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Special theme:

SMART AND CIRCULAR CITIES

Also in this issue

Digital Inclusion:

Using Localisation Technologies and Haptic Feedback for a More Inclusive Society

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SPECIAL THEME

The special theme “Smart and Circular Cities” has been coordinated by the guest editors Erwin Schoitsch (AIT) and Georgios Mylonas (ISI, Athena Research and Innovation Center)

REEARCH AND INNOVATION

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IN BRIEF

Introduction to the Special Theme

Smart and Circular Cities

by Erwin Schoitsch (AIT) and Georgios Mylonas (ISI, Athena Research and Innovation Center)

Smart city technologies have been proliferating at a rapid pace for some years now, and at the same time, the divide between the natural and digital worlds has lessened considerably. Multiple sensing endpoints located in our environment, offices, homes, devices, and even our body, produce continuous streams of sensor data. At the same time, the concept of the circular economy has entered the mainstream, and we are now seeing many communities and businesses adopt novel approaches based on circularity (e.g., in the European Green Cities Network). European policy ("Green Deal") has reacted to the challenges of climate change and environmental footprint reduction, particularly in the context of large urban agglomeration. Smartness (intelligence) must address not only the immediate goals of human wellbeing, assisted living and comfort but, perhaps even more importantly, long-term sustainability, as defined by the 17 UN Sustainable Development Goals (Figure 1).

Figure 1: The 17 UN Sustainable Development Goals (SDGs). Source: un.org.

In this environment, Smart Cities, AI and the IoT, together with sustainability and circular economy, form a significant part of the current research landscape. Several challenges have surfaced when designing and applying these systems in fields like energy, sustainability, smart transportation and digital twinning, especially when discussing their cross-section and a multidisciplinary approach. The fact that the implementation and deployment of such systems involves the participation of a large number of citizens has also opened a window for opportunities in fields such as citizen science and co-creation.

This special theme of ERCIM News reports on academic and industry research that addresses technology, systems, applications, and services in the Smart and Circular Cities domain. This section includes articles targeting important elements such as security and privacy, as well as the integration of technologies like Digital Twins and the Smart Grid, which are still evolving at a rapid pace. Experiences from deployments that use more conventional approaches from a technological standpoint offer us glimpses of the near future, while reports from smart city projects using novel methodologies and technologies give us a better sense of how smart city research will evolve to encompass new communities and tools.

Security and Privacy Issues

Kreutzer et al. (page 6) discuss a framework for facilitating the transition from existing smart city services to smart governance, arguing that thus far research has focused more on technical aspects, leaving out of the equation more common ones, or even whole communities, e.g., in rural areas. They discuss five preventive measures that might help to mitigate cyber incidents towards smartification. When it comes to IT security in urban environments, Lämmel et al. (page 7) discuss policies and recommendations towards the secure implementation and operation of urban infrastructure. In this context, the Urban Data Partnership (UDP) aims to accelerate the digital transformation of cities and communities, while considering data security. Moreover, Pustozerova and Mayer (page 9) discuss aspects of using Federated Learning, an ML approach that is quickly gathering traction, for data security and privacy purposes in smart cities. They argue that although its adoption is growing, there are still challenges to overcome, and further investigation of defense mechanisms is needed. Furthermore, Klikovits et al. (page 10) present an approach to integrating the plethora of constantly changing IoT devices and services within a smart city setting, based on the combination of an ID provider and the Arrowhead framework.

Resilient Cities: Digital Twin and Smart Grid

Moving on to novel technologies that are quickly becoming part of the smart city landscape, the Digital Twin is one such technology. Digital Twins are currently being introduced to help us on multiple fronts, including data security and privacy. The SecurityTwin project, presented in this issue by Eckhart et al. (page 12), aims to develop the fundamental methods for employing the digital-twin concept to enhance the security of Cyber-Physical systems and provide the basis for implementing intrusion detection and response methods. Meanwhile, the Smart Grid is another field that has become a part of the research landscape, with its importance accentuated by the need to accelerate towards more sustainable cities. Efthymiopoulos et al. (page 13) present the FLEXGRID project, which investigates the constraints of current smart grid architectures preventing integration of large-scale distributed energy resources into distribution networks and aiming to mitigate circularity and sustainability in modern smart grids. The project is currently developing a digital platform to offer digital energy services helping energy sector stakeholders to automate and optimise the planning, operation and management of systems and assets.

At the same time, energy communities have been forming throughout Europe to facilitate sustainable energy production in a decentralised manner. Norbu et al. (page 15) discuss the Responsive Flexibility (ReFLEX) project, currently the UK's largest smart energy demonstrator, focusing on an energy community at the Orkney Islands in Scotland comprising 200 households. They developed algorithms for the smart control of energy assets and redistribution mechanisms, achieving a fairer redistribution in the process. At a more localised scale, within home environments, Constantinou et al. (page 17) propose the IMCF+ framework to facilitate the smart consumption of energy at the time it is produced by e.g., photovoltaics on the roof of a building. Their strategy relies on an AI-inspired algorithm to schedule energy consumption of various devices, using a variety of strategies while at the same time meeting indoor comfort level requirements.

Optimising the use of established methods and tools

Several projects utilise more established tools and technologies in the circular and smart city domain – for example, electric bikes and cars are rapidly becoming part of the urban transport landscape. Gunner et al. (page 18) discuss results obtained by fitting monitoring equipment to a fleet of electric bikes that were deployed as part of the H2020 Lighthouse Project REPLICATE in Bristol, UK. This has produced a dataset that could help us better understand aspects such as route selection by e-bike users or identify city areas where cycling infrastructure would be most beneficial. Smart water metering is another quickly evolving domain, following electric power metering. Amaxilatis et al. (page 20) describe Tethys, a large-scale water metering deployment in Thessaloniki, Greece, using water consumption data to identify patterns, behaviours and anomalies. Such data can lead to indirect observations, e.g., indoor activity levels during the COVID-19 pandemic. Moreover, the circular economy is entering our daily lives. Gentimis et al. (page 22) present a digital platform that aims to encourage citizens to recycle used cooking oil in West Macedonia, Greece. The goal is for the platform to be adopted by 10,000 households across 13 municipalities in this area.

Novel technologies and methods

Going back to major issues at the heart of smart and circular cities, traffic monitoring, air quality and pollution monitoring, as well as sustainable water resource management immediately spring to mind. Over recent years, the research community has attempted to tackle them using rather conventional approaches. However, we are beginning to see more innovative approaches adopted, utilising novel methodologies. In the context of real-time traffic monitoring, Litzenberger et al. (page 23) use fiber optic acoustic sensing and the existing telecom fiber cable infrastructure in a prototype study in Graz, Austria. Initial results suggest that it is feasible to derive real-time traffic estimation using this approach. Ruston McAleer et al. (page 25) discuss the emerging concept of city-scale Digital Twins and present the DUET project. The pilots developed in the project across three cities are expected to go live in autumn 2021, tackling mobility and air quality, city planning and public decision-making. Bruno et al. (page 28) discuss the use of plants, specifically strawberries, as biosensors to monitor air quality. They report on a large-scale deployment across Spain in the "Vigilantes del Aire" project, utilising samples from 205 municipalities and 26 Spanish provinces. Malamis et al. (page 26) address sustainable water resource management as investigated by the HYDROUSA project, which uses innovative nature-based solutions (NBS) to manage a variety of water streams. The project promotes decentralised on-site water, materials and energy conservation, treatment and reuse. It has established large-scale demonstrators in three Greek islands, while its solutions are being evaluated in 25 early-adopter cases in other Mediterranean coastal areas.

Sustainability projects in specific contexts

Finally, there is the issue of focusing on specific communities and co-creation to deliver for smart and circular cities. Ruston McAleer et al. (page 25) present the COMPAIR project, scheduled to begin in November 2021, which brings social and emotional intelligence into the decision-making process within cities. H. Lelligou (page 30) presents the ASSET project, which focused on the educational community, an important community for the transition to smart and circular cities. The project produced more than 25 training programmes on energy transition, evaluated through pilot studies. Ganos et al. (page 31) present their experiences from several smart city initiatives in the city of Patras, Greece, and argue that even small communities with limited resources can make a difference and facilitate change. Thomay et al. (page 33) tackle the issue of sustainable tourism in smart cities, and how digital tourism can provide new ways to share cities' cultural heritage. Furthermore, Abbas Petersen and Geirbo (page 34) discuss the Learning Flexibility project, focusing on waste management and circularity in regions such as small islands. The project takes a bottom-up approach, in contrast to the more conventional top-bottom approach adopted by many related projects, aiming to identify innovative and sustainable solutions.

Overall, research on smart and circular cities in Europe appears to be moving towards using innovative technologies and approaches, reaching to novel application domains, as well as encompassing communities in a more active and engaging manner.

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Smart Governance for Cybersecurity

by Michael Kreutzer and Kirstin Scheel (Fraunhofer SIT)

The topic of smartification has become ubiquitous; urban planners and public organisations are investing heavily in digitalisation projects. At the same time, cybersecurity often seems to still be a sideshow. Is there a way to get from smart cities to smart governance?

The Fraunhofer Institute for Secure Information Technology SIT is one of the world's leading research institutes for cybersecurity and privacy protection. It is part of the National Research Center for Applied Cybersecurity ATHENE and as such is an essential part of the cybersecurity strategy of the Federal Government and the State of Hesse.

As part of a project for the Hessian Ministry of the Interior and Sports on cybersecurity processes within and across Hessian municipalities, our research has led us to realise that existing work on smart city developments has tended to focus on technical challenges and/or theoretical attack scenarios. It emphasises specific aspects of different types on attack vectors, privacy impacts and also considerations for transformative frameworks to developing smart cities or protecting them from specific attacks. In addition, many papers still only talk about smart cities when in fact rural communities also benefit from digitalisation – hence our preference for the term "smart communities".

However, what seems to be missing in the race to "smartification" is a framework that helps formulate an encompassing governance perspective for all projects, which ensures that cybersecurity underpins all digital developments. Our goal is an integrated multidisciplinary security framework.

We started our project with a broad literature review, with a specific focus on publications from/on Germany's federal structures [1], as the original research ordinance is focused on the state of Hesse [2]. In addition, we launched a preliminary and continuing review of publicly available sources on real cyberattacks on public infrastructures. We supplemented this with structured interviews with public sector officials in the field of cybersecurity. The observations we are presenting here are a preliminary culmination deduced from these and need to be tested in practice. Nonetheless, we believe that the recommendations of this governance framework are transferable and help strengthen the cybersecurity of all smart community projects.

We have identified five preventive measures that might help to mitigate cyber incidents in the process of smartification. We intend these principles to be applicable as a governance framework on all areas of smart communities. The framework, represented in Figure 1, is based on the principles of:
(i) anchoring,
(ii) responsibilities,
(iii) unification,
(iv) co-operation, and
(v) improvement.

One thing to consider is that these are not meant to be building on each other – each principle is equally important and all need to be in effect to bring about the intended outcome. Considering that the most ingenious smart development is likely happening as part of an existing legacy system, it becomes clear that the governance needs to be embedded to bring about a cohesive cybersecurity framework.

Cybersecurity needs to be anchored at the top level. Top management needs to be aware of the necessity of security as a cornerstone of digitalisation and smartification projects. If you want your projects in this area to be sustainable, forward-thinking, and accepted by citizens and public employees alike, cybersecurity needs to be embedded in the organisational culture.

Clear responsibilities need to be assigned. This is particularly true in hierarchically structured organisations. Lack of responsibility or diffusion thereof can counteract preventive measures. In addition, appropriate resources to act on said responsibilities are required. For example, reporting channels and response times need to be defined. It does not end there, though – they also need to be continually practiced and lived in everyday life. Convenience, unsafe habits and "workarounds" are the bane of not just cybersecurity. So, from an organisational psychological perspective, raising awareness and strengthening a culture of responsibility is important.

Another central idea is the unification across organisational units. In the field of IT this can mean a competently set up infrastructure to prevent failures. Many cases of malware infestation can spread

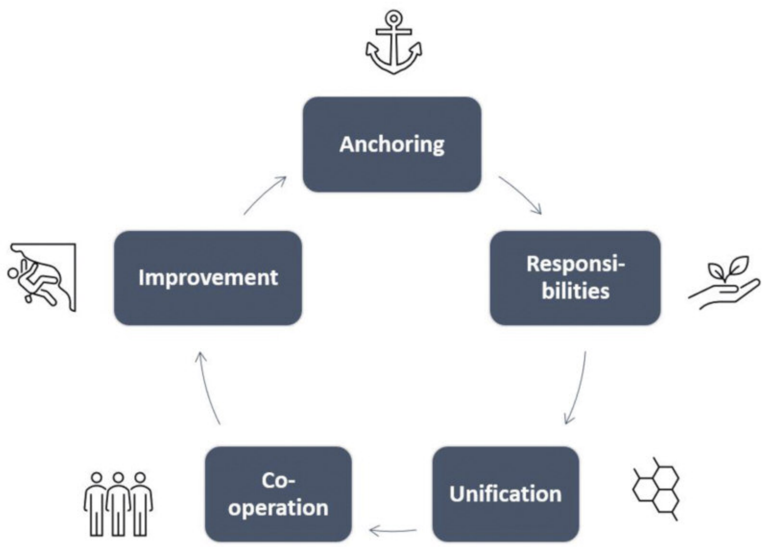

Figure 1: Proposed steps towards smart governance.

through systems that are not properly segmented. IT experts are needed – and they need to continually update their skills.

Operational co-operation and cross-divisional collaboration are also important. Especially in the public sector, resources need to be used efficiently and effectively. With regard to cybersecurity, this can help achieve a higher level of protection overall. For complex IT systems, such as those in smart communities, to work securely together, the different units need to be connected. Information needs to flow – and to actually be used as well as processed. Vertical and horizontal networking is needed.

Dynamically changing environments require continuous improvement. Learning from internal and external mistakes is essential to keep up with these developments. Innovations as well as paradigm shifts are the norm, especially in the digital world. It is necessary to make learning an integral part of the organisational culture. In the field of IT this is nothing new and is usually referred to in the form of maturity models. However, we believe that this needs to be rooted at the heart of the entire organisation and smart community.

We will continue our research in this field in the coming months as part of the current project and hope to expand on it in the future.

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Policies and Recommendations for IT Security in Urban Environments from the Morgenstadt Urban Data Partnership Project

by Philipp Lämmel, Michell Boerger, Nikolay Tcholtchev (Fraunhofer FOKUS) and Eva Ottendörfer (Fraunhofer IAO)

Urban ICT infrastructure is playing an increasingly decisive role as the technical backbone of smart cities. To guarantee the protection of the public sector and citizens in this context, the security of this infrastructure is of utmost importance and should be continuously monitored and improved. This article presents measures and recommendations towards ensuring the security of urban ICT infrastructures.

The smart cities domain is becoming ever more relevant for our society. The accelerating digitalisation of processes in urban settings is expected to lead to long-term improvements, enhancing the quality of life of inhabitants and creating more liveable, sustainable, and inclusive cities. Information and communications technology (ICT) plays an essential role as the backbone of digital transformation. New optimisation opportunities are arising due to the ICT-enabled emerging capabilities for combining and evaluating new services and data sources. In addition, digitalisation and the accompanying transformation of the economy and our everyday lives offer the potential to optimise fundamental urban processes, e.g. in the domains of mobility, transportation and energy.

To ensure that cities and communities do not have to face these diverse challenges on their own, the Urban Data Partnership (UDP) was founded by the Fraunhofer Morgenstadt network [L1]. One aim of this initiative is to stimulate the transfer of knowledge between cities/communities by creating common knowledge as well as sharing experience and strategies regarding the efficient and secure management of urban data. In the long term, the UDP aims to accelerate the digital transformation of cities and communities, while considering (data) security in an urban environment. Based on knowledge gleaned from the UDP, this article presents measures and recommendations to ensure the security of urban ICT services and systems in smart urban environments. The fundamental policies and recommendations are discussed below and summarised in Figure 1.

Stakeholder engagement and governance

An open ecosystem of diverse stakeholders who are aware of the importance of cybersecurity in a smart city is a fundamental driver for the sustainable and secure implementation of smart urban use cases. Therefore, all stakeholders, including the city government, should be encouraged from the beginning to create a culture of cybersecurity throughout all the involved public entities.

Apply security frameworks and standards

To secure a smart city/community, the security of the ICT infrastructure must be addressed as early as the conception phase. Security is important at every step of the development lifecycle and vulnerabilities should be avoided at every level. To this end, the National Institute of Standards and Technology (NIST) has published a cybersecurity framework [1] covering many topics. This framework is a must-read for anyone involved or interested in improving security in their city, community or organisation.

In addition, in 2002, the OECD published revised guidelines for information systems and network security, underpinned by nine principles [2]: (1) awareness, (2) responsibility, (3) response, (4) ethics, (5) democracy, (6) risk assessment, (7) security design and implementation, (8) security management, and (9) reassessment. NIST expanded upon these principles in their document Systems Security Engineering: Considerations for a Multidisciplinary Approach in the Engineering of Trustworthy Secure Systems [3]. This document provides a taxonomy of security design principles to be used as a basis for engineering trustworthy, reliable, and secure systems.

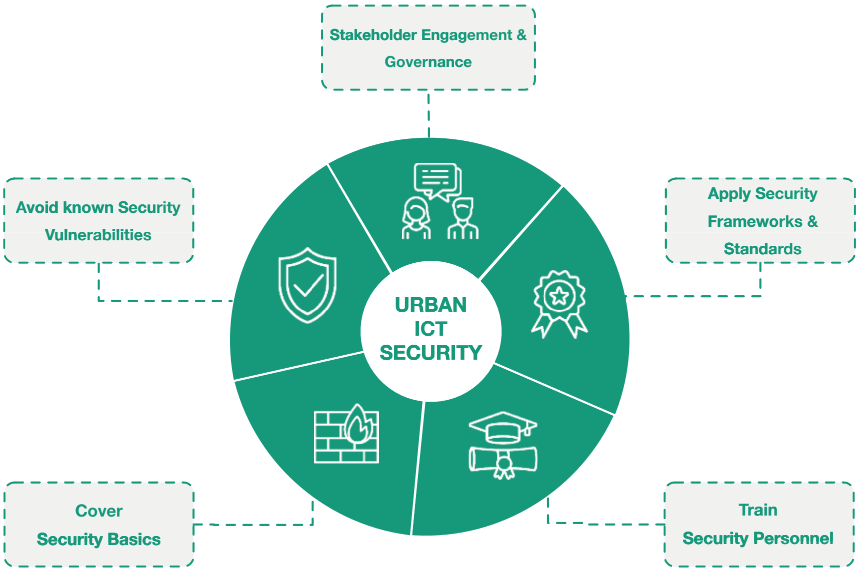

Figure 1: Overview of identified measures and recommendations which are crucial for ensuring the security of urban ICT services and systems.

Avoid known security vulnerabilities and threats

Since software is becoming increasingly complex and interconnected, the difficulty of achieving application security is also increasing exponentially. Therefore, the Open Web Application Security Project (OWASP) published the ten most critical security risks for web applications [L2]. These have become the de facto standard for application security. We recommend that all actors involved in developing an urban ICT infrastructure study the risks and resulting measures identified by the OWASP.

Cover security basics

The following security basics should be followed:
- On-time software updates: All software used in an urban ICT environment should be kept up to date, so that no known security vulnerabilities can be exploited. All firewalls and antivirus programs should be updated regularly.
- Enforce secure passwords and policies: Users should regularly update their passwords to ensure that they are unique and complex. Strict policies should be enforced to ensure that passwords are secure. Furthermore, establishing security operation centres could be helpful to monitor security, mitigate vulnerabilities, and respond to attacks.
- Correct operating procedures: Deploying firewalls is an important step in protecting a smart city/community. Determining the type of traffic allowed to pass through the firewall is one of the most central ways to protect a network from potential attacks.
- Strong access controls: All systems that are not currently in use should be disabled. Unused remote management functions and ports should also be disabled to prevent attackers from accessing them. Furthermore, network activities should be scanned regularly, and suspicious internet traffic should be monitored with the help of security incident and event management tools to detect attacks at an early stage.

Train security personnel

A further security-related challenge is the training of staff to secure an urban infrastructure. Due to the rapid growth and expansion of smart cities, there is currently a shortage of security experts in the urban context. Therefore, the training and certification of professionals for the development, construction, operation, and maintenance of urban ICT infrastructures should be urgently promoted.

Summary

In summary, particular policies and recommendations should be followed for the secure implementation and operation of urban ICT infrastructures, namely: stakeholder engagement and governance; application of security frameworks and standards; avoidance of known security vulnerabilities; training of personnel; coverage of security basics; and the establishment of adequate security processes.

Links:
[L1] https://kwz.me/h79
[L2] https://kwz.me/h7f

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Data Privacy in Smart Cities – Federated Learning to the Rescue?

by Anastasia Pustozerova and Rudolf Mayer (SBA Research)

Within any smart system, data is vital for making the management of resources and assets more efficient. At the same time, data is a potential vulnerability to data owners, and it could become a threat in the hands of an adversary. Data security and privacy are therefore critical for building sustainable smart systems like smart cities. In such systems, where data collection is distributed, federated learning seems like a prime candidate to address the issue of data privacy. However, there are still concerns that need to be addressed regarding privacy and security in federated learning.

Machine learning demands large amounts of data to build effective models that can help to improve services. In many real-world scenarios, data originates at the edge, e.g., smart meters and sensors in smart power grids. In traditional machine learning workflows, data must be centralised from different sources before performing the model training. Concentrating all data in one place creates a single point of failure – an adversary that can potentially gain access to this centralised data is a threat to multiple entities.

Federated learning enhances data privacy in machine learning by suggesting a new perspective on applying machine learning for the analysis of distributed data. The main idea is to train machine learning models closer to the place where data originates – and just aggregate these trained models instead of the (sensitive or private) data. Federated learning, therefore, eliminates the need to share and centralise sensitive data, allowing data owners to keep it private while at the same time offering comparable effectiveness of models.

Federated learning architectures often consist of data owners (clients), which perform local training of the models on their own data, and a central aggregator, which collects the models from the clients and averages them, producing a global model. The global model can be sent back to the clients for the next cycle of training to improve its effectiveness, and later utilised for predictions. Some of the main challenges of federated learning include communication costs, data and systems heterogeneity. Many works propose different optimisation algorithms to tackle these issues, e.g., via client sampling or model and gradient compression [1]. However, comparatively little attention has been put on remaining privacy and security risks, and new attack vectors open up simply due to the distributed nature of federated learning (see Figure 1).

Security risks (integrity and availability). Malicious participants of federated learning or adversaries leveraging transferred information can corrupt the learning process to degrade the global model quality or to make it perform target misclassification. In smart cities, successfully executed attacks can result in adversaries manipulating situations to favour them – for example, by manipulating demand-driven pricing – or can even result in the failure of critical services and infrastructure, and thus lead to major safety issues. Security risks in federated learning can originate through data or model poisoning (backdoor attacks), or when an adversary alters the data at inference time (evasion attack). Backdoor attacks pose one of the biggest challenges in federated learning as they are especially hard to detect. The challenge is increased by the secret nature of local training data, which makes it hard to analyse the correctness of the contribution of clients. Malicious clients can train models on poisoned data or directly manipulate model updates [3]. An adversary who is able to compromise the aggregator can perform attacks on the global model. Another threat comes from non-secure communication channels when an adversary is able to steal or maliciously modify shared model updates.

Privacy risks (confidentiality). Model parameters exchanged during federated learning represent an abstraction of the training data. Adversaries might infer information about training data having access to the model. In smart cities, data generated by sensors and IoT devices often involves personal privacy, and this is thus a great concern. It is thus important to mitigate potential leaks of this data through the machine learning process. Federated learning with the increased exchange of models might, however, increase the attack surface. Adversaries can perform different attacks on shared models in federated learning, e.g., model inversion, trying to recreate the original samples from the model, or membership inference, aiming to infer the membership of some

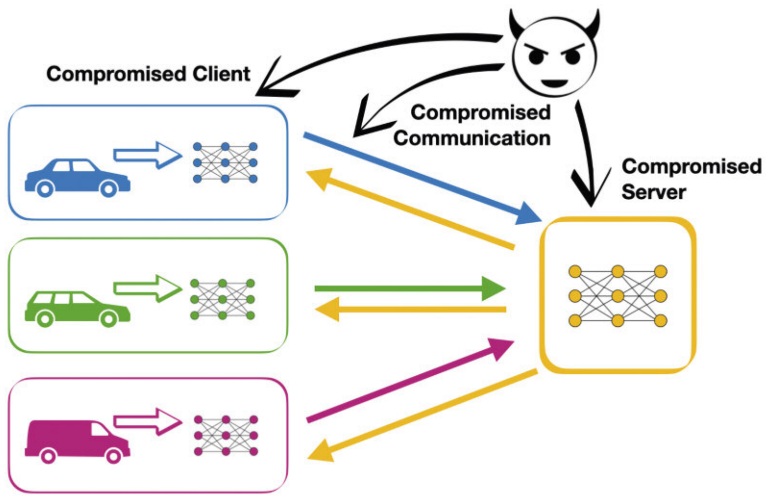

Figure 1: Federated learning architecture and attack vectors. An adversary who is able to compromise clients, a server or communication channels can threaten the security and privacy of the system.

particular instance in the training set of a target model [2]. Adversaries can be e.g., a compromised or malicious aggregator, or someone stealing models during client-server communication.

Approaches for mitigating security and privacy risks in federated learning often still lag behind attacks, but are increasingly in the focus of research activities.

Regarding privacy risks, several approaches can be employed. Differential privacy (DP) aims to bring uncertainty into the model outputs to hide personal contributions to the model; clients can add noise to shared model parameters or train a differentially private machine learning algorithm. The main downside of this approach remains that noise degrades models performance, thus there is a trade-off between privacy and utility.

Secure Multi-Party Computation (SMPC) provides a cryptographic protocol that allows joint computation of a function while keeping its inputs private. In federated learning, this can replace a central aggregator. However, SMPC poses high computational costs, therefore limiting the scalability of federated learning.

Homomorphic Encryption (HE) allows mathematical operations to be performed on encrypted data. Clients can encrypt their model parameters, and the coordinator could aggregate them but not understand them. Like SMPC, HE greatly increases computational costs.

Detecting attacks on the integrity and availability of the machine learning process is even more difficult. Defences like anomaly detection and robust aggregation aim to discover potentially harmful models and eliminate their malicious influence on the global model. Yet they fail to detect targeted backdoor attacks, as poisoned models look and behave similarly to models that were trained without backdoor [3].

There has been a dramatic increase in interest in federated learning in recent years. Many companies, including Apple and Google, are already using federated learning for their services. Interest in this technology is especially high in medical applications and smart cities, where personal data is processed, and data privacy is a major concern. However, there are still challenges to address in federated learning. Mitigation of security and privacy risk is especially important for building trust in the technology. Further investigation of defence mechanisms is therefore critical for the successful application of federated learning.

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Considering Cybersecurity with Trustworthy IoT in Smart Cities

by Christoph Klikovits (Forschung Burgenland), Clemens Gnauer (Forschung Burgenland), Patrik Abraham (Fachhochschule Burgenland)

In today’s smart cities, the question remains how to securely integrate a multitude of different and constantly changing Internet of Things (IoT) devices and services. This is where we propose the combination of an identity provider (e.g.: ID-Austria [L3]) and the Arrowhead framework [L2] to verify sensors by matching them with a known legal identity. By providing an application that assures a secure authentication and trustworthy communication for people, sensors, and services in a smart city.

A variety of technological innovations have changed the characters of cities in recent years. There are millions of devices with sensors and actuators dispatched with an upward trend in cities (weather, water and gas metering, traffic lights and controls, waste management, etc.). Applying and using evermore of these in the context of interconnected IoT systems raises the challenge of providing trust and security in this context. The Center for Cyber Security of Forschung Burgenland [L1] deals with this topic and researches an approach to increase the trustworthiness and security of IoT devices. The aim of this approach is to link existing IoT devices or services with a known legal identity. An identity provider (ID-Austria) and an additional support service of the Arrowhead framework are combined through an integrated approach. Arrowhead was created for the orchestration of large scale IoT data. It offers strong security mechanisms and in combination with the admission ticket, cities can rely on secure and trustworthy IoT data. Furthermore, the Arrowhead project is implementing more and more support services like the on-boarding procedure [2] which is used for the autonomous integration of devices into the service-oriented arrowhead ecosystem. This procedure strengthens the secure and trustworthy integration of devices or services. A proof of concept could be developed in the EFRE project (FE07) “Civis 4.0 Patria” and presented in the FIP / IEEE

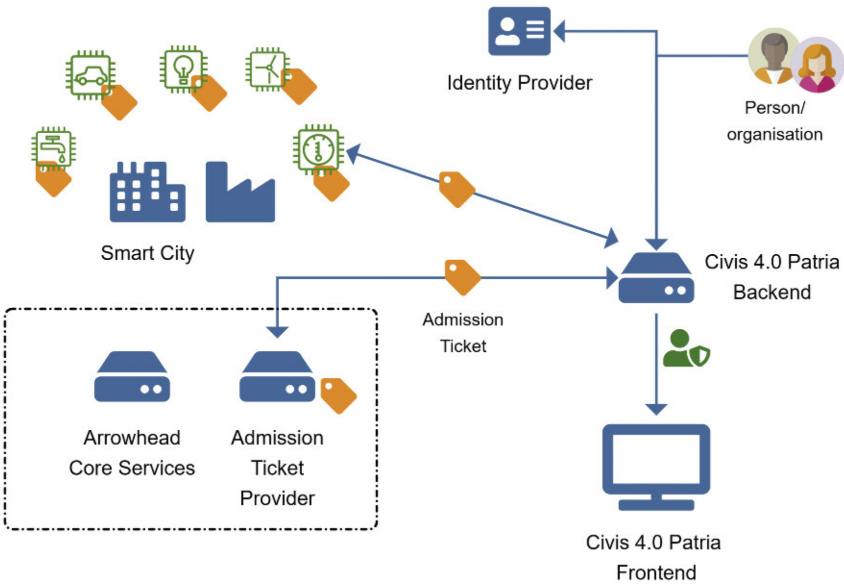

Figure 1: Architecture of trustworthy IoT in smart cities.

International Symposium on Integrated Network Management (IM) workshop [1].

As shown in Figure 1, various techniques and tools are used to create a digital admission ticket, which is created based on several parameters (IP, MAC address, etc.). In addition to the parameters listed, the electronic proof of identity from an identity provider is integrated into the creation of the digital admission tickets. Three instances and steps linked in an integrated approach are required for the creation of an admission ticket. Step 1: Firstly, a person or organization is involved in the proposed proof of concept shown in Figure 1. This natural person or corporate body requires an electronic proof of identification from an identification provider (e.g., ID-Austria [L3]). While logging into a backend layer (e.g., Civis 4.0 Patria backend), the login data is verified by the identification provider using an interface. By using the interface to the identification provider, the person or organisation does not need any additional login data for the backend layer. Step 2: In the verification process the identification provider determines an unique personal identifier, called bPK [L4], in two steps: Firstly, a character string is formed from a master number (central register or association register, commercial register entry) and the procedural area. Secondly, a specific hash algorithm calculates a secure one-way cryptographic derivation from this character string and encodes the bPK with the Base64 standard. Step 3: After the bPK has been transmitted from the identification provider to the backend layer, the person or organization is verified and clearly identified. The identified person or organization can use their identification (bPK) to register various devices or services in the backend layer. When registering, various additional parameters (IP-Address, Mac-Address, device ID, etc.), related to the device or service can be specified. These parameters, including a legal identity (bPK), are forwarded to the Arrowhead framework. Additionally, to the core services of the Arrowhead framework, a further service called the Admission Ticket Provider (ATP) was developed. The ATP is responsible for generating a hash (admission ticket) by combining the received device or service parameters (e.g., IP address or Mac-address), the unique personal identifier (bPK) and using the SHA-256 function. This delivers a string with 64 characters which will be stored in the ATP-database and transmitted to the backend for further use. Afterwards, the person or organization who registered the device or service will receive the admission ticket and must store it on the device (e.g., sensor, Raspberry Pi or smartphone) or service-platform.

The certified hash (admission ticket) created by the ATP is stored on both the respective device or service and in the ATP database. An implemented backend process automatically forwards the respective payload including the supplied admission ticket to the ATP in the Arrowhead framework every time a device or service transmits data. Furthermore, the admission ticket of the device or service is compared with the stored admission ticket in the ATP. After a successful verification of the admission ticket, the backend is informed by the ATP and allowed to publish the payload into the frontend. If an admission ticket is invalid or does not exist, the frontend release of the payload is not permitted and is discarded. As applied in a proof of concept, it shows trustworthy and secure communication in smart cities, where smart devices or services are increasingly used. Matching a unique personal identifier with devices or services enables to link a person responsible with e.g., IoT sensors, whereby trustworthiness, acceptance and security of devices and services in a smart city can be strengthened.

Links:
[L1] https://www.forschung-burgenland.at/cybershysecurity/
[L2] https://www.arrowhead.eu
[L3] https://kwz.me/h7J
[L4] https://kwz.me/h7M

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Digital Twins for Cyber-Physical Threat Detection and Response

by Matthias Eckhart, Andreas Ekelhart (SBA Research and University of Vienna), and Roland Eisl (ENRAG)

Since cyber-physical systems are the backbone of smart cities and innovative industrial applications, their safe and secure operation is paramount. However, due to the steadily increasing aggressiveness, sophistication, and stealth of cyberattacks, new methods for threat detection and response are needed. The concept of digital twins opens up new avenues of research to address these gaps.

Recent security incidents involving cyber-physical systems (CPSs), such as the 2021 Colonial Pipeline cyberattack, have again demonstrated the vulnerability of critical infrastructure. While the current state of CPS security is already strained, smart technology trends proceed to evolve, pushing traditional protection mechanisms to their limits. As a result, new methods to support the implementation of a holistic security approach are needed. Considering the interdependency of the cyber and physical domains in which these systems function, adequately protecting CPSs represents a pressing challenge. A few years ago, researchers started to explore how the concept of digital twins can be utilised to tackle this challenge [3].

Within the context of security, the term "digital twin" can be defined as "... a virtual replica of a system that accompanies its physical counterpart during phases of its lifecycle, consumes real-time and historical data if required, and has sufficient fidelity to allow the implementation of the desired security measure." [3] Since digital twins are not used for redundancy purposes when applied within the context of security, the CPS is virtually replicated by means of emulation, simulation, and modelling techniques to an extent that enables the implementation of security-enhancing features and activities. For example, digital twins that possess a sufficient degree of fidelity allow thorough security testing during both the engineering and the operation phase [1]. This use case of the digital-twin concept spares systems integrators and operators of CPSs the need to build custom testbeds or conduct security tests with the real infrastructure, thereby providing cost savings and preventing uncontrolled interactions with live systems that may lead to extensive (physical) damages. Furthermore, digital twins that run in parallel to their physical counterparts, closely following their states, provide the means to inspect the behaviour of the CPS without the risk of interference. This unique feature allows rigorous monitoring of multiple CPS layers (e.g., physics, network, logic) and can be exploited for detecting intrusions. However, such a security-focused use case necessitates a state replication mechanism to keep the digital twins in sync with their physical counterparts, and further assumes that the virtual replicas exhibit benign behaviour [2]. If an alarm is raised, the digital twins can then be used to identify possible countermeasures and to assess their effectiveness as well as their effects on the physical process from a simulation point of view. As initial efforts were directed toward developing the basic principles of this concept [3], more research is required to efficiently create, operate, and maintain these security-focused digital twins.

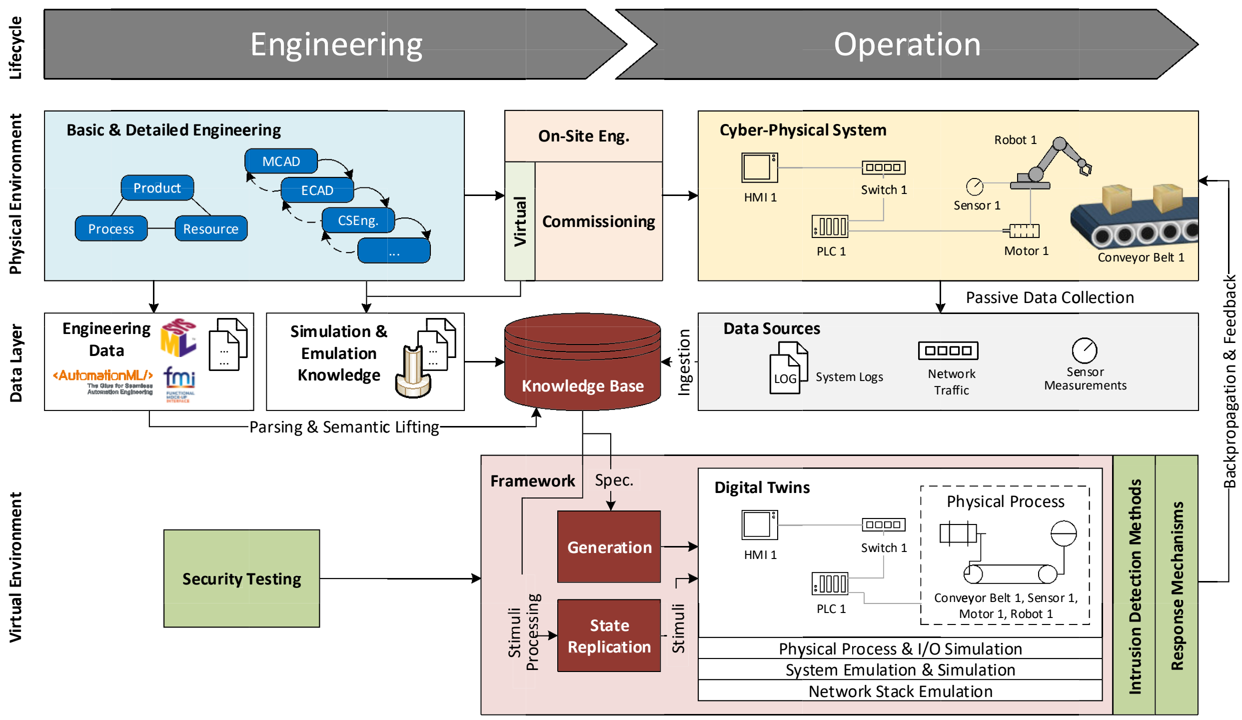

Figure 1: High-level architecture of the digital-twin framework.

The SecurityTwin project [L1] aims to develop the fundamental methods for employing the digital-twin concept to enhance the security of CPSs. As part of this project, researchers at SBA Research and the University of Vienna, together with industry professionals at ENRAG and condignum, will create a framework to efficiently build digital replicas of CPSs based on engineering data, emulating components as well as networks, and simulating physical processes. Figure 1 illustrates the architecture of the digital-twin framework on a high level. We aim to develop a knowledge base that incorporates know-how from numerous heterogeneous data sources (e.g., engineering data repositories, domain knowledge) and provides the semantic foundation for generating the digital twins. This knowledge base comprises: (i) information about the CPS itself (sourced from engineering artifacts); (ii) information concerning the simulation and emulation used as part of the digital twins; and (iii) operational data from the real CPS for state replication and intrusion detection. The digital twins can then be automatically generated by instructing the integrated emulation solutions (e.g., QEMU) and initialising the embedded simulation models. Moreover, a synchronisation mechanism will be developed, which is not only capable of automatically replicating states in a timely manner but also of recovering the digital twins from state mismatches.

Using the architecture we described, our framework will provide the basis for implementing intrusion detection and response methods. Owing to the physical models and simulations integrated into the digital twins, the designed intrusion detection system incorporates knowledge about the physical process under control and thereby will yield alerts if the process is steering toward an unintended state. Upon detection of adverse events, response measures can be identified and their applicability, as well as consequences, assessed by observing the behaviour of the virtual replicas.

Building upon our earlier work [1, 2, 3], we are currently in the process of developing the framework as described above. In addition to our contribution as part of the SecurityTwin project [L1], we want to actively stimulate scientific exchange in this emerging research area. We are therefore organising the Dagstuhl seminar 22171 [L2], which is dedicated to this topic and are encouraging other researchers to share their perspectives.

Links:
[L1] https://kwz.me/h7j
[L2] https://kwz.me/h7q

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Circularity and Sustainability in Modern Smart Grids Through Innovative Energy Market Architectures

by Nikolaos Efthymiopoulos, Prodromos Makris, Emmanouel Varvarigos (National Technical University of Athens)

Circularity and sustainability in modern smart grids require open data models that can support dynamic and efficient distribution-network-aware energy management. In this context, the FLEXGRID [L1] project is developing a digital platform that will offer digital energy services (DESs) that help energy sector stakeholders (i.e., Distribution System Operators (DSOs), Transmission System Operators (TSOs), market operators, Renewable Energy Sources (RES) producers, retailers, flexibility aggregators) to: (i) automate and optimise the planning, operation and management of their systems and assets, and (ii) interact in a dynamic and efficient way with the electricity system and other stakeholders.

The large-scale integration of Distributed Energy Resources (DERs), such as PV/wind generation (RES), electric vehicles (EVs), energy storage systems (ESS) and demand side management (DSM) equipment in distribution networks poses new challenges and opportunities for the power sector, as stated in the EU Clean Energy Package [1]. In this context, the FLEXGRID project is investigating the constraints of the current smart grid architecture that prevent large scale DER integration in distribution networks and consequently mitigates circularity and sustainability in modern smart grids.

The first reason is that DSOs use conservative constraints in distributed DER installation to ensure reliable and secure operation of their network. The root cause of this conservatism is the inability of DSOs to dynamically and accurately monitor and manage their networks. The development of a dynamic and accurate distribution network (DN) monitoring system and of an efficient and dynamic DN management system is therefore the first step towards mitigating this conservatism.

A second reason is that even in cases where DSOs dispose distribution management systems with appropriate DN monitoring capabilities, the lack of intelligence that would allow the efficient and dynamic interaction with DER operators (i.e., RES producers, retailers, flexibility aggregators) hinders DER investments. Consequently, the DN-related costs remain high (usually driven by DN upgrades with high CAPEX). In this context, FLEXGRID develops advanced DESs relevant to the operation of distribution level flexibility markets (DLFMs), aiming to facilitate the efficient management of DNs and the reduction of distribution network management cost.

Another issue tackled in FLEXGRID is the inefficient investment planning and management of DER assets. To this end, FLEXGRID evolves existing smart grid architectures, which are not able to provide information related to the electricity grid topology and the market conditions to DER investors, by addressing the aforementioned shortcomings. From this perspective, FLEXGRID exploits: (i) topology and monitoring information from the networks that it manages, and (ii) data analytics from the market that it operates in order to provide DESs useful for the design of optimal DER investment strategies and optimal DER portfolio management.

Beyond these innovation levels, FLEXGRID copes with a major inefficiency in today's smart grids, which is the lack of interaction between TSOs and DSOs. Today, the TSO is the main actor procuring flexibility from flexible units to ensure system stability. However, in the future, according to [2], DSOs will also be expected to procure flexibility to solve issues in their networks. As DSOs and TSOs might use the same sources of flexibility, this flexibility should ideally be used in a coordinated way. Different market-based and non-market-based approaches can be used by the TSO and the DSOs for the coordination of flexibility. When using flexibility to cope with a given grid operation challenge, this might have an impact on other aspects of grid operation. For example, the activation of DN-level flexibility for system balancing by the TSO might cause congestion in the distribution grid. Another example is the activation of DN-level flexibility by a DSO to solve a local congestion problem, which may cause higher re-dispatch costs at the transmission network (TN) level.

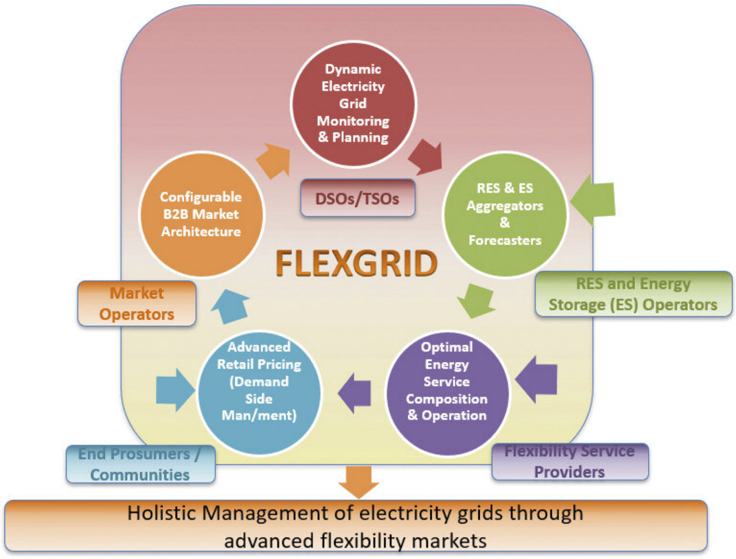

Figure 1: The FLEXGRID concept.

Another problem of ineffective TSO/DSO interaction in today's smart grids is that of suboptimal economic dispatch decisions. These are often made by the DSOs or their issuing dispatch orders to DER operators that: (i) are infeasible, due to DN constraints, and/or (ii) in conflict with dispatch instructions sent by the DSO to end energy prosumers. DSOs, on the other hand, have observability into distribution system operations but, to date, have little to no experience in creating economically optimal system operations. Moreover, DSOs have little or no observability into transmission system conditions, and, in many cases, into the investment or operation decisions of DER owners. As a result, DSOs (and, equally often, TSOs) lack knowledge about the DER and DSM potential, which may act in support of system operations. This has led to discussions about how to coordinate DSO operations with consumers, DER operators and TSOs.

In this new landscape, FLEXGRID focuses on four major research gaps.

The first examines the operation of existing energy markets and the evolu-

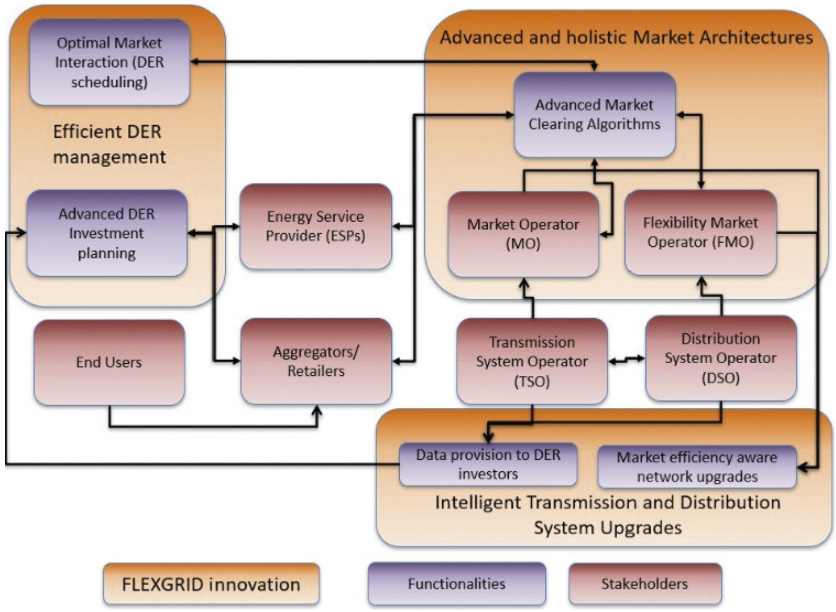

Figure 2:High Level Functional FLEXGRID architecture.

tion of their architectures in depth by focusing on the interaction between TSOs and DSOs. It also unfolds around the development of advanced market clearing and pricing algorithms that can adequately model the underlying distribution system and ensure market efficiency by considering modern DER models (e.g., ESS, DSM).

The second gap addressed by FLEXGRID is the development of DESs towards efficient aggregation of end user's DERs. This alternative facilitates their optimal and parallel usage of their capacity in multiple energy markets according to FLEXGRID's innovative energy market architecture.

The third research gap relates to the development of DESs that contribute to the optimal operation of DERs and the advanced planning of DER investments according to a sophisticated and data-driven examination of: (i) innovative FLEXGRID's markets, (ii) DN/TN topology, and (iii) competition.

The fourth research thread focuses on the monitoring and management of the transmission and the distribution networks in smart grids and in resolving problems related to the grid upgrades with respect to market power mitigation and flexibility exploitation. It co-optimises network upgrades and flexibility investments.

Link:
[L1] https://flexgrid-project.eu/

References:
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Enabling Smart Control and Fair Sharing of Renewable Resources in Energy Communities

by Sonam Norbu, Benoit Couraud, Merlinda Andoni, David Flynn (Heriot-Watt University, Edinburgh) and Valentin Robu (CWI and TU Delft)

In many smart energy communities all over the world, consumers are joining forces to jointly invest in their own renewable energy generation (wind turbine, solar panels) and battery assets. But how can we efficiently control the community-owned infrastructure, and fairly distribute the output among consumers of different sizes and consumption profiles? Researchers at CWI Amsterdam and Heriot-Watt University in Edinburgh, Scotland, are using techniques from distributed artificial intelligence to address this challenge.

One of the aims of smart cities is to reduce the carbon footprint of the citizens' energy consumption by supporting a novel decentralised production and by leveraging the new digital and smart grid technologies for the energy system. This will enable consumers to take control of their own energy generation and consumption. A recent trend, emerging in both rural communities and smart city neighbourhoods, is for groups of household prosumers to form local energy communities that invest together in jointly owned renewable generation and storage systems, sharing the benefits from these assets. Examples include the Responsive Flexibility project on the Orkney Islands [L1] the Brooklyn Microgrid project in the US, the Grid Friend project in Amsterdam North, and the many energy communities emerging in developing countries, such as Auroville in India. Looking forward, such energy communities are expected to play a key role in building a more decentralised, decarbonised, and democratised energy system in which consumers use more locally-generated renewable energy, and take control of their energy supply.

Challenges

Energy community projects, which have been established in both urban and rural environments, often involve jointly owned assets such as community-owned wind turbines, PVs and/or shared battery storage. The Responsive Flexibility (ReFLEX) project (the UK's largest smart energy demonstrator) is studying one of these communities on the Orkney Islands in Scotland [L1], comprising 200 households that share a wind turbine and storage (i.e., a community battery). Our model uses high granularity (half-hourly) consumption and generation data from each household.

While energy communities are a promising concept, a key challenge is how these assets can be efficiently controlled in real time, how the useful lifetime of the asset can be modelled and enhanced using AI, and how the energy outputs from these jointly owned assets should be shared fairly among community members, given that not all members have the same size, energy needs or demand profiles.

Solution and results

To address these challenges, we have developed new algorithms for smart control of energy assets and redistribution mechanisms that yield to fairer ways to divide joint gains, using the tools from distributed AI and cooperative game theory. First, we compare the case when individual households invest in their own home energy assets (renewable generator, storage) vs. investing in a larger jointly owned community energy asset. Our case study and dataset clearly show the benefits of a jointly owned or pooled energy assets approach. Next, we provide several practical and computationally efficient mechanisms to share the outputs from these jointly owned assets between homes in a fair way [1]. Our work makes use of the key concept of marginal value – borrowed from coalitional

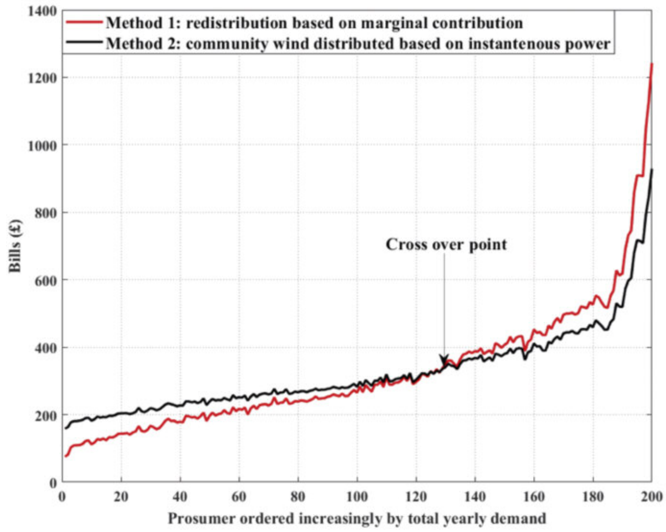

Figure 1: Individual households' yearly bills after redistribution by marginal cost redistribution method and currently practiced state-of-the-art redistribution methods.

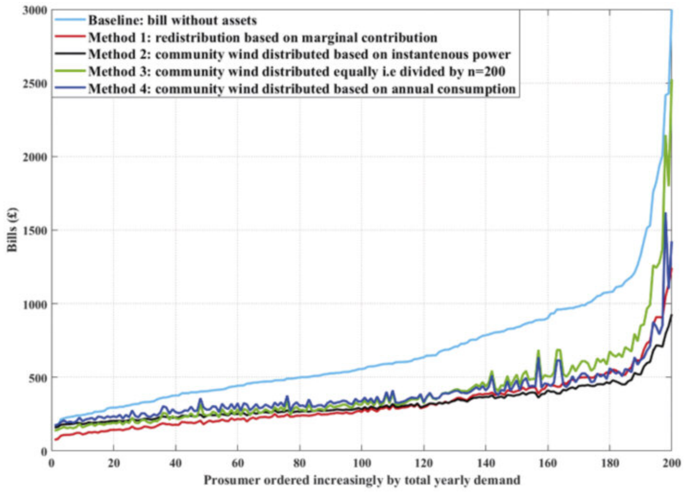

Figure 2: Individual households' yearly bills after redistribution by marginal cost redistribution method and instantaneous power redistribution method.

Figure 3: Wind turbines deployed on Orkney Islands, Scotland, UK – the "living lab" for the smart local energy demonstrator project Responsive Flexibility (ReFLEX) [courtesy: EMEC/ReFLex].

game theory and distributed AI, looking at what each member contributes to (and costs) the local community.

Figure 1 shows the annual bills of individual households after redistribution of community savings obtained from the jointly owned community energy assets for different redistribution schemes. The advantages of the proposed redistribution mechanism based on marginal contribution of each household, denoted as Method 1 in red, are that it yields to the lowest bill for the whole community, and thus the greatest savings for the community households. For Method 1 and Method 2, we performed a further comparison to evaluate the economic fairness in the redistribution scheme (see Figure 2). The crossover point between the redistributed bill curves in Figure 2 shows that the proposed marginal cost redistribution method yields to a greater reduction of the annual bill for 67% of the community households compared to method 2. Hence, under the proposed marginal redistribution method, more households can decrease their annual bills than the existing state-of-art redistribution method.

While it is true that large consumers benefit slightly less under our scheme, these households with higher demand profiles are the households who already obtain the highest bill reduction in value as compared to households with lower demand profiles as illustrated in Figure 1. Therefore, the proposed redistribution mechanism achieves a fairer redistribution than does the current redistribution scheme. From a pragmatic perspective, having 67% of households in the community, which are mainly small consumers, benefiting from the proposed redistribution mechanism would lead to greater social acceptance, and hence to more communities forming coalitions to invest in jointly owned renewable energy assets.

Further work

Furthermore, we have extended the proposed redistribution mechanism to integrate physical network/grid constraints [2], which are key for building realistic distribution grid models. Another potential extension involves modelling other use cases using these methods, such as energy communities in cities such as New Delhi in India [L2], sharing solar panels and a battery unit.

Links:
[L1] https://www.reflexorkney.co.uk/
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Green Energy Planning of IoT Rule Automation Workflows in Smart Environments

by Soteris Constantinou (University of Cyprus), Andreas Konstantinidis (Frederick University) and Demetrios Zeinalipour-Yazti (University of Cyprus)

The advancement of renewable energy infrastructure, such as photovoltaic systems, in smart buildings has highlighted the importance of energy self-consumption – i.e., the process by which IoT-enabled, energy-demanding devices intelligently consume energy at the time it is available. In contrast, user comfort levels expressed in the form of Rule Automation Workflows (RAW) are usually not aligned with renewable production patterns. We have devised an innovative framework, coined IoT Meta-Control Firewall (IMCF+), which aims to balance the trade-off between comfort, energy consumption and CO2 emissions. The IMCF+ framework incorporates an innovative Green Planner (GP) algorithm, which is an AI-inspired algorithm that schedules energy consumption with a variety of amortization strategies, implemented as part of a complete IoT ecosystem in OpenHAB.

Eighty-five percent of all human CO2 emissions come from the burning of fossil fuels, such as coal, natural gas and oil. Almost half of global greenhouse gas emissions come from electricity and heat production (25%), transportation (14%) and buildings (6%), collectively. Most of the remainder is emitted by agriculture (24%), industry (21%) and other energy requirements (10%). Consequently, minimising CO2 pollution in spaces such as houses and offices, in which people spend 80 to 90% of their time, can help to ameliorate climate change.

A key driver for the control of CO2 is the uptake of Internet of Things (IoT), which connects all the smart devices in the world that are able to "see", "hear", "think", "react", perform tasks, and communicate with each other using open protocols, and thus, power consumption and CO2 emissions controlled by IoT infrastructure can be brought under the same roof. IoT makes it possible to develop smart applications in important domains that can have significant impacts on people's quality of life and the growth of the world's economy and security. A typical family in the developed world owns 5 to 10 internet-connected devices, such as smartphones, smart TVs and other smart-home devices, and according to Gartner [3] this number is expected to increase to more than 500 smart devices by 2022, and later on to 100 billion connected devices by 2030.

Rule Automation Workflows (RAW) aim to meet the comfort level of users under specific conditions (e.g., "warm house to 22 °C if cold, or preheat electric vehicle before departing"). In the simplest case, a user expresses preferences manually through a vendor-specific smartphone app/integrated app. This process requires continuous attention by custodians, making it a cumbersome process that generates erroneous executions and that clearly calls for more automated (i.e., "smarter") approaches. Services like IFTTT, Apilio and Apple Automation expanded the expressiveness of the RAW with Boolean predicates (e.g., conjunctions) and even introduced procedural programming constructs, like variables, while loops, if statements and functions to advance RAW actuations. However, none of the above RAW technologies enables individuals or groups of users to express their comfort preferences while achieving a long-term objective.

In IMCF+, a user (or group of users) starts out by defining a vector of RAW rules, named Meta-Rule Table (MRT), and an Energy Consumption Profile (ECP), as shown in Figure 1. The high-level objective is to identify among all MRT rules the ones that must be dropped so that the user stays within the desired energy budget according to the ECP history. For this purpose, it utilises an intelligent search algorithm, which goes over the exponentially large search space of numerous combinations, quickly yielding the rules to be dropped [1,2]. Particularly, IMCF+ adopts an intelligent energy amortization process along with an AI-inspired Green-Planner (GP) algorithm we proposed, to balance the trade-off between user comfort and CO2 emissions, subject to a pre-specified energy consumption budget, while satisfying the RAW pipelines of users. The amortization plan is responsible for calculating the maximum energy budget constraint and the CO2 emission constraint through a preselected amortization formula. Then

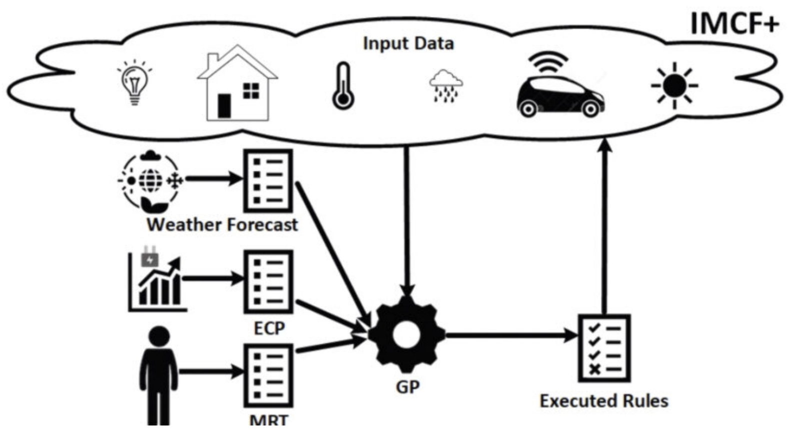

Figure 1: The Green Planner (GP) algorithm proposed, is an AI-inspired algorithm that finds the best possible energy consumption strategy with respect to user comfort and CO2 emissions by only using a Meta-Rule-Table (MRT) profile, a Weather Forecast and an Energy Consumption Profile (ECP) and without the necessity of a learning history used by machine learning methods.

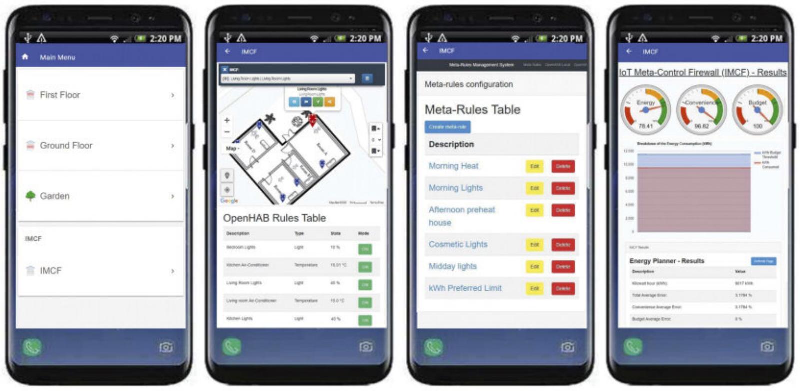

Figure 2: IMCF+ Graphical User Interface: Integration of the IMCF+ Software Library in the OpenHAB Home Automation Stack. a) Interactive and Automated Menu; b) Dashboard for smart space current state linked with Anyplace Viewer; c) Meta-Rule-Table Configurator; and d) IMCF+ Results.

an AI approach is executed to generate a green plan solution for optimizing the comfort error. IMCF+ adapts the RAW pipelines in such a way that these do not collide with the long-term objectives of users (by dropping certain rules based on preference priority). We have adopted a simulated annealing algorithm, which does not require a learning history (like respective machine learning techniques), does not require a target function (e.g., like A*), it does not get stuck in local optima (e.g., like traditional hill-climbing) and it is straightforward to implement in a resource-constraint setting like local smart controllers (e.g., Raspberry).

Our system architecture comprises a fully-fledged local controller implemented inside the Open Home Automation Bus (OpenHAB) stack, which is a smart home management software; and IMCF+, which is the software system that encapsulates the complete application logic of the energy management stack we proposed along with the respective user interfaces. For a pioneer integrated solution, we also made use of the Linux crontab daemon, the "Anyplace" for building modelling, as well as the Laravel PHP web framework following the model–view–controller architectural pattern (see Figure 2). The proposed system is protected by the authentication provided by OpenHAB and Laravel framework. The local controller is also located on the user's local network and is protected by the Ubuntu operating system firewall. Therefore, the system is secure; anyone with malicious intent will have to break through the security offered by OpenHAB and Laravel to be able to infect files or penetrate the firewall.

Given that our proposed framework requires no training data and only a primitive MRT preference profile, this can easily integrate in low end edge smart actuations platforms. We believe that by consuming energy more intelligently (i.e., green-smart IoT actuations) we can greatly reduce the environmental impact of ICT, enabling us to both improve living conditions and respect the environment, helping society to meet emissions reduction targets.

Link:
[L1] https://imcf.cs.ucy.ac.cy/

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Using Telematics to Gather User Behaviour Data from a Fleet of Electric Bicycles

by Sam Gunner, Eddie Wilson and Theo Tryfonas (University of Bristol)

As part of the Horizon 2020 Lighthouse Project REPLICATE, a fleet of electric bikes (e-bikes) were fitted with novel monitoring equipment. This hardware integrates into the e-bike's electrical system, harvesting power from the e-bike's battery and gathering data from its internal communications bus. Data has already been gathered from 3,000 journeys, covering more than 7,000 km, recording user behaviour for every single pedal stroke. This data creates a powerful detailed insight into the use of e-bikes in relation to variables such as topology, weather and remaining power – one pedal stroke at a time.

Electric bike (e-bike) usage has increased significantly over the last five years, and has been accelerated by the pandemic, which forced people away from public transport [1]. E-bikes provide a novel opportunity for telematics, the applications for which range from supporting the logistics of e-bike cycle hire schemes, to understanding cyclist choice and the impact electric bike usage has on an individual's health.

In Bristol (UK) such a telematics system was created as part of the

REPLICATE Horizon 2020 Lighthouse Project [L1]. An e-bike cycle-sharing scheme was implemented as part of its mobility interventions, and information was generated to understand how the fleet was being used. Rather than depending on manual surveys, which are often unreliable, the University of Bristol project team, including members of the University's UKCRIC Urban Observatory [L2], developed a tracking device that would integrate into the e-bike's onboard electrical system. This not only removed the requirement for the telematics device's battery to be independently charged, but also meant that messages on the e-bike's CAN bus (a "control area network" protocol widely used in the automotive industry) could be captured and stored, providing extremely detailed information about the state of the e-bike system, such as battery level, motor power, pedal torque and cadence.

Instrumentation and system development

We started developing the telematics system in October 2017, and a significant amount of reverse engineering was needed to understand how the electrical system of an e-bike could be modified in a way that was safe and would not negatively impact the operation of the e-bike. A single board computer-based design was selected, and this platform was augmented to include a GPS, CAN bus interface, accelerometer, buck-boost converter, internal battery and LoRaWAN interface to allow the device to report amalgamated statics whenever within range of a 'The Things Network' access point. WiFi connectivity was used to upload complete log files for a journey, with each file often being several megabytes in size.

An open-source data "pipeline" was implemented on a University of Bristol–based server. Telematics devices automatically encrypt log files and upload them via WiFi at the end of a journey. These files are then unencrypted by the server, which processes the raw CAN bus messages before storing them in a time series database. Message broker-based middleware was implemented [2] to allow authorised applications to receive both the raw and processed messages in real time. Web-based visualisation software was also implemented, allowing GPS and user data to be investigated together.

Figure 1: The E-bike Telematics System: (left) the devices fitted to a host e-bike during a lab trail. The lid of the waterproof enclosure has been removed to expose the internal electronics; and (right) the device after it has been fitted to an e-bike as part of the two-year-long REPLICATE technology deployment.

As shown in Figure 1, the telematics electronics were fitted inside a waterproof enclosure, and a mounting bracket was developed that would allow the device to be fitted to the handlebar of the host e-bike. Passthrough cabling was developed, al lowing signals to be intercepted between the e-bike electric drive and display. Standard connectors were employed, meaning that the system could be fitted quickly without needing the e-bike to be taken to a workshop.

Twelve devices were built, and all were installed on 16th April 2019. This deployment ran for two years, concluding with the end of REPLICATE. During that time 2,957 journeys were recorded, covering a total distance of 7,320 km. The only telematics failure was due to a corrupt SD card on one of the units, and at no point during the deployment did the telematics systems negatively impact the operation of the e-bikes themselves. The system provided the information required by the REPLICATE Project, as well as a huge amount of other data which continues to provide opportunities for ongoing research.

The data and insights

The REPLICATE e-bike telematics system generates an extremely rich dataset, providing insights into many aspects of e-bike usage. The onboard GPS records a complete trace of each journey from start to finish. Individual journeys can be inspected to understand the route selection choices that an e-bike rider has made, for example, demonstrating situations where a traffic-free route has been selected despite this adding distance to a journey. With nearly

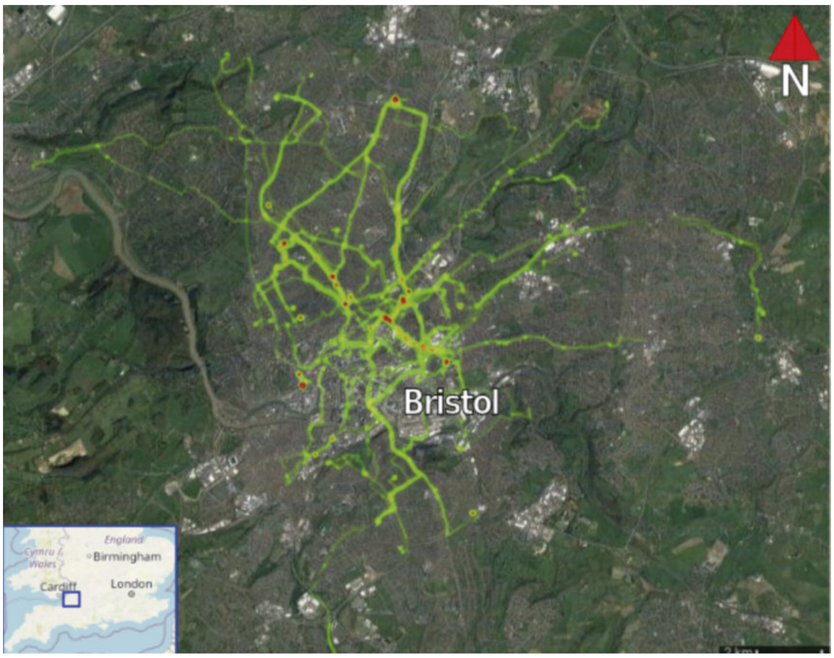

Figure 2: A heat map showing the GPS data recorded by the e-bike telematics system during

3,000 journeys recorded, the data also builds a picture of the popularity of different links within the City of Bristol road network, showing which sections e-bike users regularly avoid. Figure 2 shows a heatmap of such journeys recorded by the telematics system during June 2019. Data from the telematics system has already been shared with the local authority in the hope that it will support them in understanding which parts of the city would benefit most from improved cycle infrastructure.

In addition, the CAN bus data provides useful insights into how the e-bike is being ridden. Values that are recorded include the battery status, the amount of power going to the electric drive, the amount of torque being applied through the pedals, the pedal cadence and the speed of wheel rotation. Each of these values is recorded at a frequency of 20 Hz, providing extremely fine-grained quantitative visibility of many ride features, such as, an e-bike user's dependence on the e-bike electric assistance, and how this alters over time. This could help researchers understand the short- and long-term health implications of e-bike adoption.

This e-bike telematics system has already formed the basis of further funding applications for a number of studies, focusing on topics ranging from e-cargo-bike logistics to how e-bike usage can help avoid early mortality in the over 55s. We look forward to the utilisation of the technology continuing.

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Links:
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Tethys: An Edge Computing–Ready Water Metering System for Smart Cities

by Dimitrios Amaxilatis (SparkWorks Ltd.), Ioannis Chatzigiannakis (Sapienza University of Rome) and Simos Papadogeorgos (Power Made SA)

Water metering, a major challenge for most cities around the world, is achieved by collecting data from many thousands of water meters using either on-site visits or manual drive-by methods. The main obstacles to the digitisation of this process are the number of water meters and their operational lifetime requirements, making the use of technologies like 4/5G-based connectivity highly inefficient and inappropriate. Our work benefits from a hierarchical architecture setup using multiple layers and edge computing to increase the data collection rates, prolong the lifetime of the whole infrastructure, minimise the additional cost while increasing the benefits, and enabling the data-driven extraction of useful conclusions like consumption profiling or incident detection.

Smart water grids are an evolution of traditional water metering systems that refer to the introduction of continuous, on-demand, and bidirectional data streams between low-level water metering and flow monitoring devices, utility companies, and end-users. As with smart electrical grids, this modernisation improves the management of water reserves, risk management, and infrastructure monitoring offering benefits to both utility companies, end-users. Such information can also help reduce the losses of the system and the misuse of water resources, making the whole system environmentally friendly. High-fidelity real-time data can help utilities identify leaks, malfunctions, schedule maintenance or upgrade interventions, and promote a more sustainable operation.

The deployment of such an end-to-end data collection system is challenging. The volume of data generated from all the water meters can easily overwhelm traditional data collection systems or communication networks and even result in extremely high communication costs that can make the transition unprofitable. Novel approaches are needed to benefit from low power, low cost, and low maintenance communication technologies and systems, as well as cloud-enabled architectures that can scale regardless of the amount of data they receive.

SparkWorks Ltd is a nascent technology company delivering advanced hardware and software products in the areas of edge computing, Internet of Things, building automation, e-health, data analytics, and ambient intelligence. SparkWorks develops and offers Tethys [1, L1], a system that used novel alternative approaches to tackle all the problems presented above, including Edge Computing, to distribute the processing of water metering data in multiple layers of the system. Tethys follows a multi-level architecture combining multiple communication technologies like

Wireless-Mbus, LoRA, and 4/5G mobile networks to get the best connectivity on each level, balancing data throughput, operational cost, and device lifetime as best as possible. Figure 1 shows how our system is organised in three distinct layers, the End device layer, the Edge Computing layer, and the Cloud services layer, that communicate with each other, exchange data and control signals, and gradually process and extract all the available information from each packet received from every water meter, pressure meter and water valve in our system. The whole software stack can be deployed in minutes using Amazon Web Services (AWS) and can scale at any needed level, leveraging the cloud-ready solutions provided, including AWS Timestream, for data storage and querying, AWS Lambda for data processing, AWS IoT Core for management of all the IoT infrastructure and AWS API Gateway for exposing the collected data to client applications. Our edge nodes (called Mox and Tergo), as well as the Tethys Cloud Services, are powered by the AWS Greengrass [L2] runtime, allowing us to move components of our data processing and analytics pipeline from the cloud to the edge devices on-demand and based on the processing load of each device. All this happens on top of the basic data collection and processing.

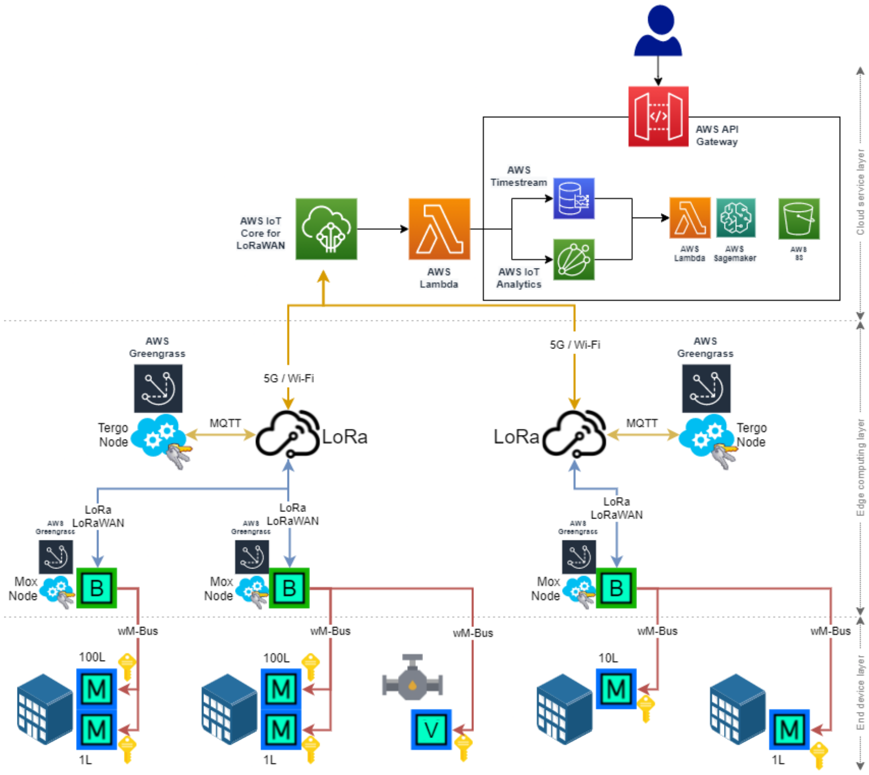

Figure 1: The Tethys system architecture and its layered operation where the end device layer contains all the smart water sensing and control equipment which can be off-the-shelf (i) water consumption meters, (ii) water pressure meters, or (iii) remote-controlled valves, the edge computing layer contains the (i) Mox and (ii) Tergo nodes that collect the data packets from the end devices and forward them to the cloud services that build the cloud services layer on the top of our stack.

Tethys is also capable of analysing the recorded water consumption data to identify patterns, behaviours and anomalies. These patterns can be used to easily identify leaks, burst pipes, or even inefficient water use by customers – behaviours that can be changed to improve their water consumption and environmental conscience. The components that provide this feedback to utilities and end-users were developed in conjunction with researchers from the University of Rome. “La Sapienza” University of Rome is Rome’s first university and among the oldest in Europe, founded in 1303. The Department of Computer, Control, and Management Engineering “Antonio Ruberti” (DIAG) has been recently recognised as one of the 180 departments of excellence in Italy.

Data security and data privacy play an important role in Tethys as they do in all remote metering applications. The system is capable of moving encryption keys to and from the edge layers, maintaining the privacy of the end-user data at all times.

Tethys has been deployed and operational, since 2019, in the campus of the Aristotle University of Thessaloniki, monitoring 24 buildings, two Tergo nodes, 28 Mox nodes, and more than 50 end devices, collecting data on variable intervals ranging from three minutes to one hour, based on the hardware of the end devices. The deployment of all the water metering infrastructure was performed by Power Made SA, including the configuration of the water meters and the interfacing of the existing water meters with IoT enabled smart water meters. Based on the data generated by the Tethys’ system deployment we were able to assess the effect of the COVID-19 pandemic on water consumption in each building and the behaviour of their users as presented in [2] and [3]. We were thus capable of identifying how certain buildings (focused on teaching and students) were left unused during the main lockdown periods while others (medical school and hospital buildings) kept operating almost as before, even with increased water consumption due to the increased hygiene measures employed.

Links:

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Circular Intelligence: Using a Smart Digital Platform to Encourage the Collection of Used Cooking Oil from Households

by Thanasis Gentimis, Theodore Chatzidimitriou and Antonis Kokossis (SymbioLabs)

A reward scheme operated through a digital platform is encouraging consumers to recycle used cooking oil in West Macedonia, Greece. Cooking oil bottles have personalised barcodes, which, upon return of the bottles, enable the user to collect points that can be redeemed on benefits and discounts in local businesses.

"Circular economy" is the economic model that aims to retain the highest value and utility of products, components and materials at all times, based on sharing, reusing, repairing and recycling. In practice, this means minimising waste and encouraging waste valorisation. Circularity can deliver substantial material savings throughout value chains and production processes, and can unlock economic opportunities while respecting the environment and the finite nature of natural resources.

Used cooking oil (UCO) is edible oil of vegetable or animal origin that has been used to cook food to the point at which the oil is no longer fit for that purpose. Two are the main sources of UCO: Commercial UCO from hotels, restaurants, and caterers (HORECA) and domestic UCO from households. Accurate estimates of global UCO production are unavailable because this data is not recorded, and estimating UCO production is very difficult. In Europe, recent estimates suggest that 1.66 Mt of UCO are available: 0.854 Mt from the household sector and 0.806 Mt from the commercial sector [1]. Commercial UCO has been actively collected in many European countries, initially to serve the needs of the animal feed market. In 2002 the introduction of regulations regarding the usage of animal by-products banned the use of UCO as animal feed in the EU. However, the rapid expansion in the biofuel industry, led to an increased demand for this feedstock.

UCO and other edible oils and fats originating from households are now mostly disposed of together with municipal waste or simply poured into drainage. These actions pose severe environmental risks. When UCO is poured down the drain, it hardens and infiltrates into local sewer, water and waste management facilities, which are not equipped to process fats, oils and grease (FOG). The environmental costs of improper oil disposal include:
- Sewer blockage from solidified FOG within pipes,
- Detrimental impacts on the health of area wildlife and their habitats,
- Overflow of unsanitary bacteria into water lines, soil and buildings,
- Fire hazards in households and infrastructure.

Figure 1: A smart digital platform for collecting used cooking oil from households in West Macedonia, Greece.

While the recycling of UCO has been required for food industry companies in most of Europe, such recycling on a household level is still not gaining traction, even though it represents a significant part of the overall production. This indicates that domestic UCO is a relatively untapped market, mainly due to the logistics involved in collecting small amounts of UCO from a very large number of households. Out of the estimated 854,000 tons of domestic UCO produced in Europe, only about 48,000 tons are collected (5.6%), with collection being quite fragmented. [2]

The success of UCO collection initiatives strongly depends on the participation of individuals, and the most important issue is probably to motivate citizens to recycle their used oil instead of simply disposing it with other municipal solid waste or down the kitchen sink. On the other hand, the major technical challenge of recycling household UCO is its collection, owing mainly to the high logistics costs of such a process. Efforts for household UCO recycling are associated with high CAPEX (special collection bins) and OPEX (logistics).

Such operations can be profitable, but only if there is sufficient UCO recycled – which means sufficient citizens participating. The key success factors for a sustainable system have been recorded, and the most crucial are:
- motivation of citizens through a "citizen-friendly" UCO disposal scheme,

- a focus on public awareness with regular, targeted communication activities,
- support from local administrations, waste management companies and other stakeholders.

Reward schemes have been implemented in European cities to increase citizen participation in better waste management practices. This approach has proven to be very efficient, as rewards can motivate citizens to be more proactive and diligent in recycling. In this respect, SymbioLabs [L1] has partnered with Diadyma S.A. [L2] to apply best practices and introduce a reward scheme designed specifically to facilitate the collection of UCO from households.

SymbioLabs developed a digital platform to manage the collection of household UCO with a two-fold aim: (i) to improve the monitoring of recycling rates in specific municipalities, and (ii) to reward citizens who participate in proportion to their contribution of UCO. Diadyma, the official body of waste management for the Region of Waste Macedonia, consisting of 13 municipalities, will deploy the reward scheme using the digital platform, with the aim of it being adopted by 10,000 households in the region.

The platform is simple to use. When they register, users receive personalised barcodes that must be applied to the bottle before depositing it in one of the specific UCO collection bins. When the bottles are collected by Diadyma for further processing and valorisation, the operator scans the barcode and then reward points are assigned to each user depending on the quantity of UCO in the bottle. The more the collected UCO is, the more points are assigned. The digital platform is fully interoperable with other initiatives of Diadyma, such as promoting reuse and repair. As a result, citizens can combine points earned from recycling UCO with points earned from participating in reuse activities then redeem them on benefits or discounts in local businesses or for entertainment (for example, theatre, cinema or concert tickets).

Links:
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Seamless Distributed Traffic Monitoring for Smart Cities Using Fibre Optic Acoustic Sensing

by Martin Litzenberger, Carmina Coronel and Christoph Wiesmeyr (AIT Austrian Institute of Technology GmbH)

Real-time traffic situation monitoring is key to optimising traffic flow using intelligent traffic systems (ITS), especially in the urban environment. Often, the high density of traffic sensors needed to achieve a seamless real-time monitoring of important arterial roads is difficult to implement due to technical constraints or installation costs. Fibre optic acoustic sensing (FOAS) is a relatively new technology that allows a seamless, real-time monitoring of road traffic over distances of up to 50 km, using the existing telecom fibre-optic cable infrastructure.

Roads have always been the backbone of transportation in the urban environment, and continual traffic monitoring is crucial to ensure continuous traffic flow. The data provided by real-time road traffic monitoring can potentially provide information about traffic jams and accidents. This information can help traffic management centres to react quickly to incidents, and intelligent transportation system (ITS) measures, such as the closure of a lane or temporary usage of the hard shoulder, can automatically be implemented.

Different technologies are currently used for traffic monitoring systems where sensors are either installed overhead, under, or next to the road to monitor traffic flow [1]. Such sensors could be laser scanners, infrared, radar, ultrasonic, magnetic, acoustic or video cameras. Another method for traffic monitoring is through crowd-sourcing of smartphone connection data or from fleets of vehicles equipped with GPS systems ("floating car") [2]. Sensors installed under the road surface come with the disadvantage of the high costs of ongoing repairs and maintenance while sensors placed overhead or next to the road, such as cameras, are susceptible to adverse weather conditions.

FOAS is a technology that allows a seamless, real-time monitoring of traffic over distances of up to 50 km without additional roadside installations [3]. It uses fibre-optic cables that are already installed in the ground next to the roads for data- and communication-networks (telephone, internet), as a distributed detector. The advantage is that the fibre-optic cable infrastructure typically installed at high density in the urban environment can be used, as it is, for traffic sensing by connecting an optical "interrogator" instrument to one end of an unused fibre. The technique allows the detection of very small changes in the optical fibre, such as the mechanical strain caused by microscopic deformations from vibrations of the cars running nearby.

FOAS systems work by sending short laser pulses through a fibre-optic cable

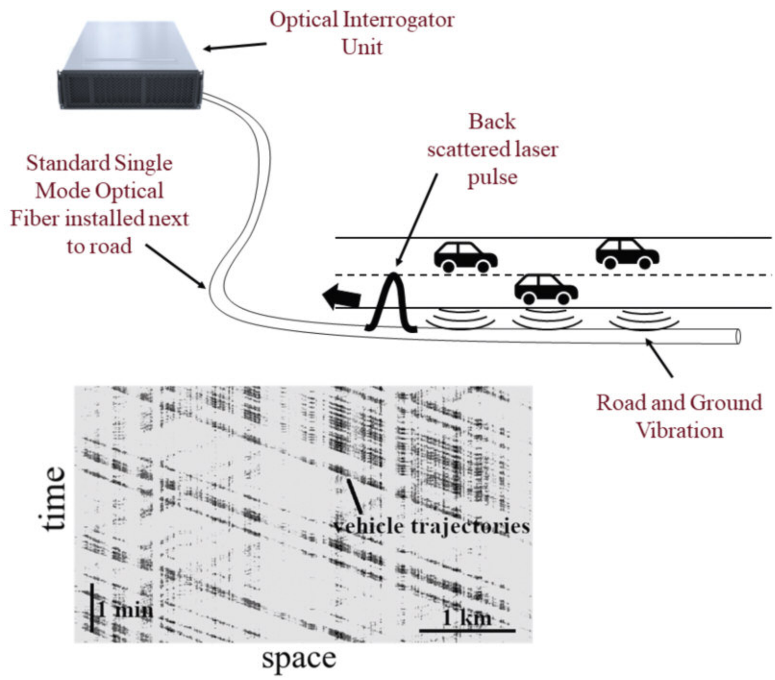

Figure 1: Top: Principle of the FOAS measurement for traffic situation monitoring. Bottom: Typical dataset of an FOAS spectral power diagram after thresholding showing recorded vehicle trajectories over 5 minutes and 4.8 km distance.

where the light is scattered via Rayleigh scattering and the light returning to the source is analysed. In FOAS systems, optical fibres of up to 50 kilometres in length can be used. An interrogator device connected to one end of the fibre transmits a series of laser light pulses into the optical fibre, as shown in the top of Figure 1.

In the glass of the optical fibre, an effect occurs that causes a continuous “reflection” of the light along the fibre. Rayleigh scattering is caused by inhomogeneities in the glass and is actually a different mechanism than reflection, but for the sake of simplicity the Rayleigh scattering effect can be described as light being reflected on a myriad of microscopic mirrors embedded in the glass. Therefore, for a single laser pulse being coupled into the fibre, instead of many distinct reflected pulses, a continuously distributed signal is returned from the fibre. The scattered light has the same frequency as the impinging light wave and can be analysed by optical means. The vibrations generated by the passing cars and trucks stretch and compress the optical fibre, affecting its optical path length. This induces a measurable phase shift in the back-scattered light, which is sensed by interferometric methods. Probing the fibre with a laser pulse of high repetition frequency (2 kHz) makes it possible to analyse the vibration spectrum produced by nearby vehicles, distinguishing them from other vibration sources and tracking their time-location trajectories along the cable.

We have recorded FOAS data for traffic flow over two days from a road section of 20.4 km in length, with the fibre-optic cable being installed next to a highway in the urban region of Graz, Austria. After thresholding of the spectral power diagram of the raw FOAS signal we obtain an “image” representation of the vehicle tracks as a time-location diagram, in which the vehicles running on the road can been identified. Figure 1 (bottom) depicts an example of the time-location diagram for five minutes duration and a road section of 4.8 km length, recorded at 2.4 km distance from the interrogator device. Driving direction and vehicle speed are represented by the inclination of the tracks in the diagram. The vehicles driving on the carriageway closer to the optical fibre cable are well represented in the data, while the vehicles driving on the other carriageway, in the opposite direction, cannot be resolved as well. A real-time estimation of the traffic situation by automatically detecting the speed changes from the trajectory pattern seems feasible, at least for the closer lanes. Traffic density can be derived as well, from the line density in the diagram. The project “Roadwise” funded in the EUROSTARS framework of the European Union, is currently investigating such methods for automatic, real-time and seamless detection of the traffic situation from FOAS data.

Given that FOAS systems only require the installation of an interrogator device connected to one end of an existing fibre-optic cable, the presented solution requires low-cost roadside maintenance and installation. An additional advantage of a FOAS-based traffic situation monitoring system is its long-range capabilities and seamless nature of the measurement.

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Forging the Future of Responsive Cities Through Local Digital Twins

by Susie Ruston McAleer, Mark McAleer and Pavel Kogut (21c Consultancy Ltd)

Visualise a world in which people can rapidly and intelligently collaborate and respond to societal challenges and unlock innovation for future service needs as easily as visiting Google Maps. A world where the urban experience becomes easily understandable at the touch of a button, breaking down service silos and enabling evidence-based decisions and behaviour changes to be made collaboratively and effectively. This vision is fast becoming a reality thanks to an emerging local digital twin market, with European innovative initiatives such as Digital Urban European Twins (DUET) [L1] and COMPAIR [L2] leading the way.

Digital twins for smarter, sustainable cities

We are in the midst of a 4th revolution, the digital revolution, with new technologies changing how we live, work and spend our leisure time. Accessing government services should be no exception, but until recently the public sector struggled to keep up with the pace of change. The impact of COVID-19, however, forced many cities to reassess their operations and recognise that the adoption of new technologies and data to deliver "smarter" approaches to delivering city services is no longer a luxury but a necessity. Using integrated digital approaches to manage city operations and support evidence-based decision making, not only enables services to be delivered remotely, but can improve existing ways of doing things. As a result of the unprecedented crisis, the newly emerging concept of cloud-based, AI-enabled, local digital twins (term coined by DG Connect, 2020) has been thrown under the world's spotlight.

Figure 1: Preview of DUET 3D digital twin interface on a laptop.

Local digital twins are virtual city replicas that make it easier for anyone to visually understand the complex real-time interrelation between different urban factors such as traffic, noise and environment. In the case of European innovation project DUET, powerful analytics embedded within the digital twins integrate data silos and model the expected impacts of potential decisions across city systems, such as the knock-on effects of road closures, new housing estates, and location of transport hubs, on roads, public transport, air quality and health. The evidence-based simulations support both city managers and policy makers in working together around common scenarios to make better, cross-domain, operational decisions and longer-term policy choices whilst enhancing transparency, citizen involvement and resource optimisation [1].

Led by Digital Vlaanderen, the IT company for Flanders, Belgium, DUET is building a 3D regional digital twin (see Figure 1) to help predict and understand the impacts of regional mobility so policy can be implemented in a way that minimises stress on both the environment and human health. A second pilot by the City of Pilsen, Czech Republic, is using its 3D digital twin for urban planning to model and assess the predicted impact of new buildings on the local area. Improving citizen engagement in public decision making is the focus of the final pilot in the city of Athens, Greece. The digital twins plan to go live to the public this Autumn (2021).

The shift from digitise to humanise

While great technological strides have been made in local digital twin development in the last two years, thanks to the pioneering work of DUET and other local initiatives, further societal value is still to be unlocked. As Birks, Heppenstall and Malleson [2] argue in their recent paper Towards the development of Societal Twins (2020) many of the current systems focus on infrastructure and not "the representations of the individual people whose actions ultimately drive the evolution of the cities they inhabit".

Pushing the state of the art in digital transformation, Digital Vlaanderen is launching a new research project in November 2021 called COMPAIR, which places citizens not just at the centre of service delivery using digital twins but empowers them as the central protagonists in identifying and solving local air-quality problems. Introducing the concept of "citizen science" COMPAIR aims to bring social and emotional intelligence into the decision-making process. Helping policy makers to develop skills for engaging and involving citizens from all echelons of society in decision making, especially hard-to-reach citizens from lower socioeconomic status, helps to remove biases from traditional consultation methods. Participants in COMPAIR will not just be able to use DUET digital twin interfaces to view and understand urban data but they will also be able to identify the issues that affect them and their communities, collect data themselves using sensors, and be able to upload anonymised personal information such as emotions (e.g., how a space/location makes them feel, heart rate information etc). Populated with more nuanced spatio-temporal data the local digital twins can then provide a more accurate representation of the city experience for data-driven decision making and can become a true force multiplier for co-creating societal good. Cities won't just be smart, they will be citizen driven and automatically responsive to societal needs.

In conclusion

With the right data, current digital twins can model and simulate whole urban systems in ways that were unimaginable only a few years ago. This new technology has the potential to become the central linchpin for administrations to efficiently leverage all its locally generated data and new technology to effectively meet public sector missions. However, to truly be a game changer and enter a new era of not just smarter, but "responsive" cities, long-term success is dependent on supplementing physical information with social and emotional data which enables local digital twins to better support the co-creation of meaningful, intelligent, data-driven urban experiences for all.

Links:
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Recovering Non-Conventional Water Sources in the Mediterranean: The HYDROUSA Project Experience

by Simos Malamis, Stavroula Kappa, Eleni Nyktari and Constantinos Noutsopoulos (National Technical University of Athens)

The work of the HYDROUSA project is revolutionising the water value chains in the Mediterranean region. We use innovative nature-based solutions to utilise disregarded forms of water to combat water scarcity and to support tourism and agricultural activities.

Global environmental change is closely linked to the water crisis. Undoubtedly, climate change is amplifying water cycle fluctuations, increasing the probability of extreme weather-related events, reducing the predictability of available water resources, reducing global biodiversity and threatening one of the fundamental human rights: the right to safe drinking water and sanitation [1-2]. The Mediterranean region is considered to be one of the world's hot-spots in terms of water scarcity; it is characterised by irregular allocation between water demand and water supply, both spatially and temporally. Agriculture is the largest consumer of water in the region (> 72% of total consumption), while other sectors, such as the tourism industry, exert additional seasonal pressure and significantly decrease the available water resources [3]. In order to balance this increased demand, desalination plants have been established, which increase energy consumption locally, while the resulting brine by-product is not valorised and is released untreated into marine ecosystems. The gradual implementation of the Water Framework Directive and the Urban Waste Water Treatment Directive have improved water/wastewater management, resulting in the development of some infrastructure. However, several Mediterranean areas still discharge inadequately treated wastewater into the sea. Consequently, the region faces significant issues in terms of water resources and biodiversity management.

To address these challenges, an EU Horizon2020 Innovation Action project (call topic CIRC-02-2016-2017 - Water in the context of the circular economy) HYDROUSA was launched in July 2018 to reimagine a water resilient economy, mitigate climate change and reform the agro-food system. Its consortium consists of 28 highly competent organisations involved in water/wastewater management, agricultural activities, ICT and business/marketing, dissemination/communication spanning throughout the whole water supply chain, consisting of universities, research institutes, SMEs, NGOs, municipalities and water utilities.

The main objective of HYDROUSA is to set up, demonstrate and optimise on-site, innovative nature based solutions (NBS) for the management of a variety of water streams, including wastewater, rainwater, groundwater, atmospheric vapour water and seawater to produce valuable resources (energy and nutrients) and high quality water, which can then be used to enrich the domestic water supply and valorised to increase agricultural production and boost the economic activities of water-scarce Mediterranean areas. HYDROUSA aims at closing all water loops at local level, taking advantage of local resources, promoting the concept of decentralised on-site water, materials and energy conservation, treatment and reuse (Figure 1).

HYDROUSA implements a number of innovations related to technology and

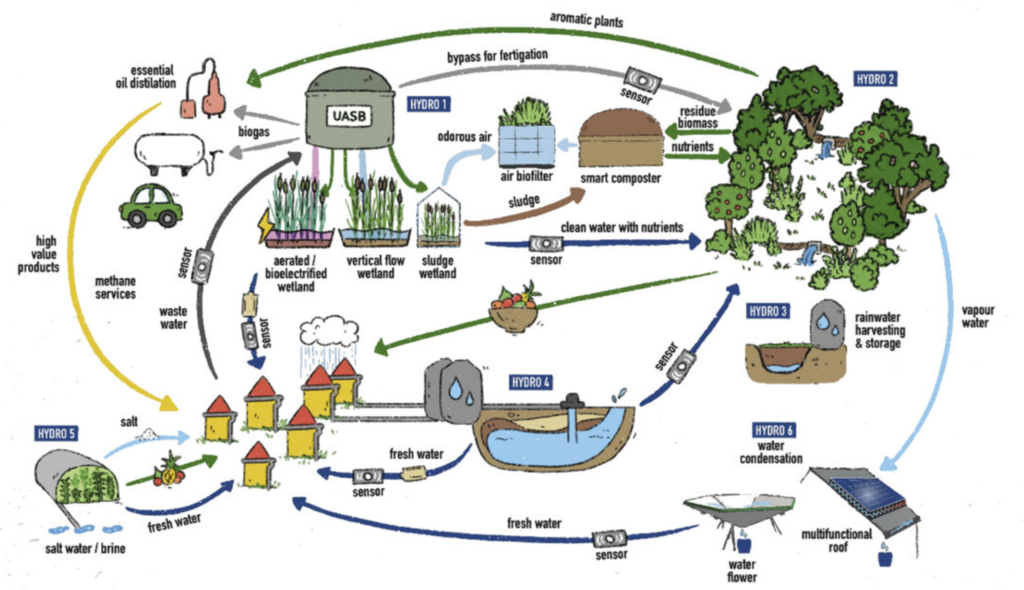

Figure 1: HYDROUSA water loops implemented in the Mediterranean.

services. Innovative NBS that are characterised by low energy and carbon footprint are demonstrated at full scale in three Greek islands (Tinos, Mykonos and Lesbos). In addition, HYDROUSA solutions are assessed in 25 early adopter cases in other Mediterranean coastal areas and islands and at several water-stressed rural and peri-urban non-Mediterranean areas. The innovations of HYDROUSA project include the:

- demonstration of biHYDROUSA receives funding from the
European Union`s Horizon 2020
research and innovation program under
the Grant agreement No. 776643.odiverse constructed wetlands (CWs) to treat wastewater and produce reclaimed water. HYDROUSA´s CWs are richer in biodiversity resulting in more resilient ecosystems. Furthermore, pilot scale electroactive constructed wetlands are demonstrated to produce energy from sewage, resulting in much lower footprint requirements
- integration of grey with green infrastructure (anaerobic treatment by upflow anaerobic sludge blanket coupled to vertical flow constructed wetlands) to treat wastewater and produce reclaimed water that is safe to reuse and rich in nutrients to be valorised for plant growth. Energy is produced from wastewater through the anaerobic treatment of sewage
- demonstration of sludge treatment wetlands coupled with composting to treat anaerobic sludge and produce high added value compost
- rainwater/stormwater harvesting, storage into the aquifer to produce service water and agricultural irrigation water
- the use of advanced techniques to monitor water quality and quantity. A low-cost water monitoring system has been developed and applied, which measures and records water quality, water quantity and meteorological data, integrating water treatment with agriculture
- development of an agroforestry system: HYDROUSA has developed a biodiverse agroforestry system, based on the output of the local community, which is fertigated/irrigated with reclaimed water obtained from the treatment of sewage. It consists of trees and shrubs as superfood providers, and several local varieties of vegetable crops and aromatic plants as added value products
- innovative and low-cost seawater desalination: The biomimicry Mangrove Still system has been developed to recover freshwater from seawater via a process of evaporation and condensation run by sunlight
- defining new circular economy financing models: In HYDROUSA, different business cases for each technology will be identified to build innovative business models that map costs, resulting in economic, social, human and natural benefits.

HYDROUSA has developed "a community of water allies". Members of the local community (farmers, water utilities, etc.) along with researchers and other stakeholders have a dominant role in the project as they are transformed in key actors, co-developers and evaluators of water solutions and services. This is being accomplished through the implementation of various participatory methodologies, such as co-creation and citizens' science activities. A successful case that has already been implemented is the design of the low-cost water monitoring systems of HYDROSUA project, which was based on the specification and requirements of the local users through the conduction of co-creation workshops and one-to-one interviews.

HYDROUSA receives funding from the European Union`s Horizon 2020 research and innovation program under Grant Agreement No. 776643.

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Vigilantes del Aire – Measuring Air Quality in Spain

by Daniel Bruno, Miguel Sevilla-Callejo, Enrique Navarro (Pyrenean Institute of Ecology) and Francisco Sanz (Ibercivis Foundation)

Did you know that we could use plants as sensors to monitor the air quality and pollution in our cities? The Ibercivis Foundation together with the Pyrenean Institute of Ecology has developed the "Vigilantes del Aire" project to measure air quality in Spain. Using citizen science, samples from 205 municipalities in 26 Spanish provinces were successfully obtained and processed.

Human activities are responsible for the emission of many toxic substances into the atmosphere, including a wide variety of heavy metals. The pollution measuring stations that are spread throughout our cities are capable of measuring particulate matter (PM) and the main pollutants continuously and accurately. However, the high cost of these infrastructures means that there are only a few per city, which limits the spatial representativeness of the data. According to scientific literature, the magnetic properties of strawberry leaves are related to the concentration of particulate matter (PM) in the air below 10 microns, especially PM10, PM2.5 and PM0.1, which allows their use as an indicator of air quality and the presence of pollutants, especially metals.

In recent years, citizen science has established itself as a collaborative and open tool, with great potential to increase the spatial, temporal and social scope of many scientific projects. New technologies facilitate societal collaboration from the local to the global scale, which is particularly important for environmental projects, such as monitoring air and water quality in the context of global change. One of the great benefits of citizen science is the ability to source quality environmental data from virtually any location on the planet. In this way, a large amount of environmental data can be obtained, and remote locations can be monitored that would otherwise have been unfeasible due to cost, logistics and socio-economic factors.

Citizen science allows social factors to be considered in its experimental design, so it can also be an inclusion tool for disadvantaged groups or those who experience gender, economic or educational biases. With this in mind, the Ibercivis Foundation [L1] together with the Pyrenean Institute of Ecology [L2] developed the Air Watchers projects [L3] - Vigilantes del Aire - to measure the air quality in Spain.

The methodology

Through the Ibercivis Foundation, 5,790 organic strawberry (Fragaria vesca L.) plants were distributed to citizen scientists in different urban and rural areas between late September and early November 2020. The geographical distribution was designed to cover population centres of different sizes representative of both urban and rural areas at a national level, reaching a wide spatial coverage that includes large cities and towns (Madrid, Barcelona, Valencia, Zaragoza, Erandio district in Bilbao), to medium and small cities (Vitoria, Granada, Castellón, Algeciras, Burgos, Girona, Pontevedra, Torrelavega). With regard to smaller towns, the aim was to cover a population gradient from large (Villanueva de la Serena, Tuy, Atarfe, A Estrada) through to small towns (Belorado, Báguena, Luna, Erla, El Poyo del Cid) and even villages (Luco de Jiloca, Las Pedrosas).

With the help of the regional ambassadors of the project, each of the citizen scientists was responsible for installing the plant outside his or her home as well as for the care of his or her plant and sending the leaves after more than two months of exposure to the environment (between the end of September 2020 and the end of January 2021, depending on the date of installation of the plant in the house) by filling in a form characterising its location (site, type of exterior, height, number of days exposed, degree of environmental protection, etc.) for subsequent analysis and mapping. The samples of strawberry leaves were received in pre-franked envelopes from the citizen scientists of the different geographical areas, grown under controlled condi-

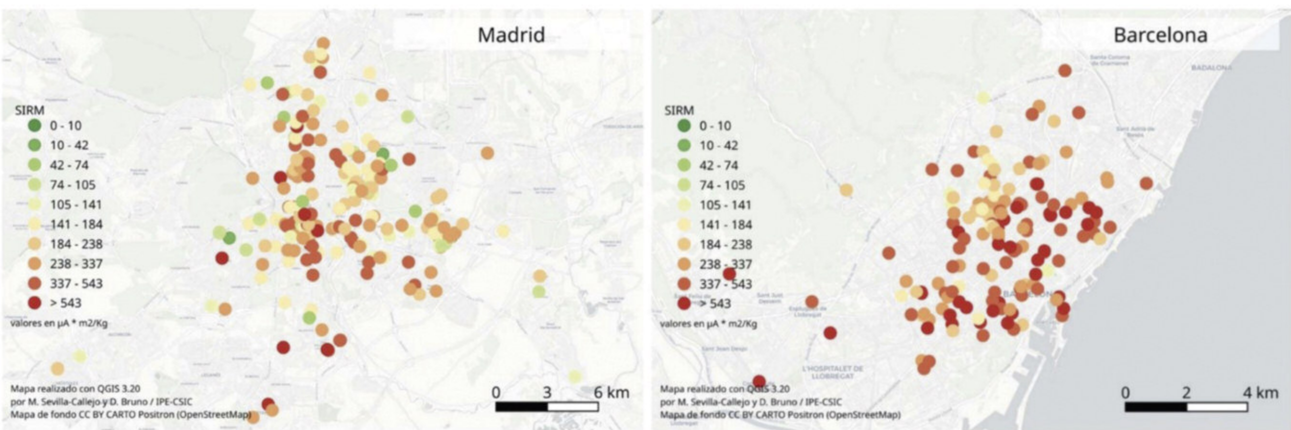

Figure 1: Strawberry leaves SIRM results, Madrid and Barcelona metropolitan areas.

Figure 2: Clockwise from upper left: a) Highly sensitive 2G 755 superconducting magnetometer (10-12 A m2) with alternating field demagnetiser system, used for SIRM analysis, b) Distributing strawberry pots in Zaragoza, c) Distributing strawberry pots in a retirement home, d) Distributing strawberry pots La Puebla de Fantova (Aragón-Pyrenees).

tions in greenhouses at the facilities of the Pyrenean Institute of Ecology (IPECSIC).

The SIRM (Saturation Isothermal Remanent Magnetization) technique was used to analyse the strawberry leaves. This technique measures the remanent or residual magnetisation remaining after an intense magnetic field has been applied to a material; a variable related to PM10, PM2.5 and PM0.1, as well as to several metals (especially Zn, Cd, Pb and Cr) present in the leaf after exposure to the urban environment [1].

Participation and results

A total of 2,755 samples were received from 205 municipalities in 26 Spanish provinces, which means that Airwatch 2020 has operated in more than half of the Spanish territory. This represents a plant return rate of 47.8%, a figure that can be considered successful in this type of citizen science project. Moreover, participation was higher than that obtained in the pilot project carried out in the city of Zaragoza in 2017 where 30% of the samples were recovered (300 of the 1,000 pots distributed).

As expected, pollution levels follow a decreasing gradient from cities with higher population, traffic and polluting industrial activities in their periphery to sparsely populated towns and rural areas with little traffic, with natural, semi-natural or extensive land uses. Monitoring with biosensors (burrs) combined with environmental magnetism analysis in a citizen science framework seems to be a very useful and affordable tool for air quality monitoring, both economically and logistically, while increasing the knowledge and training of the participating citizens, establishing interesting synergies between citizenship, environmental monitoring and science. There is a complete analysis [2] available for download.

We would like to thank not only the Spanish Foundation for Science and Technology-Ministry of Science and Innovation, the founder of this project, but also all citizen scientists who selflessly and passionately contributed to increase our knowledge of air quality in Spain. Special mention should be made of regional ambassadors and local coordinators in each site, as well as their respective teams, without whom we would not have had the opportunity to reach so many corners of Spain.

Links:
[L1] https://ibercivis.es
[L2] http://www.ipe.csic.es/
[L3] https://vigilantesdelaire.ibercivis.es

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A Holistic and Scalable Solution for Research, Innovation and Education During the Energy Transition

by Helen C. Leligou (University of West Attica)

The energy transition challenges the education and training of students, technical /energy professionals, service designers and marketers, and citizens throughout the EU. The project ASSET has developed a set of tools that address this challenge and are evaluated by end users.

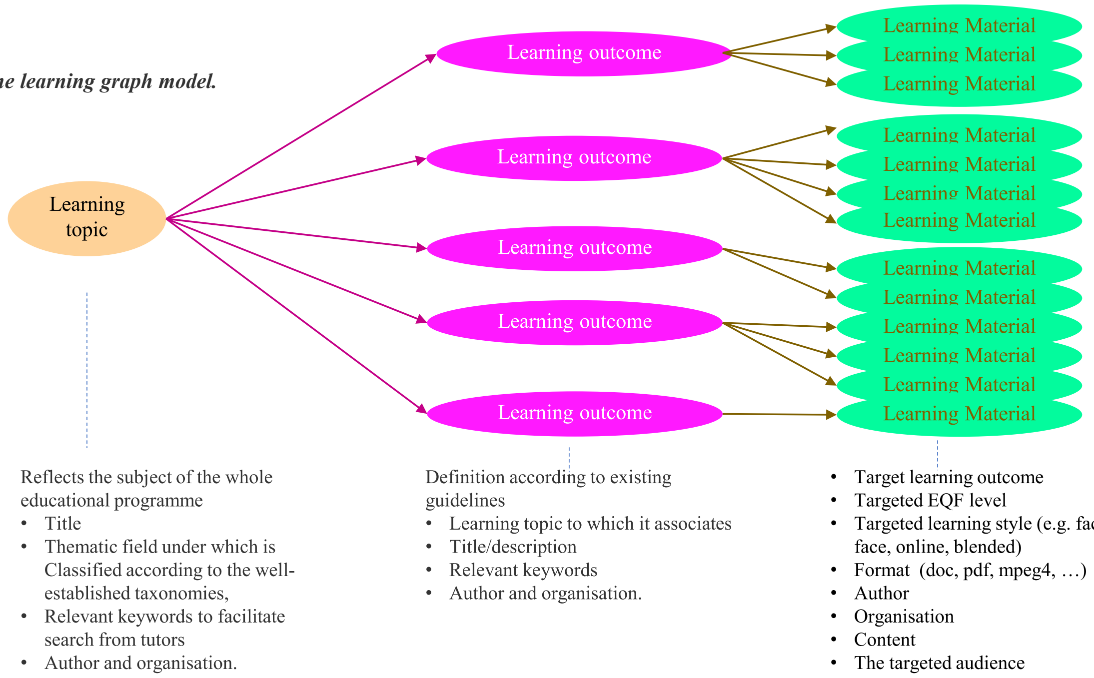
ASSET (A holistic and scalable solution for research, innovation, and education in energy transition) was an H2020 project that focused on boosting research, innovation and educational capacities for the energy transition [L1]. The energy transition is tightly bound to the smart city concept: the transition to renewable energy requires the wide deployment of smart cyber-systems that capture the city's characteristics in terms of the technical infrastructure, citizens' activities and the climate. The ASSET project aimed to address the challenges of: (i) improving the efficiency of education and training because the energy transition mandates the education/training and upskilling of many people of diverse technical, business, cultural and societal backgrounds; (ii) cultivating the interdisciplinary competencies necessary for the design, development and consumption of smart energy services; and (iii) uniting industry and the academia to help realise the energy transition.

ASSET broke down its aims into two tangible goals: (i) To create a sustainable and scalable ecosystem (community) that included all energy transition and education stakeholders: companies from the energy sector, universities and training actors, public authorities and policy makers, and society; (ii) To deliver the framework and means for the continuous collaborative definition of the knowledge/competencies/skills required for the energy transition and for continuous resource pooling to efficiently educate or train large numbers of people in diverse and interdisciplinary topics and for carrying out research and innovation activities.

During the project we brought together a community comprising the main energy transition actors, and developed a conceptual framework accompanied by the ASSET digital platform to speed up the creation of (single or multi-disciplinary) learning programmes. We delivered more than 25 training programmes, all of which were thoroughly evaluated through pilot studies, and are still accessible through the project website. In addition, as part of the project we promoted interdisciplinary approaches in research, education and innovation by strengthening collaboration between academia and the industry.

One of the most important exploitable results delivered by the project was the learning graph tool which assists trainers and professors in designing learning programmes in a structured manner, adopting the learning graph model [1] and also facilitates sharing of learning materials as these are described in the platform in a way that accelerates search. The model is shown in the following figure which also shows the information kept per graph element. Namely, the learning materials are associated with the targeted learning outcome, the learning style (blended, face-to-face, asynchronous) and the corresponding EQF (European Qualification

Figure 1: The learning graph model.



Framework) levels. This tool was assessed by external experts and was found to accelerate the learning programme design by more than 25%, which significantly contributes to delivering knowledge to larger audiences faster [1].

Another valuable tool resulting from the project was the ASSET Marketplace, which enables matchmaking between industry and academic training actors. The Marketplace has two main functionalities: (i) Offer – where educational programme providers announce their offerings in the ASSET marketplace, and companies can find educational programmes that match their needs; (ii) Demand - Companies that do not find the educational programmes they are looking for can insert a request on the platform ("open request") and educational programme providers can respond with a specific offer.

Other interesting results include the assessment of education/training programme delivery: we offered several programmes in multiple delivery forms (face to face, Massive Open Online Course- MOOC and blended form) and their evaluation by users (trainees) is reported in [1] and [L2]. We also assessed the satisfaction and interest of the users (students) from the completion of interdisciplinary courses. The results showed that the students considered the non-technical topics to be very useful. Additionally, we delivered MOOCs for citizens, which were also very positively received and are still open in the EMMA platform [L3]. Last, but not least, the project investigated societal issues relevant to the energy transition. The results, which are detailed in [L4], report the level of understanding of the energy transition and its impact on everyday life of European citizens and stakeholders.

The two-year project, which was coordinated by ATOS Spain, ended in April 2021 [L1]. The consortium included well-known European Universities and training providers (Aalborg University, OTE Academy, RWTH University of Aachen, University of Naples Federico II, University of Valencia, University of West Attica), an association of energy companies (European Association for Storage of Energy), an organisation focusing on skill gap detection (Logical Soft) and two energy communities (ECOPOWER and ENOSTRA).

Links:
[L1] https://energytransition.academy/
[L2] https://kwz.me/h7G
[L3] https://platform.europeanmoocs.eu/
[L4] https://kwz.me/h7I

Reference:

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How Small Initiatives Create Smart City Dynamics: The ICC Experience of Patras

by Petros Ganos, Athanasios Kalogeras, Tanya Politi and Lena Tsipouri

Owing to limited human and financial resources, some medium-sized cities, particularly those that are less technologically advanced and with poor administration, risk falling behind their more advanced metropolitan counterparts in the transition into smart cities. A systematised approach is needed to help such cities catch up. The EU ICC initiative helped a group of leading thinkers of the city of Patras to organise a roadmap, consult, design and adopt individual projects, sowing the seeds for a later systematic digital transformation.

As cities face unprecedented challenges, clear policies and investments are needed to achieve climate neutrality and resilience in alignment with European Union policy priorities and initiatives [1]. The Intelligent Cities Challenge (ICC) is an initiative that supports 136 cities in using cutting-edge technologies to lead an intelligent, green, and socially responsible recovery [L1].

Patras, a medium-sized city in South-Western Greece with limited resources due to both the financial crisis and the rigid national regulation for municipalities, benefitted from the interaction and support provided by the predecessor of the ICC. Patras's involvement in the initiative led to the formation of an encompassing Steering Committee and the creation of an open platform project repository [L2] ensuring transparency and potential synergies. This has allowed the creation of a common city-wide vision and an agreed roadmap that promotes intra-city cooperation but also proves that the selected projects are mature, widespread, and merit being funded by the regional and national authorities. The major lesson learned is that even in difficult situations a small number of volunteers can make a difference if an appropriate frame is offered. The four most recent endeavours in this context are illustrated in the following.

Interoperability centre of the municipality of Patras

At the municipality level there exist independent digital systems and applications in different formats that focus on the minimum strategy for exporting and interpretation of results and correlation with each other to generate new data. The solution is the creation of an interoperability centre for integration, control and monitoring of smart infrastructure and services of the municipality of Patras. It should function as a single dashboard for monitoring applications' performance by interconnecting the different subsystems and providing a supervisory management and decision support tool (Figure 1).

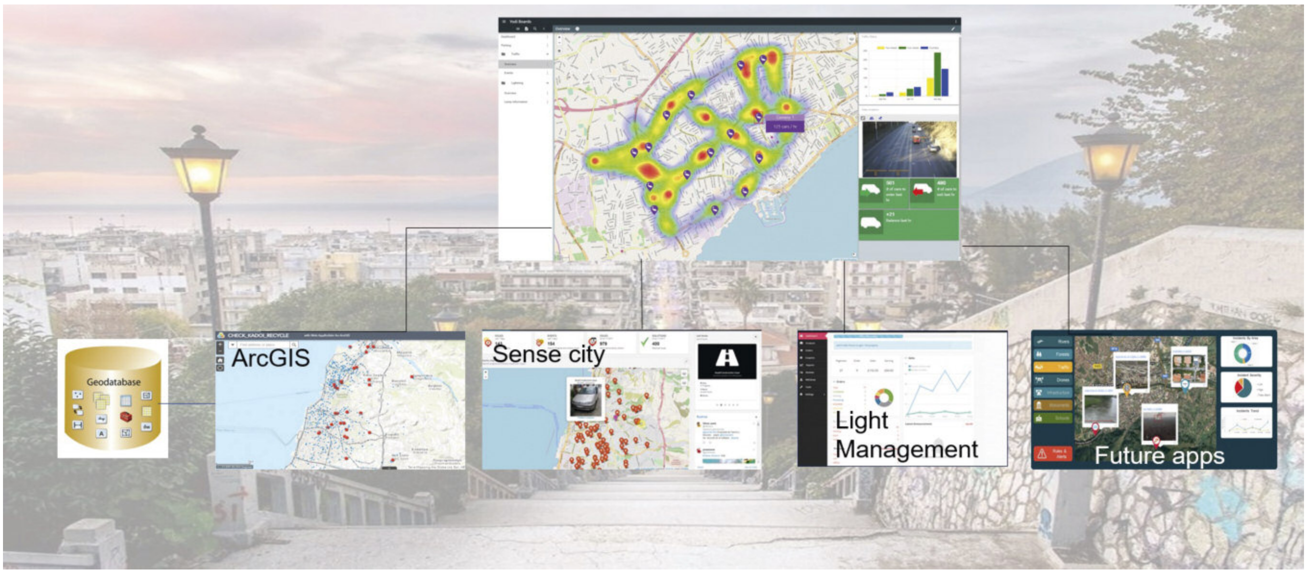

Figure 1: Interoperability centre of the City of Patras.

Integration of systems with the appropriate radial structure reduces the total management cost without falling behind in terms of efficiency. The motivation of interoperability beyond digitalisation and smart applications is mainly the strengthening of decisions at a local level, the improved reliability and the possibilities of flexibility in the adoption of technology with a positive impact on the daily life of citizens.

Open data platform of the municipality of Patras

The City of Patras comprises a rich digital ecosystem with many researchers and entrepreneurs being very active in the area of data acquisition, data transmission and analysis in different application areas. Through ICC, the City of Patras attempts to consolidate these disperse activities and create a momentum through integrating and providing access to this data while facilitating innovation capacity building for all interested parties. In this respect, one of the specific solutions is an open data platform, which will integrate existing platforms with existing data, accelerate access to newly created sets and enhance usability and visualisation of data as well as the creation of innovative applications. A team of experts has already been assembled to describe functional and non-functional requirements, while the roadmap with emphasis to sustainability has been set.

Upskilling–reskilling

The vision of Patras to become a smart digital city mandates digital upskilling and reskilling of the entire quadruple helix ecosystem, so that it can participate in the digital transformation and exploit new opportunities. To this end, a target under ICC is the establishment of an upskilling–reskilling academy that will diffuse the technological assets of the region, including academic expertise and experimentation over existing digital infrastructure deployments, enhancing overall digital operational maturity. Appropriate curricula will be established capitalising on existing training and capacity building services of the academic world as well as business and business representative organisations in the area. The resulting skills framework will offer vertical learning paths related to areas such as artificial intelligence and cybersecurity, while engaging in horizontal skills training in such fields as digitalisation, green procurement, circularity, and a green deal.

Circularity in the urban area of Patras

The Municipality of Patras has set a local waste management plan (LWMP) with the main aim of enhancing recycling at its origin. The main objectives of the LWMP are: increasing reuse and recycling, reducing disposal of waste to the landfill, reducing transport and waste management costs, utilising smart applications and raising public awareness. One of its priorities is the creation of a "green point network" that contributes significantly to solving the present problem of the ineffective collection of specific recyclable materials. In particular, it will increase the reuse and recycling of certain categories of waste, such as metal, plastic, paper, glass, fabric, wood and packaging waste, resulting in lower volumes of waste ending up in landfill. The ubiquity of digital infrastructures and extended deployments of smart devices and Internet of Things can be an enabler for smart applications and active citizen participation, helping to "break the silos" among application domains and enhance circularity. The main outcome is the monitoring of the waste collection system and increased public awareness of waste management through collection of separate streams of recyclable materials.

Links:
[L1] https://kwz.me/h7z/
[L2] PSCR (isi.gr)

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Digital Cities, Digital Tourism, Digital Arts – A Research Agenda

by Christian Thomay and Markus Tauber (Research Studios Austria FG), Christoph Schmittner (Austrian Institute of Technology GmbH) and Beatriz Tadeo Fuica (IRCAV, Sorbonne-Nouvelle University)

Increasingly, digital cities are investing in digital tourism, which has benefited from advances in digital arts. Digitisation projects can widen both the scope and accessibility of cultural heritage content and allow for interactions in a more sustainable, environmentally respectful fashion. Recent advances in digitalisation have opened the door to a range of new research directions.

Digitisation is marching steadily onwards, enhancing our lives with opportunities for new experiences and ways to connect. As the devices in our pockets become smarter, so too do our cities, with an increasing range of technologies and applications that link and enrich the experiences of citizens, enabling us to become more active participants in our communities. With our growing understanding of human-induced climate change and the Earth's finite resources, smart cities must also address the increasingly significant challenge of sustainability. Clearly, the smart city of the future must be smart not only in the technologies and applications it enables, but also in its usage and respect for its resources, and in the environment it ultimately creates for its residents [1].

One increasingly high-profile aspect of smart cities is their ability to enrich, enhance, and distribute cultural heritage [2]. This could, for example, reduce mass tourism while still allowing cities to share their cultural bounty with the outside world. Digital tourism now allows people to explore new cultural experiences either entirely from the comfort of their own home or at the location, equipped with additional means and resources to enhance their experience (Figure 1). For example, portals such as Europeana [L1] offer access to the content of thousands of museums and archives, allowing anyone to peruse millions of books, artworks, and musical pieces. However, cities are doing – and can do – a lot more to allow tourists and their own citizens to interact with heritage sites that might otherwise be overlooked.

An example of a city exploring and expanding its digital-cultural toolbox can be found in the Austrian city of Salzburg. Historic home to composer Wolfgang Amadeus Mozart, Salzburg's city centre constitutes a UNESCO World Heritage Site [L2], and cultural institutions and universities are exploring new ways to share the city's cultural heritage. The Mozarteum University Salzburg expands upon the accessibility and immersion of cultural content in projects such as MozART VR [L3] and Mozart Contained! [L4] in the scope of the interdisciplinary Spot On MozART project, which aims to reframe the perception of Mozart's music in both auditory and visual ways. VR MozART does this by allowing viewers to experience a performance recorded in 360°, putting the viewer at the centre in a VR environment. Mozart Contained! invites up to four participants into a container, in which interactive light sculptures represent the four strings in the 'Dissonance' quartet. The participants' interactions with the sculptures affect the intensity of the respective instrument, creating a new interpretation of the piece with every quartet of visitors. The container can be set up in various locations, reducing the distance between the music of Mozart and the everyday visitor. Projects such as these show how cultural content can be delivered to a wide audience, retaining a sense of immediacy in contrast to the sometimes exclusionary nature of classical music.Similarly, the city of Paris allows visitors to explore urban heritage through a geo-localised application [L5], in the context of a SmartCity

Figure 1: Smart cities allow digital visitors to experience cultural heritage in novel ways.

project developed in the Cité International Universitaire de Paris (CIUP).

Salzburg and Paris represent just two examples of many worthwhile projects in this area, but sometimes smart city projects have missed interesting opportunities by not targeting the promotion of cultural heritage as an end in itself, for example in projects undertaken in Amsterdam, Barcelona, and London [3].

On one hand, the smart city of the future requires a holistic vision – one that recognises its role in sustainability, and the benefits to its citizens that come from discovering, creating, and sharing their culture, within and outside of the bounds of the city. On the other hand, given the great potential of digitisation to promote cultural heritage, clear aims in this area should be specified when planning the development of smart cities.

Many requirements and challenges still need to be addressed for technology to live up to its promise to deliver content to those seeking to explore it, and to do so in a sustainable, ethical, and secure fashion. Some of the immediate open research questions centre around the challenge of how cultural heritage assets are digitalised and conserved. This includes issues such as how ambient light or noise affects users' experience and perception of the asset, and how to quantify the impact of this; how people respond to an augmented reality environment versus a physical installation; and how to consider and emulate reality in a fully virtual experience. Another line of enquiry should explore to what degree preexisting digital infrastructures in smart cities can be exploited by digital arts and tourism in order to improve and extend the range of high quality content delivery.

Finally, a vitally important topic is privacy and safety, as individuals interact with digital tourism and digital arts not only in a digital but also a hybrid manner. We need smart city infrastructure to reflect the highest standards of ethics and privacy, in line with initiatives such as the IEEE Global Initiative on Ethics of Autonomous and Intelligent Systems [L6]. We plan to investigate these interesting research questions, and the emerging interdependencies between them, in future projects.

Links:
[L1] https://www.europeana.eu/
[L2] https://whc.unesco.org/en/list/784/
[L3] https://kwz.me/h7X
[L4] https://kwz.me/h7Z
[L5] http://www.heritage-experience.fr/
[L6] https://kwz.me/h8C

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Circularity in Small Island Cities

by Sobah Abbas Petersen (SINTEF Digital) and Hanne Cecilie Geirbo (Oslo Metropolitan University)

In order to design digital technologies that solve problems in smart and sustainable ways, it is vital to consider the challenge from a bottom-up perspective. Studying waste management and circularity in confined areas, such as small islands, highlights the specific challenges presented by resource and space limitations and raises questions about the geographical scale of a circular economy or a smart and circular city.

Smart city technologies, such as sensors, are often used to monitor waste collection facilities and enable efficient management of resources. This often appears to be a top-down technical infrastructure–focussed approach, independent of the city or the geographical context. Studying waste management and circularity in small and confined spaces, such as the islands in The Maldives, highlights specific challenges presented by local resource and space limitations and raises questions about the geographical scale of a circular economy or a circular city [1]. Our studies identify the need for digital technologies that go beyond monitoring and optimisation of waste collection. Addressing the challenges from a bottom-up perspective is vital for the design of appropriate technologies for smart and sustainable solutions.

The Learning Flexibility project takes a bottom up approach and aims to identify innovative and sustainable solutions that arise locally through crises and vulnerabilities [L1]. The motivation for the project is to identify sustainable solutions from around the world that may benefit Norwegian and European cities. Thus, the project has conducted field studies in several cities, including Beirut, Lebanon and two islands in The Maldives, where the focus has been on waste management. A major finding from these studies is the necessity for circularity, particularly in confined areas with limited resources, such as the islands in The Maldives.

Figure 1: Solid plastic waste remains that need to be transported for recycling.

The impacts of waste management on the environment are well known and this is one of the key elements of environment vulnerability faced by small islands [2]. We conducted a case study in The Maldives to understand the challenges of waste management and potential innovative solutions to the problem. On one small inhabited island, the whole community is educated about waste sorting and recycling and almost 100% of household waste from the kitchen and foliage are composted; the compost is then used locally, but also has the potential to be sold outside the island. Activities to promote circular thinking are promoted, such as collecting rainwater and using compost for agriculture. Specific challenges include the local resources and capacity to process all the waste – e.g., a large volume of solid plastic waste remains, which needs to be transported for recycling (Figure 1). Similarly, the island is not able to consume all the compost produced locally, so some must be transported to other islands.

On another island, which is a tourist resort and spa, the community focuses on 5 Rs: refuse, reduce, reuse, repurpose and recycle. This has resulted in substantial waste reduction; most waste materials, from glass to oil, are recycled. Activities such as agriculture for local consumption are practised, where recycled grey water and locally produced compost are used. The resort manages to operate as a circular island city, where most of its waste is reused and recycled. However, plastic waste remains one of the main challenges, requiring transport off the island to be recycled into sports shoes and clothing [L2].

Clearly, circularity is a key aspect of managing waste, and in line with the ideas of the circular economy, recycling requires resources and reuse requires consumers. While circularity remains central to the waste management approaches practiced throughout many islands and cities, the lack of adequate local resources and physical space are challenges. The small geographical scale of the islands does not provide the resources for recycling or the consumers for the products.

We have identified three main areas where digital technologies could contribute to waste management and a circular economy approach. To refuse, reduce and reuse waste, digital technologies can play a central role in raising awareness and educating the community, enabling outreach to a larger number of people, particularly in isolated islands. It is evident from these field studies that the small geographical scale of the island cities precludes a complete circular economy; transportation is needed to obtain the desired circularity. Transportation, which relies mainly on diesel, is a major contributor to environmental pollution and poses risks to marine ecosystems. Optimising transportation is necessary to maximise the benefits of circular waste management, and this could be achieved by expanding the geographical scale of the circular island city. Thus, another important way that digital technologies could enable a circular approach is in the coordination and logistics of waste collection from the different islands and the transportation to recycling plants and landfill. Furthermore, digital technologies could provide a platform for connecting the different stakeholders and actors of the circular system, such as potential consumers or transportation agents.

Learning Flexibility is a multidisciplinary project, funded by the IdeLab program, Norwegian Research Council. Other field studies conducted by the project include waste management and urban micro forests in Beirut, Lebanon, politics, violence and public spaces in Medellin, Columbia, and urban decline and renewal in Detroit, USA. In addition to the authors, the project partners include The Peace Research Institute and the Oslo School of Architecture, Norway.

Links:

[L1] https://kwz.me/h7A

[L2] https://kwz.me/h7D

References:

[1] T.E Graedel, et al.: "On the Spatial Dimension of the Circular Economy", Resources, 2019. 8(1): p. 32.

[2] A. Periathamby and S. Herat: "Sustainable waste management in Small Island Developing States (SIDS)", Waste Management and Research, 2014. 32(8): p. 681 –682.

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Digital Inclusion

Using Localisation Technologies and Haptic Feedback for a More Inclusive Society

by Barbara Leporini (ISTI-CNR) and Maria Teresa Paratore (ISTI-CNR)

People with special needs face specific challenges in everyday activities. People with visual impairments, for example, have problems with orientation and mobility; moreover, they face serious issues when it comes to accessing information and services or perceiving the surrounding environment. Technologies such as the Internet of Things (IoT) and artificial systems can offer interesting solutions to overcome these limitations and can support users with special needs in an inclusive way.

With human communication and provision of services becoming increasingly reliant on computers and smartphones, it is important to consider different users' requirements in order to build an inclusive society. Concepts such as confidence in, and awareness of, artificial devices and digital content need to be addressed and personalised according to user characteristics and preferences. Confidence is essential, since it allows humans to tackle both known and unfamiliar tasks with hope, optimism, and resilience. Awareness enables confidence, because the more we know about the task we have to perform and about the agent with which we are interacting, the more confident we feel; this is even more true for people with special needs (e.g. visual impairments).

As an example, consider an app conceived to guide users through a complex building such as an airport; it will provide information about the available services (e.g., ATMs, check-in points, toilets), their locations, opening hours, and how they can be reached. Many projects have developed apps for this purpose, but few have considered incorporating tactile information to assist people with visual impairments. TIGHT (Tactile InteGration between Humans and arTificial systems) is a project whose main goal is to help humans achieve awareness of their environment via novel tactile communication paradigms [L1].

The tactile channel is still under-exploited as a means to provide hints in assistive and common applications; in the context of the project, the tactile sense is considered to be an effective way of exchanging information to help the user perceive their environment. Useful information for orientating, moving, and accessing specific contents can be conveyed via wearable haptic devices, which can be exploited to perceive the touch through the body [1]. TIGHT will use knowledge from the recent field of wearable haptics to tackle the technological and neuroscientific challenges of developing wearable haptic interfaces. Applications of such interfaces include orientation, guidance and information communication for people with visual impairments. Haptic interfaces can be used in domains such as domotics, education, leisure

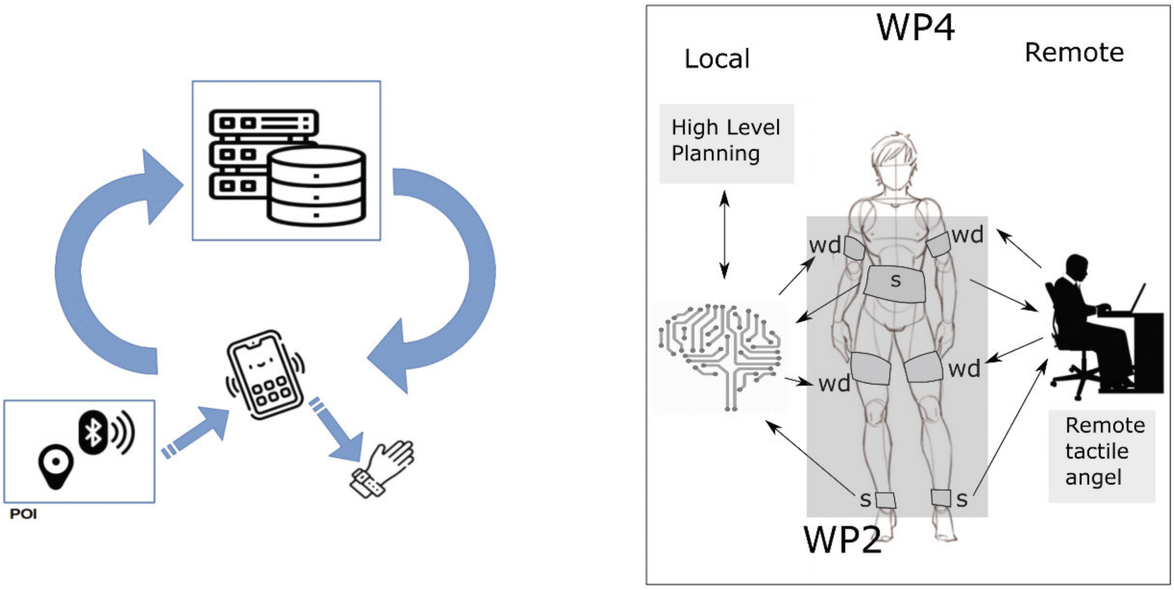

Figure 1: The typical flow of information between the various components in a mobile navigation system that exploits haptic feedback and an excerpt from the TIGHT project documentation, showing the role of haptic feedbacks in the project itself.

and navigation, and mobility applications. Indoor navigation applications have been widely adopted to assist people with visual impairments since they effectively increase social inclusion and autonomy [2]. The continual evolution of technologies related to sensors and mobile devices have increased the popularity of mobile applications for indoor localisation. Wi-Fi, radio-frequency identification (RFID), Bluetooth Low Energy (BLE) and Ultra Wide Band (UWB) have been adopted to build ad-hoc infrastructures that are located within public buildings and urban areas.

The most important requirement for an indoor positioning system is that it makes users aware of the surrounding space by guiding them through the environment and signalling relevant places or objects, known as Points of Interest (POIs); another fundamental feature is disclosing information related to POIs (e.g. descriptions associated to works of art in a mobile museum guide, or the opening hours of shops in a shopping mall). A typical architecture for an indoor mobile navigation app must hence include at least two layers, one to discover the POIs signalled by the hardware infrastructure, the other to convey information to the user in a proper way, and here is where wearable haptics come into play. Tactile stimuli are an effective means to signal the presence of POIs to visually impaired users, and to guide them through a path in the presence of physical obstacles. An example of such an architecture is shown in Figure 1. The architecture can be generalised with respect to the hardware adopted for the positioning strategy. In our example we assumed to be using Bluetooth Low Energy transmitters (AKA BLE beacons), which are extremely popular, thanks to their ease of installation, low power consumption and fair localisation accuracy; infrastructures based on BLE beacons are in fact often present in public urban areas and public buildings of most of our cities. A beacon transmits its unique identifier, so that it can be recognised by any nearby device that is equipped with a Bluetooth sensor. A UID can be used to retrieve information related to the corresponding POI from a remote server. Information will then be processed and presented to the user. The figure shows how each POI signals its presence to the Bluetooth sensor shipped on the smartphone via the associated BLE beacon; as soon as the mobile app on the smartphone detects the presence of the POI, it will issue a request to a remote server asking for details about the place or the object represented by the POI itself. Haptic stimuli to guide the user may be issued via the smartphone itself and/or a wearable component such as a bracelet. Haptic stimuli may be assigned a semantic value; different tactile hints may be associated to specific features of a POI, such as its position and its distance from the user's current position. In order to tailor the retrieved information upon the user's needs, a further personalisation layer may be present; actually, such a layer is advisable in order to provide a better user experience.

A solution based on user localisation and haptic notifications issued by transmitters placed within the surrounding environment can be applied in many different use cases, not only involving users with special needs. The use of the haptic channel is in fact very suitable to perceive contents in a non-intrusive way without having to overload the other senses, allowing them to be delegated to other tasks.

Link:
[L1] https://kwz.me/h8h

References:
[1] F. Barontini, et al.: "Integrating Wearable Haptics and Obstacle Avoidance for the Visually Impaired in Indoor Navigation: A User-Centered Approach". IEEE Transactions on Haptics 14(1), 109-122, 2021. https://doi.org/10.1109/TOH.2020.2996748
[2] D. Plikynas, et al.: "Indoor Navigation Systems for Visually Impaired Persons: Mapping the Features of Existing Technologies to User Needs", Sensors 20(3), 636, 2020. https://doi.org/10.3390/s20030636

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Supporting Privacy Preservation by Distributed and Federated Learning on the Edge

by Davide Bacciu (UNIPI), Patrizio Dazzi (CNR-ISTI) and Alberto Gotta (CNR-ISTI)

The H2020 TEACHING project puts forward a human-centered vision for adapting and optimising autonomous applications, leveraging users' physiological, emotional and cognitive states. Such a goal can be achieved by building a distributed, embedded and federated learning system complemented by methods and tools to enforce its dependability, security, and privacy preservation.

Automation enables processes to run with minimum human involvement in the sensing, decision, and actuation loops. Automation can be used to operate cyber-physical systems of systems (CPSoS), comprising complex, multi-faceted, and dynamic virtual and physical resources that operate at the crossroads of the physical and virtual worlds. Humans interact with the autonomous system either as passive end-users (such as passengers in autonomous transportation) or as active co-operators in a mutual empowerment relationship towards a shared goal. Such a cooperative, connected, and autonomous system of systems can be a game-changer in multiple domains if it can positively exploit such an inescapable human factor.

The H2020 TEACHING project [L1] is a three-year endeavour supported by a consortium of 10 partners from five European countries (Austria, France, Germany, Greece, Italy) aiming to design an autonomous CPSoS application with a human-centric perspective, bringing in critical requirements in terms of adaptivity, dependability (safety, security, reliability) and privacy. The project realises a computing and communication architecture with an integrated artificial intelligence (AI) as a service (AIaaS) platform supporting concepts of dependable engineering, federated, and distributed learning.

AI is central to the TEACHING perspective, as it is a crucial technology to develop autonomous applications – particularly when such applications are realised within the inherently dynamic, connected and interacting context of a CPSoS. An effective AI for the CPSoS should exhibit certain key design features. Machine intelligence, in such scenarios, is distributed and pervasive, where the AI components can be potentially deployed in every element of the CPSoS, enabling it to embed intelligence at the edge, close to where the information is produced by devices or close to where the application consumes the AI predictions. Information processing should follow as much as possible principles of locality and compositionality, respecting the inherently distributed nature of the system of systems. This allows us to contain the deluge of noisy, redundant, heterogeneous, and fast-flowing data produced by the CPSoS elements, thus minimising the negative impacts on communication, storage, and energy consumption. Local consumption of information can also be an advantage in unreliable connectivity scenarios and when data privacy is a crucial issue.

A human-centric perspective on CPSoS intelligence inevitably brings up how to elicit the necessary feedback to drive adaptation in the right direction. When the human is in the loop, it is natural to consider him/her a source of informative and dependable teaching information. TEACHING leverages such a human-centric perspective by developing novel adaptation mechanisms that exploit noisy learning signals under the form of human psycho-physiological reactions. Such concepts of weak supervision are integrated with aspects of lifelong learning [1], where the components of the learning federation are allowed to learn continuously from streams of experiences.

The principles of the locality of computation, previously highlighted for AI models, should also be consistently applied to the issue of dependability. The AI models cannot and should not be left alone at the edge of the CPSoS, especially in safety and mission-critical applications. They should be supported and followed at the edge by dependability and security-related watchdogs. This entails the need for novel systems and engineering methods, also developed within TEACHING, providing CPSoS with native support to cybersecurity and dependability requirements, possibly integrating AI and dependability aspects within the same edge devices.

The TEACHING project investigates the development of learning models explicitly designed to support key concepts

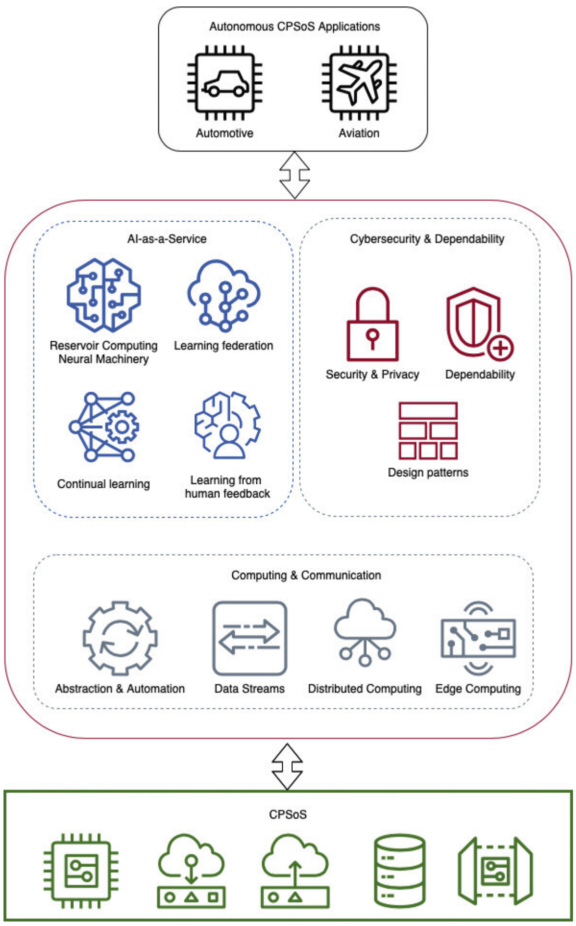

Figure 1: Conceptual architecture of TEACHING.

of computational efficiency, processing of noisy streaming data, and federated learning. The learning methodology is being built around the concepts of randomised recurrent neural models from the Reservoir Computing paradigm [2]. These models allow effective predictors to be realised that can be efficiently embedded on edge devices containing computational, memory, and energy fingerprints. They also ease the development of robust mechanisms to fuse the local AI models of the federation into a centralised model without needing to transfer data collected locally on edge devices [3]. This means that it is possible to realise a federated learning deployment with an excellent trade-off between accuracy and privacy preservation as data does not need to be communicated out of the edge devices where it is produced. The conceptual architecture of the TEACHING project is depicted in Figure 1. At its bottom stands a heterogeneous set of resources realising the CPSoS. The central part of the figure represents the salient aspects of the TEACHING ecosystem, which revolves around three main pillars.

1. The (distributed) computing and communication platform, organised accordingly with the principles of edge computing, aiming at the efficient management of the pool of resources belonging to the TEACHING CPSoS;
2. The mechanisms, the policies, and a set of design patterns developed ad-hoc to ensure the platform's security and privacy and to satisfy the requirements of dependability, making the platform a viable solution in real-world scenarios;
3. An AI-as-a-service subsystem supporting federated learning processes based on reservoir computing that enables continuous learning that exploits human feedback to improve its performance.

The upper part of the figure reports two use cases, in the fields of autonomous automotive and avionic transport, that demonstrate the added value of TEACHING. Such use cases are characterised by high challenges connected with their needs for autonomy, dependability, and capability to adapt to human needs and reactions. They are also highly relevant for the industrial competitiveness of the European Union, and they are hence excellent testing cases for the TEACHING design.

Link: [L1] https://teaching-h2020.eu

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[1] G. L. Parisi, et al.: "Continual Lifelong Learning with Neural Networks: A Review", Neural Networks, 113, 54-71, 2019.

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CT Scans Reveal a Double Panel in an Oil Sketch after Rubens

by Marta Domínguez-Delmás (UvA), Francien Bossema (CWI), Erma Hermens (Rijksmuseum, UvA)

CT scans of a Rijksmuseum panel painting in CWI's FleX-ray laboratory have revealed a surprising insight: it turns out it was not painted on oak, as was always assumed, but on tropical wood. The panel painting "Cadmus, Guided by Minerva, Observes the Spartoi Fighting" is a small oil sketch on panel attributed to an unknown follower of Peter Paul Rubens.

The CT scans were taken at CWI as part of a larger investigation into the history and origin of the painting. An interdisciplinary group of researchers from the UvA, the Rijksmuseum and CWI worked together to retrieve CT images of the wooden panel and date it using dendrochronology. The purpose of the CT scans was therefore to obtain a digital cross-section of the oak board and to visualize the tree rings. The tree rings could not be observed from the outside, due to oak strips attached to all sides of the panel. Dating the wood can provide crucial information for determining a production date, which in some cases can support or refute an attribution to an artist or a studio.

Figure 1: Painting in the scanner of the FleX-ray Lab at CWI.

The painting was taken to CWI's FleX-ray laboratory for CT scanning. The CT images yielded a surprise as we observed that the support was made of two panels glued together. The original panel used for the oil sketch, is made of a tropical wood, whereas the back panel is made of oak. The tree rings of the oak board were perfectly visible in the CT images, and it was possible to date the panel to 1548 (last ring measured in the panel), with an estimated felling date for the tree after 1557 CE. However, this date became irrelevant, as the oak board was probably trimmed to meet the size of the original board and was glued to it at some point in time. The board used for the painting has been identified as probably Swietenia sp., a species seldom used in 17th-century Netherlandish workshops, but there are some early occurrences in the 1630s, Due to this wood type, we cannot establish through dendrochronological examination when the painting was likely made hence the panel remains undated. The oak board may have been added later for conservation purposes or with misleading intent, namely to pretend that the painting was in fact painted on oak, which would have been typically used in 17th-century Netherlandish painting, including in Rubens' studio.

Non-invasive imaging techniques are rarely used for dendrochronological examination of art objects, despite the valuable information they provide. In this case, the CT scan was the key to discovering the two different panels and enabled dating of the oak panel. This research shows that implementing non-invasive imaging techniques to study artworks of different shapes and materials can be of great added value and can sometimes lead to so far not found new information.

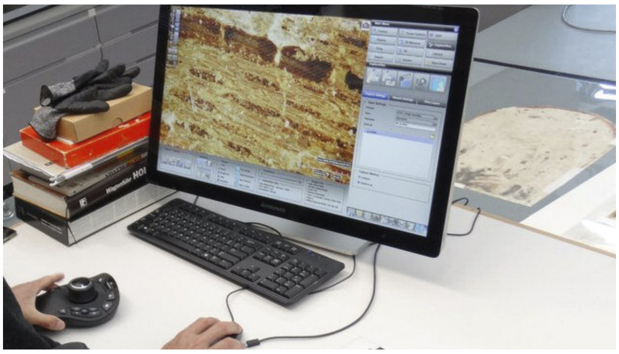

Figure 2: Inspection of the panel painting.

Follow-up research

Because the painting was not painted directly on the oak panel, the established felling date is not indicative of the sketch itself. Many questions remain open for further research. The discovery that the oil sketch was painted on a tropical wood panel and not on oak as we all assumed, adds important new data but also raises many new questions about the dating and place of production and about the function of the panel. Hopefully, with research into the painting technique and materials, the story of this sketch can be further completed.

The painting

The panel painting "Cadmus, Guided by Minerva, Observes the Spartoi Fighting" (26.2 x 42.3 cm) is described as a copy after an original by Rubens (Private Collection, UK). The original sketch was the model for a larger painting executed by Jacob Jordaens, part of an ensemble of over 60 paintings Rubens was commissioned in 1636 to carry out for Philip IV, for the Torre de la Parada, Philip's hunting lodge near Madrid.

Link:

YouTube video about the FleX-ray Lab at CWI:
https://youtu.be/6Zjm_L-cXEc

Reference:

M. Domínguez-Delmás, et al.: "X-ray computed tomography for non-invasive dendrochronology reveals a concealed double panelling on a painting from Rubens' studio", in: PLOS ONE, 25 August 2021.

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26th Conference on Formal Methods for Industrial Critical Systems

by Maurice ter Beek (ISTI-CNR)

The yearly conference of the ERCIM Working Group on Formal Methods for Industrial Critical Systems, FMICS, the key conference at the intersection of industrial applications and formal methods, reached its 26th edition this year. Unfortunately, also this year the conference took place virtually, in Paris, France, from 24-26 August.

The aim of the FMICS conference series is to provide a forum for researchers interested in the development and application of formal methods in industry. It strives to promote research and development for the improvement of formal methods and tools for industrial applications.

The conference was chaired by Alberto Lluch Lafuente (Technical University of Denmark) and Anastasia Mavridou (NASA Ames Research Center, USA) and organized under the umbrella of QONFEST 2021, alongside with CONCUR, QEST and FORMATS, organized by Benoît Barbot (Université Paris-Est Créteil, France) and his team. FMICS 2021 attracted quite a lot of participants from many countries worldwide, both from academia and industry.

A good number of 31 papers were submitted, of which 16 (10 regular, 4 tool and 2 short) papers were accepted. The program moreover included the wonderful and thought-provoking invited keynote "Haunting Tales of Applied Formal Methods from Academia and Industry" by Joe Kiniry (Galois Inc. and Free & Fair, USA), which was very well received and well attended by over 60 participants. Videos of the live sessions are available from the QONFEST 2021 YouTube channel.

Following a tradition established over the years, Springer provided an award for the best FMICS paper. This year, the program committee selected the contribution "Automated Verification of Temporal Properties of Ladder Programs" by Cláudio Belo Lourenço, Denis Cousineau, Florian Faissole, Claude Marché, David Mentré, and Hiroaki Inoue for the FMICS 2021 Best Paper Award. The awarded paper is a nice example of how to realize the vision of FMICS when industry and academia collaborate.

Links:

https://qonfest2021.lacl.fr/fmics21.php
YouTube channel: https://kwz.me/h8i

Reference:

[1] A. Lluch Lafuente and A. Mavridou (eds.), Formal Methods for Industrial Critical Systems, Proc. of FMICS'21, LNCS, v.12863, Springer, 2021. https://doi.org/10.1007/978-3-030-85248-1

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Advertisement

PerAwareCity & WSCC 2022

IEEE PerAwareCity and WSCC Joint Workshop 2022 on Pervasive Smart Sustainable Cities

March 21-25, 2022, Pisa, Italy
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The ongoing advances in Pervasive Computing technology have delivered interesting hardware platforms that are suitable for city-scale infrastructure deployments. In addition, the success of mobile communication devices and mobile broadband connectivity enables citizens to tap into the digital resources that surround them anytime and anywhere. Another foremost important technology for building the future generations of smart city applications is intelligent (real-time) analytics and decision making by processing streaming sensor data available from the surrounding environment. With such data, both centralized analytics and decentralized analytics could play a key role in data sense-making and decision-making. In addition, such analysis can be combined with data from increasingly deployed fixed sensors or IoT infrastructure in the city. Recently researchers are actively engaged in finding the applications of Artificial Intelligence (AI) and Machine Learning (ML) in solving various data analytics and decision-making problems related to Smart Cities, which can benefit society as a whole. Therefore, PerAwareCity & WSCC solicits papers addressing relevant topics, including - but not limited to - the following:

- Smart City systems and platforms
- Smart Cities as a system of systems
- 6G and alternative communication architectures
- IoT, edge/fog, and cloud computing for smart and circular cities
- Experiences from real-world applications, experiments, and deployments
- Smart City pilots and applications, e.g., smart traffic management, smart healthcare (including approaches adopted for fighting COVID-19 virus), smart grid, smart waste management, pollution control and management, environmental sustainability, water quality monitoring, criminal activity profiling
- Applications of AI for smart cities
- Crowd-sourcing and human computation
- Internet of Things, Web and Linked Data technologies for Smart Cities
- Data management, open data and knowledge extraction in smart cities
- Big data in Smart City, Smart City Intelligent Data Processing
- Cyber-physical systems and society
- End user involvement, acceptance, and user support aspects
- Participatory sensing and processing
- Sensor, actuators and their networking in Smart Cities
- Safety, security, and privacy for Smart City applications
- Scalability of Smart City systems and beyond (Smart Regions / Countries)
- Adaptable, recoverable, and fault tolerant Smart City systems
- Management, configuration, and deployment of Smart City infrastructures, Smart Infrastructure Health Monitoring
- Accessibility in Smart Cities (e.g., designing accessible routes for users with mobility assistant devices)
- Citizen science and education-related aspects related to smart cities and circular economy
- Digital Twins and their application in Smart Cities and Sustainability
- People-centric systems and crowdsensing solutions in smart cities
- Studies on behavioral change aspects for sustainability
- Tools and techniques for urban co-creation

Submission Guidelines

Submitted papers must be original contributions that are unpublished and are not currently under consideration for publication by other venues. Paper submissions should be no longer than 6 pages with a font size of 10 using the IEEE conference template. Papers must be submitted electronically as PDF files through the EDAS link https://www.edas.info/newPaper.php?c=28982. All submitted papers will be subject to single-blind peer reviews by Technical Program Committee members and other experts in the field. All presented papers in the conference will be published in the proceedings of the conference and submitted to the IEEE Xplore Digital Library. **Each accepted workshop paper requires a full PerCom registration (no registration is available for workshops only or for students).**

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Important Dates
- Submission Deadline: November 14, 2021 (AoE)
- Acceptance Notification: January 05, 2022 (AoE)
- Submission of camera-ready: February 05, 2022 (AoE)

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W3C/SMPTE Joint Workshop on Professional Media Production on the Web

9-18 November 2021; online event

How web technologies support the digitization of media production streams

Professional media assets, including audio-visual TV and motion pictures, are increasingly being stored in the cloud. In parallel, there is a growing interest in building Web applications for end-users.

To help bridge media streams, W3C/SMPTE are organizing a workshop scoped to professional media production using the Web platform, including editing, quality control, grading/color correction, dailies, visual effects, sound, mastering, translation and servicing. The goal is to demonstrate how web technologies such as WebCodecs, WebGPU and WebAudio can be used for professional media production and identify potential new areas for collaboration and standardization.

We invite you to submit a speaking proposal by 12 October on one or more topics described at:

https://www.w3.org/2021/03/media-production-workshop/#topics

Speaker invitations will be issued on 15 October. This workshop is free and open to invited attendees who are encouraged to register by 5 November. We look forward to great conversations!

ERCIM “Alain Bensoussan” Fellowship Programme

The ERCIM PhD Fellowship Programme has been established as one of the premier activities of ERCIM. The programme is open to young researchers from all over the world. It focuses on a broad range of fields in Computer Science and Applied Mathematics.

The fellowship scheme also helps young scientists to improve their knowledge of European research structures and networks and to gain more insight into the working conditions of leading European research institutions. The fellowships are of 12 months duration (with a possible extension), spent in one of the ERCIM member institutes. Fellows can apply for second year in a different institute.

“The ERCIM fellowship was a great opportunity to pursue high end research with a multinational team in a distinguished institute. It also allowed me to establish promising collaboration with different international research teams. I believe that the fellowship is an excellent chance for ambitious researchers to join high level research teams and contribute to evolving scientific topics.

Noha EL-GANAINY
Former ERCIM Fellow

Why to apply for an ERCIM Fellowship?

The Fellowship Programme enables bright young scientists to work on a challenging problem as fellows of leading European research centers. ERCIM fellowship helps widen and intensify the network of personal relations among scientists.

The programme offers the opportunity to ERCIM fellows:
- to work with internationally recognized experts;
- to improve knowledge about European research structures and networks;
- to become familiarized with working conditions in European research centres;
- to promote cross-fertilization and cooperation, through the fellowships, between research groups working in similar areas in different laboratories.

Conditions

Candidates must:
- have obtained a PhD degree during the last eight years (prior to the year of the application deadline) or be in the last year of the thesis work;
- be fluent in English;
- have completed their PhD before starting the grant.

The fellows are appointed either by a stipend (an agreement for a research training programme) or a working contract. The type of contract and the monthly allowance/salary depends on the hosting institute.

Application deadlines

Deadlines for applications are currently 30 April and 30 September each year.

Since its inception in 1991, over 700 fellows have passed through the programme. In 2020, 21 young scientists commenced an ERCIM PhD fellowship and 77 fellows have been hosted during the year. Since 2005, the Fellowship Programme is named in honour of Alain Bensoussan, former president of Inria, one of the three ERCIM founding institutes.

http://fellowship.ercim.eu

SCHLOSS DAGSTUHL
Leibniz-Zentrum für Informatik

Call for Proposals

Dagstuhl Seminars and Perspectives Workshops

Schloss Dagstuhl – Leibniz-Zentrum für Informatik is accepting proposals for scientific seminars/workshops in all areas of computer science, in particular also in connection with other fields.

If accepted the event will be hosted in the seclusion of Dagstuhl's well known, own, dedicated facilities in Wadern on the western fringe of Germany. Moreover, the Dagstuhl office will assume most of the organisational/ administrative work, and the Dagstuhl scientific staff will support the organizers in preparing, running, and documenting the event. Thanks to subsidies the costs are very low for participants.

Dagstuhl events are typically proposed by a group of three to four outstanding researchers of different affiliations. This organizer team should represent a range of research communities and reflect Dagstuhl's international orientation. More information, in particular, details about event form and setup as well as the proposal form and the proposing process can be found on

https://www.dagstuhl.de/dsproposal

Schloss Dagstuhl – Leibniz-Zentrum für Informatik is funded by the German federal and state government. It pursues a mission of furthering world class research in computer science by facilitating communication and interaction between researchers.

Important Dates
- *This submission period:*
  October 15 to November 1, 2021
  Seminar dates: In 2023

- *Next submission period:*
  April 1 to April 15, 2022
  Seminar dates: In 2023/2024.

Marta Kwiatkowska and Susan Murphy win CWI's Van Wijngaarden Awards 2021

The Van Wijngaarden Awards 2021 are awarded to computer scientist Marta Kwiatkowska and mathematician Susan A. Murphy for the numerous and highly significant contributions they made to their respective research areas: preventing software faults and improving decision making in health. The five-yearly award is established by CWI, the national research institute for mathematics and computer science in the Netherlands, and is named after former CWI director Aad van Wijngaarden. The winners receive the prize during a festive soirée on 18 November in Amsterdam.

CWI Van Wijngaarden Award winners 2021: Marta Kwiatkowska (University of Oxford; on the left) and Susan A. Murphy (Harvard University).

Marta Kwiatkowska (University of Oxford) is a computer scientist who pioneered research on modelling, verification, and synthesis of probabilistic systems.

Susan A. Murphy (Harvard University) is a professor of statistics and computer science. Her research focuses on improving sequential, individualized, decision making in health, in particular on clinical trial design and data analysis to inform the development of just-in-time adaptive interventions.

The five-yearly Van Wijngaarden Award is named after Adriaan van Wijngaarden (1916–1987). Van Wijngaarden was directly involved in the introduction of the computer in the Netherlands and has been of invaluable importance for CWI. He is also one of the founders of computer science in the Netherlands and laid the foundation for several mainstream computer languages. Van Wijngaarden was the director of the Mathematical Center from 1961-1980, currently known as Centrum Wiskunde & Informatica (CWI). This year is the 75th anniversary year of CWI.

It is the fourth time the Van Wijngaarden Awards are presented. Previous awards went to Nancy Lynch and Persi Diaconis (2006), Éva Tardos and John Butcher (2011) and Sara van de Geer and Xavier Leroy (2016).

This year's jury consisted of: Karen Aardal, Peter Apers, Jos Baeten (chair), Sander Bohté (secretary), Remco van der Hofstad and Rineke Verbrugge. Krzysztof Apt and Peter Grünwald will give the laudatio lecture about the winners in November.

ERCIM – the European Research Consortium for Informatics and Mathematics is an organisation dedicated to the advancement of European research and development in information technology and applied mathematics. Its member institutions aim to foster collaborative work within the European research community and to increase co-operation with European industry.

ERCIM is the European Host of the World Wide Web Consortium.

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