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| **Co-Supervised Doctorates 2019**  **I-SITE ULNE – Ghent University**  **Thesis project proposal**  to be completed in English |

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| **Deadline: May 2, 2019 (23:59 GMT+1)**  **Please send your application by e-mail to the following address:** [projects@isite-ulne.fr](mailto:projects@isite-ulne.fr)  (Please copy the promotors and co-promotor(s) on the message.) |

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| **Checklist of mandatory documents**  ***(no hard copies are required)***  *Please send your documents using the following name template:*  *“[****First name]\_[name]\_[Document name]\_CotutellesGand\_2019****”.*  ☐ 2-page CV for each promotor and co-promotor  ☐ Application form duly completed  *For the applicant:*  ☐ Curriculum Vitae  ☐ Cover letter  ☐ Copy of passport for students who are not French citizens  ☐ Grades obtained during your last 3 years of graduate studies and a description of the degree programme and courses taken for studies completes outside of France. (Official academic transcripts must be provided for each semester of each year.)  ☐ Copy of post-secondary diplomas (with translation for degrees that were not obtained from an English- or French-speaking country; at this stage these copies do not have to be legalized)  ☐ A letter of support from the potential I-SITE ULNE promotor |

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| **I-SITE ULNE Help desk:**  [stephane.thys@isite-ulne.fr](mailto:Stephane.thys@isite-ulne.fr) [alexis.boulet@isite-ulne.fr](mailto:alexis.boulet@isite-ulne.fr) |

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| 1. **PROJECT INFORMATION** | |
| Project title (English) | Multi-Agent Reinforcement Learning and Big Data for Supply Chain Optimization |
| Project acronym | MARLSC |
| Keywords (between 3 and 6) | Multi-Agent Reinforcement Learning, Big Data,  Supply Chain Optimization, Planning and Scheduling, Inventory Management |

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| * 1. **Identification of the PhD candidate** |
| First name: Last name: |
| Gender:  Nationality:  Date of birth: |
| University of origin:  Master’s degree obtained: |
| Postal address: |
| Personal telephone: |
| Work telephone: |
| Email address: |
| Signature[[1]](#footnote-1): |

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| * 1. **Identification of the I-SITE ULNE promotor** |
| First name: Kim-Phuc  Last name: Tran |
| Institution[[2]](#footnote-2): ENSAIT |
| Faculty/Department: |
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| * 1. **Identification of the Ghent University promotor** |
| First name: El-Houssaine  Last name: Aghezzaf  ORCID-ID: 0000-0003-3849-2218 |
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| Telephone: +32 (0)9 254 55 00 |
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| Signature[[3]](#footnote-3):  Karel Bauters - ISyE-UGent-FM  PO/ E.-H. Aghezzaf |

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| * 1. **Identification of the Ghent University co-promotor (*if applicable*)** |
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| 1. **Abstract of the thesis project** (250 words maximum) |
| Supply chain management (SCM) affects manufacturing companies in a variety of ways, including the availability of inputs needed for production processes, costs, and profitability of manufactured items, company infrastructure and ways in which companies interact with their suppliers and customers. In many sectors, the current supply chain is faced to challenging issues due to strong demand uncertainty and fluctuation, a lack of homogeneous and efficient tracking method, a more and more customized demand, social and ecological requirements, an increase of transportation costs, ... In current competitive environment supply chain professionals are struggling in handling the huge data. This project focuses on several important problems in SCM, involving supply chain monitoring, supply chain planning and scheduling, and inventory management. The traditional methods like statistical process monitoring are no longer suitable for a digital supply chain. Similarly, supply chain planning and scheduling are also facing the uncertainties coming from continuous changes in customer demands and operating. Moreover, inventory management is critical to the function of supply chain management. The objective of the project is to develop several new AI-based approaches to deal with these problems. The new approaches are expected to handle efficiently the real-time Big Data in SM; enable to timely detect abnormalities in the supply chain; optimize supply chain planning and scheduling by considering multiple constraints and optimizing for each, and real-time inventory control system. A Python package containing the proposed algorithms will be developed, providing enterprises a powerful tool to optimize their supply chain. |

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| PRESENTATION OF THE PROJECT (max. 3 pages excluding the bibliography) |
| * The doctoral project and methodology, including concrete calendar and selected bibliography * Added-value of the participation of the (co-)promotors in the project * Strategy for dissemination and exploitation of the research |
| * 1. Context   Supply chain management (SCM) is a systematic approach to managing the distribution of goods from producers of raw materials, through manufacturers and eventually down to end users. In recent years, the amount of data produced by the end-to-end supply chain has increased exponentially. Indeed, this huge data is a significant opportunity to collect rich information to optimize their activities. By analyzing all the hidden relationships among the hugely collected data, the Artificial Intelligence (AI) algorithms and the Big data techniques can significantly improve supply chain processes.   * 1. Objectives   This project aims to develop several AI algorithms to deal with some important challenges in SCM. Specifically, we will focus on the following objectives:  Firstly, **supply chain monitoring** to identify and fix problems in real-time is an important problem in digitized supply chain management. The traditional methods like statistical process monitoring (SPM) are no longer suitable for real-time data that becomes available in a *digital supply chain* thanks to the Internet of Things (IoT) technologies. Instead, more advanced models to monitor the data in real-time are required. The models should be proven to be statistically accurate enough to determine when a production process is deviating from any normal operating condition, and perhaps even predict when a current process might start deviating from accepted conditions. The Big Data from Supply Chain is nowadays measured with a high frequency, high dimension and large variety and can therefore not be treated in the traditional way. Therefore, it is necessary to develop new methods to be adapted and to monitor this Big Data. We will use advanced deep learning algorithms such as long short-term memory (LSTM) (Nguyen et al. (2019)) and recurrent neural network (RNN), combined with anomaly detection methods (Vuong et al. (2017)) to monitor the Supply Chain. We will also develop new deep learning methods for real-time topological data monitoring (AXE1).  Secondly, **supply chain planning and scheduling** is the process of thinking about and organizing the activities to get the right product, on-time, in quality, to the right place, and to the lowest cost to satisfy the customer requirement. In general, most studies in scheduling have focused on the development of exact and suboptimal procedures for the generation of a baseline scheduling, assuming complete information and a deterministic environment. However, uncertainties, which are not considered at the planning phase, may lead to numerous schedule disruptions. For example, new orders can arrive, or operations could take longer than expected. In these scenarios, it is necessary to develop new methods for real-time scheduling in order to come up with uncertainty, scalability issues and increase the robustness. We aim to propose a **new multi-agent reinforcement learning** (MARL) methodology and leverage the power of **deep neural networks** approach for multi-objective scheduling problems. We will propose the use of both centralized and distributed models. Here, all agents (smart containers for instance) become aware of the actions of other agents, which mitigates the non-stationarity (AXE2).  Finally, the traditional methods for **inventory management** are usually based on mathematical models with constant assumptions about customers’ demand or lead time, Stefanescu (2009). These assumptions might not be true in practice as customers’ demand often changes over time and the lead time depends on the supply ability of each company and market demands. AI algorithms such as long short-term memory and recurrent neural network are useful tools to solve this problem. By constantly and online updating market demands, supply chain real-time data, historical data and other impact factors such as weather, the data-driven AI algorithms are able to predict the optimum inventory level without using any mathematical assumptions. A lot of research has been done to contribute to the inventory management topic, see Aghezzaf et al. (2019), Verbeeck et al. (2019), Verbeeck et al. (2014), Lefever et al. (2018), and Sagaert et al. (2018). However, to the best of our knowledge, there is no study about this promising application of AI for inventory management in the literature. In this context, we will propose a **new multi-agent reinforcement learning** (as discussed above) method for application in the real-time inventory control system. This is the more advanced artificial intelligence approach that involves a model taking serious control of the inventory operations, with human checks and balances. We will also develop new methods for automated inventory monitoring using deep LSTM, kernel density estimation, and exponentially weighted moving average (EWMA) control chart, see Tran et al. (2016b) (AXE3).   * 1. Methodologies   The methodologies are used to in our project include deep learning algorithms (RNN, LSTM), EWMA technique and Multi-Agent Reinforcement Learning algorithms. To evaluate the effectiveness of the proposed methods, it is required to experiment with the operation of a real supply chain system to study the effects of the change which can lead to a more efficient and advanced system than the current one. However, the direct improvements may be expensive or in some cases do not produce the expected results. Simulation models are then useful tools for testing of efficient changes. Among several simulation algorithms, discrete event simulation (DES) is one of the most important and widely used techniques of simulation. The DES refers to a method of simulating the behavior and performance of a real-life process, facility or system. It models the system as a discrete sequence of events in time. Each event occurs at an instant in time and marks a change of state in the system. Between consecutive events, no change is assumed to occur; thus, the simulation can directly jump in time from one event to the next. We will simulate the supply chain and apply these new methods on a DES model. Data for this subject will be provided by a company in the field SCM in France and/or Belgium.   * 1. References   [1] K.P. Tran, P. Castagliola, and G. Celano. “Monitoring the Ratio of Two Normal Variables  Using EWMA Type Control Charts”. Quality and Reliability Engineering International, 32(2):1853–1869, 2016b.  [2] V.V. Trinh, K.P. Tran, and T.H. Truong. (2017), “Data-driven anomaly detection method for Wireless Sensor Networks”, IEEE International Conference on Advanced Technologies for Communications, Quy Nhon, Vietnam, October 18-20, 2017.  [3] W. Herroelen and R. Leus. “Project scheduling under uncertainty: Survey and research potentials”. European journal of operational research, 165(2):289–306, 2005.  [4] C. Stefanescu. “Multivariate customer demand: modeling and estimation from censored sales”. Available at SSRN 1334353 (2009).  [5] E. H.Aghezzaf, V. Gylian and D. Bram. “A data-driven framework for predicting weather impact on high-volume low-margin retail products”. Journal of Retailing and Consumer Services, 48:169–177, 2019.  [6] C. Verbeeck, et al. "A fast solution method for the time-dependent orienteering problem." European Journal of Operational Research 236.2 (2014): 419-432.  [7] W. Lefever, E. H.Aghezzaf, K.Hadj-Hamou, and B. Penz. (2018). “Analysis of an improved branch-and-cut formulation for the Inventory-Routing Problem with Transshipment”. Computers & Operations Research, 98, 137-148.  [8] Y. R. Sagaert, Aghezzaf, E. H., Kourentzes, N., & Desmet, B. (2018). “Tactical sales forecasting using a very large set of macroeconomic indicators”. European Journal of Operational Research, 264(2), 558-569.  [9] H.D. Nguyen, K.P.Tran, S. Thomassey. “Anomaly detection using Long Short-Term Memory Networks and its applications in Supply Chain Management”, 9th IFAC Conference on Manufacturing Modelling, Management and Control, Berlin, Germany, August 28-30, 2019   |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | **Task** | **Month** | | | | | | | | | | | | | | 1-3 | 4-6 | 7-9 | 10-12 | 13-15 | 16-18 | | 19-21 | 22-24 | 25-27 | 25-30 | 31-33 | 34-36 | | 1 |  |  |  |  |  |  | |  |  |  |  |  |  | | 2 |  |  |  |  |  |  | |  |  |  |  |  |  | | 3 |  |  |  |  |  |  |  | |  |  |  |  |  | | 4 |  |  |  |  |  |  | |  |  |  |  |  |  | | 5 |  |  |  |  |  |  | |  |  |  |  |  |  | | 6 |  |  |  |  |  |  | |  |  |  |  |  |  |   1) Literature review, 2) doing AXE 1, 3) doing AXE2, 4) doing AXE3, 5) writing Ph.D thesis, 6) create a Python package containing all the AI algorithms developed in each problem   * 1. Added-value of the participation of the (co-)promotors in the project   The Ph.D student will work on the project under the guidance of Dr. Kim Phuc TRAN, Dr. Sébastien THOMASSEY, and Prof. Xianyi ZENG. Dr. Kim Phuc TRAN is an expert in data mining, AI, and their applications in industry. His recent research works focus on real-time anomaly detection, AI, machine learning, deep learning and their applications. Dr. Sébastien THOMASSEY is an expert in Data Mining, Big Data and supply chain management. Prof. Xianyi ZENG is an expert in computer engineering, big data applications and data mining. The Ph.D student will have opportunities to interact with some related research projects at GEMTEX (led by Prof. Xianyi ZENG), e.g., Fashion  Big Data Business MODEL (<http://www.gemtex.fr/curent-projects/fbd_bmodel/>). For added values Prof. Aghezzaf and Prof. Cottyn brings in, see Section 4.   * 1. Exploitation and dissemination   The results of this research project will be exploited/disseminated by using  different mechanisms:   * publications in peer-reviewed international journals: The aim is to publish at least 3   papers, one for each research objective.   * Presentation on international conferences: the student will attend at least 3   international conferences on to broaden his knowledge in the research domain and  discuss his work with the international community.   * An open source package containing all the AI algorithms developed in each problem   for supply chain optimization will be developed in Python and provided free to the  academic and industrial community.   * Based on the research results, we aim to develop new leads for industrial and   research projects, both on a regional as well as the European level.   * The aim is to apply the developed MARL on at least one real-life use case provided   by a logistics company in France or Belgium to validate the research. |

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| Specific Questions |
| Expected duration of your stay at Ghent University (Min. 6 months): 12 months |
| Explain briefly what scientific activities you plan to carry out during your stay at Ghent University (max. 300 words) |
| During a first stay (6 months) in Ghent, I will spend most of my time in developing the simulation models to generate the necessary experimental data to develop the reinforcement learning framework. This will mainly be done in Flexsim. The model will be based on several real-life use cases. Therefore, I will also have access to the network of industrial contacts of Ghent University to gather the required data and information.  During this period, I will also be able to follow the course on supply chain engineering in the framework of the “doctoral schools” program to broaden his knowledge on supply chain management strategies and inventory management.  In a second period (6 months) I will mainly focus on the inventory management framework and more specifically on the use of Big Data and leading impact factors to enhance the framework with better demand forecasts. To do this, I will have access to the domain knowledge and competences build up in past research projects (Sagaert 2018). |
| Explain how the involvement of (co-)promotors from Ghent University in the framework of a co-supervised Ph.D. is an added value to the Ph.D. research. (max. 300 words) |
| The department of industrial engineering and product design (ISyE-PD) of Ghent University and more specifically the research group “Supply Networks & Logistics Research Center” (SNLRC) of which prof. Aghezzaf is a member, conducts advanced research and provides scientific consultancy in supply networks engineering and management. The core competency of the center is in the development of integrated optimization-simulation-based solutions to effectively, efficiently design and manage the various production and logistical processes of complex enterprises Systems Engineering. Examples of performed research in the last years are:   * optimization of vehicle routing planning for the logistics industry (Verbeeck 2014)  stochastic and robust optimization algorithms for the inventory-routing problem and its extensions (Lefever 2018)enhancing sales forecasts using increasingly open and detailed global macro- and micro- economic data. (Sagaert 2018) SNLRC is also an active member of the Flanders Innovation cluster for Logistics (VIL). VIL performs innovative and sustainable company-driven projects to support the Flanders region to become one of the main Logistics Hubs in Europe and the world. Through this network, I will have access to various logistics companies to gather the necessary data, knowledge, and information to validate his research.  Besides VIL, ISyE (Prof. Cottyn is the core lab manager of ISyE) is also active in various research initiatives such as Flanders Make, and several European projects e.g., in the context of smart cities. All these projects and initiatives some common ground with supply chain engineering. I will be able to interact with researchers active in these domains to broaden his knowledge on many different aspects of the supply chain. Furthermore, I will have access to the research labs and infrastructure of the department, especially the digital twin control room, which is an experimental setup aimed to test, optimize and validate different manufacturing and logistics control strategies using simulation models. |

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| CVs of all promotors and co-promotors *(Send each CV as a separate PD file)* |
| Please send the CV of each promotor and co-promotor listed under point 2. The CV should include the 10 most important projects and/or publications of the past 5 years. |

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| Mandatory documents for the applicant *(Send each as a separate PDF file)* |
| * Curriculum Vitae (CV) * Cover letter (one-page minimum) * Copy of passport for students who are not French citizens * Grades obtained during your last 3 years of graduate studies and a description of the degree programme and courses taken for studies complete outside of France. (Official academic transcripts must be provided for each semester of each year.) * Copy of post-secondary diplomas (with translation for degrees that were not obtained from an English- or French-speaking country; at this stage these copies do not have to be legalized) * A letter of support from the potential I-SITE ULNE promotor |

1. Scanned signatures are acceptable [↑](#footnote-ref-1)
2. Université de Lille, Centrale Lille, ENSAIT, ENSCL, IMT Lille-Douai, Sciences Po Lille, ESJ, ENSAPL, ENSAM- Campus de Lille, CNRS, INSERM, INRIA, CHRU de Lille and Institut Pasteur de Lille [↑](#footnote-ref-2)
3. Scanned signatures are acceptable [↑](#footnote-ref-3)