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International Master of Science on Cyber Physical Systems "MS@CPS"

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INTERNATIONAL MASTER OF SCIENCE ON CYBER PHYSICAL SYSTEMS

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Master of Cyber Physical Systems

MS@CPS in Brief

With the widespread proliferation in various technologies, such as the Internet of Things (IoT), autonomous cars, smart phones, embedded systems, cloud computing, big data and 5th Generation Internet. The integration between software and hardware becomes very crucial to have reliable, secure and flexible systems. Despite the fact that software and hardware work in two different layers and domains, both components should be optimized to consider the characteristics and limitations of each other. Cyber Physical Systems (CPS) a new multidisciplinary subject that tackles the integration process between the various software and hardware technologies, while maintaining a user friendly and secure human computer interface. The International Master of Science on Cyber Physical Systems (MS@CPS) provides a specialized and unified view of the industry-oriented research field, aiming to prepare the students to be highly skilled analyzers, designers and developers of both the software and hardware aspects for various industry related systems and applications in the context of CPS. By enrolling in this program, the students will interact with people from several distinct countries, with

diverse cultural backgrounds to promote globalization and technological development based on students' choices and expectations. MS@CPS is a collaborative effort among European (Germany, Sweden and the UK) and MENA countries (Jordan, Tunis and Palestine) to establish an International Master of Science on Cyber-Physical Systems.

The envisioned master programme will focus on the contemporary recent technologies in various important applications in our daily life, such as Internet of Things, autonomous driving, smart phones, embedded systems, big data, semantic computing, cloud computing, etc. The project is founded by the European Union.

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https://www.linkedin.com/company/mscps/

Goals and Objectives

Main goal of MS@CPS is to establish an International Master of Science on Cyber Physical Systems. In order to achieve this goal, MS@CPS aims at:

- Provide expertise of primary focus areas: Embedded systems and knowledge-based systems for industry in programme and partner countries – Increase the mobility, capacities and advance knowledge, skills, and competencies in the field of CPS.
- Develop pedagogical methods to control the teaching tracks direct and implement learning outcomes and achieve a high level of knowledge, skills, and competencies in practice to create top talent in the field.
- Analyze the (MS@CPS) program requirements.
- Execute training courses for faculty members and staff.
- Create and develop technical courses to immediately meet the market needs.
- Setting the program admission policies dealing with institutional regulations and national legislations problems.
  - Identify the targeted students based on quantitative and qualitative analysis of

the market needs for graduates with Embedded Systems (ES) and Knowledge Based Systems (KBS) skills.
- Establishing advanced labs in the project partner universities equipped with latest technology of hardware, and software tools.
- Cooperate with local networks of companies and experts.
- Align with the European Credit Transfer and Accumulation System (ECTS) as well as EU related initiatives such as U-Multirank and others.
- Establishing summer school / winter school.

- Economic entrepreneurship.

PROJECT INFORMATION

Number:
598750 - EPP-1-2018-1-DE-EPPKA2-CBHE-JP

Key Action:
Cooperation for innovation and the exchange of good practices – Capacity Building in the field of Higher Education

Consortium

Institutions of the program countries include the University of Siegen in Germany, the leader of program.

University of Hertfordshire in the UK, and the KTH Royal Institute of Technology in Sweden. Institutions from the partner countries include the German Jordan University and Tafila Technical University from Jordan,

Carthage University and the University of Sfax from Tunisia, as well as Al-Quds University and Palestine Technical College - Deir El-Balah from Palestine.

F2F MEETINGS

Kick-off Meeting Press Release

On February 6th and 7th, 2019 the kick-off meeting of the Erasmus+ MS@CPS project took place in Siegen, Germany, in which 20 partners from 9 countries participated. During the kick-off meeting, several important aspects have been elaborated and discussed. MS@CPS is a collaborative effort among European (Germany, Sweden and the UK) and MENA countries (Jordan, Tunis and Palestine) to establish an International Master of Science on Cyber-Physical Systems (CPSs).

F2F meeting at GJU

The second face to face meeting held at the German Jordanian University (GJU) campus at Amman, Jordan. The meeting from 25 June 2019 to 27 June 2019. The consortium discussed progress and next steps in implementing the project. The MS@CPS acknowledges the GJU for hosting this event and appreciates her excellency Prof. Manar Fayyad, the president of GJU, for giving a welcome speech. At the second day of Amman face to face meeting which is held at the old city campus of the German Jordanian University (GJU), participants from programme and partner countries are participating in a workshop dedicated for discussions on curricula development and pedagogy methods of the MS@CPS project. The discussions also cover best practices in

teaching at the participants' countries as well as presenting some case studies.

The workshop concluded with discussing the upcoming best practices for MS@CPS. Dr. Reem Al Khader, the project officer at the national Erasmus+ office of Jordan, conducted the first monitoring visit to the German Jordanian University (GJU) to evaluate the progress of the MS@CPS project. Dr. Dhiah el Diehn Abou-Tair and Dr. Ala' Khalifeh from GJU team presented the project status in preparation activities, curricula development, quality plan and lastly the disseminatiom and exploitation plan.

The discussions were very fruitful and Dr. Al Khader praised the progress conducted so far and suggested some activities in the future for reaching optimal results of the project. Representatives of consortium members from all partner countries who were attending the third day of face to face meeting at GJU participated in this meeting with Dr. Al Khader.   In parallel to the monitoring meeting, another meeting was held among other consortium members to finalize the approaching deliverables according to schedule.

F2F meeting at Sfax university

MS@CPS consortium face to face meeting at Sfax university. The meeting discussed current status and progress of the MS@CPS project. The meeting from 5-7 November 2019 and it is hosted by higher institute of computer sciences and Multimedia of Sfax. Dr. Isam Ishaq from Al-Quds University is presenting mapping the requirements and the courses Bologna system.

Dr. Rashid Jayousi from Al-Quds University and Dr. Ezzaldeen Edwan from Palestine Technical College - Deir El-Balah presented the accreditation progress in Palestine.

Dr. Ala Khalifeh from the German Jordanian University presented the quality monitoring progress of MS@CPS project.
Dr. Raimund Kirner from the university of Hertfordshire presented progress in identification of the needs of women in partner countries.
Mr. Christian Weber from university of Siegen, the project leader, presented a presentation on finalizing the learning outcomes and curricula.
Mr. Christian Weber from the university of Siegen, the project leader, presented and moderated a session on development work package for mapping the learning outcomes to local courses for accreditation and as well on MS@CPS pedagogy.
Dr. Cali Nuur and Mr. Mohammed Saleh from KTHSweden presented progress on work package 3 which is related to cooperation with industry. They presented their experiences in developing the entrepreneurship course.
 MS@CPS consortium members have had an interview and open discussion with students at the higher institute of computer sciences of Sfax about their expectations on the CPS master program.

WORKSHOPS

Industry Workshops

Al-Quds University held its first workshop in cooperation with industry in the field of computer engineering and information technology to discuss with them the establishment of Master program on cyber physical systems according to market needs and requirements within the MS@CPS Erasmus+Project. The meeting was attended by academics from the faculty of engineering, computer department and dual studies program at the university to discuss with industry representatives the modern technologies in this field and to respond to market needs. The representatives of the local companies contributed by providing their suggestions and notes according to their experience.

Palestine Technical College – Deir El-Balah (PTC) held on the 16th of May 2019 its first workshop in cooperation with industrial sector of computer engineering and information technology. The workshop aims to discuss the establishment of Master program on cyber physical systems according to market needs and requirements within the MS@CPS Erasmus+ Project. Academic staff from engineering program and computer science departments at PTC and from IT and computer faculties at the Gaza Strip attended the meeting. From industry side, the meeting was attended by the projects officer Dr. Mazen Abu Qamar at the Palestinian Information Technology Association of Companies (*PITA*) in the *Gaza* Strip. The attendees discussed the modern technologies in this field and how to respond to market needs.

The meeting included two presentations given by Dr. Ezzaldeen Edwan, the local coordinator at PTC. The first presentation was an overview of the projects covering its goals and objectives and the second one was introductory one about the field of cyber physical systems and its potential for economy and society in the Gaza Strip.
Finally, PTC representative agreed with PITA representative and presented the project concept at the coming gathering of IT companies in Gaza for celebrating the World Telecommunication and Information Society Day, is held on the 21st of May 2019.
Higher Institute of Computer Sciences and Multimedia (HISCM) – University of Sfax, Tunisia, held on the 16th of May 2019 its first

workshop in cooperation with industrial sector of computer engineering and information technology. The workshop aims to discuss the establishment of Master program on cyber physical systems according to market needs and requirements within the MS@CPS Erasmus+ Project. Pr. Faiez Gargouri, Dr. Bassem Bouaziz and Dr. Zied Loukil from HISCM attended the meeting. From industry side, the meeting was attended by ASM firm, Dr. Saleh Ouerda and Expert Dev solutions, Dr. Mounir Ketata. The attendees discussed the modern technologies in this field and how to respond to market needs.

Carthage University (CU) held on May 29, 2019 its first workshop in cooperation with Tunisian industrial sector of computer engineering and information technology. The workshop aims to discuss the establishment of Master program on cyber physical systems according to market needs and requirements within the MS@CPS Erasmus+ Project. Academic staff at CU along with Tunisian

industrial partners in the field of computer engineering and embedded systems attended the meeting. The attendees discussed the modern technologies in this field and how to respond to market needs.
The meeting included two important presentations given by Prof. Nadia Aloui, the local coordinator at CU. The first presentation is an overview of the project covering its goals and objectives and the second one is about the field of cyber physical systems and then attendees were divided into several working groups for internal discussions.

Online workshop about curriculum development

The project leader University of Siegen organized on September 17, 2019 an online workshop over video conference among all partners of the project to proceed in the tasks of curriculum development at work package 2. The meeting started with a presentation given by Christian Weber from the University of Siegen entitled: "Envisioned MS@CPS pedagogy methods in a nutshell: Between Courses in Practice and Design and Development Case Studies".

The workshop ended with a discussion about "Local Best Practices", where partners talked about forms of teaching applied on the local levels at their universities. The aim of this workshop was to discuss the current state of teaching and find the best approach to realize the project. The workshop comes as work is being progressed on the accreditation applications at each partner country. On the 30th of September 2019, the project leader University of Siegen organized a second

online workshop over video conference among all partners of the project to proceed in the tasks of curriculum development at work package 2. The meeting started with a presentation given by Christian Weber Christian Weber from the University of Siegen that discussed concepts of "Projects in Practice" and "Design and Development Case Studies". He presented as well another short presentation about "Futures" of learning, along technology. The aim of this workshop was to discuss the current state of teaching and find the best approach to realize the project. The workshop comes as work is being progressed on the accreditation applications at each partner country.

EVENTS

The monitoring visit to Al-Quds University (AQU)

On 17th of September 2019, the national Erasmus+ office of Palestine represented by its director Dr. Nedal Jayousi accompanied with the programme officer Ms. Rawan Saqfalhett conducted the first monitoring visit to Al-Quds University (AQU) to evaluate the progress of the MS@CPS project. Dr. Rashid Jayousi the local coordinator, Dr. Isam Ishaq and Dr. Salah Oudeh from AQU team presented the project status in preparation activities, curricula development and quality plan. The discussions were very fruitful and Dr. Nedal Jayousi praised the progress conducted so far and suggested to finish early the accreditation procedure to reach optimal results of the project and expressed his support for the project. Representatives of Palestine Technical College – Deir El-Balah (PTC) the other Palestinian consortium partner were present as well via video conference and presented progress in dissemination and exploitation activities. Moreover, representatives of project leader the University of Siegen presented the management status of the project and other consortium partners participated in this meeting as well via video conference.

NEWS

MS@CPS Publishes a paper at ICPET 2019 Conference

On 23 of October 2019 Eng. Asmaa Shaheen and Dr. Ezzaldeen Edwan presented the

MS@CPS paper entitled "Work in Progress – Establishing a Master Program in Cyber Physical Systems: Basic Findings and Future Perspectives" at the international conference on promising electronic technologies ICPET 2019 in the first session which is entitled Capacity Building. The presentation is followed by open panel from the audience. Questions showed great interest from academia and industry in the project. It should be noted that the presented paper is published with the conference proceedings at IEEE Xplore digital library.

Open Day 2019 (JPO'2019) event - Concerning MS@CPS

The higher Institute of computer science and Multimedia (ISIMS) at the university of Sfax organized on the 4th of December 2019 the Open Days 2019 (JPO'2019) event. It comes after achieving success during the last years in organizing such events.

Many enterprises were invited and the doors were open to students and industrial representatives in order to exchange ideas. The aim of this event is to create communication channel between students and the industry representatives. Moreover, it aims to align the contents of the offered courses with the needs of the market through plenary sessions presenting subjects in the context of innovation and digitization. JPO 2019 also contained interviews and direct contact between students and companies

about the cyber physical systems master program which will be launched next year with the frame of Erasmus+ MS@CPS project.

A keynote talk in the event was given by the dean of the institute, Professor Faiez Gargouri, who presented the proposed CPS master program for the students and for industrial representatives. The master program captured the interest of computer science industrial attendees.

In conclusion, JPO 2019 enabled the ISIMS to listen to industrialists working on large-scale projects and discuss with them CPS master program structure. Moreover, it created sustainable cooperation through developing educational programs that meet the needs of companies. Lastly, it Introduced topics for internship so that students can interact with professionals and learn about the benefits of the proposed internships.

MS@CPS at Erasmus+ Info Day 2019 - Gaza City, Palestine

The team of MS@CPS at Palestine Technical College – Deir El-Balah (PTC) participated and presented the MS@CPS in the Erasmus Plus information day, which took place at the Islamic University of Gaza in Gaza City on Monday 23rd of December 2019. The event, which is devoted to increasing awareness of the Erasmus+ calls that are available for academic community. MS@CPS was present with brochures and a roll-up of the project at the event venue. The event was launched by president of the Islamic university of Gaza Prof. Naser Farahat and the director of the National Erasmus+ Office Dr. Nedal Jayousi. The event included presentations about the different calls of the Erasmus+ program.

Health Monitoring and Fault Diagnosis of Cyber-Physical Systems (CPS); an HVAC System based on Wireless Sensors and Actuator Networks

Recent advances in ICT, especially in embedded systems, enable the development of cyber-physical systems that profoundly couple our physical world to the computation world. The term cyber-physical system (CPS) came out in 2006 by Helen Gill from the National Science Foundation in the U.S. [1] refers to the integration of the computation world, performing by embedded computers, with physical processes via network fabric aims at monitoring and control. Physical processes affect computations and vice versa via feedback loops. Therefore, it is not enough to separately consider cyber and physical parts of the system, but also the CPS designer has to be able to understand the intersection of these fields. This joint integration causes certain issues to appear that are not prevalent in general-purpose computing e.g. the time of task operation. In CPS, it is not desired to perform tasks as quick as possible, rather, it's important to do the tasks at their right schedule considering the pace of the physical environment. Another issue is that in contrast to the sequential and discrete behavior of the cyber world, the physical processes behave comply with continuous dynamics.

On the other hand, a major part of the energy consumption in buildings is related to the Heating, Ventilation and Air Conditioning (HVAC) systems that keep thermal conditions in a comfort zone and indoor air quality (IAQ) in an acceptable range. Recent research trends and technologies that emerged based on advanced control strategies in building energy management systems (BEMS) indicate there is a potential energy saving up to 30% of total energy consumed in a building [2]. The U.S. Department of Energy denotes that the HVAC systems consume 48% of the energy consumed in residential buildings and from this amount 33% is the only share for space heating and ventilation which confirms the potential of energy saving [3].

The Chair for Embedded Systems at the University of Siegen designed a robust and predictable HVAC model in MATLAB/Simulink environment based on the CPS concepts with embedded processing units orchestrating the nodes of wireless sensors and actuators networks with the physical environment to adaptively control the air quality and temperature of the designed office building evolved over time that is named adaptive demand-controlled ventilation (DCV) and heating system. The integration of the continuous time-driven nature of the adaptive DCV and Heating system with the discrete event-driven nature of WSAN highlights the mentioned issue of developing the CPS.

The reliabilities of the system functionality and acquired information are not always guaranteed due to faults occurring in the system or network fabric.

The dependability of the CPSs necessitates design methodology that supports scalability and complexity management through modularity and composability. This project introduces a suitable HVAC technology with minimum energy consumption providing utmost indoor air quality and occupants thermal comfort besides a higher level of its robustness in functionality, e.g. against various probable faults and failures, in a composable and scalable architecture.

In HVAC systems, the faults can be the reason for energy waste up to 20% of total energy consumed by HVAC systems and excess pollutant emissions besides decremented thermal comfort for occupants [4], [5]. Faults in system components such as sensors and actuators can result in different types of failures and severe implications on the efficiency of the adaptive DCV and heating system [2].

The faults that are not detected and diagnosed at the right time can propagate into a component to produce an error. After the diagnosis of a strict fault, the recovery action is done to prevent the component or system failure. Otherwise, the error may propagate in a form of component failure or can propagate to another component or system that causes failure somewhere else. For this reason, it is necessary to apply mechanisms capable to assess the reliability of sensor information and guarantee the dependability of CPS.

AUTHORS


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Prof. Dr.-Ing. Roman Obermaisser is a full professor at the Division for Embedded Systems at the University of Siegen. He studied computer sciences at the Vienna University of Technology and received his Master's degree in 2001. In February 2004, Roman Obermaisser finished his doctoral studies in computer science with Prof. Hermann Kopetz at the Vienna University of Technology as his research advisor. In July 2009, Roman Obermaisser received the habilitation ("Venia docendi") certificate for technical computer science. His research work focuses on system architectures for distributed embedded real-time systems. He wrote a book on an integrated time-triggered architecture that was published by Springer-Verlag, U.S.A. He is the author of several journal papers and conference publications. He has also participated in numerous EU research projects (e.g., DECOS, NextTTA) and was the coordinator of the European research projects GENESYS, ACROSS, and DREAMS.

M.Sc. Ali Behravan,
Ali Behravan is a Ph.D. candidate at the University of Siegen, Germany, since 2016 and he received Master's degree in mechanical engineering in 2014. He is a member of the Institute of Electrical and Electronics Engineers (IEEE), the European AI Alliance, as well as the Association of German Engineers (Verein Deutscher Ingenieure, VDI). Besides his Ph.D. studies, he is serving as a research associate in the area of embedded mechatronic systems such as Smart Buildings' new HVAC technologies and fault-tolerant systems aligned with the German Research Foundation (DFG) projects. He served as the lecturer at graduate level at the Department of Electrical Engineering at the University of Siegen since 2016. Ali advised numerous Master Theses, Student Works (Studienarbeit), and Seminar Works at University of Siegen. He is selected as the scientific committee member for the ICIE 2020 in Portugal and CoDIT 2019 in France while he served reviews for Elsevier journals, e.g. Energy, Energy, and Buildings, etc. He has published scientific papers at prestigious IEEE conferences as well as reputed journals and received the Best Paper Award at IEEE IEMCON 2018, University of British Columbia, Vancouver, Canada.

However, tracing the component and system behavior back to the faults is a challenging task [2]. This project conducts the research to study the health monitoring and fault diagnosis techniques on the developed platform for finding the nature, value, time of occurrence, and locality of faults using a mapping from failures to faults. Therefore, a fault injection simulation framework established during this project according to system characteristics such as model composability and scalability to test and evaluate a newly developed signal- and model-based diagnostic technique besides artificial intelligence (AI) algorithms e.g. deep learning as a part of data-driven methods based on artificially injected faults.
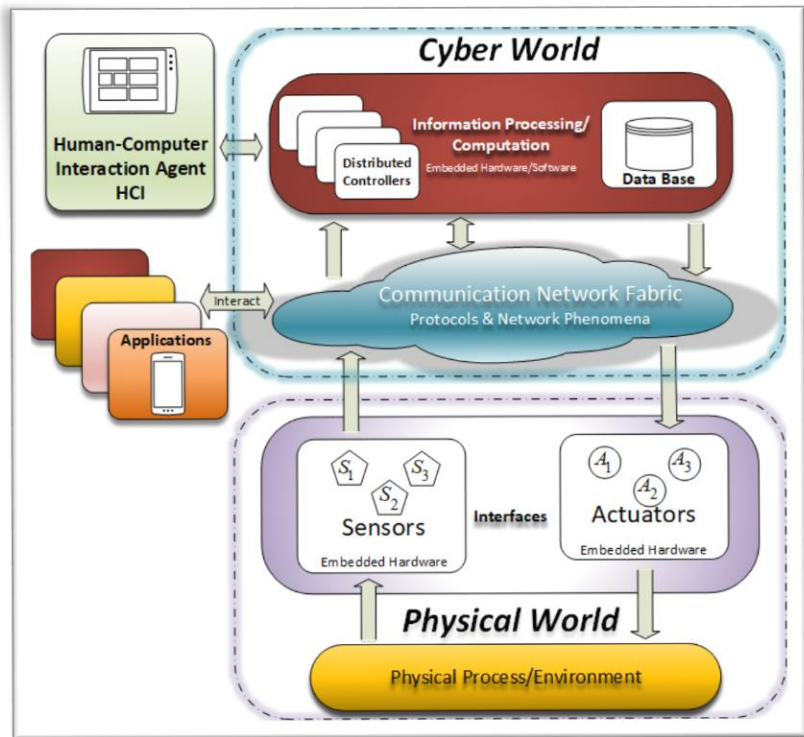
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Project Leader

The consortium is led by the University of Siegen in Germany. The University of Siegen has a long running experience of combining embedded systems, as the overarching concept for CPS, knowledge management and intelligent systems, to continuously utilize the intersection for research and teaching throughout the master's degree domains of computer science and electrical engineering. In consideration of the implemented best practices at the University of Siegen, a jointly developed pedagogy is in focus of the MS@CPS master program.

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