The mobile ecosystem has been the precursor of great changes in society, not only because of technological improvements in communications and better performance due to the new characteristics of mobile phones, but also in the way devices are used, which have changed behaviour and consumption habits.

Obviously, the main use of mobile phones is no longer to make voice calls to another person. Instead, they are a point of access to data around the world. They are not only a source of information, leisure and entertainment, but also a channel for users to access a multitude of services from a portable device that fits in our pocket.

Over a decade has passed since the GSMA brought to Barcelona one of the main events in the presentation of the new mobile technologies, the Mobile World Congress. Then, improvements in the components that mobile phones contained were presented as innovations (for example, cameras with more megapixels, greater memory and processing capacity, etc.). The first touch screen mobiles (2008) and the adoption of Android as an operating system (2010) were what made standardised and facilitated the generation of third-party apps, putting mobile phones at the centre of an entire ecosystem of leisure and consumption.

In recent editions, the big brands have continued to take advantage of the event to show the public innovations in new models of mobiles, gadgets and accessories. In addition, there is also space for new business models derived from the uses of the telephone and the devices that we can connect to it.

The population uses mobile devices more frequently to access various services to facilitate and improve their quality of life. In this respect, mobile phones are expected to help to promote the Sustainable Development Goals (SDGs) established for 2030. This includes helping people to obtain all the benefits provided by accessing health information, public services and digital payments, and taking advantage of new technologies to reduce pollution, mitigate climate change and increase energy efficiency.

The adoption of the technology surrounding smartphones is so relevant that in each technological evolution (streaming of audiovisual contents, Internet of Things (IoT), 5G, edge computing, AI, blockchain, biometrics, etc.) the mobile telephone continues to expand its functionalities or services and remains the main user interface.
All these changes are due to improvements, perhaps not so much in appearance as in new communication protocols that allow connection with more devices and with better latency and data transmission speed conditions.

Improvements in connectivity, together with ever smaller and more powerful processors, make the implementation of new applications, goods and services possible. Most of these are based on the digital economy that is enriched by data. In addition, they make it possible to interact remotely with other devices, which have sensors and/or actuators that generate data for future use and exercise the function for which they were created. This multi-connectivity helps technological advances to expand and develop independently.

In addition, advances in artificial intelligence and automation have promoted new models of use due to the reduction in costs and execution times, the generation of overlooked processes and decentralisation of business models.

The UPC develops solutions based on its expert knowledge and experience that responds to current challenges in smart connectivity at various levels. Participation in three of the leading initiatives in mobility innovation is an example of the range of areas in which the UPC applies the connectivity technologies that it develops in a cross-cutting way and in a global environment, in collaboration with companies in the sector:

- UPC forms part of 5G Barcelona, a public-private initiative that works to transform Barcelona Metropolitan Area into an open, neutral urban laboratory so that 5G technologies and applications can be adapted in a real environment. 5G Barcelona is being promoted by the UPC, the Government of Catalonia, Barcelona City Council, Mobile World Capital Barcelona, i2CAT, CTTC and Atos.

- The UPC is the Catalan institution that participates in the most transformative technological areas in R&D projects that are successfully transferred to industry, within the emerging technologies programme launched by the Government of Catalonia. The UPC participates in six of the nine strategic partnerships that have been promoted by the Catalan government and leads two of them on Industry 4.0 and 3D printing, respectively. This programme is part of the Catalan research and innovation strategy for smart specialisation (RIS3CAT) and is jointly funded by the European Regional Development Fund (ERDF). In the Industry 4.0 area, Looming Factory has been founded as a partnership between research, development and innovation groups in the university world and industry. The aim is to facilitate and accelerate the market launch of emerging technologies that are aligned with new industrial challenges resulting from digital transformation: smart, connected factories and collaborative robotics in production environments, with demonstration of these technologies in real environments.

- In addition, the UPC is the founding member of CARNET - the Future Mobility Research HUB, along with SEAT and Volkswagen Group Research and coordinated by the CIT UPC. CARNET is an open hub based on public-private collaboration between industrial and academic partners to design future urban mobility through research and innovation.

- In addition, the UPC is the founding member of EIT Urban Mobility, a European Institute of Innovation and Technology (EIT) project that aims to become the main European initiative that transforms urban mobility.
5G is expected to be disruptive due to improvements in the capacity to host devices on the network, reductions in latency in communications and increased transmission speed. Given these innovations, there is a need to implement protocols that adapt established networks, such as fibre optics to enable the flexibility and robustness required for new use cases.

5G integrates the concept of a software-defined network (SDN), software-defined wireless networking (5G-SDWN) and software-defined radio (SDR) and establishes that the elements in the network incorporate protocols in higher open system interconnection (OSI) layers, that is, that the elements of the network incorporate applications and are no longer simple links between terminals.

In addition, 5G will optimise communication between IoT devices as it represents a qualitative and quantitative jump in related applications such as industry 4.0, autonomous and connected vehicles, monitoring of assets and remote surgery; which are not very feasible with 4G networks but are with 5G, given the increase in connected devices that they can serve and the ultra-low latencies.

In addition, the greater connectivity of devices adds intrinsic challenges to industry, with the implementation of better cybersecurity systems in line with the new scenarios. The exchange of information in business processes is facilitated, but at the same time the potential vulnerability of connected devices increases in the face of potential external attacks.
A NEW ENVIRONMENT THAT IMPROVES THE FLEXIBILITY OF THE 5G SERVICE

The Optical Communications Group (GCO) has worked on SliceNet. The aim of this European project is to maximise the potential of 5G infrastructures and their services through the design and implementation of an advanced network management and control system for 5G services. This ensures that requirements are met in terms of flexibility, enhanced operational capacities with respect to service quality, and the experience from the terminal to the operating system.

The SliceNet management and control system has been tested in three use cases to provide vertical services in the fields of smart cities, e-health and smart grid. Specifically, the cases are smart management of public streetlighting, a connected ambulance grid. Specifically, the cases are smart management of public streetlighting, a connected ambulance grid. These network services must be orchestrated end-to-end over several segments or sections of the network and computational resources (IT) with varying characteristics. The aim is to ensure high scalability of interconnecting anything (for example, people, things, processes and contents) in any place, through a set of network services that really meet communication requirements (in terms of bandwidth, latency, reliability, etc.).

These network services must be orchestrated end-to-end over several segments or sections of the network and computational resources (IT) with varying characteristics. The aim is to ensure high scalability and reactivity in the face of unexpected traffic and resource state changes in an energy-efficient way.

In ALLIANCE B, new transmission techniques have been researched based on advanced modulation formats to optimise spectral efficiency and energy consumption throughout the optical network. This creates a high capacity, flexible optical network that can support the establishment of 5G services. In addition, optical network infrastructures that are spectrally flexible (in signal commutation) are being investigated, with ultra-high capacity compared to current optical systems.

NEW OPTICAL TECHNOLOGIES FOR THE NEEDS OF 5G APPLICATIONS

The project has also focused on architectures and technologies for the control and management of virtualised infrastructure resources for optimal provision of end-to-end services.

ALLIANCE B works on the design and implement management and orchestration solutions based on cognitive techniques to guarantee the quality of service (QoS) and quality of experience (QoE) of services that are rolled out. One ambitious objective of ALLIANCE B has been to design and implement machine learning-based techniques for optimal end-to-end service provision.

The project lasts three years (January 2018 to September 2021) and has received 91 million euros of funding from the RETOS programme of the Ministry of Science, Innovation and Universities.

The Wireless Networks Group (WNG) has developed a new signalling protocol model to improve efficiency in the handover mechanisms of 5G networks.

When users are subjected to handover processes (changes in the connection of a device from one base station to another depending on coverage), these must take place in the shortest time possible and under the best conditions. The aim of 5G networks is to reduce these times or latencies, even though the current handover mechanisms that are specified in the standard are not always the best.

Within the 5G-AURA project, this signalling is restructured to reduce latency and provide perfect continuity of communication without altering existing data structures. Based on a small modification in the transmitter, using Software Defined Networking (SDN), information transfer duplication is avoided, and the number of messages is reduced, while the current protocol and data structure is maintained.

The new system, which has given rise to a patent, is designed to restructure the sending of messages without a profound change in mobile phone standards, to enable operation between networks of different generations (2G, 3G, 4G and 5G), and to improve the transmission quality and service. This will optimise the performance and reduce handover latency by up to 48.83%, total transmission costs by up to 50%, and processing costs by up to 50%. In total, it will reduce the amount of data transferred by up to 10.56%.

This optimisation opens the opportunity to reduce the cost of services for the end users and will facilitate the transition to new networks and mechanisms for suppliers and operators.

The 5G AURA project lasted 4 years (2015-2019) and had a budget of 634,417 euros.
As part of the SOCRA (Software Defined Small Cell RAN Optimization) project, the Cellular and Ad-hoc Networks (GRXCA) research group has developed an algorithm for optimisation under demand of the energy consumed in 5G mobile networks.

The forecast increase in connected devices in coming years will create an unprecedented increase in the traffic that is generated, and consequently greater general use of resources in telecommunication networks and greater energy consumption by them. The increase in energy consumption has a clear economic and environmental impact. Therefore, it is vital to optimise the energy that is consumed by all network elements, according to the circulating traffic, to offer a service that is committed to the user without decreasing quality and using the least amount of energy possible.

The algorithm developed as part of SOCRA adapts the topology of the network to existing traffic conditions and regulates the use of links in the access network for users and the links between base stations in the 5G network, so that resources whose use is not considered necessary at a certain moment can enter a state of deep sleep. All this reduces the overall energy consumption of the network. The benefits of the algorithm are particularly clear at night-time, when the network load is quite low. In these circumstances, reductions in network energy consumption of up to 90% are obtained. Currently, the group has defined algorithms whose simulation results meet the established expectations in terms of precision. The testbed phase will begin shortly.

Participants in the SOCRA project consortium are the Karlstad University (KAU) in Sweden, Huawei Technologies Sweden AB, Gotmic AB and Bluewave Microsystems AB. SOCRA lasted three years (2015-2018) and had a budget of 510 million euros.

The 5G&B Runner project has received funding of 181,500 euros from the Ministry of Science, Innovation and Universities, and it lasted 4 years (December 2016 to September 2020). It was coordinated by the Signal Processing and Communications (SPCOM) at the UPC.
5GWIRELESS – ARCHITECTURES, TECHNOLOGIES AND INNOVATIVE TOOLS FOR THE HIGH-CAPACITY 5G NETWORK

The Signal Processing and Communications (SPCOM) group has participated in 5GWireless, a European project in the H2020 programme. The project is one of the Marie Skłodowska Curie Innovative Training Networks (ITN) actions and is centred on the study and design of innovative architectures, wireless technologies and tools for high capacity, sustainable 5G ultra-dense cellular networks.

5GWireless is a fully integrated, multi-disciplinary network worked on by 15 early stage researchers (ESR) in ten research institutions in six European countries (Germany, the United Kingdom, Sweden, Greece, Spain and France). The network provides a cross-sectoral environment in which the researchers have been able to develop new concepts, methodologies and tools in a range of fields such as device-centred cellular architectures, ultra-dense networks and millimetre-wave communications.

Two of the researchers have undertaken their work at the UPC in two subject areas.

One of the areas is large-scale multi-antenna (MIMO) technologies (Massive MIMO) for millimetre-wave communications (above 28 GHz). The project is mainly focused on the design of hybrid (analogue/digital) low-energy consumption MIMO transceivers using simple devices, 1-bit sampling and fewer RF chains than the number of antennas (single-RF MIMO). In turn, the design takes advantage of the characteristics of the propagation channel to select antennas in order to obtain high spectral efficiency. Developments have been made for the uplink and downlink channels, and multi-user transmissions have been considered in both links.

Another area is the development of advanced analysis tools for dense networks with small cells using stochastic models. These tools are key as they can be used to simply assess configurations of the network, aggregate interference values and predict the performance of these networks without the need to undertake costly simulations with long execution times. From this perspective, these tools could be particularly attractive for operators of new generation cellular systems.

Four universities have participated in the project consortium, as well as a research centre and five private companies.
BEAMFORMING IN MULTI-ELEMENT ANTENNAS AT VERY HIGH FREQUENCIES FOR THE CONNECTED CAR

To develop the connected car, improvements must be made in the field of electronics, such as advanced driver assistance systems (ADAS), new infotainment systems, and more recently communication systems and sensors that provide progressively higher levels of autonomy. These applications need to produce a beam of radiation that is sufficiently directional and adaptable that can scan the space to establish efficient communication or locate a target accurately. This is the case of the new multi-element antennas for data communications or radar detection, particularly for antennas working at millimetre wave frequencies. In this context, technology has been developed to adapt the use of these types of antennas of connected vehicles using a technique called Beamforming. This technique is increasingly used in wireless communication such as 5G, LTE and Wi-Fi, in groups of 3D sensors, sonar, medical imaging and audio systems. However, it has not been used for communications in the automotive industry to date.

Beamforming enables the antenna to form narrow beams that can simultaneously or sequentially scan the 3D space to select concentrations of radiation transmitted or received from an antenna in a specific direction and/or space. This selective concentration of radiation improves the signal-to-noise ratio and eliminates interference. The result is an improvement in the reliability of the system for complex and high velocity situations (for the various urban, suburban and rural zones), an improvement in the scope of V2X (V2V and V2I) systems, a significant increase in capacity by achieving 8Gbps speeds, greater spectral and energy efficiencies and higher resolution and accuracy in general, which increases with frequency. In addition, the introduction of a reconfigurable multibeam communication system for sub-6GHz, particularly at MMW frequencies, should provide information (angle and/or arrival time) on the source of the incoming signal (location of the infrastructure, another car, the satellite system, etc.) for safety applications or to reduce interference in a highly dense environment, and to connect with land-based and satellite systems.

Eventually, an advanced Beamforming technique could also lead to the development of a cognitive radar with improved resolution, better radar image quality, immunity from interference and capacity to learn from the environment. Combined with the sensors, it could provide full, robust information that brings us closer to a virtual image of the 3D environment in real time.

In short, the Beamforming technique applied to the next generation of reconfigurable vehicle communication systems will create the opportunity for a safer generation of vehicles that are better connected, have a greater knowledge of the environment and are more environmentally friendly for data transmission in high velocity environments.

METHOD OF DATA MODULATION FOR WIFI DEVICES TO COMMUNICATE WITH NON-WIFI DEVICES

The Wireless Networks Group (WNG) has worked on a data modulation method. This technology enables communication from a Standard WiFi device to IoT devices that are non-WiFi, through a simple software update. A new WiFi transmitter has been designed to generate radio signals that the receiving IOT devices can “understand”. The technology enables a new use of the functions and signals that are already present in WiFi transmitters.

The project lasted four years (2016–2020) and had a budget of 204,853 euros. This technology led to a patent.

OUR EXPERTS SAY

“The technology for manufacturing integrated circuits will continue to improve in other aspects such as 3D integration. Doubtless the role of architecture will gain particular relevance to continue to innovate. One of the main challenges in the area of computer systems architecture will be improvement in energy efficiency.”

Antonio González, researcher specialised in Computer Architecture, director of ARCO
LOW-POWER-RADIO INTERNET-OF-THINGS WIRELESS MESH

The Wireless Networks Group (WNG) is leading a project to design and implement a wireless mesh for the internet of things (IoT) with low-power radios. The Internet of Things (IoT) allows the integration of all kinds of objects into common telecommunications networks, facilitating interaction between users and “things” in everyday environments through applications for home, the city, transport or the intelligent industry, among many others. IoT devices generally have a wireless communication interface, but due to their very low consumption and low cost requirements, the technologies commonly used for personal communications (e.g. Wi-Fi or LTE) are not suitable.

In a Wake Up Radio (WuR) system, there is a primary radio for high capacity and low latency communications, having also high energy needs, which is why it is desirable to keep it in an energy saving state as long as possible. While the primary radio is off, a low-power secondary radio remains active. This secondary radio or wake-up radio is responsible for “waking up” the primary radio upon request.

This project is proposed as an extension of the ALLINONE project, which was also developed by WNG. In ALLINONE, WuR mechanisms are developed and tested with the potential to be used to communicate devices with non-compatible primary radios. With this approach, in addition to the application focused on energy savings, the possibility of having an additional low-cost and low-power radio in any electronic device opens the doors to a large number of new applications. These new applications are the focus of the project, which aims to design, analyze and develop different applications of a low power radio system within the framework of a wireless mesh network. This architecture could facilitate the integration of IoT in 5G (case of mass communications between machines), being also useful in vehicular communications scenarios or even in satellite networks.

The project was funded by the Spanish State Research Agency with an allocation of 163,350 euros. The project started in 2020 and will finish in 2024.

ULTRA-LOW CONSUMPTION RADIO RECEIVERS

The Communication Circuits and Systems Research Group (CIRCUIT) has developed a radio receiver to meet the increasing need to establish radiofrequency (RF) wireless data links that are low cost and have very low energy consumption. The consumption of the architectures that have been developed could reach values that are up to five times lower (or more) than standard superheterodyne architectures.

The new paradigm of sensor networks includes wireless connectivity between a potentially very high number of nodes and with extremely strict limits of available energy. In various situations, such as the use of wearables devices, certain medical applications that require numerous sensors distributed around the body, RF-ID identification, or the use of distributed sensors in smart cities, the consumption and cost can be reduced by intrinsically simple architectures such as that developed.

The results of this project have led to a patent.
WINTER: INTERFERENCE MANAGEMENT IN COMMUNICATIONS AND INFORMATION PROCESSING

The research group Signal Processing and Communications (SPCOM) led the Wrestling with Interference in Communications and Information Processing (WINTER) project to find solutions to new challenges caused by 5G communication networks.

It is well known that the new 5G communication networks require greater transmission rates, greater security, faster connectivity and terminals with less complexity and consumption. The WINTER project has tackled these challenges by focusing on the management of interference according to three complementary approaches.

First, mitigation of interference was considered, by having an impact on the design of new signal formats that minimise interference on other terminals operating at the same frequency or in adjacent bands. In addition, opportunistic communication strategies were studied to probe the state of the network and identify free dimensions in which to transmit without generating interference.

Second, cancellation of interference was considered by designing interference cancellation schemes for full-duplex systems (two-way simultaneous communication in the same band). In networks with many users accessing a central node simultaneously, the distribution of power between users was optimised to maximise the performance of the central node interference canceller.

Finally, the detection of (intentional) interference was addressed using analysis and processing techniques to detect malicious attacks on networks and multimedia contents. Robust schemes were designed to detect abnormal events, with results that can be applied to communication networks and to other information processing applications.

In addition to the UPC, the University of Vigo participated in the project. WINTER lasted four years and was funded by the Ministry of the Economy, Industry and Competitiveness with a budget (UPC) of 210,298 euros.

OPTICAL REMOTE NODE DEVICE AND SUPPORT EQUIPMENT FOR CONSTRUCTING AND EXTENDING FIBRE OPTIC ACCESS NETWORKS

The Wireless Networks Group (WNG) has worked on a device that carries out the functions of a communication node in passive fibre optic access networks. This node must be situated at a remote point in the network, without the assistance of an electricity supply, in an environment that is not controlled for temperature or humidity and with no other active elements, to meet the requirement that these access networks are passive to considerably reduce the costs of their installation and use. In this way, new sections can be incorporated into a previously installed access network, to provide a means of growth that can provide a service for new users in situations in which it would not be possible or would be very expensive to install a new access network for them.

The project was led by IHP GMBH Innovations for High Performance Microelectronics/Leibniz-Institut für Innovative Mikroelektronik and involved the participation of over 16 other European members. It had a budget of 100,625 euros and lasted four years (2017–2020).

DUAL CONNECTIVITY TO IMPROVE NETWORK ACCESS SPEED

The Communication Circuits and Systems Research Group (CIRCUIT) has launched the first free, open dual connectivity platform that will enable experiments to be carried out in real conditions.

Dual Connectivity is a new technology that enables a mobile device to be connected to two network stations simultaneously. This improves the rate of data transport and therefore the service experience.

Current mobile devices can only be connected to one base station of those available within the coverage area. They select the station with the strongest signal, which tends to be the one that is closest geographically. When the signal gets weaker, mobile devices automatically connect to the strongest signal from the next closest station.

Dual Connectivity enables a simultaneous link to be established between the mobile device and two base stations, whether they are 4G, 5G or a combination of both. In this way, information can be transmitted to the mobile from the best base station or via both stations. This improves the data rate (data aggregation) and or/or involves changing to the fastest station (fast switching).

The testbed developed by Dual Connectivity is fully implemented in open code, which means that any person or company can collaborate in the project. It is expected that the solution that is developed will save researchers and developers around 4 months of work.

The testbed was developed by Dr. Ilker Demirkol and the doctoral student Carlos Pupiales of the UPC. Other collaborators in the project were Eurecom (France), National Instruments (Germany) and the Rutgers University of New Jersey (USA). The Dual Connectivity project won the Best Demo Award at the IEEE MASS Conference 2019.
The Research Centre for Supervision, Security and Automatic Control (CS2AC) has participated in the SECUTIL project through which a comprehensive security chain management system has been created for networks and infrastructure that supply utilities (such as water, gas and electricity). The system improves physical security, access control and cybersecurity.

CS2AC has developed algorithms to detect cyberphysical attacks (for example, to detect images in a security circuit that appear normal but have been introduced by attackers, when the real images would show intruders accessing the facilities) and technologies that increase resilience to attacks. The detection technologies are based on watermarking signals, which add copyright information or other verification messages to digital documents and show whether images have been altered by an attacker. In addition, algorithms have been developed that can be used to reconfigure the control algorithm once an attack has been detected and isolated, using tolerant control technologies. All these technologies are being tested in laboratory studies and pilot tests in real environments.

As part of the project, cryptographic solutions have been developed to ensure the security and privacy of personal data throughout the service and technology cycle. This reduces the window of risk for critical infrastructure information systems. In addition, simulation tools have been designed and implemented to assist in decision-making by the critical infrastructure's security management team and new systems and infrastructure security models have been researched.

SECUTIL is a project of the RIS3CAT Utilities 4.0 Community, coordinated by Eurecat. Other participants in addition to the UPC’s CS2AC are Cetaqua-AGBAR, Naturgy, Retevisión, the University of Lleida and the Barcelona Supercomputing Center. The aim of the community is to transform the utilities sector by identifying a set of tools and solutions that enable digital transformation to the utilities 4.0 concept, and the creation of an industrial fabric through the development and application of these new solutions.

The project, which has taken three years and ended in March 2021, was funded by the EU’s European Regional Development Fund (ERDF) as part of the FEDER 2014–2020 Operational Programme, with a budget of €100,869.91.
The Communication Circuits and Systems Research Group (CIRCUIT) at the UPC is working on the Smart Factory project as part of Looming Factory. The aim is to develop advanced monitoring algorithms, to increase the flexibility and adaptation of monitoring and control systems. This must enable the implementation of predictive maintenance strategies and provide responses in systems of faults or malfunctioning of industrial plants.

The aim of the project is to develop prototypes of devices that integrate sensor, data processing and wireless communication technologies for industrial use. Specifically, a system is being developed for monitoring the activity of factory workers (monitoring the temperature at which they work, the humidity, noise levels, detection of potential occupational hazards, etc.) and a system for monitoring machinery in production lines to report various parameters relating to the state of the machinery or to extract information that facilitates stock monitoring, all with integrated sensor technology and wireless communication. The systems that are developed provide information on workers and machinery in real time and accumulate and store data for subsequent analysis.

Looming Factory is comprised of four projects (Smart Factory, Connected Factory, Robots on Factory, Factories of the Future), and is a partnership between research, development and innovation groups in universities and industry to facilitate and accelerate the introduction into the market of emerging technologies aligned with the needs and the new industrial challenges that result from the digital transformation: smart, connected factories and collaborative robotics in production environments, with the demonstration of these technologies in real environments.

Looming Factory will last three years (it will be completed in December 2021) and is jointly funded with 2 million euros from the European Regional Development Fund (ERDF), as part of the ERDF Operational Programme Catalonia 2014–2020.

The research group Low Power Design, Test, Verification and Integrated Circuits (QINE) at the UPC has worked to develop a cybersafe hardware system for the identification of integrated circuits and for new generation memory devices. The project has been developed using prototypes of memristors, new generation memory devices that can store in a specific area ten times more information than current flash memories.

In the project, hardware strategies are proposed and analysed to detect and avoid the effects of external attacks on integrated circuits. Taking advantage of the natural variability of the device, unique digital fingerprints are implemented for each of the integrated circuits, which are hard to copy as a result. In addition, safe memory cells are proposed to restrict information leakage.

These studies were part of a three-year project (2015–2018) and received funding of 122,815 euros from the Spanish Ministry of Economy and Competitiveness.

**OUR EXPERTS SAY**

“Industry 4.0 enables us to analyse and control the entire process, detect incidents and resolve them remotely.”

Joseba Quevedo, director of the Monitoring, Safety and Automatic Control Research Centre (CS2AC UPC)
Initially, patterns of water and energy consumption were identified throughout the respective processing chains. In a second step, through monitoring and real-time management techniques to reduce the consumption of water and energy, these processes were modelled (that is, technological scenarios were established to identify potential savings) and microbial stabilisation techniques, heating, texturisation and drying were applied. The resulting parameters were assessed to establish the resource use strategy, the treatment of effluent from the process and the technologies of water reuse to ensure the quality and safety of the food. The results have been validated in pilot tests under industrial conditions during a three-month period.

The project, which is part of 7PM, received 5.1 million euros of funding and lasted 4 years. The consortium, which is led by the Fraunhofer Institute for Interfacial Engineering and Biotechnology, was formed by 15 members from 6 countries, including the specific research centre CS2AC, which was responsible for monitoring tasks and real-time management to minimise water and energy consumption.
Another great technological advance is the automation of tasks and processes. The traditional approach brings to mind a physical entity (or robot) that will be used to carry out monotonous, repetitive tasks. However, automation software, along with artificial intelligence, is also considered one of the drivers of the mobile economy. For example, when we use location-based applications to go to a specific place, a multitude of algorithms are executed to estimate the best route, including traffic models and real-time information.

Although most AI algorithms continue to train in data centres, using large quantities of data, the increase in calculation capacity of mobile terminals enables artificial intelligence algorithms to be executed on the same device.

This will reduce network dependence (for example, to transcribe a voice message or translate in real time), which will avoid the transfer of large amounts of data to remote locations in the network and lead to improvements in usability, greater speed and less consumption for service execution, as well as greater security and privacy.

It will also facilitate the generation of small devices (gadgets or wearables) that are equipped with advanced algorithms to detect patterns, biomarkers or events. A sector that will benefit is that of health and well-being with the emergence of very useful devices in the monitoring of patients, particularly in chronic, non-infectious diseases, and a reduction in the digital gap through natural interaction interfaces, such as voice assistants to access basic, fundamental services.

“In thirty years, Barcelona will have robots everywhere, from robotised assistants in residential centres, hospitals and civic centres, and in airports and train stations. We will see robot gardeners cutting flower beds and maintaining roadside ditches. And of course, robots will also be doing surveillance tasks.”

Carme Torras, Researcher at the Institute of Robotics and Industrial Informatics CSIC-UPC

COCOUNIT: PROCESSORS OF THE FUTURE FOR SMART COMPUTER SYSTEMS

CoCoUnit is a new processing unit for incorporation into existing processor units (general purpose cores, GPUs, etc.) that will be capable of developing cognitive functions with extremely high energy efficiency. The new unit will make new user experiences that require cognitive functions possible in real time in numerous devices, including mobile devices (such as smart phones and portable devices) and servers in data centres.

This innovative unit, developed by the Architectures and Compilers (ARCO) research group led by Antonio González, will contribute to the development of what is already known as cognitive computing.

OUR EXPERTS SAY
Through new architectures inspired by the brain, the aim is to expand the capacities of information systems so that they can develop tasks that are traditionally associated with human intelligence such as voice recognition, automatic translation, speech synthesis, image classification or object recognition. In short, the aim is to give computers learning, synthesis and reasoning capacities similar to those developed by the human brain.

Like the brain, the future CoCoUnit will be based on massively parallel architecture with extremely simple units, as it has been found that many simple units are more energy efficient than a few complex units.

The new unit will reduce data movement. He von Neumann architecture that is currently used in processors has enormous energy costs as data have to be moved around the system: all the instructions and operands must be extracted from the memory and sent to the execution units, and the results must be written again in the memory hierarchy. The interconnections for moving the data consume most of the energy of a microprocessor. Reducing these movements could therefore represent considerable energy efficiency benefits.

CoCoUnit will also include specialised hardware for some key functions and will be based on a different computing model, focused on ‘intelligence’: learning, rather than ‘imperative programming’ will play a key role in this new approach. In addition, the new unit will explore resilience and approximate computing for greater energy efficiency.

This project has received an Advanced Grant, the highest award given by the European Research Council (ERC) to research projects at the frontiers of knowledge. The project began in September 2019 and will last five years, with funding of 2.5 million euros.

DEVELOPMENT OF FASTER PROCESSORS FOR ARTIFICIAL INTELLIGENCE WITH LESS ENERGY CONSUMPTION

The research group N3Cat (NaNoNetworking Center in Catalonia) of the UPC leads the WiPLASH (Wireless Plasticity for Heterogeneous Massive Computer Architectures) project to develop processors for artificial intelligence and automatic learning that are much faster and consume less energy than the current ones.

The aim of WiPLASH is to develop miniaturized, wireless graphene antenna that operate in the terahertz band to provide plasticity and reconfigurability for future computing platforms.

To date, computer processors or chips have been of two types: general purpose that can undertake any function with certain velocity, and processors that are ultraspecialized in a specific task, which carry out just one function in a very efficient, fast way. One example is the real-time facial recognition technology that most new smart phones include. This is a sophisticated authentication method that enables a user to unlock their device or verify payments. In this case, a processor can carry out hundreds of thousands of millions of operations per second to process the images.

The prototype of the processor that will be developed in the WiPLASH project is designed for artificial intelligence and automatic learning, disciplines that have been growing exponentially in recent years. When an algorithm, which is a programming code, is run through a large server it consumes an enormous amount of energy. That is why miniaturized wireless graphene antennas are key. They are up to a hundred times smaller than a metal antenna and can operate at extremely rapid frequencies of terahertz. WiPLASH will verify whether these graphene antennas enable communication networks within a chip for artificial intelligence processors.

These new computing chips could be used in implants in the body, the internet of things, mobile phones, large servers and will open the door to a disruption in which artificial intelligence reaches more places and where size and energy consumption are critical.

The WiPLASH project lasts three years and has received three million euros from the European Commission as part of the Horizon 2020 programme, within the FET OPEN call. Participants in the project include seven European research centres and computing companies.
CARAMEL – CYBERSECURITY BASED ON ARTIFICIAL INTELLIGENCE FOR CONNECTED AND AUTOMATED VEHICLES

The Wireless Networks Group (WNG) at the UPC participates in CARAMEL, a European project whose main objective is to respond to current cybersecurity challenges of connected vehicles, through advanced technologies of Artificial Intelligence and Machine Learning.

To achieve this, various types of vehicles will be considered (cooperative, connected, autonomous and electric), and new methods and solutions will be sought to reduce the cybersecurity risks associated with each of them. Although protocols currently exist to guarantee security, vehicle connectivity, autonomous driving systems and smart charging of electric vehicles introduce new cybersecurity breaches that should be tackled.

As part of CARAMEL, intrusion detection system (IDS)/intrusion prevention system (IPS) products will be developed as well as advanced technologies and services to manage complex cyberattacks and reduce potential damage. In addition, new interoperable, scalable ICT infrastructure will be designed to provide sustainable cybernetic security and digital privacy.

Cybersecurity is one of the four most serious global risks that we are facing, according to the World Economic Forum in Davos at the start of 2018. In 2020, experts predict that 20 billion devices will be connected, which will doubtless lead to a higher number of cybernetic attacks.

The pilot tests of CARAMEL will be carried out in Karlsruhe, and they are scheduled in January 2022.

The CARAMEL project has received funding of 5 million euros from the Horizon 2020 programme of the European Union and will be executed over 30 months (October 2019 to March 2022). The project is coordinated by i2CAT and has 14 other participating members from 8 European countries (Germany, Spain, Cyprus, Portugal, the Netherlands, the United Kingdom, Greece and Austria).
The health sector has benefitted greatly from mobile technologies. Despite the complexity of incorporating technology into a sector as regulated as that of health, in which an innovative solution could have a time-to-market of over five years due to the processes of classifying medical devices, the capacity to create ever smaller connected equipment has enabled new measuring and monitoring systems of health indicators to be developed. This has resulted in more portable systems that would enable the hospital to be taken to the home instead of moving the patient to the hospital.

The opportunity to offer health services remotely makes it possible to reduce the costs of trips, reduce the burden on health centres, facilitate access and cover regions that are further from urban centres, to improve healthcare quality, for example, in chronic patients with non-infectious diseases.

The emergence of artificial intelligence in the health field has been a vehicle for the creation of new diagnostic systems. For example, it can be used to detect medical images that are hard for humans to perceive, or in new smart systems to improve the diagnosis of prevalent diseases or even to support decision-making in key moments of complex interventions.

NICVA: A NON-INVASIVE DEVICE FOR FAST CARDIOVASCULAR CONDITION ASSESSMENT

The Instrumentation, Sensors and Interfaces Group (ISI) has developed NICVA, a new, non-invasive portable medical device to rapidly assess cardiovascular functioning.

Cardiovascular diseases are one of the main causes of death worldwide. This type of diseases do not tend to present previous or warning symptoms, and the first sign may be a heart attack or a stroke. Early diagnosis and periodic monitoring of patients at cardiovascular risk could reduce mortality. The current technology that we have only offers partial solutions as extra-hospital devices measure a limited number of physiological parameters and each one of them needs a specific device, such as an electrocardiogram (ECG), blood pressure monitor, pulse oximeter, echocardiogram or ergometer for stress tests.

NICVA is a medical device, currently in prototype phase, that can monitor the functioning of the cardiovascular system by detecting the electrocardiogram (ECG) and at the same time obtaining data on the mechanical function of the heart and arteries through a proximal arterial pulse wave and two distal waves with respect to the heart. These three waves provide information on myocardial contractility and arterial elasticity, which is related to arterial blood pressure. All of this is achieved with just four dry electrodes, two for each hand or arm. The arterial pulse waves are obtained by measuring changes in electrical impedance between electrodes, that is, how difficult it is for an electrical current to flow through tissues between electrodes. The current is imperceptible and harmless, like those used in some devices used to measure body composition manually or in scales.

Blood ejection and pulse wave propagation on each heartbeat reduce the electrical impedance. The time interval between the ECG and the proximal pulse wave is an indicator of the speed with which the left ventricle contracts and the elasticity of the arterials close to the heart. The time interval between the proximal pulse wave and the distal pulse wave in each arm is, in turn, an indicator of the elasticity of peripheral arteries. The difference in arrival time of the two distal pulse waves is an indicator of a possible autonomic neuropathy. The system also obtains the respiratory frequency and information on the volume of air inspired and expired with each breath.
rehabilitation leads in chronic cases to deterioration of motor functions recovered in acute treatment after injury. This results in an increase in dependency, which has a direct impact on the family economy, a reduction in autonomy and the emergence of associated new pathologies. This regression completely excludes the person from entering the job market and leads to gradual impoverishment due to an increased need for support and care. It also increases the risk of social exclusion.

The project is developed in collaboration with the Functional Diversity Association of Osona (ADFO). The ADFO is a social entity that works for the universal integration of people with a physical disability in different social environments. Those involved in the project include biomedical and mechanical engineers, a social educator, a physiotherapist and an occupational therapist.

On 1 March 2021, a system viability test was started with ten users of ADFO who had had a stroke. A group of five users use the applications in their homes and another group carries out conventional exercises given to them by the hospital. After eight weeks, the roles are changed (crossover study). The effect of the use of these applications on movement is analysed. Currently, dynamic analyses are being incorporated and gaming tools are being introduced to the application.
The Multimedia Applications Laboratory (LAM UPC) is working to develop a new method to identify and characterise deep inferior epigastric perforators using digital image processing algorithms for computed tomography angiography.

The main aim of the project is to develop a quantitative method for describing relevant parameters such as longitude, average diameter, thickness and volume of deep inferior epigastric perforator flaps before and after passing the rectus abdominis muscle. This information will help surgeons to decide which perforators have the optimal conditions to be used in specific surgery.

Furthermore, an additional tool will be developed to project optimal inferior epigastric perforators based on the parameters mentioned above to provide for the surgeon the location and conditions of different perforators of the patient on the operating table. This tool will be implemented using data from patients in a database that includes around 195 patients with an AngioTAC of the abdominal section, of different sexes and between 37 and 74 years (with an average of 55 years), treated by surgeons or radiologists at the Hospital de Bellvitge in Barcelona from July 2017 to October 2020.

The project lasts two and a half years, until the end of 2023, and is funded by the Surgery Service of the Hospital de Bellvitge, with an amount up to 6,500 euros.

AN APP TO ASSIST WITH THE DIFFERENTIAL DIAGNOSIS OF PATIENTS WITH PARKINSON’S DISEASE AND ESSENTIAL TREMOR

The Multimedia Applications Laboratory (LAM UPC) has developed a mobile application that helps in the differential diagnosis between patients with Parkinson’s disease and essential tremor, using smartphone sensors.

Essential tremor is a type of movement disorder that is frequently erroneously diagnosed as Parkinson’s disease. While Parkinson’s disease has a neurodegenerative nature and affects movement at rest, essential tremor is not degenerative and presents rhythmic tremor in movement that is generally accentuated in fixed positions. The treatment with dopamine that is administered to Parkinson’s patients is extremely aggressive and harmful if it is given to patients who do not suffer from this disease (for example, patients with Essential Tremor). In addition to this major drug contraindication, the test to determine whether a patient has Parkinson’s disease, Single Photon Emission Computed Tomography (SPECT), is extremely costly. SPECT is an examination that requires the administration of a radiopharmaceutical (a source of gamma radiation) to the patient to identify the distribution in brain regions and determine the amount of neurodegeneration.

The new application is based on a biomechanical test in two positions (relaxation and tension) that registers hand tremors with the accelerometer/gyroscope incorporated into a smartwatch or mobile phone. The linear acceleration and/or angular velocity of the movements is processed to provide biometric characteristics of the patients in the frequency domain. Then, algorithms are used based on neural networks. The resulting values are compared with those obtained in diagnosed cases to determine whether the patient has Parkinson’s disease or essential tremor, with a reliability of 80%. This percentage is obtained based on the results from a database of 90 people. Currently, the database is being expanded to improve the reliability of the tool for differential diagnosis. The diagnosis provided by the application will provide doctors with additional information on complex patients or patients in early phases in which the right treatment is vital to improve quality of life.

This new technology is accessible for developing countries that lack more sophisticated diagnostic devices.

The project is being developed in collaboration with the doctors Josep Valls and Eduard Tolosa, from the neurology unit of Hospital CLINIC, the Universidad Autónoma de Occidente de Colombia, Universidad de Chile and the Ostbayerische Technische Hochschule of Germany. The project will be end in 2022.
The Multimedia Applications Laboratory (LAM UPC) has developed an application that measures the anteroposterior movement of the tibia with respect to the femur to help in the diagnosis of anterior cruciate ligament knee injuries. The process consists of two phases. First, surgeons record a 5–8 second video with their mobile phones while they carry out standard Lachman and Pivot-Shift tests on the injured area, on which three circular stickers have been placed. Then, once the video has been uploaded to the application, the movement between the tibia and the femur is calculated using image processing techniques (OpenCV library). In around ten seconds, the app can give a result that helps the doctor to form an objective diagnosis.

The application will be available in open access on Android (using OpenCV libraries) and has been developed together with the Catalan Institute of Traumatology and Sports Medicine (ICATME) of the Dexeus University Hospital. A viability test has been carried out in a sample of seven injured people and the results have been published in a scientific journal.

Beyond the analysis of the injured person’s movement, work is being done on a project to develop an application that can predict the range of movement after a knee operation, using biomechanical optimisation and modelling. In the framework of this project, funding was obtained from the Ministry of Science and Innovation in the call “Europe Research 2020”.

AN APPLICATION TO ASSIST THE DIAGNOSIS OF INJURIES TO THE ANTERIOR CRUCIATE LIGAMENT OF THE KNEE
As we have seen in the health field, the cross-cutting nature of automation enables new business models to be generated in a wide-range of sectors, and the reformulation of more tradition sectors such as banking and insurance or even models of urban mobility.

An example of this can be seen in Blockchain technology, under the umbrella of distributed ledger technologies (DLT): how to automate an accounting book and transfers of assets between authorised devices through smart consensus algorithms that prevent fraud techniques such as double spending.

Blockchain technology is opening a wide range of application possibilities in terms of new ways to share data between devices and new business models, although its implementation is still in its early days. According to the ACCIÓ Blockchain report in Catalonia, there are at least 35 companies in the Catalan blockchain ecosystem.

The number is growing due to the promotion of innovation in the mobility sector. In turn, the Government of Catalonia has drawn up the Catalan Blockchain Report and Strategy, which prioritises various use cases due to their transforming potential such as “Mobility and public transport”, including mobility as a service (MaaS).

The latest generation mobile phones already include hardware prepared with wallet functionalities in which to store these new assets recognised by the European Parliament as online currency. Despite the lack of adoption, the mobile phone will again be in a central position as a device for use (and payment) in these new business models, probably with greater decentralisation.

In addition, new positioning systems such as GALILEO, the electrification of vehicles and the features of new systems of communication such as 5G are leading to improvements in the models of urban mobility and by extension public transport services. The greater precision and accuracy of new navigation satellites could be key to the circulation of autonomous vehicles and to provide a better service for citizens, as they can pinpoint the exact position of a fleet of public transport vehicles.

OUR EXPERTS SAY

“Blockchain applied to mobility benefits citizens. Blockchain has a very clear application in what is known as Mobility as a Service (MaaS). In this approach, for instance, blockchain will make agents more transparent and increase interoperability for new decentralised business models.”

Laia Pagès, Executive manager at CARNET
The automation of last-mile delivery will help cities to reduce the amount of space allocated for commercial vehicles to stop and park. In addition, it will optimise routes and their management, reduce costs, and lead to nocturnal operations of distribution companies, which will increase operational opportunities for the service and thus improve it.

The CARNET initiative, coordinated by the CIT UPC, has generated a small autonomous vehicle, called ADD, to carry out the last-mile delivery of goods. The vehicle can carry out its journey autonomously using a Lidar 3D system and laser technology that, together with a GPS, a stereo camera and HRI lamps, can model the environment, determine the route and react to obstacles. The vehicle also improves the mobility system overall by increasing safety in urban areas and reducing traffic and emissions:

- Their **small size** (1.2 m³) means that three of these vehicles can replace a van that measures 3–4 m³ or seven can replace a large lorry of 8–9 m³ for journeys from shops in urban areas to the final destination.
- Their **autonomy** means that the delivery times can be made more flexible to reduce the congestion that currently occurs at rush hour, caused by vehicles delivering goods to homes, among other factors. In addition, platoons can be created, that is, groups of ADD connected virtually over a short distance with the same destination, to optimise routes and times. Considering all these factors, the implementation of ADD could reduce by 70% the number of vans used to deliver goods, at the same service level as now.
- Given the reduction in the number of vans operating on urban streets to deliver goods, the introduction of ADD would reduce **CO2 emissions in urban centres by 30%**. This would be directly to the lower number of vans and to the reduction in congestion, as the autonomy of the ADD means that delivery times can be flexible, with more nocturnal deliveries and the corresponding reduction in impact on traffic in cities.
- The **modularity** of the ADD means that they are **scalable**, so fleets of ADD can be adapted to the needs of various operators.

This project uses all of the technology required for autonomous driving. The ADD generate virtual models of their environment to avoid potential obstacles and they are also connected to a general model of the mobility system of the urban centre so that their route can be optimised and the travel time reduced. Their autonomy also means that journeys can be programmed in advance. The technology represents progress towards automatization of all goods distribution processes.

The inLab FIB has participated in the development of a system to characterise and model passenger demand on buses. Specifically, it has developed a module for predicting occupation that has been integrated into the application of the Autocorba company, which operates urban and interurban lines in the Barcelona Metropolitan Area. The app enables users to check the estimated occupation of buses throughout the day. The aim is for users to be able to choose the emptiest buses, so that service supply and demand can be balanced. In the context of the COVID-19 health service, this will help to reduce crowds on buses.

The algorithms are based on data-driven methodologies drawn from a wide range of sources (ticketing, the schedule and bus cameras). Classical methods for processing time series have been incorporated into the prediction module. These include the ARIMA method and neural network...
algorithms that enable important variables such as the school calendar to be included in the occupation time series.

The new functionality is integrated within the Intelibus ecosystem of tools, a real-time information system in the passenger transport system, which uses GPS positions of buses and the ticketing system to provide useful information for public transport users and the service operator.

Testing of the beta version of the app began on 11 May and is available for Android (on Play Store) and iOS devices.

MOBY is a project whose aim is to improve the Integration of e-micromobility vehicles within European cities.

MOBY is designed to increase the usability of these new technologies (scooters, skateboards, unicycles, among others), promote their integration with other transport modes, and take advantage of their potential by improving the safety of users and streets.

The MOBY project lasted one year (2020). In the first stage of the project, researchers identified and analysed the main incentives and barriers to the implementation of e-micromobility vehicles in a way that is safe for users and sustainable for cities. Various studies were carried out on the integration of electric mobility in urban mobility plans and use cases were proposed to improve safety aspects of e-micromobility in cities.

In this aspect, the Wireless Networks Group (WNG) participated in the development of an implementation guide through a general IT tool for the successful integration of micromobility vehicle solutions in the existing mobility systems in two pilot cities: Munich and Tel Aviv. This tool supported public interest groups and suppliers of micromobility vehicles to maximise the potential positive impacts of new micromobility vehicle services. It contributed to make urban spaces habitable and to a clean, safe, fast, accessible urban mobility. This is a tool that is highly customisable so that it can be applied in all European cities.

The MOBY project was funded with 499,647 euros from the EIT Urban Mobility in its Business Plan (BP) 2020. It has CARNET as a participant, which is an initiative coordinated by the CIT UPC. Other participants include SEAT, UnternehmerTUM GmbH and five further members.
Blockchain technology is opening up a wide range of application possibilities in terms of new ways of sharing data between devices and new business models, although its implementation is still incipient.

According to the ACCió Blockchain report in Catalonia, there are at least 35 companies in the Catalan blockchain ecosystem. The number is increasing due to the promotion of innovation in the mobility sector. For its part, the Government of Catalonia has developed the Blockchain Strategy of Catalonia, in which several cases of use have been prioritised because of their transformative potential, including “Mobility and public transport” relating to Mobility as a Service (MaaS).

The Hyperlieux Mobiles project defines a new concept in the area of mobility, in the framework of connectivity and the development of electrical, autonomous and connected vehicles.

The Hyperlieux Mobiles project defines a new concept in the area of mobility, in the framework of connectivity and the development of electrical, autonomous and connected vehicles. The aim of Hyperlieux Mobiles is to identify and study the various current and future forms of mobility beyond the mere transport of goods and people, to better understand the changes that are currently occurring in habits and in the opportunities provided by technology. In this context, the characteristics of new hybrid vehicles Hyperlieux Mobiles are defined as an advance in mobility ecosystems, prototypes of mobile, multifunctional urban microspaces that can bring activities or a service closer to the final user. This type of mobility services will free the user from the need to travel and one or several services can be provided in areas such as health, sport, leisure or work, to give some examples. This will promote the use of existing infrastructures and reduce the need to produce new ones, as a response to the challenges of sustainable development.

The international team, promoted by the Institut pour la ville en mouvement (City on the Move Institute), is investigating varied regions on different continents. It registers no less than 600 mobile activities, including bicycles fitted with solar panels that distribute electricity to underequipped areas in Africa for cell phone charging, and provide WiFi access to connect to the world. Another example is the case of a mobile abattoir in Sweden, as close as possible to the place where livestock are bred, which respects both the animals and the employees. Other examples are various types of mobile cinema, library buses or mobile doctor’s practices.
One of these pilot projects directed by Carles Llop, architect and researcher in the Urbanism Research Group of the DUOT at the UPC, coordinated with the NGO Dentists on Wheels (DSR) and with the support of the UPC Centre for Development Cooperation (CCD), is being carried out in Senegal. Through lorries adapted for mobile activities, the NGO provides dental services by establishing routes around various communities that do not have this basic health service. The success of this project is not only to bring the service to the users, but also the appearance of positive externalities for the communities, for example, avoiding travel to the metropolis to search for services, the creation of “squares” in which the population is provided with shared services with numerous activities available, and greater cohesion in these communities.

Currently, ETSETB is developing a system to provide connectivity and digitalisation of the aforementioned service data; a pilot test that will serve as the basis for future provision of activities and services.

Hyperlieux Mobiles has been promoted and organised by the City on the Move Institute, which forms part of the French Institute for Energy Transition, Vedecom. Other participants in the project apart from the UPC are Transdev, PSA Groupe, Michelin and La Poste, as well as the Mackenzie Presbyterian University of Sao Paulo, the National University of Colombia in Bogota, Telecom Paris, the University of Gustave Eiffel and the Tongji University in Shanghai, among others.
As we have seen, connectivity technologies as well as analysis, artificial intelligence and processing tools are cross-cutting technologies that drive many solutions in different fields. One strategic area at all levels is to use connectivity technologies, considering sustainability and the environment, as one of the pillars for the future of society.

In this regard, research is developed to generate solutions for reducing waste with new recovery technologies. These may be for solid waste such as that found in the technologies surrounding the mobile sector, or waste chemicals and their derivatives that we may find, for example, in water resulting from the activity of the main operating sectors. We highlight, among others, a circular economy project that enables recovery of the materials that we can find in waste from electronic devices such as the printed circuit boards of mobile phones, which can be extrapolated to all kinds of domestic appliances.

In addition, advances in mobile technology, taking advantage of the digitalisation of recent decades, facilitate access to information on our smartphone. For example, we can find out where shops are located in which we can buy goods without plastic packaging.

One fact that has been revealed in the current pandemic situation is that connectivity technologies make it possible to carry out tasks at a distance. Teleworking or remote monitoring of resources, without detriment to productivity, facilitates the continuity of tasks and enable a reduction in costs, for example the costs of journeys or energy resources in work centres.
A NEW ENERGY OPTIMIZATION SYSTEM FOR TELEWORKING ASSISTANCE

InLab FIB has developed a new energy optimization system for teleworking assistance that is called TurnItOn. This web platform can be used to manage the energy status of computers in the work environment, so that they are only switched on when needed.

TurnItOn ensures that computers are switched on for the minimum amount of time necessary. It reduces energy consumption and provides workers with a simple tool so that they can turn their computers on and off whenever and from wherever they want, making it a crucial tool for teleworking.

TurnItOn gives you the ability to schedule smart computer shutdowns; define a schedule for starting and stopping computers; start the computer remotely, making it easy to connect to the desktop from home; and check the power status of computers, that is, whether they are on or off.

Currently, TurnItOn has been installed on 700 computers. If we assume that approximately half of the computers used to be left on at night and a proportion of them at weekends, and that daily working hours are 7.5 (therefore the computer should be functioning for around 1,650 hours a year), this would lead to consumption of around 165 KWh per computer per year. The total consumption per year would be 99,000 KWh during working hours, plus 96,000 KWh during non-working hours, that is, 195,000 KWh. With the use of the tool, the annual consumption of 700 computers is around 99,000 KWh. Therefore, consumption is cut by almost half.

This reduction in KWh consumption also leads to a drop in CO₂ emissions by almost half. If we assume that 1 KWh is equivalent to 0.43 Kgr of CO₂, as stated on the Ministry for the Ecological Transition and Democratic Challenge website, the emissions of CO₂ without TurnItOn are 83,850 Kgr of CO₂, and with the new platform they are 42,570 Kgr of CO₂.

TurnItOn has been selected as finalist in the category of Solutions and Services of the enerTIC Awards 2020, innovation and technology awards for energy efficiency in the digital age that are given by the enerTIC platform. The winners will be announced on 2 and 3 December at the Smart Energy Congress (Madrid).

BIOMETALLUM PROJECT: RECOVERY OF METALS FROM ELECTRIC AND ELECTRONIC WASTE, BIOGAP GROUP

The business project Bioextraction of Metals from Disused Electronic Equipment (Biometallum) is a business proposal based on the design, construction, and installation of plants for extracting valuable metals from disused electrical and electronic equipment, and advisory and maintenance services for installations.

The promoters of this business idea took the principles of the circular economy and urban mining to offer an economically advantageous solution, adapted to the specific characteristics of each company that manages electrical and electronic waste. The solution promotes waste recovery as an alternative source of the metals that are in great demand in the current technological society. In short, the aim is to increase the value of waste by taking advantage of its high metal content and offering an economical, sustainable technology based on a biotechnological process.

The technology that has been developed uses the capacity of certain microorganisms to regenerate the agents that are responsible for separating metal components from the complex matrices in which they are found. These microorganisms feed on the scrap metal in the electronic boards of certain devices, such as mobile phones, to separate material that is not useful and recycle the recoverable metals.

In the process, electronic waste containing metals of interest such as copper, gold, chrome, zinc, nickel, and aluminium, is put into contact with bacteria adapted to extract the metals, which can then be used again. Instead of attacking the waste chemically, advantage is taken of the oxidation capacity of certain microorganisms under controlled conditions. This dramatically reduces the use of reagents and the energy consumption.

The technique has already been applied to printed circuit boards of mobile phones, but it could easily be adapted to other kinds of electronic waste such as televisions, computers, or fridges.

The proposal presented here is an alternative to the conventional processes that are used today. These require high energy expenditure and high consumption of aggressive reagents, which have a negative impact on the environment and make it impossible for most waste managers to use them. Consequently, companies must sell waste at a lower price than the value of the metals it contains.

The business proposal is aimed at waste management companies and related businesses. In Catalonia alone, there are 250 companies of this type, grouped together under the Gremi de Recuperació de Catalunya (Catalan Recovery Guild). Initially, Catalan companies will be approached, then the proposal will be extended to the rest of the Spanish market, and within a period of five to six years it will be offered on the International market. According to the researchers’ analysis, it will take 2.8 years to see returns on the investment.

The research project undertaken prior to obtaining the product was part of, and financed by, the Government of Catalonia’s Industrial Knowledge Programme, with European Regional Development Funds. It was judged to be among the five best proposals and chosen as a successful case to be included in the presentation of the next call for applications for the programme. The product resulting from the research is being protected by a patent.
The monitoring kit consists of a low-cost embedded system that can be used to obtained information on the energy that is produced, the residence’s consumption and the state of the batteries in the photovoltaic installation.

The information that is gathered is stored locally in the kit and sent to a remote web server so that it can be monitored from a distance by means of graphics. This information can be used to determine the real-time state of the installation, carry out predictive control and detect potential faults.

The system is based on an AVR microprocessor that is commonly used in Arduino boards. It can simultaneously make various measures, calculate means and detect critical parameters to generate alerts. This prototype is focused on measuring the voltage provided by photovoltaic panels, that of a DC-to-DC converter to 24 V and that of the current consumption provided by a DC-to-AC converter at 230 V. Based on the measures, root mean square values are calculated, values of power and performance.

On a Raspberry Pi motherboard, the entire communications system has been assembled to send and store the data gathered in a local server and remotely in the cloud. The data are displayed using Grafana (open code software for the analysis and supervision of temporal data sets). There are local (display, LED and buzzer) and remote alert systems (via a Telegram bot). The communication system has a Wi-Fi and GSM connection, offering a virtual private network (VPN).

In addition, a second improved version of this prototype is being developed with a direct application in monitoring the consumption of electric machines in the industrial environment. It incorporates standard inputs for industrial sensors: digital (0–24 V) and ananalogue (voltage: 0–10 V, current: 4–20 mA), and a 485 communication port. This second version is being applied to the monitoring of electricity consumption and vibrations in an industrial milling machine.

This project was started on 1 January 2019 and ended on 31 March 2021. It is part of the Smart Factory initiative of the Looming Factory project, with joint funding from the European Regional Development Funds of the European Union as part of the ERDF Operational Programme Catalonia 2014–2020, with a grant of €2 million.

El Data Management Group (DAMA UPC) has been the technology partner in the development of the GoZero Waste app, which was created to facilitate local shopping without waste. The idea emerged from the personal experience of Martí Morató and Magda Cebrián, two people from Barcelona who proposed shopping with less use of plastic and much more centred in small shops in the neighbourhood.

The application has an interactive map to geolocate shops in the area that do not use plastics and have alternatives to conventional products. Searches can be carried out by product, location or name of the shop. In addition, the application has a series of challenges that encourage users to take small actions to gradually change their consumption habits and make them more sustainable.

The current version of the app has been developed through collaboration between Go Zero Waste and Sparity Technologies, a spin-off of the Data Management group (DAMA UPC) and marketer of the technology developed by the group. The app published in May is present in Spain and eight other countries (Chile, Argentina, the United Kingdom, Netherlands, France, Belgium, Andorra, Germany and Italy) and has been downloaded over 15,000 times. Currently, work is being carried out on new functionalities and on the expansion to more countries. Some of the new functionalities include enabling shopkeepers to manage the information about their shop and offer discounts, and recommendations and aspects relating to mobility.

The Communication Circuits and Systems (CIRCUIT) research group has developed a system for remote monitoring of photovoltaic energy generation systems.

CIRCUIT has applied this system (a monitoring kit) to a UPC Centre for Development Cooperation (CCD) project in Senegal, in collaboration with the PUSE Foundation (For a smile in Africa). The project focused on needs that require solutions in the ICT area in the PUSE Foundation’s residence in Mbour, Senegal, and in a high-mountain refuge in Spain (Refugi de Góriz). The CIRCUIT group installed in situ a control system to facilitate the remote control of the photovoltaic station in the PUSE station.

GO ZERO WASTE – THE APP THAT LOCATES SHOPS WHERE YOU CAN BUY WITHOUT PLASTIC

REMOTE MONITORING OF PHOTOVOLTAIC ENERGY GENERATION SYSTEMS IN SENEGAL

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