such algorithms one has to study the structure of the models, the special properties of the problems. This is the subject of combinatorial optimization, applying graphs, hypergraphs, matroids, special cases of linear programming using totally unimodular matrices etc. With the help of these tools previously intractable problems (or at least some special cases of them) could be solved by polynomial algorithms.

The suggested research concentrates on these tools (especially matroid theory) and on their engineering applications (especially in the design of very large scale integrated (VLSI) circuits, in the extensions of classical results of electric network theory for networks containing active and/or nonreciprocal devices, and in the qualitative study of the rigidity of bar and joint frameworks (and their generalizations, the tensegrity frameworks).

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Declarative Programming

Declarative programming (DP) is a branch of computer science dealing with declarative programming languages, techniques and tools. As opposed to traditional, imperative languages, built around commands, a declarative program consists of statements. Declarative languages have a straightforward semantics and their execution regime can be viewed as a process of mathematical deduction.

Declarative programming has two main branches: logic programming (LP) and functional programming (FP). Constraint Logic Programming (CLP) is an important extension of LP, which provides very efficient reasoning techniques in a specific domain of interest.

The task of the applicant is to take part and contribute to ongoing research work in declarative programming, especially in the following areas:

- Declarative languages and their implementation (distributed and parallel implementations, partial evaluation, abstract interpretation).
- Joint use of multiple declarative approaches and techniques, such as constraint programming techniques for different domains.
- The Semantic Web and its mathematical foundations (OWL – Web Ontology Language, description logics and their reasoning algorithms).
- Application of declarative languages and semantic technologies in various areas.

Recommended preparatory reading: Logic, Programming and Prolog (2nd edition) by Ulf Nilsson and Jan Maluszynski; John Wiley & Sons Ltd., 1995, http://www.ida.liu.se/~ulfni/lpp/

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Reduced complexity routing with OpenFlow

keywords: software defined networking, OpenFlow, testbed, greedy routing

Routing architectures and algorithms historically suffer from overhead related illnesses. Causes like large routing tables and the messaging burden of routing protocols manifests in symptoms such as increasingly difficult packet forwarding, slow convergence and failure recovery. Routing in a greedy manner over physical or virtual geographic coordinates can eliminate such side effects for the price of moderate requirements regarding the network topology. The beneficial properties of "greedy routing" e.g., it is totally distributed, uses only local information, does not require routing table in the traditional sense, makes it a candidate solution for networks with well defined/designed topologies e.g., Data Centers.

Our activity in which the candidate can participate is focusing on the implementation of greedy routing in OpenFlow which involves the extension of software switches and placing the additional tools in the OpenFlow controller. The research part of our work is dedicated to design topologies over which greedy routing achieves extremely high performance. We also address building testbeds based on our research results and running experiments and performance measurements.

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Internet topology measurements

keywords: complex networks, Internet, AS level topology, measurements

Description: The first decade of the XXI. century was the decade of "complexity". The dire efforts to understand the behavior of real-world complex systems evinced that the tangled interconnection of the huge number of constituting elements is the key question to be studied. By now the theory of complex networks has many results that traces back the characteristics of real-world networks (biological, technological, economical, social etv.) to the same phenomena.
The palette however is not complete. The analysis of the structure of the Internet significantly contributed to the triumph of complex networks by providing evidence of heavy-tailed degree distribution and small-world phenomenon in the AS level Internet graph.

Now we turn our (and our candidates) attention towards analyzing the searching and routing functionality of the Internet. In this field most theoretical studies are concerning mainly shortest path routing and derive results using the premise that the traffic in complex networks flows along shortest paths. From our Internet measurements we know that this is not the case. In connection with this topic the candidates can elaborate more specific Internet measurements where we seek for artifacts in the Internet topology that are generated by the non-shortest-path nature of the transiting traffic.

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Network formation games

keywords: network formation games, Nash equilibrium, network topology

Description: Network formation games constitute a nice game theoretical framework providing considerable insight into the mechanisms that form the topology of real world complex networks. In such games the emphasis is on the economic driving forces behind the emergence of different network topologies as equilibrium solutions. The framework effectively analyzes the tradeoff between link costs and distance costs between selfish and rational players of the game (network nodes), as the key incentives of building specific network topologies. In these games however the distance between two players is almost exclusively measured by hopcount of the shortest path that connects them. When it comes to infocommunication networks there are several reasons why this simple view is limited. In order to ensure an expedient flow of information through the network, one often needs to provision routes taking into consideration a broader set of attributes beyond mere path length, such as path reliability and resilience constraints bandwidth and perceived congestion, business relations and service level agreements between ISPs, etc. These path selection strategies are usually described under the umbrella of policy routing and indeed, a significant portion of the Internet today runs over policy routing.

The candidates choosing this topic can analyze of Nash equilibriums coming out of such modified games and participate in a more deep understanding and design the topology and functioning of such complex economy-driven infocommunication networks.

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Development of a Network Planner/Designer Framework for broadband access networks (AccessPlan)

keywords: Network planning, Software Development, Optimization, Analysis, Next Generation Access, Broadband Access

Abstract: Our research group has worked 3 years by now on digital map based network planning algorithms, which are implemented in a framework now, including map processing, network design and analysis capabilities. The methods and the software lead us to various research projects and industrial partnerships. The student will be involved in the development of the framework, and the ongoing projects.

Description: Next Generation Access (NGA) networks provide enormous bandwidth, low latency and high availability, enabling real triple-play services. The technical development is mainly driven by the utilization of optical transmission, therefore these new access network technologies rely on the roll-out of optical fibre.
The optical network roll-out requires a massive investment from network operators (or municipalities), therefore optimal network design is fundamental. Techno-economic comparison supports the optimal choice among the various existing technologies for the selected service area. Choosing the right technology and the optimal roll-out strategy together ensures profitability.
The network design/planning process is treated as an optimization problem, and handled by a software framework, which has three main building blocks:

1. Map processing module: it is capable to handle digital maps, GIS (Geographic Information System) databases in order to define the input for the network planning process. The knowledge earned by the student working in the field of GIS systems and databases becomes beneficial in different other areas, e.g. global positioning systems (GPS).
2. Network planning / optimization module: a set of highly effective optimization algorithms, heuristics and sophisticated network modelling approaches are used to solve the problem of calculation the optimal network layout, which connects all demand points to the central offices, considering the physical and administrative constraints on the network topology. The students are guided to earn optimization, clustering and algorithm development skills, which could be beneficial later in a wide set of areas, not only in network planning, but e.g. logistics, automation and process optimization, etc.
3. Analysis module: various network layouts are designed, according to requirements of different network technologies, for the same service area. These network layouts are then analyzed from technical, and even more from economic aspects, providing an in-depth techno-economic evaluation and comparison of the various technologies, including not only the deployment (CAPEX) and operational expenses (OPEX), but Cash Flow, Return of Investment, Total Cost of Ownership (TCO) calculations, in order to provide a complete Business Case Analysis for the network operators.
4. Students are encouraged to join our group, and take part in the development of any of the above described modules.

More information about the framework: http://safranek.tmit.bme.hu/accessplan

Prerequisites: We are looking for students taking part in a complex team-work activity, who are also capable to solve problems individually. We offer innovative and challenging problems, and provide the necessary professional background and consultations: our goal is to let you solve real problems.

Software development is an important part of our business, so you have to be familiar with one of the following languages/tools: C++, C#, Java, MatLab.

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Congestion Games for Designing Scalable Resource Allocation Mechanisms

MSc Thesis Work only

Description: Sharing the resources (transmission capacity, buffer space, frequency) among flows in fair and efficient manner has utmost importance for economical operation of communication networks. For example, elastic (like TCP) flows produce a global bandwidth sharing scheme which is a result of simple local rules and interactions of the underlying congestion control. The resource allocation among multiple competing users in general has also been widely studied from network game theoretical perspectives.

The discriminatory processor sharing (DPS) queuing discipline and modeling framework introduced first at the dawn of Internet (for modeling the processor serving capacity share among the different jobs in mainframe computers) have been widely investigated in packet based communication networks for modeling the bandwidth sharing mechanisms.
For designing scalable resource allocation method a viable approach is the use of canonical resource allocation games.

The tasks of the MSc candidate are to be the following:

- Reviewing the literature on proportional allocation mechanisms, resource allocation mechanisms, discriminatory processor sharing, congestion controls for elastic flows, congestion games.
- Formulating a canonical resource allocation problem, in which a finite number of users are competing to acquire a share of resource of fixed capacity, assuming each user has a utility function which increases in the amount of the resource received and the goal is to maximize the aggregate utility function.
- Studying the underlying optimization problem in the Discriminatory Processor Sharing allocation mechanism, with special attention on the constraints imposed on the user access mechanisms.
- Linking the DPS model and the canonical resource allocation problem, when the users (agents) are strategic, in order to design the resource allocation mechanism robust to gaming behavior.
- Analyze a simple price taking and price anticipating resource allocation mechanism. In case of price anticipating users, study the price of anarchy, i.e. how much utility is lost because the users are price anticipating.
- Document the studies performed and the results achieved during the diploma work semesters.

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The Effect of Access Rate Limits in Elastic Flows

BSc Thesis Work only

Description: Congestion and flow controls are important traffic management function in packet based infocommunication networks. Closed loop congestion control (e.g. TCP, ARQ) can be applied when the flows have no specific bandwidth requirement, however, the reliable transmission (the loss of information is very low or zero) and a tolerable delay have utmost importance.
Discriminatory Processor Sharing is widely accepted modeling framework for elastic traffic bandwidth shares. In this model, the classes are distinguished from each other by weights of service capacity shares, and users within a class share the capacity in an egalitarian manner. In the model, technological and economical constraints should be also taken into account, e.g. the users' access rates should have upper limits, and the bandwidth share not fully utilized by users (due to their access rate limits) should be redistributed among the others.

The tasks of the BSc candidate are to be the following:

1. Reviewing the congestion and flow control mechanisms in packet based communications.
2. Studying the Discriminatory Processor Sharing, as a possible modeling framework for bandwidth sharing mechanisms.
3. Studying the possibilities of introducing access rate limits in the DPS resource allocation mechanism.
4. Investigating by simulation and/or numerical analysis a bandwidth efficient access rate limit method.
5. Comparing the results to the rate limitless case and exploring rate limited single class case.
6. Document the studies performed and the results achieved during the thesis work semester.

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Towards Green Networking: Simulation of Architectures and of Resource Management

The energy requirement of modern infocommunications grows faster than the traffic itself. Furthermore, it grows faster, than energy requirement of any other area.

For sustainable growth of infocommunications the technology, the architecture, the design and the maintenance of modern networks must be enhanced in order to decrease the power requirements.

The task of the students is to evaluate the energy requirements of various components of various architectures, to propose novel architectures, novel management methods (algorithms) and to evaluate all these by simulations.

For implementing algorithms we propose the LEMON (C++) (http://lemon.cs.elte.hu/trac/lemon) environment for simulations we propose the OMNeT++ (http://www.omnetpp.org/home/what-is-omnet) environment.

The evaluations should be performed for converged heterogeneous fixed-mobile access networks as well as for optical metro-core and backbone networks.

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Future core optical networks

Keywords: optical networks, simulation, WDM, modulation

Abstract: The bandwidth demand in core networks is rapidly increasing. In these optical systems 100Gb/s can be reached on a single channel summing up to 8Tb/s each fiber. The next generations will operate at 400Gb/s/channel or 1Tb/s/channel requiring complex modulation formats such as 16QPSK or OFDM. The topic offers better knowledge on optical networks and digital signal processing.

Description: Today's common optical networks operate at 10Gb/s with on-off keying modulation formats (usually NRZ or RZ) and a WDM system consists of up to 80 channels. 40G and 100G transponders have recently become commercially available using polarization multiplexed BPSK or QPSK signals and exploiting advanced digital signal processing on the receiver side. Telecom operators are now migrating to the new technology and the appearance of 400G transponders with 16QAM modulation is expected, while the next generation OFDM systems using flexible grid instead of the traditional fix WDM are not far away either.

Based on your field of interest and current studies you can choose from the following topics: theoretical study of the next generation flexgrid optical systems, implementing a simulational model of a scalable coherent optical receiver, implementating a simulational model of an optical OFDM transponder.

Joining the team offers the possibility of participating in national or international telecom projects which grants innovative and practical topics but sometimes lead beyond the required credit number. We use VPI optical simulator, Matlab, or any other useful tool.

Prerequisites: We expect students with at least basic knowledge on optical networks or common modulations (OOK, PSK, QAM).

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Multimedia mining

Description: Multimedia mining deals with the extraction of implicit knowledge, multimedia data relationships, or other patterns not explicitly stored in multimedia files. Multimedia mining is more than just an extension of data mining, as it is an interdisciplinary endeavor that draws upon expertise in computer vision, multimedia processing, multimedia retrieval, data mining, machine learning, database and artificial intelligence.

Possible tasks in this area are:

- Feature extraction from images. The difficulties of the feature extraction is the finding the appropriate attributes, which represent the picture well.
- Automatic video segmentation. The task is to divide long videos into little parts, as chapters, scenes, etc.
- Image classification. The aim is to categorize images into semantic classes (e.g. emotional classes) that are manually precategorized in the training image set.
- Object recognition. The task is to find a given object in an image or video sequence. The image of the objects may vary in different viewpoints, in many different sizes or scale, this should be considered in object recognition.

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Knowledge Management

Description: Knowledge management deals with the explicit, implicit or tacit knowledge of professional experts. It combines two main approaches:

- concentrate the existing mass of information into knowledge using data and text mining methods
- index the supposed knowledge of human experts, and organize processes to share their knowledge Both approaches need information technology tools.

Possible tasks in this area:

- Mapping competences and knowledge with extraction from different types of CV-s
- Find relevant keywords and key experts on defined specialization area
- Evaluate a given Human Resource pool in a project starting situation

These systems will be used mainly by HR managers of the larger organizations or developers of social media networks.

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Video processing and content analysis

The task of the student(s) is to extract a set of video frames from an arbitrary video source (can be file or stream) and identify physical characteristics of recurring objects like bounding box, relative height/width ratio etc. The technologies that can be used are ffmpeg, DirectX or any video API. The task requires good C/C++ skills.

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Automatic accentuation in mobile software

Several state-of-the-art mobile devices and applications mainly support English as input language and lack of the possibility of typing accentuated characters. T9 works well only for typing short text like SMS. When writing a longer text in mobile applications, T9 becomes more than annoying (editing an office document). The task of the student(s) is to design an application that automatically accentuates text typed with English keyboard with the help of an existing spell checking tool.

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Automatic test data generation based on SQL schema

Test data used for testing telecommunication protocols are generated based on the definition of protocol data units given in the standards. Data types of protocol/service data units can be described as an SQL schema. The task of the student(s) is to design an application can automatically generate an SQL schema from formal abstract data type definitions and define SQL queries that retrieve records that contain random and boundary values.

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Distributed hierarchical inter-network cooperation

keywords: peer-to-peer, distributed network management, network composition

Today, the Internet has become essential for enabling data information flow exchanges all over the world enabling in turn a wide range of applications and services. The novel The IP based networks tend to become a single integrated architecture that spans the globe and enable customized services, which will offer both social and economical benefits to all stakeholders. Therefore the future Internet can be thought as being a large, heterogeneous, global and dynamic networking environment.
The management of such networks and services hit the limits of scalability of the established (legacy) management frameworks. In legacy network management, the management-plane is a centralized process, being responsible for a vast area of functionalities, as described by the FCAPS (Fault, Configuration, Accounting, Performance, Security) structure of TMN (telecommunication network management). In order to meet the above challenges of future networks the network management systems have to become more dynamic, more self-managing, and they have to participate more actively in (inter)-networking, going beyond “classical” or legacy network management paradigms.
The goal of the Thesis is to offer network management solution for dynamic network composition in self-organizing networks. This should be done by the adaptation of a hierarchical peer-to-peer (p2p) overlay network structure that enables the realization of the management plane functions. Maintaining the overlay structure in a highly dynamic distributed environment presents many challenges. The task of the student is to develop and test the performance of an algorithm that governs the interaction (composition) of networks in a distributed manner.
The tasks of the student:

- Survey the literature and describe the stat-of-the-art in the field of distributed network management systems and peer-to-peer technologies.
- Understand the already proposed hierarchical peer-to-peer (p2p) overlay network structures and their adaption to the network management. Develop a simulation tool that models this environment.
- Propose a distributed algorithm that can handle the compositions in distributed manner. Analyse the performance of the proposed algorithm and discuss the results.
- Document its work.

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Motion tracking

Image processing has different number of applications in industrial and automation field. Many of them are facing with the problem of motion detection, tracking and motion analysis. The relative motion of a camera versus the surrounding 3D objects results in such visually detectable changes on the 2D image sequence which can characterize the relative motion and the structure of the a-priori unknown environment as well.
For example: with the help of the camera(s) fixed on a vehicle an automatic 3D navigation system might help the driver in pedestrian detection, road tracking, obstacle avoidance, etc.
The algorithmic solutions might be mainly classified by means of searching and tracking of "features" or "templates" on the images. In the frame of a former project the motion estimation was based on a specific feature detection and tracking using the KLT algorithm. As a next step we would like to take advantages of the more direct template detection too - using the Optical Flow approach.

In the frame of the above research area, various levels of foreign student activities can be formulated, like: individual practice, diploma work, PhD thesis, etc. Depending on the level, the specific work theme will cover one or more from the following sub-tasks:

- Survey on the general methodology of feature and template detection on image(s)
- Evaluation of available 3D navigation tools and algorithmic approaches from the point of view of robustness, accuracy, complexity, real-time implementation, etc.
- Comparisons between the different feasible implementations
- Implementation questions of the Lucas-Kanade, Horn-Schunck optical flow algorithms
- The real-time aspect (GPU/DSP/FPGA implementation, hardware-software co-design)
- Various applications based on an optical flow.

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Synthesis and Application of a Task-dependant Pipelined Multiprocessing Structure

The aim of this activity is to develop and apply a method for designing a special multiprocessing structure for making the pipeline function possible as a special parallel processing even if no efficiently exploitable parallelism were discoverable in the task description. The starting point of this synthesis method is the task description assumed to be given by a program written in a high level language (e. g. C, Java, etc). The next step is a decomposing algorithm for generating proper segments of the task-describing program. The desired number of the segments and the main properties of the processor set implementing the segments can be given as input parameters for the decomposition algorithm. The estimated communication time-demand is also taken into consideration. For constructing a beneficial pipeline structure, the high-level synthesis (HLS) methodology of pipelined datapaths is applied. The HLS methods attempt to optimize by executing the scheduling and allocation steps applied on a task-oriented input dataflow graph. Therefore, the resulted multiprocessing structure is not a uniform processor grid, but it is shaped depending on the task to be solved, i.e. it can be called a task-dependant multiprocessing or multi-core structure. In order to evaluate the whole method as a framework, a specific HLS tool is applied. For illustrating and evaluating the method, practical benchmark tasks will be solved step-by-step.

In the frame of the above research and development program, various levels of foreign student participation can be formulated, like: individual practice, diploma work, PhD thesis, etc.

Depending on the level, the specific work theme will cover one or more from the following sub-tasks:

- Developing algorithms for decomposing high-level task descriptions
- Handling the estimated communication time-demand of various standard bus structures
- Developing methods for considering the main practical properties of processing units implementing the segments
- Generating a task oriented data-flow graph as the input for a high-level synthesis tool
- Synthesis and evaluation with a high-level synthesis tool
- Solving and evaluating practical benchmark problems

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Assistive control of cranes

The efficient control of cranes needs usually experienced operators to overcome the oscillations of the load and to reject the effect of uncertainties such as load mass variations and external disturbances such as winds (and waves if cranes are mounted on cargo ships). New features of crane control systems will offer methods to comprehensively assist operators during the operations without losing the close grip and feeling on the motion of the load. Several assistive schemes exist including input shaping methods and force feedback provided to the operators. An additional question is to identify the model (the transfer function if possible) of the crane operators. The project ultimately aims to realize assistive algorithms in simulation and on a real, two-dimensional crane system present in the laboratory. The simulations and the assistive control design will be carried out using a Matlab and Simulink based development environment together with a DSpace tools for the rapid control prototyping.

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