Onderwerpen masterproeven 2021-2023 aan de onderzoeksgroep “Operations Research and Scheduling”

- Mario Vanhoucke (ZAP)
- Annelies Martens (PostDoc)
- Tom Servranckx (PostDoc)
- Jakob Snauwaert (WP)
- Dries Bredael (WP)
- Rojin Nekoueian (WP)
- Forough Vaseghi (WP)

Aantal beschikbare onderwerpen: **28**
Totaal aantal studenten toegewezen aan een onderwerp: **0**

Belangrijke boodschap aan studenten: Voor sommige onderwerpen waar reeds studenten werden toegewezen laten we ook nog andere studenten toe. Indien interesse in een onderwerp dat reeds werd toegewezen, kan je alsnog een mail sturen naar de desbetreffende begeleider. De begeleider laat dan asap weten of het onderwerp nog kan gekozen worden. Uiteraard zijn alle openstaande onderwerpen nog beschikbaar.

Enkele belangrijke data:
- Indienen titel masterproef: uiterlijk 26 oktober 2021
- Indienen summary sheet: uiterlijk 15 februari 2022 (richtlijnen beschikbaar bij de begeleider)
- Indienen tussentijds rapport: uiterlijk 13 mei 2022
- Indienen executive summary: uiterlijk 3 oktober 2022 (richtlijnen beschikbaar bij de begeleider)
- Indienen thesis: Mei 2023 (datum nog nader te bepalen door FSA)

Wij zijn op zoek naar gemotiveerde studenten die zich met plezier willen inwerken in het domein van Operationeel Onderzoek & Management Science.

Wij verwachten van de studenten:

We verwachten van alle masterproefstudenten dat zij zelfstandig kunnen werken en dat zij een kwantitatieve ingesteldheid hebben. Voor sommige onderwerpen zijn we op zoek naar studenten die graag programmeren en die bereid zijn de basisprincipes van C++ onder de knie te nemen. Voor andere onderwerpen is kennis van programmeren totaal overbodig. Wat we vooral verwachten is:
- Inzet en motivatie vanaf begin oktober
- Samenkomsten op vooraf geregelde tijdstippen om de voortgang en/of resultaten gezamenlijk te bespreken
- Opmaak van de masterproef in LaTex
- Aanleren van de basisprincipes van C++ voor de start van het academiejaar (handleiding beschikbaar) (indien programmeerkennis vereist is voor de thesis)

De output bestaat uit een tussentijds thesisverslag in jaar 1 en een finale versie in jaar 2.

Jaar 1. Tussentijds verslag.

Het tussentijds verslag telt mee als deel van de finale evaluatie, en moet dus grondig worden opgemaakt. Download daarom de richtlijnen van het tussentijds verslag en lees deze aandachtig. Om deze richtlijnen wat concreet te maken, hebben we via onderstaande links drie voorbeeldverslagen beschikbaar gesteld:

- Verslag 1. Zwak verslag, Het verslag bevat geen enkele vernieuwing en is puur een samenstelling van bestaand onderzoek. De onderzoeksvraag is niet afgelijnd en het toekomstig werk werd niet perfect gedefinieerd.
- Verslag 2. Matig verslag. Het verslag bevat voldoende materiaal dat kan dienen als overzicht van de thesis, maar mist een grondig overzicht van het reeds gedane werk en bijhorende behaalde resultaten. Bovendien is het verslag niet origineel en vernieuwend.
- Verslag 3. Excellent verslag. Het verslag bevat concrete doelstellingen, voldoende vooruitgang en diepgang én een sterke kijk op het toekomstig werk. Schitterende verzorging.

Jaar 2. Finale thesis.

De praktische richtlijnen qua lettertype, vormgeving, etc. voor het finaal thesisverslag kan je op Ufora vinden. De inhoudelijke richtlijnen die wij als OR&S onderzoeksgroep nastreven vind je via de volgende link: finale thesis.

Wij bieden aan de studenten:
- Een onderwerp dat in de lijn ligt van onze huidige onderzoeksactiviteiten
- Opvolging van de ontwikkeling van het programma en de analyse van de resultaten

Bij elk onderwerp worden de contactpersoon, vereiste vaardigheden, maximaal # studenten en inhoudelijke aspecten kort vermeld. De inhoudelijke aspecten beschrijven kort waar de klemtoon van de masterproef ligt, maar dit kan uiteraard ten alle tijde, volgens de interesse van de student, aangepast worden.

Inhoudelijke aspecten zijn:
- Literatuurstudie: ondersteunend, eventueel uitgebreid, uitgebreid of hoofddoel van de masterproef
- Case study/oefening: neen, optioneel of hoofddoel van de masterproef
- Software gebruik: neen, optioneel of ja
- C++: neen, optioneel of ja (of eventueel een andere taal, bv. Java, VBA in excel, etc.)

Research topics

Students are free to propose any other topic related to project management or operations research. Alternatively, they can select one of the challenging topics from the list below.

Topic: An analysis of empirical and case study data in project management: planning, risk or control.

A crucial part of project management research is the validation and extension of research ideas and methodologies proposed in the literature using empirical data. The difference between the controlled, artificial setting and the real, practical environment implies that certain techniques will need to be adjusted in order to better fit with the needs of project managers. Also, theoretical results might deviate from practical and empirical experience resulting in relevant managerial insights. Finally, empirical research might show that certain techniques perform better for certain types of projects or industries. The focus can lie on one of the following three themes (or a combination) as described below:

- Project planning: Resource-constrained project scheduling and its extensions are topics that are investigated widely in the literature, and the OR&S group has done a lot of research for these challenging domains. There is a increasing interest to collect and analyse data about project schedules with flexibility, multi-skilled workforces, project portfolios, etc.
- Project risk: Schedule risk analysis requires detailed risk information on the activity level as well as data about external risk factors. The more accurate the data, the more reliable the results of a traditional simulation study. Further, (external) risks at the activity level affect the final project duration and cost. Techniques such as reference class forecasting help in assessing the impact of these risks on the project outcome. This thesis focuses on data collection and empirical validation of this challenging domain.
- Project control: Project control is traditionally done using Earned Value Management (EVM) methodologies. Studies have shown that (1) numerous extensions are available that extend the EVM methods to more realistic methodologies and (2) theoretical results often deviate from practical and empirical experience. In recent years, techniques such as tolerance limits for project control and corrective actions (activity crashing, fast tracking and variability reduction) received increased attention. Since most studies have used artificial data, these techniques should be validated on empirical data.

Empirical research can be conducted in one of the following ways (or a combination) as described below: (1) Analysis of existing data, (2) Collection (and analysis) of new data and (3) Generation of case study data. First of all, the OR&S research group has collected a large dataset of real project data over the past years that can be used by the student(s) to test hypotheses and investigate existing methodologies. Secondly, the student(s) can contact companies to collect new project data, using a standardised methodology of the OR&S research group, and afterwards analyse this data. Thirdly, the student(s) can develop complex case studies based on an extensive literature review or web-based methods. Based on a good knowledge of the project management problem, these case studies can be used to obtain novel insights and/or test existing hypotheses using a controlled, yet pragmatic approach. More information about the existing data, as well as the tool to analyse new results, can be found at www.projectmanagement.ugent.be/research/data.

- Advisor: Mario Vanhoucke

- Contact person: Tom Servranckx (tom.Servranckx@UGent.be)
- Required skills: Project Management, Scheduling, Risk analysis, Earned Value Management
- Extra information:
  - This thesis is suitable for two students. Use of LaTeX is mandatory.
  - Literature review is supportive but not the main theme of the thesis
  - Case study is required
  - Software use is optional (MS Excel, ProTrack, …)
  - Modeling and analysis: Main goal of the thesis

Topic: Improved project scheduling techniques for sustainable construction projects: a case study

In recent years, there is an increased interest for green or energy-efficient construction projects. Already during the early project planning phase, the project manager needs to balance profit/time-driven objectives with green objectives in order to ensure a low environmental impact during the construction process. In this thesis, the traditional project scheduling techniques (RCPSP, MRCPSP, RCPSP-AS) will be extended to incorporate sustainability parameters of activities, resources and technologies. In case that activities are selected and resources/technologies are deployed, the student will not only consider the basic time and cost information, but also monitor and optimise the sustainability component (carbon emissions, electricity usage, etc.). In this thesis, the student will develop a heuristic approach to schedule green construction projects using empirical data. This data can be obtained using existing datasets from - for example - the OR&S research group at Ghent University (www.projectmanagement.ugent.be/research/data) or the DS&A research group at UNSW Sydney (https://research.unsw.edu.au/projects/decision-support-analytics-research-group) as well as real-life data obtained from Upgrade Estate.

- Advisor: Mario Vanhoucke
- Contact person: Tom Servranckx (tom.Servranckx@UGent.be)
- Required skills: Project management, Construction planning, Sustainability, Optimisation
- Extra information:
  - This thesis is suitable for two students. Use of LaTeX is mandatory.
  - Literature review is supportive but not the main theme of the thesis
  - Case study is required
  - Software use: Depends on how the research will be approached
  - Modeling and analysis: Main goal of the thesis

Topic: Framework for green technologies in construction projects: an empirical approach

Project managers aim at delivering project outcomes that generate the required benefits for the project funder. With the construction of energy-friendly and carbon-neutral buildings, this match between project outcomes (i.e. building's functionalities) and project benefits (i.e. sustainable way of living) is more than ever impacted by clean and green construction. Innovative technologies are crucial for matching these project outputs and benefits, however, insufficient knowledge is available about the impact of these green technologies in construction projects. The objective of this thesis is to identify and categorise green technologies through interviews with field experts and quantify this information such that it can be processed in project scheduling software. An analytical approach to organise and map the technologies, outcomes and benefits should be presented based on - for example - quality function deployment (QFD). In this thesis, the student will develop a framework to identify and select green technologies for the construction sector as well as validate this framework using case data. This data can be obtained using existing datasets from - for example - the OR&S research group at Ghent University (www.projectmanagement.ugent.be/research/data) or the DS&A research group at UNSW Sydney (https://research.unsw.edu.au/projects/decision-support-analytics-research-group) as well as real-life data obtained from Upgrade Estate.

- Advisor: Mario Vanhoucke
- Contact person: Tom Servranckx (tom.Servranckx@UGent.be)
- Required skills: Project management, Construction planning, Sustainability, Optimisation
- Extra information:
  - This thesis is suitable for two students. Use of LaTeX is mandatory.
  - Literature review is supportive but not the main theme of the thesis
  - Case study is required
  - Software use: Depends on how the research will be approached
  - Modeling and analysis: Main goal of the thesis

Topic: The short-term and long-term impact of green technologies in construction projects: a simulation study

Construction projects are characterised by two main phases. First, the project is completed and delivered in the project execution phase, subsequently, the long-term maintenance phase starts in order to update the project over a finite (but unknown) time horizon. Project and maintenance scheduling are crucial to ensure project success in the short-term (project completion) and long-term (project maintenance). Where the impact of the decisions taken by the project manager during project scheduling on the project outcome have already been extensively investigated in the literature, the link with maintenance scheduling is less studied. Maintenance scheduling focuses mostly on customer-related aspects (such as number of defects and downtime) or cost-related aspects (such as the maintenance costs). In the future, however, we will need to also consider sustainability aspects during both project execution and long-term maintenance of construction projects. In this thesis, the student will investigate the impact of technology choices during project execution on environmental performance measures 1) throughout the construction phase and 2) many years after project completion. The objective of this thesis is to simulate the impact of different technologies on various criteria using scenarios based on empirical data. This data can be obtained using existing datasets from - for example - the OR&S research group at Ghent University (www.projectmanagement.ugent.be/research/data) or the DS&A research group at UNSW Sydney (https://research.unsw.edu.au/projects/decision-support-analytics-research-group) as well as real-life data obtained from Upgrade Estate.

- Advisor: Mario Vanhoucke
- Contact person: Tom Servranckx (tom.Servranckx@UGent.be)
- Required skills: Project management, Construction planning, Sustainability, Optimisation
- Extra information:
  - This thesis is suitable for two students. Use of LaTeX is mandatory.
  - Literature review is supportive but not the main theme of the thesis
  - Case study is required
  - Software use: Depends on how the research will be approached
  - Modeling and analysis: Main goal of the thesis

Topic: Modeling and simulating uncertainty in corrective actions to improve the project control decision making process

Project control is the process of monitoring the project progress during execution and taking corrective actions when necessary. In the project management literature, different corrective actions types are discussed (i.e. activity crashing, fast tracking and variability reduction). While actual activity durations and costs are regarded to be uncertain, the impact of corrective actions is often assumed to be fixed and known in advance. In this thesis, the uncertain impact of actions should be modeled for each type of corrective actions, and a simulation study should be conducted to compare the different corrective actions types, given their uncertain outcome.

- Advisor: Mario Vanhoucke
- Contact person: Annelies Martens (annelies.martens@ugent.be)
- Required skills: Project management, project control
- Extra information:
  - This thesis is suitable for two students. Use of LaTeX is mandatory.
  - Literature review is supportive but not the main theme of the thesis
  - Case study is not possible
  - Software use: P2 Engine / Python / C++
  - Modeling and analysis: Main goal of the thesis

Topic: Modeling and simulating the impact of activity duration dependencies and side-effects of corrective actions during the project control process

Project control is the process of monitoring the project progress during execution and taking corrective actions when necessary. Several types of corrective actions have been proposed to get the project back on track and ensure timely project completion (i.e. activity crashing, fast tracking and variability reduction). However, corrective actions on an activity might cause side-effects on other activities, such as quality losses and an increased probability that rework might be required. Further, activity durations are not necessarily independent, since they can be correlated with other activities or might suffer from a project-wide estimation bias. The goal of this thesis is to model these side-effects and activity dependencies and to conduct a simulation study in which the impact of these elements on the project outcome is examined.

- Advisor: Mario Vanhoucke
- Contact person: Annelies Martens (annelies.martens@ugent.be)
- Required skills: Project management, project control
- Extra information:

- This thesis is suitable for two students. Use of LaTeX is mandatory.
- Literature review is supportive but not the main theme of the thesis
- Case study is not possible
- Software use: P2 Engine / Python / C++
- Modeling and analysis: Main goal of the thesis

Topic: Comparing a resource level and activity level control approach: modelling and simulating corrective actions for resource uncertainty

Project control is the process of monitoring the project progress during execution and taking corrective actions when necessary. In general, project delays are considered to be caused by variability in the actual activity durations and corrective actions are focused on the activity level (i.e. activity crashing, fast tracking and variability reduction). Besides activity duration variability, uncertainty regarding the project resources is a common cause of project delays. Therefore, this thesis aims at modelling resource uncertainty (variability in availability and potential breakdowns) and proposing corrective actions at the resource level (i.e., increasing, the availability, reducing the variability and reducing the probability of failure). A simulation experiment should be conducted to compare the effectiveness of activity level and resource level corrective actions

- Advisor: Mario Vanhoucke
- Contact person: Annelies Martens (annelies.martens@ugent.be)
- Required skills: Project management, project control
- Extra information:
  - This thesis is suitable for two students. Use of LaTeX is mandatory.
  - Literature review is supportive but not the main theme of the thesis
  - Case study is not possible
  - Software use: P2 Engine / Python / C++
  - Modeling and analysis: Main goal of the thesis

Topic: Simulation study on strategies for the corrective action taking process to improve the project control decision making process

Project control is the process of monitoring the project progress during execution and taking corrective actions when necessary. The corrective action taking process comprises several decisions that should be made simultaneously, i.e. how much and which activities should be taken corrective actions on, which type of actions should be taken and how large should the action be in order to achieve timely project completion without incurring excessive costs. The aim of this study is to identify different strategies for the corrective action taking process and conduct a simulation experiment to review the effectiveness of these strategies.

- Advisor: Mario Vanhoucke
- Contact person: Annelies Martens (annelies.martens@ugent.be)
- Required skills: Project management, project control
- Extra information:
  - This thesis is suitable for two students. Use of LaTeX is mandatory.
  - Literature review is supportive but not the main theme of the thesis
  - Case study is not possible.
  - Software use: P2 Engine / Python / C++
  - Modeling and analysis: Main goal of the thesis

Topic: Multi-attribute decision-making to select alternatives in the project structure

The project management process consists of scheduling the project activities, analysing the project risk and monitoring the project progress. However, these steps assume that the scope of the project is determined by the project manager (i.e. the required activities are determined, the skilled resources are identified and the complex relations between activities are analysed). In other words, the project manager will have to choose between different alternative ways to execute work packages in the project or even select appropriate subcontractors to execute the work packages, prior to project scheduling. This is a complex decision-making problem since the alternatives/subcontractors will be scored on different attributes that all contribute to the project objective. In general, information is collected about the expected or past performance of alternatives for high-level attributes such as financial metrics or production output. In project management, lower-level attributes that are related to the project scheduling process could be used. In this thesis, the student will identify relevant attributes for selecting alternatives in the project scheduling process and develop a framework for multi-attribute decision-making.

- Advisor: Mario Vanhoucke
- Contact person: Tom Servranckx (tom.Servranckx@UGent.be)
- Required skills: Project scheduling, optimisation, simulation

- Extra information:
  - This thesis is suitable for two students. Use of LaTeX is mandatory.
  - Literature review is supportive but not the main theme of the thesis
  - Case study is possible
  - Software use: C++, optionally RanGen
  - Modeling and analysis: Main goal of the thesis

Topic: The impact of alternative options on hierarchical objectives: a quantitative and qualitative evaluation.

A project is successfully managed when it is completed within time and budget…and within the project scope that has been promised to the client. The scope objective is often overlooked during project management since it is assumed that the project scope is fixed and pre-determined. However, the project manager can identify and investigate alternative ways to execute subparts of the project, called work packages, in order to improve the time or budget performance of these work packages, without considering the impact on the overall project scope (i.e. the alternative options might change the scope of the project). Therefore, the positive or negative impact of each alternative option on the low-level objectives (i.e. at the work package level) should be assessed, but this impact should be propagated bottom-up in the hierarchy of objectives towards the high-level objectives (i.e. at the project level). The student(s) should investigate whether the techniques from Requirement Engineering can be applied to project scheduling with alternative options. In this thesis, a hierarchy of objectives for project scheduling should be investigated and both quantitative and qualitative evaluation techniques should be compared.

- Advisor: Mario Vanhoucke
- Contact person: Tom Servranckx (tom.Servranckx@UGent.be)
- Required skills: Project scheduling, optimisation
- Extra information:
  - This thesis is suitable for two students. Use of LaTeX is mandatory.
  - Literature review is supportive but not the main theme of the thesis
  - Case study is possible
  - Software use: C++, optionally RanGen
  - Modeling and analysis: Main goal of the thesis

Topic: Robust workforce composition under unknown resource requirements

Organisations are always striving for a diversified workforce. A good balance of older, more experienced, employees and younger, more dynamic and creative, employees is paramount in today's organisational structure. Equally important is the inclusion of a set of specialist workers that counterbalance the large group of regular workers. Clearly, differences in skill-level and heterogeneous efficiencies will characterise these workforces. The focus of this thesis will be on analysing the characteristics of a robust multi-skilled workforce that is composed before the details of the final project are available. More specifically, the goal is to find the features of a robust workforce that can deal with unknown resource requirements. The student starts by incorporating this into a project scheduling problem and analyses the existing literature. Additionally, the student collects or generates data and uses it to test their heuristic approach to this problem.

- Advisor: Mario Vanhoucke
- Contact person: Jakob Snauwaert (jakob.snauwaert@ugent.be)
- Required skills: Project Management, Project Scheduling, Optimisation
- Extra information:
  - This thesis is suitable for two students. Use of LaTeX is mandatory.
  - Literature review is supportive but not the main theme of the thesis
  - Case study is possible
  - Software use: C++
  - Modeling and analysis: Main goal of the thesis

Topic: Frameworks for resource and skill assessment in real-life projects: analysis and development

One of the most substantial gaps in the current multi-skilled project scheduling literature involves the mismatch between the required resource and skill data for academic research and the available resource and skill data in real-life projects. In academic research, the resource-constrained multi-skilled project scheduling problem (MSRCPSP) goes out from perfect data which is not always available when solving and analysing case study projects. Therefore, the goal of this thesis is to collect and analyse existing frameworks from the literature and compare them to how resource information is collected and stored in real-life projects.

Furthermore, the student will then develop a new framework that can be used in real-life projects to fill this gap in the current literature.

- Advisor: Mario Vanhoucke
- Contact person: Jakob Snauwaert (jakob.snauwaert@ugent.be)
- Required skills: Project Management, Project Scheduling, Optimisation
- Extra information:
  - This thesis is suitable for two students. Use of LaTeX is mandatory.
  - Literature review is supportive but not the main theme of the thesis
  - Case study is required
  - Software use: C++
  - Modeling and analysis: Main goal of the thesis

Topic: Resource Renting Problem with heterogeneous efficiencies

The Resource Renting Problem (RRP) is a subproblem in project scheduling that intends to minimise resource availability costs under temporal constraints. The RRP looks for the optimal moments to hire and fire workers. This results in a trade-off between keeping idle resources, which will increase the renting costs, and firing them, which brings along procurement and removal costs. In this case, there is the extension of heterogeneous efficiencies, which means that the resource costs will vary among the different workers. The student is expected to collect empirical data and find additional practical applications of this case. This data and its characteristics will be compared to the literature. Afterwards the student analyses the empirical data thoroughly and develops a solution approach for the problem.

- Advisor: Mario Vanhoucke
- Contact person: Jakob Snauwaert (jakob.snauwaert@ugent.be)
- Required skills: Project Management, Project Scheduling, Optimisation
- Extra information:
  - This thesis is suitable for two students. Use of LaTeX is mandatory.
  - Literature review is supportive but not the main theme of the thesis
  - Case study is required
  - Software use: C++, optionally RanGen
  - Modeling and analysis: Main goal of the thesis

Topic: Coalitional Skill Games for multi-skilled resource assignment in projects

Coalitional Skill Games are part of the set of Coalitional Structure Generation problems which deal with a relevant question in multi-agent systems: “How can a number of agents be divided into multiple groups in order to maximise performance?”. The goal of the student is to apply Coalitional Skill Games on a multi-skilled project workforce in order to optimise task assignment and management in a multi-skilled resource-constrained project scheduling problem. The student starts by extensively researching the existing literature on Coalitional Structure Generation problems and multi-skilled project scheduling. Additionally, the student creates a solution approach for this problem and uses artificial data to analyse it.

- Advisor: Mario Vanhoucke
- Contact person: Jakob Snauwaert (jakob.snauwaert@ugent.be)
- Required skills: Project Management, Resource Assignment, Optimisation
- Extra information:
  - This thesis is suitable for two students. Use of LaTeX is mandatory.
  - Literature review is supportive but not the main theme of the thesis
  - Case study is optional
  - Software use: C++, optionally RanGen
  - Modeling and analysis: Main goal of the thesis

Topic: A case study on skills in project management: Empirical data collection and solutions

The goal of this thesis is to collect empirical data of projects that incorporate skills. In the well-known RCPSP every activity has a demand for resources, or more specifically resource types. In this case, we are looking for projects that have a demand for skills, to which these resources can be assigned to. The student will visit companies and gather real-life data which he will analyse thoroughly. Additionally, the student will develop a procedure that assists in dealing with the data. From this procedure and its outcome the student will gain new knowledge and give managerial insights.

- Advisor: Mario Vanhoucke
- Contact person: Jakob Snauwaert (jakob.snauwaert@ugent.be)

- Required skills: Project Management, Project Scheduling, Optimisation
- Extra information:
  - This thesis is suitable for two students. Use of LaTeX is mandatory.
  - Literature review is supportive but not the main theme of the thesis
  - Case study is required
  - Software use: optionally
  - Modeling and analysis: Main goal of the thesis

Topic: Optimising multi-mode, multi-project portfolio scheduling of competing projects

A project portfolio can have one overall goal but many ways (projects) of achieving that goal. We call these projects competing projects because the successful conclusion of one project renders the others obsolete. This is a common characteristic in R&D project scheduling. A lot of uncertainty is involved in scheduling these projects. Project failure is a significant risk that leads to a waste of the invested resources. This risk is higher when the (activities of the) project are rushed to reduce its makespan. An alternative approach is to minimise risk of failure by allowing for more time in each R&D stage (activity) but this might lead to significant project delays. The optimal approach is probably somewhere in the middle. Additionally, for this study, we are interested in how earlier activities could impact the failure and delay risk of later activities.

- Advisor: Mario Vanhoucke
- Contact person: Dries Bredael (dries.bredael@ugent.be)
- Required skills: Project scheduling, optimisation, simulation
- Extra information:
  - This thesis is suitable for two students. Use of LaTeX is mandatory.
  - Literature review is supportive but not the main theme of the thesis
  - Case study is possible
  - Software use: C++, CPLEX or Gurobi
  - Modeling and analysis: Main goal of the thesis

Topic: The impact of sharing and trading behaviours in decentralised project portfolio management under uncertainty

An organisation running a portfolio of projects is often managed by different project managers. These managers are responsible for the performance of their assigned project(s). They can be evaluated on the performance of the project portfolio, which would encourage them to help other PM's by sharing their own assigned resources if needed. Alternatively, they can be evaluated based solely on the performance of their own projects. In this situation, the managers will only cooperate if it improves their own performance. They would only trade resources if the trade is beneficial to both parties. The goal of this thesis is to quantify the impact of these two kinds of behaviours on the performance of a multi-project portfolio. The project activities are characterised by uncertainty in their resource requirements and/or durations. To this end, one or more trading mechanisms will have to be constructed and the performance of both behaviours needs to be analysed through a simulation study. Additionally, different levels of negotiating powers between project managers could be considered.

- Advisor: Mario Vanhoucke
- Contact person: Dries Bredael (dries.bredael@ugent.be)
- Required skills: Project scheduling, optimisation, simulation
- Extra information:
  - This thesis is suitable for two students. Use of LaTeX is mandatory.
  - Literature review is supportive but not the main theme of the thesis
  - Case study is possible
  - Software use: C++, CPLEX or Gurobi
  - Modeling and analysis: Main goal of the thesis

Topic: Network partitioning strategies for multi-project scheduling

In multi-project scheduling, a portfolio of projects is considered where projects typically have no precedence relations between each other. When the goal is to minimise the Average Project Delay (APD), A well-known, effective strategy is to schedule the projects in a certain order, prioritising the most urgent projects. However, when we consider a project portfolio where projects do have precedence relations between the activities of their project and another, this strategy becomes infeasible without adaptations. One approach to alleviate this, is to artificially construct 'sub- projects' within the overarching project where the subprojects only have precedence relations to their (artificial) start-activity and from their finish-activity. The goal of this thesis is to find an effective partitioning strategy to construct these artificial sub-projects and to analyse the performance of the prioritisation strategy with these sub-projects as input to minimise the APD through a simulation study.

- Advisor: Mario Vanhoucke
- Contact person: Dries Bredael (dries.bredael@ugent.be)
- Required skills: Project scheduling, optimisation, simulation
- Extra information:
  - This thesis is suitable for two students. Use of LaTeX is mandatory.
  - Literature review is supportive but not the main theme of the thesis
  - Case study is possible
  - Software use: C++, CPLEX or Gurobi
  - Modeling and analysis: Main goal of the thesis

Topic: A study on flexibility mechanisms on hierarchic decision making in a multi-project portfolio

Commonly, the decisions on (multi-)project selection and scheduling are done in two distinct phases. In the first phase, the selection phase, a decision is made on which projects to include in the portfolio. Usually, the goal is to maximise NPV under a budget restriction, also known as a knapsack problem. In the second phase, the scheduling phase, the previously selected projects must be scheduled with limited renewable resources. Since the first selection phase didn't fully capture the complexity of the renewable resource constraints, suboptimal schedules might result where certain projects are late and incur penalties. To partly alleviate this issue caused by suboptimal decision making, project managers rely on a variety of flexibility mechanisms to minimise the late fees. The goal of the thesis is to analyse the benefit of different types and magnitudes of flexibility mechanisms in this situation through a simulation study. Examples are the use of overtime for some or all resources, outsourcing/subcontracting, or others. The effects of different types of operational uncertainties can additionally be analysed as well.

- Advisor: Mario Vanhoucke
- Contact person: Dries Bredael (dries.bredael@ugent.be)
- Required skills: Project scheduling, optimisation, simulation
- Extra information:
  - This thesis is suitable for two students. Use of LaTeX is mandatory.
  - Literature review is supportive but not the main theme of the thesis
  - Case study is possible
  - Software use: C++, CPLEX or Gurobi
  - Modeling and analysis: Main goal of the thesis

Topic: Cost minimisation of projects with alternative technologies considered as resource-constrained project scheduling with alternative subgraphs

Some projects can be executed using alternative technologies. The work breakdown structure of these projects includes work packages that can be executed in different alternative ways. Each technology could differ in terms of activity duration and type of resource requirement. Therefore, the unit resource cost, the overhead cost and the cost per time unit of each activity are different for the execution of a work package with different technologies. One of the main objectives for project scheduling with constrained resources is to minimise the total cost of a project. Choosing different alternatives for a work package has an impact on the resource usage, overhead expenses and execution cost of activities. In summary, crucial decisions have to be made to choose between these alternative technologies in order to find optimal schedules for projects based on the cost minimisation objective.

- Advisor: Mario Vanhoucke
- Contact person: Rojin Nekoueian (rojin.nekoueian@UGent.be)
- Required skills: Project scheduling, optimisation
- Extra information:
  - This thesis is suitable for two students. Use of LaTeX is mandatory.
  - Literature review is supportive but not the main theme of the thesis
  - Case study is possible
  - Software use: C++
  - Modeling and analysis: Main goal of the thesis

Topic: Preemptive resource-constrained project scheduling with alternative subgraphs

Activity preemption is an assumption that aims to improve the practical relevance of the resource-constrained project scheduling problem (RCPSP). This assumption allows activities to be preempted or stopped at any time and restarted later on at no additional cost. Considering preemption for activities with a

fixed duration, this duration will be split into several duration units. Therefore, it is possible to optimally utilise leftover resources in order to minimise the project makespan. In the resource-constrained project scheduling problem with alternative subgraphs (RCPSP-AS), work packages can be executed in different alternative ways. For some alternatives, these resource leftovers are noticeable and could be used by allowing activity preemption. Including activity preemption within the RCPSP-AS in order to find optimal schedules that minimise the project makespan will change current solutions and algorithms for the RCPSP-AS, which is the aim of this thesis.

- Advisor: Mario Vanhoucke
- Contact person: Rojin Nekoueian (rojin.nekoueian@UGent.be)
- Required skills: Project scheduling, optimisation
- Extra information:
  - This thesis is suitable for two students. Use of LaTeX is mandatory.
  - Literature review is supportive but not the main theme of the thesis
  - Case study is possible
  - Software use: C++
  - Modeling and analysis: Main goal of the thesis

Topic: Resource-constrained project scheduling with alternative subgraphs considering set-up time for resources

Resource-constrained project scheduling with alternative subgraphs (RCPSP-AS) is an extension of the resource-constrained project scheduling problem (RCPSP) with work packages that can be executed in different alternative ways. Different resources (e.g. machines) might have different set-up times for activity execution and these setups needs to be done before an activity starts. Considering resource set-up times for alternative work packages and activities implemented with different resources, optimal schedules that minimise the project makespan should be developed in this thesis.

- Advisor: Mario Vanhoucke
- Contact person: Rojin Nekoueian (rojin.nekoueian@UGent.be)
- Required skills: Project scheduling, optimisation
- Extra information:
  - This thesis is suitable for two students. Use of LaTeX is mandatory.
  - Literature review is supportive but not the main theme of the thesis
  - Case study is possible
  - Software use: C++
  - Modeling and analysis: Main goal of the thesis

Topic: Multi-objective resource-constrained project scheduling with alternative subgraphs

Resource-constrained project scheduling with alternative subgraphs (RCPSP-AS) is an extension of the resource-constrained project scheduling problem (RCPSP) with work packages that can be executed in different alternative ways. There might exist several objectives for this scheduling optimisation. Cost minimisation, makespan minimisation, resource levelling maximisation or resource idleness minimisation are examples of objectives that can be considered together for the RCPSP-AS. Let us consider a construction company that builds a house using different, alternative technologies. For some alternative technologies, the activities could be executed in parallel in case that the company would hire extra workers for some days. Therefore, the company can deliver the building in a shorter project completion time. The decision to temporarily add resources to the system depends on the penalty for late project delivery and the cost for adding resources. As a result, the optimality of the decision to add resources in some periods depends on the combined minimisation of the project makespan and cost.

- Advisor: Mario Vanhoucke
- Contact person: Rojin Nekoueian (rojin.nekoueian@UGent.be)
- Required skills: Project scheduling, optimisation
- Extra information:
  - This thesis is suitable for two students. Use of LaTeX is mandatory.
  - Literature review is supportive but not the main theme of the thesis
  - Case study is possible
  - Software use: C++
  - Modeling and analysis: Main goal of the thesis

Topic: Technology selection for a project portfolio, including projects with alternative technologies in common

A project portfolio is a set of projects that are selected in order to satisfy specific goals (e.g. cost and risk minimisation) of an organisation. Projects of a portfolio can use alternative technologies for the execution of work packages. These technologies could be shared among different projects in the portfolio. Since each technology has its own specification (e.g. usage of specific resources and specific duration of activities) using different technologies for projects in a portfolio makes the project management process more complex. Therefore, it is easier for a project manager to share the same technologies among multiple projects. Also, using the same technologies might be less risky since the same resources can be shared between projects and thorough information is only needed for a limited number of technologies rather than a lot of different technologies. However, putting more pressure on one type of resource will increase the probability of resource breakdowns. In summary, this thesis aims to identify the optimal, alternative technologies for a project given the specific goals of the company.

- Advisor: Mario Vanhoucke
- Contact person: Rojin Nekoueian (rojin.nekoueian@UGent.be)
- Required skills: Project scheduling, optimisation
- Extra information:
  - This thesis is suitable for two students. Use of LaTeX is mandatory.
  - Literature review is supportive but not the main theme of the thesis
  - Case study is possible
  - Software use: C++
  - Modeling and analysis: Main goal of the thesis

Topic: Determining the project completion time of complex project networks: a comparison of analytical bounding approaches and Monte Carlo simulations

One of the most important factors to calculate the distribution of the project completion time for a project network is its network structure, which can be reflected by the complexity index (CI). For networks with a CI equal to zero (series-parallel graph), the distribution of the project completion time is easy to determine exactly. However, for activity networks with a complexity index higher than zero, one needs to use some approximation methods like bounding the project completion time distribution in an analytical way, or simulation. The goal of this thesis is to compare the bounding approaches to the results of simulation for project networks with different complexities to find a relation between the height of the CI and the performance of the bounding approaches.

- Advisor: Mario Vanhoucke
- Contact person: Forough Vaseghi (forough.Vaseghi@UGent.be)
- Required skills: Project Management, Simulation, Stochastic network analysis, Continuous probability distributions
- Extra information:
  - This thesis is suitable for two students. Use of LaTeX is mandatory.
  - Literature review is supportive but not the main theme of the thesis
  - Case study is not possible
  - Software use: P2 Engine / Python / R / C++
  - Modeling and analysis: Main goal of the thesis

Topic: Determining the project completion time of complex project networks: an analysis of the impact of the project network topology

One of the most important factors to calculate the distribution of the project completion time for a project network is its network structure, both in terms of complexity (complexity index CI) and in terms of topology (serial/parallel indicator SP, activity distribution indicator AD, Length of Arcs indicator LA and Total Float indicator TF). For complex project networks (CI>0), the project completion time distribution cannot be determined exactly and should be approximated by using analytical bounding approaches or Monte Carlo simulation. The goal of this thesis is to analyze the relation between the network topology and the performance of the approximation approaches.

- Advisor: Mario Vanhoucke
- Contact person: Forough Vaseghi (forough.Vaseghi@UGent.be)
- Required skills: Project Management, Simulation, Stochastic network analysis, Continuous probability distributions
- Extra information:
  - This thesis is suitable for two students. Use of LaTeX is mandatory.
  - Literature review is supportive but not the main theme of the thesis
  - Case study is not possible
  - Software use: P2 Engine / Python / R / C++
  - Modeling and analysis: Main goal of the thesis

Topic: An analysis of the impact of activity duration distributions on the project completion time of stochastic project networks

The project completion time of stochastic project networks is determined by the distribution of the project activities. These activity distributions can vary in terms of distribution type and distribution parameters. In this thesis, the impact of different types of distribution that have been used in literature (normal, lognormal, exponential, beta, etc.), and the impact of the distribution parameters should be analyzed from a managerial point of view (accuracy and computational effort). In order to conduct this analysis, both analytical approximation methods and simulation methods can be used.

- Advisor: Mario Vanhoucke
- Contact person: Forough Vaseghi (forough.Vaseghi@UGent.be)
- Required skills: Project Management, Simulation, Stochastic network analysis, Continuous probability distributions
- Extra information:
  - This thesis is suitable for two students. Use of LaTeX is mandatory.
  - Literature review is supportive but not the main theme of the thesis
  - Case study is not possible
  - Software use: P2 Engine / Python / R / C++
  - Modeling and analysis: Main goal of the thesis

Topic: A computational study on bounding methods for the distribution of the project completion time in stochastic activity networks

While the project completion time of projects with a complexity index (CI) of zero can be determined exactly, the analytical evaluation of the distribution of the project completion time for activity networks with a CI higher than zero is an NP-complete problem for which approximation methods like bounding are required. In this thesis, the most promising of these bounding algorithms should be computationally evaluated to compare their suitability for practical applications in terms of accuracy and computational cost. The main goal is to find the most important properties of the networks (complexity index, serial/parallel indicator, etc.) that influence the results of the methodologies.

- Advisor: Mario Vanhoucke
- Contact person: Forough Vaseghi (forough.Vaseghi@UGent.be)
- Required skills: Project Management, Simulation, Stochastic network analysis, Continuous probability distributions
- Extra information:
  - This thesis is suitable for two students. Use of LaTeX is mandatory.
  - Literature review is supportive but not the main theme of the thesis
  - Case study is not possible
  - Software use: P2 Engine / Python / R / C++
  - Modeling and analysis: Main goal of the thesis