Master Projects

Architecture of Information Systems

October 2014

The AIS group offers you thesis topics and supervision in a group

- lead by one of the most cited and influential researchers in the area of business processes and process-aware information systems worldwide, Wil van der Aalst,
- that has invented and developed cutting edge technologies that were applied in over 100 different companies and is now being used in various industrial tools,
- that has set and contributed to various standards in the area of process-aware information systems,
- that actively cooperates with many large companies in the area of process-aware information systems in the Netherlands and worldwide, as well as with universities and researchers from all over the world (we are currently running 17 projects with different partners),
- that received a perfect score in the 2012 evaluation of Computer Science groups in the Netherlands,
- that gives you clear and regular guidance through the challenges of a Master's thesis project with the freedom to develop your own ideas, and
- that after all is fun and supportive to work with.

This newsletter tells you more about the research in the AIS group, the topics that we focus on, with whom we collaborate, in what kind of projects, who we are and typical Master's thesis topics that we supervised in the last years. The AIS group is continuously looking for bright students eager to do a Master project, internship, seminar, or capita selecta. So, please approach us when you are interested or want to know more!

Are you looking for a Master's thesis topic that

- solves a challenging real-world problem,
- allows you to become a specialist in the area of processes and information systems,
- gives you cutting-edge knowledge to solve today's problems regarding processes and their use in all kinds of organizations and companies?

Research lines

Assignments for master projects typically fall in one of the main three research lines of AIS:

Research Line 1: Process Modeling/Analysis

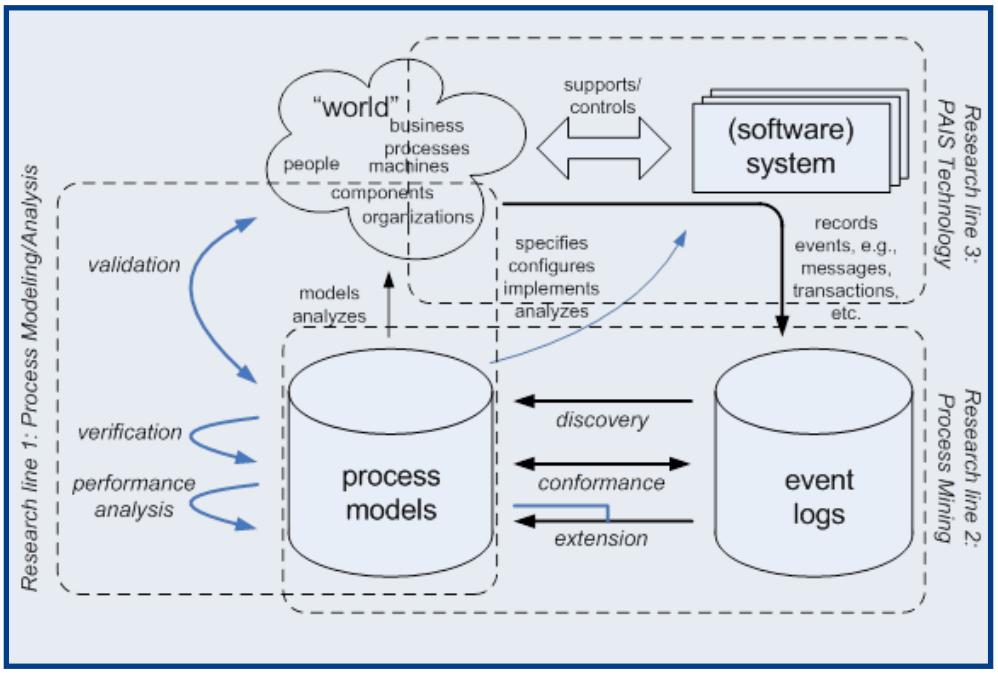
While various types of process notations are used in industry, formal models such as Petri nets and temporal logics are more suitable for analysis purposes. Driven by questions from the other two research lines (process mining and PAIS technology), particular models (e.g., WF-nets, WF-nets with data and resources, and declarative models) are used to answer questions related to correctness and performance. The main techniques that are used are model checking, structural techniques (e.g. invariants), and simulation.

Research Line 2: Process Mining

Process mining techniques are used to extract process-related information from event logs, e.g., to automatically discover models, check conformance, and augment existing models with additional insights extracted from some event log. The main difference with Research Line 1 is that event logs play a central role (rather than predefined process models). One of the main challenges is to significantly improve the state-of-the-art in process discovery, e.g., we want to be able to deal with less structured processes and huge data sets ("Big Data").

Research Line 3: PAIS Technology

PAISs are used to manage and execute operational processes involving people, applications, and/or information sources. Examples are WFM (Workflow Management), BPM (Business Process Management), and ERP (Enterprise Resource Planning) systems. Increasingly, these systems are driven by models (connection to Research Line 1) and produce high-quality event logs (connection to Research Line 2). We are interested in the artifacts used and produced by these systems (i.e., models and logs) as these are essential for testing the techniques developed in the two other research lines.



The diagram

The connections between the three research lines are illustrated by the diagram. Process models can be used to describe and analyze processes, but may also be used to specify, configure, or implement information systems. The left-hand-side of diagram shows some examples of design-time analysis: validation (i.e., testing whether the process behaves as expected), verification (i.e., establishing the correctness of a process definition), and traditional (i.e., non-log based) performance analysis (e.g., using simulation to evaluate the ability to meet requirements with respect to throughput times, service levels, and resource utilization).

Traditionally, most of AIS's research focused on design-time analysis. However, more and more information about (business) processes is recorded by information systems in the form of so-called "event logs". IT systems are becoming more and more intertwined with these processes, resulting in an "explosion" of available data that can be used for analysis purposes. The goal of process mining is to extract process-related information from event logs, e.g., to automatically discover a process model by observing events recorded by some information system. However, process mining is not limited to discovery and also includes conformance checking (investigating whether reality conforms to a given model and vice versa) and extension (augmenting an existing model with additional insights extracted from some event log).

About the AIS group

The Architecture of Information Systems (AIS) research group investigates methods, techniques and tools for the design and analysis of Process-Aware Information Systems (PAIS), i.e., systems that support business processes (workflows) inside and between organizations. We are interested in these information systems, their architecture, and innovative techniques to model and analyze the business processes and organizations supported by such systems.

Our mission is to remain one of the worldwide leading research groups in process modeling and analysis, process mining, and PAIS technology. We aim at results that are highly original and applicable in real-life situations. Our motto is

"Process Technology that Works"

The research concentrates on formalisms for modeling and methods to discover and analyze models. On the one hand formal methods are being used, e.g., the group has a long tradition in Petri-net modeling and analysis. On the other hand, we are interested in modeling languages widely used in industry (BPMN, EPCs, UML, BPEL, etc.). In contrast to many other research groups we do not accept a model as an objective starting point, i.e., we also try to discover process models through process mining and check the conformance of models based on reality.

The AIS group tries to make research results accessible by providing (open-source) software. Notable examples are ProM (process mining and process analysis), YAWL (workflow management), Declare (workflow management) and CPN Tools (model-based analysis, simulation). These implementation efforts illustrate that the problems of tomorrow's practice are the driving force behind the development of new theory, methods, and tools by AIS.

Fluxicon Process Laboratories	Process Mining
Pallas Athena (now part of Lexmark/Perceptive Software)	Business Process Management, Process Mining, and Simulation
Futura Process Intelligence (now part of Lexmark/ Perceptive Software)	Process Mining
IBM Research (Haifa & Watson)	Artifact-Centric Business Process Management
Academic Medical Center (AMC)	Business Process Management, Process Mining
Maastricht University Medical Center	Healthcare, Process Mining
Isala Clinics	Healthcare, Process Mining
Institute of Mental Healthcare Eindhoven (GGzE)	Healthcare, Process Mining
Philips Healthcare & Philips Research	Process Mining
Cordys	Process Mining
Dimpact	Business Process Management and Configurable Process Models
Philips Research	Process Mining
Thales	Process Mining
SAP	Process Mining
Quintiq	Optimization, Planning and Scheduling
HumanCapitalCare	Healthcare, Process and Data mining
Vanderlande	Process Modeling, Verification
CoSeLoG municipalities (10 Dutch municipalities)	Business Process Management, Configurable Process Models, and Process Mining

Cooperation with Other Organizations

The AIS group aims to do high-quality research that has a high scientific and societal impact. This can be measured by articles in peer reviewed top journals (IS, CACM, TDKE, DSS, etc.) and top conferences (BPM, Caise, etc.), citations, open-source software, downloads of our software, spin-off's, commercial tools extended/based on our ideas, and organizations using our ideas and software. To achieve our ambitious goals we are collaborating with a large number of academic and industrial parties in the Netherlands and abroad. For example, we are working with Business Process Management (BPM) groups all over the globe: Queensland University of Technology, University of Rostock, Technical University of Lisbon, Katholieke Universiteit Leuven, Universitat Politècnica de Catalunya, Humboldt-Universität zu Berlin, Tsinghua University, Universität Innsbruck, Ulsan National Institute of Science and Technology, Vienna University of Technology, WU Vienna, Universität Ulm, University of Padua, University of Tartu, and Moscow Higher School of Economics. We also work with many organizations (software vendors, consultancy firms, and end-user organizations). For example, we have applied our process mining tools in more than 100 organizations (e.g., Philips Healthcare, AMC Hospital, ASML, and IBM). We are also leading the IEEE Task Force on Process Mining (involving more than 50 organizations) and established both the Dutch and the European BPM Roundtables to interact with industry.

The table to the left shows some of the organizations we are actively collaborating with.

Impact and societal relevance

When selecting a Master project it is advisable to consider the track record of the research group supervising the project. Therefore, we briefly discuss the impact and societal relevant of AIS's research.

The work of the AIS group is world renowned, especially in the fields of (1) the modeling and analysis of workflow processes (cf. workflow nets and the seminal soundness notion), (2) workflow patterns (the DAPD paper on the workflow patterns is the most cited paper in the BPM domain and the Workflow Patterns web site www.workflowpatterns.com is the most visited web site on workflow management over the last decade), and (3) process mining (e.g., we established an international process mining community). The impact of our work is reflected by the many citations of the publications of the AIS group. For example, Wil van der Aalst is the highest ranked European computer scientist based on Google Scholar. His work has been cited more than 50,000 times and his Hirsch Index is more than 100. During the last evaluation of all computer science groups in the Netherlands, the AIS group got the highest marks possible: 5-5-5-5-5 (i.e., a perfect score).

The workflow patterns have had a very positive effect on commercial WFM/BPM products. Today, the patterns are widely used to describe workflow functionality in a language/system-independent manner. In addition, the patterns are also highly visible. The www.workflowpatterns.com web site has been one of the most visited web sites in the field of BPM averaging more than 300 unique visitors per working day over the last decade. Several vendors changed their tools to support more patterns and some have provided wizards based on the patterns. For example, IBM recently added a wizard-like functionality to their WebSphere product inspired by the patterns. Also standardization efforts were influenced by the patterns, see for example BPMN.

AIS is closely collaborating with various software vendors and consultancy firms. For example, we have been working with Pallas Athena-recently acquired by Lexmark/Perceptive Software-for more than 15 years. Ideas and software related to process mining, simulation and case handling developed by AIS have been integrated in their products. They are also sponsoring the chair on Business Process Technology (prof. Reijers) and two PhD positions. AIS also collaborates with end-user organizations. For example, Philips Healthcare uses our software and sponsored a PhD position during the review period. In the CoSeLoG project we are working with 10 municipalities (Bergeijk, Bladel, Coevorden, Eersel, Emmen, Gemert-Bakel, Hellendoorn, Oirschot, Reusel de Mierden, and Zwolle). The core processes of these Dutch municipalities are compared and analyzed using process mining. Moreover, we are realizing a prototype BPM system where the different municipalities are sharing a cloud-based BPM solution based on configurable processes models (C-YAWL). Another example is the Stress@work activity in the context of EIT ICT Labs where we develop e-services for job stress management, based on the methods developed for operational support (prediction and recommendation) services for business processes. Combinations of innovative stress measuring sensor technologies and data and process mining techniques are tested in collaboration with Philips Research, Aalto University and HumanCapitalCare (an occupational health organization).

Open Source Software

The AIS group aims to impact society by developing open-source software that is widely used. Our tools serve as examples for commercial systems. This impact is illustrated by the number of downloads. YAWL has been downloaded more than 125,000 times (approx. 54,500 times since 2009), ProM has been downloaded more than 87,000 times (approx. 62,000 times since 2009), and CPN Tools has been downloaded more than 65,000 times (approx. 28,000 times since 2009). Note that ProM, YAWL, and CPN Tools are not commodity tools, but advanced software products related to the business process analysis and enactment. Hence, these numbers are quite remarkable. Our open-source software tools also serve as examples for developers of commercial tools. For example, our ideas related to process mining have been used in BPM|one, Reflect, Disco, and ARIS PPM.

We have applied ProM in over 100 organizations. Examples are municipalities (about 20 in total, e.g., Alkmaar, Heusden, and Harderwijk), government agencies (e.g., Rijkswaterstaat, Centraal Justitieel Incasso Bureau, and the Dutch Justice department), insurance related agencies (e.g., UWV), banks (e.g., ING Bank), hospitals (e.g., AMC hospital and Catharina hospital), multinationals (e.g., DSM and Deloitte), high-tech system manufacturers and their customers (e.g., Philips Healthcare, ASML, Ricoh, and Thales), and media companies (e.g., Winkwaves).

Staff involved

Dr. Natalia Sidorova is assistant professor at the AIS group. She actively works on topics related to process modeling and verification. The application domains include business processes and distributed systems. She has published more than 70 conference and journal papers. She is active in the Health and Wellbeing Action Line of EIT ICT Labs, taking lead of projects towards the development of innovative services for disease prevention making use of modern sensor technologies together with mining, conformance analysis, prediction and recommendation techniques.

Dr. Boudewijn van Dongen is assistant professor at the AIS group. He has been doing research in the process mining area for more than 10 years and he has been involved in the development of the process mining framework ProM from the start. His research focuses on process discovery and conformance and he has published numerous papers in journals and conference proceedings in both areas. For his teaching, Boudewijn has received a best teacher award from the students association GEWIS. In his courses, Boudewijn focuses not only on the correct design, but also on the correct use of various modeling techniques.

Dr. Dirk Fahland is assistant professor at the AIS group researching in the area of distributed systems. His research and teaching interests include distributed processes and systems built from distributed components for which he investigates modeling systems (using process modeling languages, Petri nets, or scenario-based techniques), analyzing systems for errors or misconformances (through verification or simulation), repairing erroneous/misconforming systems, discovering system models from event logs, and synthesizing systems and components from specifications. Dirk Fahland has published 20 conference and journal articles and actively develops several software tools and plugins which realize his ideas. List of available Master thesis topics.

Dr. Massimiliano de Leoni is assistant professor at the AIS group. His research focuses in the areas of Process-aware Information Systems and Business Process Management, predominantly on multi-perspective process mining, process-aware decision support systems as well as on visualization techniques for business process management and analysis. He has a genuine interest in the practical applications of his research in real-life settings, which led him to concretely develop his ideas in term of software tools and apply them with a large number of organizations world-wide.

Prof. Wim Nuijten is a part-time professor at the AIS group focusing on Intelligent Information Systems. He is an expert in the area of constraint programming en advanced planning and scheduling. Currently, he is working for Quintiq, a company leading in the area of advanced planning and scheduling. Before, we worked within IBM and ILOG.

Prof. Hajo Reijers is a part-time professor at the AIS group as well as head of BPM research at Perceptive Software. He is interested in the interplay between science and industrial practice, specifically when it relates to the use of advanced technologies to improve and support the execution of business processes. Hajo Reijers published over 150 scientific papers, chapters in edited books, and articles in professional journals. He has worked for several years at companies such as Deloitte and Accenture and spent research stints at MIT, Stevens Institute of Technology, and Queensland University of Technology. He is open to supervise master projects in the areas of case management, configurable models, social BPM, and operational workflow support.

Prof. Wil van der Aalst

Prof. Wil van der Aalst is head of the AIS group and an active researcher working on topics ranging from concurrency theory to process-aware information systems. His research and teaching interests include workflow management, process mining, Petri nets, business process management, process modeling, and process analysis (simulation, verification, etc.). Wil van der Aalst has published more than 165 journal papers, 17 books (as author or editor), 350 refereed conference/workshop publications, and 60 book chapters. Many of his papers are highly cited (he has an H-index of more than 100 according to Google Scholar, making him the European computer scientist with the highest H-index) and his ideas have influenced researchers, software developers, and standardization committees working on process support.

Example projects

Model merging in the context of configurable process models

Borana Luka—internal/CoSeLog project involving 10 municpalities

While the role of business process models in the operation of modern organizations becomes more and more prominent, configurable process models have recently emerged as an approach that can facilitate their reuse, thereby helping to reduce costs and effort. Configurable models incorporate the behavior of several model variants into one model, which c4an be configured and individualized as necessary. The creation of configurable models is a complicated process, and tool support for it is in its early steps. In her thesis, Borana Luka evaluates two existing approaches to process model merging which are supported by tools and test an approach to model merging based on the similarity between models. Borana's work resulted in a paper presented in the 2011 International Workshop on Process Model Collections.

Process mining tools: A comparative analysis

Irina-Maria Ailenei—External (Fluxicon)

In her thesis, Irina-Maria Ailenei proposes an evaluation framework that is used to assess the strengths and the weaknesses of process mining tools. She applied the framework in practice for evaluating four process mining systems: ARIS PPM, Flow, Futura Reflect, and ProcessAnalyzer. The framework is based on a collection of use cases. A use case consists of a typical application of process mining functionality in a practical situation. The set of use cases was collected based on the functionality available in ProM and was validated by conducting a series of semi-structured interviews with process mining users and by conducting a survey. The validated collection of use cases formed the base of her tool evaluation. The project was conducted within Fluxicon and was created based on a request from Siemens. The work also resulted in a paper presented at the BPI workshop in Clermont-Ferrand in 2011.

Discovery and analysis of field service engineer process using process mining

Stefania Rusu—External (Philips Healthcare)

In her thesis, Stefania Rusu applied process mining techniques using event logs from Philips Healthcare to get insights into the workflow of Field Service Engineers. In order to get insights into Philips's Field Service Engineers Stefania created hierarchical models that abstract from the low levels at which events are stored to higher levels of activities, based on the role of the analyst. Performance analysis based on process mining techniques helped to identify bottlenecks and thereby generated ideas for improvement regarding the work of Field Service Engineers within Philips Healthcare. Stefania proposed a new approach to annotate process maps with performance information extracted from event logs. To support the approach and to apply in in practice, she implemented a new plug-in in the ProM framework.

Configurable Declare

Dennis Schunselaar—Internal

Declarative languages are becoming more popular for modeling business processes with a high degree of variability. Unlike procedural languages, where the models define what is to be done, a declarative model specifies what behavior is not allowed, using constraints on process events. In his thesis, Dennis Schunselaar studies how to support configurability in such a declarative setting. He takes Declare as an example of a declarative process modeling language and introduces Configurable Declare. Configurability is achieved by using configuration options for event hiding and constraint omission. He illustrated our approach using a case study, based on process models of ten Dutch municipalities. A Configurable Declare model is constructed supporting the variations within these municipalities.

Guided configuration of industry reference models

Cosmina Cristina Niculae—External (To-Increase)

Configurable process models are compact representations of process families, capturing both the similarities and differences of business processes and further allowing for the individualization of such processes in line with particular requirements. Such a representation of business processes can be adopted in the consultancy sector and especially in the ERP market, as ERP systems represent general solutions applicable for a range of industries and need further configuration before being implemented to particular organizations. Configurable process models can potentially bring several benefits when used in practice, such as faster delivery times in project implementations or standardization of business processes. Cosmina Niculae conducted her project within To-Increase B.V., a company that specializes in ERP implementations. She developed an approach to make configuration much easier, implemented it, and tested it on real-life cases within To-Increase.

Artifact-Centric Process Analysis, Process discovery in ERP systems

Erik Nooijen—External (Sligro)

In his thesis, Erik Nooijen developed an automated technique for discovering process models from enterprise resource planning (ERP) systems. In such systems, several different processes interact together to maintain the resources of a business, where all information about the business resources are stored in a very large relational database. The challenge for discovering processes from ERP system data, is to identify from arbitrary tables how many different processes exist in the system, to extract event data for each instance of each process in the system. Erik Nooijen identified a number of data mining techniques that can solve these challenges and integrated them in a software tool, so that he can automatically extract for a process of the ERP system an event log containing all events of that process. Then classical process discovery techniques allow to show the different process models of the system. Erik conducted his project within Sligro where he is actively using his software to improve the company's processes. The thesis resulted in a workshop paper presented at the International Conference on Business Process Management 2012 in Tallinn, Estonia.

VDSEIR - A graphical layer on top of the Octopus toolset

Bram in 't Groen—External (ESI)

In his work, Bram in 't Groen introduces a graphical representation for DSEIR (a language used in the Octopus toolset for designing embedded systems) called Visual DSEIR (VDSEIR). By using VDSEIR, users of the toolset can create specifications in DSEIR by means of creating graphical models, removing the need for those users to know how to program in the Octopus API. Bram in 't Groen provides a model transformation from VDSEIR to DSEIR that makes use of an intermediate generator model and a parser that is automatically generated from an annotated JavaCC grammar. The graphical representation for DSEIR consists of several perspectives and it contains a special form of syntactic sugar, namely hierarchy. It is possible to create hierarchical models in the graphical representation without having support for hierarchy in the original DSEIR language, because these hierarchical models can be translated into non-hierarchical DSEIR models. This way, additional expressiveness is created for the user, without modifying the underlying toolset.

Procedure for Master projects

Within the AIS group, we believe that students should be as free as possible to find a supervisor for their Master projects. Therefore, we encourage students to contact a potential supervisor as early as possible in their studies (typically around the end of the first year, after you have obtained 40 to 50 credits). Students should talk to potential supervisors about the possibilities for a Master project, but at some point the student has to commit to a particular supervisor. Only then an actual assignment can be defined, either internal or external. Within the AIS group, we do not keep a ready-made list of possible assignments, as generally assignments are defined for an individual student, with that student's skills in mind. It's important for students to commit to a supervisor, since contacting companies for assignments is a time-consuming task, in particular for these companies, and it would make a bad impression if a company reserves time for an assignment and then a student would decline such an assignment.

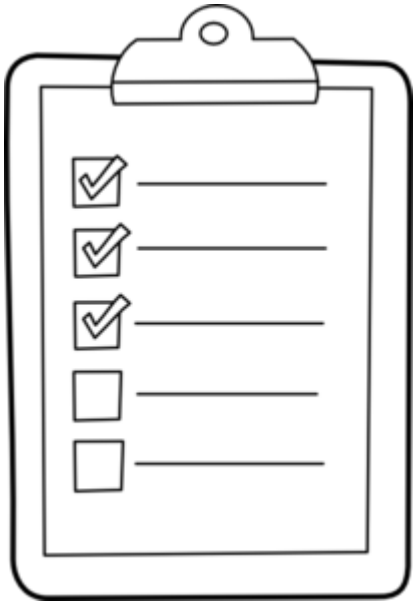
Once the student commits to a supervisor, the student and supervisor together decide on the elective courses that the student will include in his/her study program. These electives may be specifically chosen to prepare for an assignment or to broaden the knowledge of the student which can be of use in their future careers. The study program listing these electives is filled out by the student and signed by both student and supervisor before being sent to the administration. In some cases, special permission from the examination committee is needed for a particular set of electives.

While finishing the last couple of courses, but before the start of the Master project, the student fills in the graduation plan, which includes a short description of the assignment. This form needs to be signed by the supervisor, the student, the head of the area of expertise (for AIS, this is prof. Wil van der Aalst) and the student advisor (dr. Peter Veltkamp). A student can start his/her Master project only after obtaining sufficient credits. Furthermore, all homologation and bachelor courses need to be completed. If not all credits have been obtained, then the graduation supervisor has to agree that there are still uncompleted courses. Please be aware that taking courses next to doing a Master program is generally ill-advised and will always lead to a delay in the Master project.

Towards the end of the Master project, an assessment committee has to be formed, consisting of your supervisor, a company supervisor (or, in case of an internal assignment, your tutor) and an external member. This external member has to be an (assistant) professor working in another area of expertise, or in the Information Systems group of the department of Industrial Engineering and Innovation Sciences. The assessment committee form needs to be filled out no later than 1 month before the actual presentation date.

No later than two weeks before the presentation, the student has to send his/her Master thesis to the external member of the assessment committee. This should be the final version of the thesis, i.e. without missing chapters etc.

After the presentation, the Master defense will take place. The procedures for the Master defense are as follows. First, the student presents, in about 30 minutes, his/her work. This presentation is public and we encourage you to invite family and friends to this presentation, although the intended audience are your fellow students. After the presentation, the audience can ask questions. Once all these questions are answered, the actual defense start. During this 30 to 45 minutes, the assessment committee will ask the student questions about their work, but also about related topics. This defense is not public and the goal of the assessment committee is to assess the academic quality of the work. Finally, the assessment committee will fill out the graduation form and inform you of the grade.



Links

- Short overview of this procedure,
- Forms