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TABLE 7 – PhD Programme in COMPUTER SCIENCE AND ARTIFICIAL INTELLIGENCE

THE PhD PROGRAMME	
Administrative Location	University of Udine - Department of Mathematics, Computer Science and Physics (DMIF) – via delle Scienze 206, 33100 Udine, Italy (+39 0432 558400).
Associated Location	Fondazione Bruno Kessler – 77 via Santa Croce, 38122 Trento (TN), Italy
Location for Training, teaching and research activity	Teaching and other training activities will take place primarily at the administrative programme location or in other locations of the University of Udine. The research program will be mainly developed, with reference to the assigned scholarship, at one of these locations: administrative location, enterprise.
Coordinator	Federico Fontana – University of Udine (coordinatore.iai@liste.uniud.it)
Programme duration	3 years
Curriculum	-
Programme website	https://www.dmif.uniud.it/dottorato/iai https://phd.fbk.eu/

ADMISSION REQUIREMENTS	
Required degree	Italian Laurea (before DM 509/99) or Italian Laurea Specialistica/Magistrale (ex DM 509/1999 and Decree DM 270/04). Foreign degrees and titles: refer to art. 3 and 4 of the Call.
Knowledge of the following foreign language	English

DOCUMENTS AND TITLES TO BE ATTACHED TO THE APPLICATION FOR ADMISSION	
Compulsory documents (Art. 5 of the Call)	<ol style="list-style-type: none"> 1. Certification or self-certification (refer to art. 5 paragraph 5 of the Call) of the academic title needed for admission to the PhD programme (with candidate's grade and highest possible grade) and certified list of the exams (with candidate's grades, average grade, highest possible grade) passed during the Italian first level (bachelor) and the Laurea Specialistica/Magistrale programmes or during the Italian programmes ante D.M. 509/99 or during the foreign academic programmes; 2. Curriculum vitae et studiorum, dated and signed; 3. Copy of a valid identity document (citizens of countries not belonging to the European Union a copy of a valid passport, comprehensive of the pages containing the holder's photo, personal details, passport number, date and place of issue, date of expiry); 4. Master thesis ("Tesi di Laurea") associated to the degree/title providing access to the PhD programme. Applicants who are not graduated on the expiration date of this Call can submit an extended abstract in place of the complete thesis, in Italian or English language, signed by the thesis Supervisor (between 15,000 and 25,000 characters, spaces included); 5. A research project, dated and signed, developed in accordance with the description of the research topic of interest, which highlights the contribution that the applicant can offer to the development of the same topic (approximate limit 10,000 characters, spaces included, in English language); 6. Motivation letter from the Applicant explaining the reasons for admission to the PhD programme, dated and signed (between 1,500 and 2,500 characters, spaces included).
Optional documents (Art. 5 of the Call)	<ol style="list-style-type: none"> 1. Publications (max 3); 2. Recommendation letters (max 2) written by university professors, scientific researchers or other experts in the specific research topics (art. 6 of the Call).
All titles must be presented exclusively in PDF format, dated and signed by the candidate.	

SELECTION COMMITTEE	
Appointed Members	Luca Di Gaspero – Associate Professor – University of Udine Federico Fontana – Associate Professor – University of Udine Gianluca Foresti – Full professor – University of Udine Niki Martinel – Assistant Professor – University of Udine
Alternate Members	Carlo Drioli – Associate professor – University of Udine Michele Geronazzo – Assistant Professor – University of Udine Daniele Salvati – Assistant Professor – University of Udine

ADMISSION
GENERAL COMPETITION (art. 8 of the Call for Applications)
Positions available: 2



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Detailed description	N.	Funding	Annual gross amount	Period abroad	Period in enterprise (identified by the Univ. of Udine)	Research Topic
Positions WITH SCHOLARSHIP: 2	1	National Operational Program (PON) Research and Innovation 2014-2020 “Education and research for recovery – REACT-EU (M.D. 1061/2021) and University of Udine	€ 15.343,28	max 6 months optional	min 6 - max 12 months mandatory	1.1 Green Topic “Models and algorithms for the intelligent management of waste collection through fleets of electric vehicles” (PON RI 2014/2020 Axis IV Action IV.5)
	1	National Operational Program (PON) Research and Innovation 2014-2020 “Education and research for recovery – REACT-EU (M.D. 1061/2021) and University of Udine	€ 15.343,28	-	min 6 - max 12 months mandatory	1.2 Innovation Topic “Improving trust in cloud computing” (PON RI 2014/2020 Axis IV Action IV.4)

Competition procedure and schedule

Evaluation of qualifications and oral examinations.

For the evaluation of applicants’ attitude for scientific research and their knowledge to develop the topic of interest, the Selection Committee can attribute up to 100 points to each applicant: at most 30 points to the qualifications and at most 70 points to the oral examination. The applicant is admitted to the interview if he/she scores at least 18 points for the qualifications. The oral examination is passed by scoring at least 49 points. The applicant is eligible for the PhD programme if he/she passes the oral examination. Only for eligible applicants, the points attained in the oral examination will be added to the points of the qualifications.

Scholarships are assigned according to the provisions of art. 10 of the Call.

DATE FOR THE PUBLICATION OF THE ADMITTED APPLICANTS TO THE INTERVIEW: within November 2, 2021

DATE FOR THE PUBLICATION OF THE FINAL RANKING LIST: within November 11, 2021

Foreign language that can be used for examination	Italian or English	
Evaluation of the titles	Curriculum vitae et studiorum, academic title, exams and master thesis (or its abstract)	Max 18 points
	Research project, scientific publications, Applicant’s motivation letter and Referees’ recommendation letters	Max 12 points
Oral examination	Starting score bonus	2/3 of the total score obtained from the evaluation of the titles
	Interview about titles, previous career and research project also aimed at understanding the Applicant’s knowledge about fundamental topics in computer science and artificial intelligence, as well as his or her full eligibility to receive, if preferred, a scholarship funded by external institutions. Reading and understanding a short scientific text in English.	Max 50 points
Calendar of the oral examination	Date	November 3, 2021
	Time	10:00 am
	How to conduct the examination	The oral examination will be held online (MS Teams)
	The oral examination may take more than one day. Applicants must exhibit a valid personal ID.	

Research Topics Description

Research Topic 1.1: Models and algorithms for the intelligent management of waste collection through fleets of electric vehicles

The project aims at developing innovative models and algorithms for waste collection operations management that improve their environmental efficiency while contributing to the reduction of the climate change impact. These objectives will be pursued, in a sustainability perspective, by



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using low environmental impact vehicles (electric vehicles, or mixed solutions limiting the use of internal combustion vehicles) and through the intelligent operations planning of by means of the information obtained from dedicated sensor networks.
In addition to the advancement of scientific knowledge and its practical implications, the results of the project will also be exploited in terms of the development of innovative software products or services based on the know-how built in the project.

NSRF Coherence:

- Digital Agenda, smart communities, smart mobility systems
- Trajectory 1: Intelligent urban mobility systems for logistics and people

The aim of the project is to design urban logistics systems for waste collection that are intelligent and efficient.

Trajectory 3: embedded electronic systems, smart sensor networks, internet of things

The project envisages the exploitation of data from smart devices and sensors associated with waste collection operations (smart bins or other).

Smart and sustainable industry, energy, and environment

Trajectory 6: systems and technologies for toilet and waste treatment

The project aims to develop innovative systems for waste logistics, thus impacting on the transport part related to the treatment of the same

PNR Coherence:

- System Priority

Enhance the circulation of knowledge and skills between the world of research and the production system

The explicit aim of the project is to work on industrial problems directly agreed with the reference companies so that the proposed technologies can be validated together at least at TRL level 4. The developed models will be available to companies for the continuation of research within them to increase their TRL.

- Digital, industry, aerospace

Artificial intelligence

The technologies used in modeling and solving management problems are part of the so-called Computational Intelligence, one specific kind of AI technique. It is also planned to use machine learning methods for the analysis and exploitation of data arising from intelligent sensors.

- Climate, energy, sustainable mobility

Sustainable mobility

The project aims at increasing the sustainability of the waste collection logistic process by improving its efficiency and using low environmental impact vehicles.

PNR Coherence:

Ecological transition

The modification of management and operations models for the low environmental impact vehicles use is consistent with this theme.

Objectives and expected results, proposed research activities, methodologies, and contents:

Due to the increase in waste production and the impact of such activities both from an economic and ecological point of view, efficiency in the management and collection of municipal and special waste is one of the crucial aspects in the transition toward the so-called smart green cities. In particular, the management of urban or special waste collection vehicles is a field of research that has recently attracted interest in the scientific community of transport optimization (i.e., vehicle routing) because of its immediate and practical effects and also for the scientific challenge of conceiving sophisticated mathematical models and algorithms for the solution of the resulting computational problems.

To date, the main objective of research in this area has been to increase the efficiency of collection operations in economic terms. However, in recent years, also the goal of lowering the ecological impact of operations has been considered. To improve economic efficiency, solutions have been proposed for the dynamic routing of vehicles, for example for the management of special waste requiring immediate treatment, or models for on-demand collection (both from the point of view of waste production and treatment). As for the ecological impact, instead, there are models that take into account in addition to fuel consumption also the impact on greenhouse gases (GHG) of collection operations, trying to account for and minimize it.

The recent availability of electric vehicles can further reduce the ecological impact of collection operations, but it also poses new challenges in modelling and solving their efficient operations. In fact, the "last mile" logistics related to waste collection can be carried out with this type of vehicle which, however, have much more stringent autonomy limitations than classical combustion engine vehicles. These conditions require to rethink the optimization models and, consequently, the organization of the collection operations. Especially in vast territorial contexts (rural / mountain), there is also the need to design a network of charging stations optimizing their positioning with respect to the collection demand. In addition, operations management can benefit from the availability of real-time data from Internet of Things devices, generating intelligent collection plans that can further increase the operations efficiency.

The project aims to develop, analyze, and compare the infrastructures and waste collection models that make use of electric vehicles in different territorial contexts (urban, rural, mountain). A particular focus will be on the dynamical exploitation of the information coming from IoT sensors associated with the collection (smart bins, charging stations, etc.). The overall goal is the proposal of intelligent algorithms to support the operations management in terms of reducing their ecological impact and increasing their efficiency.

To achieve these objectives, the following phases of study and research are envisaged:

- 1) Analysis of the literature on waste collection systems, both from the organizational point of view and from the point of view of mathematical modeling and computational solutions (TRL1).
- 2) Literature analysis on the logistics management of electric or mixed vehicle fleets (TRL1).
- 3) Analysis of the solutions implemented by the host company and positioning of the same in the framework of the existing literature (TRL1).
- 4) Design, in collaboration with the host company and any institutional subjects (e.g., local authorities), of new organizational models for waste collection operations that exploit the availability of electric vehicle fleets and the availability of IoT data (TRL2).
- 5) Collection of data relating to case studies of the situation as is or generation of synthetic data through the creation of simulators and their validation (TRL2).
- 6) Mathematical modeling of the decision and optimization problems resulting from the design activities (TRL3).



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<p>7) Implementation of algorithms and of software systems for problem solving (TRL3).</p> <p>8) Validation of the models and comparison of their effectiveness using, possibly, the simulators of the activities and comparison and discussion of the results with the host company and with institutional subjects possibly involved (TRL4).</p> <p>Some of the activities envisaged in the PhD project can contribute to the definition of climate actions of institutional actors (local authorities).</p> <p>References</p> <p><u>Research activities to be carried out in the company and degree of involvement of the same in the definition of the training course:</u></p> <p>The activity in the company will mainly concern the analysis of the status as is of the collection operations and the evaluation of the necessary changes, both at a strategic, tactical, and operational level, of these activities following the new organizational problems related to the introduction of electricity collection fleets. Similarly, the company's experience will allow to define possible networks of intelligent sensors that can be used to increase the efficiency of operations. The company will be fully involved in phases 3 and 4 of the project, possibly in phase 5 and, finally, in phase 7 of validation of the results.</p> <p><u>Expected results and outcomes of the research activity for the growth of the skills of the PhD student with reference to the field of intervention:</u></p> <p>The main expected results of the research activity and outcomes on the PhD student concern the learning of state-of-the-art knowledge in the technical-scientific field of modeling and solution of waste logistics management problems both from a computational and organizational point of view. The PhD student will actively contribute to the definition of new organizational models and algorithms validated in the laboratory in this area. At the end of the training course, the PhD student will possess the technical-scientific knowledge that will allow him/ her to participate as an expert in the development of innovative products and services in the field of waste collection and, more generally, in green logistics.</p> <p><u>Research contribution to the pursuit of horizontal priorities (climate, digital transition; biodiversity, equality between men and women):</u></p> <ul style="list-style-type: none"> • Climate <p>Promotion of sustainable development by reduced the climate impact of waste logistics operations.</p> <ul style="list-style-type: none"> • Digital transition <p>Use of information technologies through intelligent sensors in a smart green city perspective.</p> <p>Using information technologies, the research aims to contribute to the reduction of environmental impact, in particular, in terms of reduced emission of greenhouse gases.</p> <p><u>Presence within the doctoral project of quantifiable and measurable targets consistent with the PON:</u></p> <ul style="list-style-type: none"> • Participation, as a speaker, in workshops, conferences, national and international scientific conferences • Publication of scientific articles in international scientific journals • Scientific collaborations with national and international research groups • Persons achieving a third-level university degree <p>Research Topic 1.2: Improving trust in cloud computing</p> <p><u>Relevance of Innovation themes:</u></p> <p>Cloud computing is by definition a universal paradigm for processing and storing delocalized data; as such, however, its actual use depends on the degree of trust placed by the owners of the data. Any measurable improvement of this degree therefore determines a strong push in favor of the use of services by a supplier who, as an IT tool, is in turn a vector of innovation</p> <p><u>Coherence of the proposed research with PNR themes:</u></p> <ul style="list-style-type: none"> - System priority <p>Enhance the circulation of knowledge and skills between the world of research and the production system</p> <p>It is explicitly planned to work at a theoretical-practical level on an IT problem directly agreed with a reference company active in the field of the supply of software solutions, so as to be able to validate together the proposed technology at least at TRL level 4. The developed model will be the subject of scientific dissemination and at the same time made available to the company for possible further development.</p> <ul style="list-style-type: none"> - Security for systems <p>Security of facilities, infrastructures and networks</p> <p>Research develops a security model for cloud computing.</p> <ul style="list-style-type: none"> - Digital, industry, aerospace <p>Digital Transition - i4.0</p> <p>The project explicitly plans to increase the state of the art in the reliable processing of delocalized data.</p> <p><u>Coherence of the proposed research with the PNRR themes:</u></p> <p>Mission 1: Digitalization, innovation, competitiveness and culture</p> <p>Trust in cloud computing is today one of the driving forces in the process of digitizing the country and, consequently, of its capacity for innovation and level of competitiveness.</p> <p><u>Objectives and expected results, proposed research activities, methodologies and contents:</u></p> <p>The project will specifically consider malware-based attacks based on polymorphic obfuscation techniques that prevent detection, which aim to read data in the cloud. The student aims to demonstrate how the use of appropriate techniques can significantly improve the security of data from this specific type of attacks.</p> <p>The methodology is based on the use of the Page Rank algorithm normally used to classify web pages on the web based on an importance metric. In the proposed method, each mobile malware is represented by a node in the score graph of similarity measured according to a trigonometric alignment calculated using cosine functions. The score thus takes into account the similarity of mobile malware based on characteristics such as the level of authorization achieved, mobility and the main activity of the malware. The greater the similarities between malware, the greater their alignment and finally the higher the ranking.</p> <p>To evaluate the generality of the methodology, more advanced functions will also be tested by calculating similarity scores from modified cosines and other functions developed ad-hoc, which take into deep consideration the level of risk linked to the level of authorization reached by the malware.</p> <p>The student will begin with i) the review of the attacks on delocalized data based on malware that occur more frequently today, ii) will carry out a classification of this type of attacks to the extent of their expected weakness with respect to the defense technique he intends to develop, iii)</p>
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will apply the hypothesized calculation and ranking method, and on the basis of the results obtained from time to time iv) it will refine the alignment functions at the same time identifying evolution criteria useful for adapting the proposed technique to new malware.

Research activities to be carried out in the company and degree of involvement of the same in the definition of the training course:

The activity in the company will concern the study of how to integrate anti-malware features into applications based on sharing data in the cloud, already provided to customers or in development at the same company.

This integration will take place at the level of software engineering, where the possibility of inserting security modules into existing architectures will be evaluated dynamically updatable based on the evolution of polymorphic malware attack techniques.

Expected results and repercussions of the research activity for the growth of the skills of the PhD student with reference to the sector of intervention:

The research will contribute to increasing the added value of software that processes delocalized data, with particular reference to the ability to defend users from attacks on data integrity and protection.

The PhD student will develop currently strategic knowledge at both the theoretical level, through the study of computer security in academia, and application in the context of the application of research within commercial-level software architectures.

Research contribution to the pursuit of horizontal priorities (climate, digital transition; biodiversity, equality between men and women):

Digital transition.

Presence within the doctoral project of quantifiable and measurable targets consistent with the PON:

- Participation, as a speaker, in workshops, conventions, national and international scientific conferences
- Publication of scientific articles in international scientific journals
- Scientific collaborations with national and international research groups
- People who achieve a third-level university degree.