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INTRODUCTION

Congratulations! You’ve got a Master’s degree within the area of computer science and engineering or equivalent experience in the industry and you’ve got a clear view of what the digital future will look like.

You know you want to be part of the latest revolution in computer science and become one of the world’s top experts on the Internet of Things. To make this happen further specialisation within the right community is absolutely essential.

This brochure is the key to unlocking that specialisation. The Post-graduate in IoT is a unique programme created in collaboration with the University of Antwerp, Ghent University, Vrije Universiteit Brussel and lecturers of KULeuven and the Antwerp Management School and embedded in an equally unique broad ecosystem of small and large world-leading IoT companies. It consolidates all specialist knowledge you need to become a true Internet-of-Things expert. And it takes place in Flanders’ number-one smart city: Antwerp. The programme represents a unique stepping stone to a new highly innovative and/or entrepreneurial career in the IoT sector.

The Internet of Things is waiting in the wings... This programme offers you a unique chance to help put it centre-stage. The IoT sector and IoT-adopting industries need you!
YOU, YOUR PROGRAMME, YOUR FUTURE

“The fastest growing industry. Five years ago, it did not exist. In five years you cannot imagine being without.”

Gert Pauwels - Orange
CAN YOU ENROL?

You can enrol in the postgraduate after undergoing a suitability check. Use the procedure below to apply.

YOU HAVE ONE OF THE FOLLOWING DEGREES:

- Master of Computer Science
- Master of Electrical Engineering
- Master of Electronics and ICT Engineering Technology
- Master of Engineering: Computer Science
- Master of Science in Applied Sciences and Engineering: Computer Science
- Master of Science in Electrical Engineering
- Master of Science in Computer Science Engineering
- Master of Science in Electrical Engineering
- Master of Science in Information Engineering Technology
Applicants must be proficient in English. Candidates with a degree from universities or colleges outside Flanders must prove their proficiency in English by submitting one of the following documents:

- you have studied at least one academic year (or 60 ECTS credits) in an English-language bachelor or master programme;
- a language certificate showing you obtained the following results:
  o TOEFL (Test of English as a Foreign Language, organised by ETS): paper-based TOEFL level of minimum 550, or an internet-based TOEFL level of minimum 79-80. You can find more information on the TOEFL-website;
  o or IELTS (International English Language Testing System): a minimum score of at least 6.5, and on each part at least 6.0. You can find more information on the IELTS-website;
- or knowledge level B2 of the Common European Framework.

Complete and submit the online form, your CV, a copy of your diploma/degree certificate and a copy of your language proficiency certificate (if necessary) at http://postgraduaatinternetofthings.be/application.

Final-year Master students can also apply. You must have completed the required degree by the time you enrol.

YOU HAVE A DIFFERENT MASTER’S DEGREE OR EQUIVALENT

Complete and submit the online form, your CV, a copy of your diploma/degree certificate, a copy of your language proficiency certificate (if necessary) and a motivation letter at http://postgraduaatinternetofthings.be/application.

TUITION FEES AND GRANTS

For more information about the tuition fees and grants available, please visit:

http://postgraduaatinternetofthings.be/tuitionfees
http://postgraduaatinternetofthings.be/application
IS THE POSTGRADUATE IN IOT RIGHT FOR YOU?

You’ve just graduated or you already are an IT expert within your company for a long time. No doubt you know that expertise in distributed embedded software, ranging from small microcontrollers all the way up to a cloud environment, is key in current state-of-the-art software development. This is where the exciting world of IoT begins.

The Internet of Things is made up of three key areas:
- communication (Internet/low power)
- data (big data/AI/deep learning)
- distributed embedded software
This isn’t in a standardised environment though, but in an environment with very specific constraints:

- low power
- limited computational resources
- hyperscalability
- huge quantities of data
- security

It’s also important to take into account the social and economic aspects of this kind of environment:

- user perception
- market potential of applications
- impact on the city
- legal issues (e.g. privacy)

This programme focuses on the impact that the technology has in each of the three key areas on the abovementioned constraints. Students will use the acquired knowledge to implement total solutions while taking into account important social and economic issues.
FUTURE PERSPECTIVES

“For the industry, with IoT it will be the same as with the Internet. Adopt the technology or vanish.”

Peter Hellinckx – UAntwerpen/imec
According to Gartner, 8.3 billion devices are now connected to the Internet. Cisco expects this figure to rise to 50 billion devices by 2020. IoT solutions are typically used to increase the productivity of processes, improve product quality and/or create innovative products such as sensors and wearables.

Recent polls show that around 70% of Flemish technology companies need IoT solutions like these to remain competitive but keeping up with the latest developments is no easy task. Companies with insufficient knowledge of expected IoT developments run the risk of investing in outdated technologies.

What’s more, realising new IoT solutions successfully requires interdisciplinary teams with both technical and socioeconomic skills. This combination of expertise remains underrepresented in Flemish companies.

This postgraduate programme aims to respond to the increasing demand in Flemish industry and research for people who can play an innovating, leading role in this rapidly evolving technology.

This demand is clear when we look at the companies and research institutes who have already lent their support to the postgraduate programme through funding or the Resonance Council: Agfa-Gevaert, Antwerp Management School, Atlas Copco, Cronos, DSP Valley, imec, KU Leuven, Nokia, Orange, Port of Antwerp, Proximus, PSA Antwerp, Rombit, Telenet, University of Antwerp, Ghent University, Vrije Universiteit Brussel, the City of Antwerp, and more.
"Internet of Things is about augmenting human and machine senses by ambient intelligent data. Future IoT experts should be ready to make this happen."

John Baekelmans - imec
STUDY PROGRAMME

The study programme consists of 66 credits and is divided into eight mandatory modules worth a total of 36 credits, a project component worth 24 credits and an optional component (course/module) of at least 6 credits.

You may choose to take the programme full-time or part-time in modules. Part-time students may only take Advanced IoT Networking Lab if IoT Communication Protocols and Context-Aware Wireless Embedded Systems are taken simultaneously and the IoT Project in may only be taken in the graduation year.

Students who have already obtained credits for one or more of the programme components may put together a personalised programme in consultation with the Guidance Committee.

All programme components are taught in English.

You will receive a certificate when graduating.
# STUDY PROGRAMME

<table>
<thead>
<tr>
<th>MANDATORY PROGRAMME COMPONENTS</th>
<th>36 CREDITS</th>
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<tbody>
<tr>
<td>Advanced IoT Networking Lab</td>
<td>3 credits</td>
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<tr>
<td>Context Aware Wireless Embedded Systems</td>
<td>6 credits</td>
</tr>
<tr>
<td>Data Representation, Reduction and Analysis</td>
<td>6 credits</td>
</tr>
<tr>
<td>Internet Economics and Entrepreneurship</td>
<td>6 credits</td>
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<tr>
<td>IoT Communication Protocols</td>
<td>6 credits</td>
</tr>
<tr>
<td>IoT Distributed Embedded Software</td>
<td>3 credits</td>
</tr>
<tr>
<td>IoT Security</td>
<td>3 credits</td>
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<tr>
<td>Transforming Business</td>
<td>3 credits</td>
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| IOT PROJECT                                           | 24 CREDITS |


## STUDY PROGRAMME

### OPTIONAL PROGRAMME COMPONENTS

<table>
<thead>
<tr>
<th>Component</th>
<th>Credits</th>
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<tbody>
<tr>
<td>Big Data Science</td>
<td>6 credits</td>
</tr>
<tr>
<td>Business Aspects of the Software Industry</td>
<td>3 credits</td>
</tr>
<tr>
<td>Distributed Computing and Storage Architectures</td>
<td>4 credits</td>
</tr>
<tr>
<td>Industrial Seminars</td>
<td>3 credits</td>
</tr>
<tr>
<td>Knowledge Economy and the City</td>
<td>3 credits</td>
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<tr>
<td>Management and Performance Analysis of Sensor Networks</td>
<td>3 credits</td>
</tr>
<tr>
<td>Prototyping</td>
<td>3 credits</td>
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<tr>
<td>Transport Policy and Business: Concepts and Practice</td>
<td>3 credits</td>
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PROGRAMME COMPONENT INFORMATION

ADVANCED IOT NETWORKING LAB
The Advanced IoT Networking Lab is an opportunity for students to put into practice the knowledge they acquired in the modules on Context-Aware Wireless Embedded Systems and IoT Communication Protocols. They are asked to build entire end-to-end IoT systems consisting of a combination of the following components: one or more embedded devices, a wireless IoT communication network, a gateway, a back-end system connected to the Internet, and a mobile application. In realising this system, they make use of off-the-shelf hardware, open-source software components and the latest IoT protocol standards.

Building these fully integrated systems enables students to acquire the necessary knowledge and insights into how total solutions come into being. Students are also required to analyse the strengths and weaknesses of their systems in terms of openness, scalability, management complexity, etc., as well as potential use cases that could be realised.
CONTEXT AWARE WIRELESS EMBEDDED SYSTEMS
This module focuses on hardware-software interactions in low-power wireless embedded IoT systems. We discuss the impact of hardware and software design choices on performance and energy use. We also look at specific programming strategies for running embedded hardware systems efficiently and for determining the context for these systems (location, environmental parameters, etc.). We analyse how to use sensors efficiently and how to achieve optimum system integration with energy supply and communication modules in mobile embedded systems. The module also covers a number of indoor and outdoor localisation algorithms (proximity-based, attenuation-based, pattern-matching, etc.) and how hardware sensors can be used to improve these location estimates. All of these aspects of hardware-software interaction are taught through a mixture of lectures and practical exercises.

DATA REPRESENTATION, REDUCTION AND ANALYSIS
In the current era of data abundance, enormous quantities of data are continuously being collected from diverse information sources and in various domains, ranging from science and technology to business and telecommunications. Petabytes of high-dimensional data from multi-modal imaging systems, social media, recommendation systems and large-scale research experiments all require advanced solutions for information representation, dimensionality reduction and data analysis. In response to these ‘big data’ challenges, this module teaches students the basics of signal processing and machine-learning tools, which allows them to detect, display, collect and process high-dimensional data from low-dimensional measurements.

INTERNET ECONOMICS AND ENTREPRENEURSHIP
This module addresses the characteristics of new media from various perspectives, including innovation economics and strategic management. Topics include web-based media and social media, but also smart environments and the Internet of Things.
Using both a theoretical/conceptual framework and a number of case studies, we discuss important concepts related to innovation, standards, networks and platforms. The module also sheds light on certain business aspects that are relevant to entrepreneurship in new media, in relation to business models in new-media products and services. The students acquire deeper insights into these issues by applying their knowledge to a case study which changes from year to year.

**IOT COMMUNICATION PROTOCOLS**

During the IoT Communication Protocols module, students learn which wireless communication systems and network protocols are available for building the Internet of things. The module discusses the challenges and current potential of connecting devices, as well as of building IoT systems that can work together. We look at the impact of the various communication protocols currently in use, ranging from MAC protocols and IP connectivity to embedded web services technologies. The technologies and protocols covered in the course include Zigbee, Bluetooth, IEEE802.11ah, SigFox, LoRa, SigFox, 6LoWPAN, CoAP, OMA LWM2M, etc. The students will also gain practical experience of using these protocols during lab sessions. At the end of this module, students will be able to assess the impact of IoT system design decisions (e.g. choice of communication technology, interaction model, etc.) and to choose and design communication protocols that suit the requirements of the application and the limitations of the embedded devices.
IOT DISTRIBUTED EMBEDDED SOFTWARE
The module teaches students how to develop heterogeneously distributed software applications. They learn to take into account the particular constraints of each device (e.g. energy, computational power, price of resources) and the scalability requirements of IoT applications (rapid upscaling) when distributing software over various heterogeneous platforms. They also learn to test applications correctly. Besides component-based testing, simulation-based hyper-scale testing plays an important role in this. By the end of the module, the students should understand that they can only assess the limits and potential of an IoT application if it has been tested at the correct scale, and that simulation offers a useful solution.

IOT SECURITY
This module teaches students to have a clear understanding of the available IoT platforms and their security and privacy aspects in order to evaluate the existing systems. They will get to know technology that tackles frequent security issues: security techniques on a system level, on a network level, on an application level in order to assess the applicability (and the corresponding trade-offs). Students will become familiar with the most important building blocks of a security solution within the IoT context: authentication, authorisation, cryptographic components, key management, etc. They will be able to select these building blocks (keeping in mind the pros and cons) for a specific architecture. This module also teaches students to apply existing methods for
security and privacy analysis and design to IoT systems and their applications. Students, as security architects, will be able to apply the aforementioned knowledge to a specific case study and also be able to assess which innovations will be available within the next 5 years based on an overview of worldwide leading research.

**TRANSFORMING BUSINESS**

One secret to maintaining a thriving business is recognizing when it needs a fundamental change. Seven out of ten companies are engaging in business model innovation, and an incredible 98% are modifying their business models to some extent. Business model innovation is about fundamentally rethinking your business around a clear—though not always obvious—customer need, then realigning your resources and processes with this new value proposition.

In the module “Transforming Business” you will learn about different business model innovations from a value creation, financial and human resources perspective. You will apply this in a business case and enhance your understanding of developing and transforming to a new business in discussion with your fellow students. Not only the strategic aspect, namely “what could a future oriented business model look like”, but also the people aspect, namely “how can you get your team on board” are subjects of the module.

**IOT PROJECT**

This is the final component of the postgraduate programme. With the help of an individual supervisor, the students use the knowledge they acquired in the technical modules taught during the first semester to work out a total solution in the IoT context. The idea is that students demonstrate, in their total solution, portfolio, paper and public defence, that they are capable of selecting, adapting and combining the right technologies from each of the three key areas (communication, data and software). Their solutions should work reliably within the constraints of the IoT environment and take the social and economic aspects of the application into account.

“Antwerp is currently laying the foundations to bring together like-minded parties around IoT in order to come to a co-ordinated smart city.”
Koen Matthijs - MCS Groups
The programme components are taught on the campuses of the University of Antwerp, Ghent University, Vrije Universiteit Brussel, KU Leuven or the Antwerp Management School. Several components can also be made available at UAntwerp through video streaming.
Site Zwijnaarde-Technologiepark

Campus Etterbeek
Groenenborgerlaan

Middelheim Park

Campus Groenenborger
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@PG_IoT
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