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Next Generation Internet of Things

Workshop Report

IoT and Edge Computing: Future Directions for Europe

5 November 2020

IoT and Edge COMPUTING: Future Directions for Europe[1]

September 11, 2020, 10:00 -16:00 CEST

This report summarizes the main results of the NGIoT workshop on IoT and Edge Computing of September 11, 2020. The workshop brought together stakeholders from industry, SMEs, academia, and the public sector to share views on the emerging opportunities for European IoT and Edge computing, to learn from key voices across sectors and to shape future European pathways.

The workshop was hosted by the Next Generation IoT (NGIoT) CSA project and organised together with the European Commission and the Alliance for IoT Innovation (AIOTI), to reflect on opportunities and challenges, the position of European stakeholders and possible measures to reach consensus on an agenda and roadmap for European IoT research, innovation and deployment in the world.

The workshop was opened by Max Lemke, Head of Unit IoT, DG CONNECT, European Commission; Rolf Riemenschneider, Head of Sector IoT, DG CONNECT, European Commission; Martin Brynskov, Coordinator, Next Generation IoT (NGIoT), DITCOM, Aarhus University; and Parm Raeewal, Chair, Alliance for IoT Innovation (AIOTI) and Steering Board, Vodafone. Monique Calisti, CEO, Martel Innovate acted as moderator. Jelena Vidović, Teamlead, Dunavnet, and Adriënne Heijnen, Senior scientific advisor, DITCOM, Aarhus University were rapporteurs.

Concept

With the proliferation of IoT, the need to develop critical Edge computing is becoming urgent. By bringing responsiveness and innovation to where it is needed, intelligent IoT devices accelerate the convergence of Information Technology (IT) and Operational Technology (OT) and fuel the digital transformation of areas like energy, agri-food, automotive, manufacturing and smart cities & communities.

Computing at the Edge has grown steadily over the past decade, driven by the need to support computing and analytics closer to things in the physical world in order to reduce latency and tackle data deluge due to billions of connected devices and systems. Edge computing lies between physical things in the real world as monitored and controlled by IoT devices (sensors and actuators), via layers of Edge nodes connected to data centres. In addition, the emergence of AI as major force in IoT efforts runs simultaneously with several important IoT-related trends like Cloud-based IoT services and the dramatic increase of AI capabilities in data centres.

Massive IoT data generation is pushing network capacity to its limits across industries; analysing data close to where the data is generated in the physical world reduces network load, saves energy and costs as well as reducing the time lag (latency) between generating data and acting on it. Time is critical to optimise industrial processes, autonomous driving, mobile health, and integration of volatile energy sources into grid operations. Localisation of data and computation can improve privacy, security, reliability, resilience and safety, which, taken together, comprise trustworthiness.

In this workshop, 25 presentations followed by discussions on the opportunities and challenges of IoT and Edge computing in Europe, as well as on the current position of the European stakeholders were delivered to more than 170 participants.

[1] Programme, slides of the presentations and recordings of the Webinar are available at: https://www.ngiot.eu/event/iot-and-edge-computing-future-directions-for-europe/?instance_id=91

KEY OUTCOMES & RECOMMENDATIONS

The European Commission's key takeaways

1. Key sectors acknowledge the great potential from Edge Computing for Europe.
2. Next Generation IoT means smart, connected, powerful devices at the Far Edge.
3. Edge Computing drives decentralisation and decarbonisation.
4. Edge Computing is glueing control/automation systems and the Cloud.
5. Through a focus on the Edge, Europe can build on its strengths: sensors, applications, systems.
6. Driving Cloud-Edge convergence beyond GAIA-X.
7. We currently see a paradigm shift for IoT: from monitoring to outcome-driven platforms and more intelligent devices.
8. In this context we need new Operating Systems at the Edge.
9. EU actors need a platform approach to collaborate.
10. The EU needs to identify the catalysts that speed up innovation at the Edge.

Main recommendations and key takeaways from the IoT community

1. Europe should build on its strengths: sensors, applications and systems, maintain autonomy in these sectors and master the value chain (especially the digital part).
2. Edge computing is a key technology for IoT and 5G/6G to support applications with more stringent requirements, zero-latency, higher capacity and massive connected devices.
3. Edge computing transforms IoT. The Cloud Edge renders IoT near-real-time and interactive. With the advent of 5G combined with Edge, IoT is moving from passive monitoring to interactive control and intelligence.
4. Convergence of technologies is key, as between AI and IoT.
5. The move to more intelligent devices needs to be supported; learning capabilities should be integrated in the devices. AI and Machine Learning are Key Enabling Technologies in this respect.
6. The orchestration of the complexity is crucial; Future research challenges should cover open distributed Edge computing architectures.
7. The EU needs to adopt a human-centric and inclusive approach to IoT. The Edge should be explored from Europe's strength of diversity and as an opportunity to develop IoT in an inclusive manner, including socially, urban/rural and enterprise/SME.
8. Data security and confidentiality can partially be addressed by keeping the local data at local level (Edge) and by ensuring data sovereignty.
9. Europe should focus on standards and interoperability, strive for independence in standards and protocols, as well as harmonisation across Member States.
10. Avoid fragmentation: Edge computing is currently being tackled by multiple fora and standardization bodies from different perspectives and an effort to find technical synergies and convergence should be done to avoid fragmentation. Collaboration across verticals, sectors (public-private) and borders is also key.

11. Future communication services should offer higher reliability and flexibility in an autonomous way in a changing environment, and connectivity will have to involve even higher data intensity for AI based network management, besides the data for AI execution at the Edge.
12. Expected future evolution of Edge computing: Swarm computing, brings a lot of potential combining connectivity and Edge computing together with multi-Cloud computing based in a collaborative environment.
13. Edge computing, i.e. the de-localisation of Cloud resources, may bring new business opportunities for (small) localised players and help the raise of new business models.

Future Research and Innovation Priorities identified by the IoT community

- Open distributed Edge computing architectures.
- Wireless communication and networking.
- Edge computing for IoT.
- Built in end-to-end distributed security, trust and privacy elements.
- Tactile Internet & AI to control objects remotely.
- Intelligence methods to optimize the offload process in operations to the proper level of the computing continuum.
- How to increase the embbeded intelligence of the devices?
- Contextual management and reactive adaptation.
- Active and adaptive security within the IoT lifecycle and mobility and transition of the devices.
- ML techniques as key for a more effective detection and mitigation of security and privacy attacks.

Barriers for the advance and uptake of IoT identified by the IoT community

The workshop identified numerous barriers and challenges, sector-based, as well as cross-sectoral that need to be solved to advance IoT.

The main barriers in the food & farming sector are:

- battery lifetime,
- bandwidth,
- costs of devices
- accuracy of sensors
- security and privacy
- customers' mindset

The main barriers in the energy sector are:

- scaling up, and thus, harmonised penetration across Member States,
- harmonisation,
- security

In the public sector:

- vendor lock-in
- investment risk

Cross-sectoral barriers and challenges

Particular challenges around cross-sectoral AI technology enablers, such sensing, measurement and perception, which still need to be solved:

- **Trustworthiness**: transparency of algorithms, data processing and management, traceability, privacy, integrity, and accountability;
- **Capacity**: connectivity coverage, quality, and capacity for carrying large volumes of data, Edge capacity and security to cope with decentralized big data and AI processing, energy consumption by physical sensors;
- **Heterogeneity**: handling of the heterogeneity of data sources, formats, collection mechanisms, access methods, flows, and meta-data, as well as coping with diverse environmental conditions;
- **Effectiveness**: research and development of measuring mechanisms, methods, and criteria to assess key metrics to evaluate progress, quality, and adoption of sensing-enabled technologies and services;
- **Scale**: the still insufficient scale of publicly available, quality data (real or synthetic) needed to adequately model the required complexity that represents the physical world(s).

Key current challenges for Edge computing

- Decentralized management
- Distributed setups
- Data intense heterogeneity
- Volatility of resources
- Lack of connectivity
- The lack of standards and interoperability (are the biggest obstacles for integration)
- Costs, e.g. in relation to large amounts of devices for building solutions
- Investment and policy cycles
- Security, especially while operating in multi-domain realities
- Discovery of, and optimal (re)-routing to an Edge Cloud capable of serving application clients

- Service continuity (offloading)
- Smart application placement to allow the optimized deployment of applications at the Edge infrastructure
- Cloud applications would enhance the user experience if they could leverage services offered by the network
- Edge federation across multiple MNOs.

1 WELCOME SESSION

Max Lemke, Head of Unit IoT, DG CONNECT, European Commission

Summary

DG Connect, European Commission, operates within the political priorities shaping Europe's Digital Future. The coming research and innovation programmes, Horizon Europe and Digital Europe, should be understood in the context of these political priorities. Two publications are key: Firstly, "A European Strategy for Data", with a focus on establishing dataspaces and creating a European federation of "energy-efficient and trustworthy" Cloud infrastructure and services, and, secondly, the EC's whitepaper: "On Artificial Intelligence - A European approach to excellence and trust", as Artificial Intelligence (AI) is the technology to be used when we in the future will see an increase of intelligent and smarter devices.

Future trends from a technology perspective

- Digital enabling technologies strategies convergence: A holistic approach is needed, as it is no longer relevant to organise data, processing, computing, connectivity and intelligence in separate silos. IoT is bringing it all together.
- System level approaches: there are other words for the Internet of Things, like Cognitive Cyber-Physical Systems. They are very close to each other, depending on the definition of these concepts.
- Paradigm shift from the Cloud to the Edge – Today, 80% processing of data takes places in the Cloud and 20% on the Edge. We expect this to be the opposite in the next 5 years. This paradigm shift is driven by the needs for privacy protection, ensuring security in critical applications, real time decisions, saving energy and protecting the environment.
- Computing power is moving to the Edge, to the data. This means that intelligence goes to the Edge, leading to smarter devices.
- The closer to the Edge, the more application-specific customisation is needed.
- Cloud continuum.
- In the near future, IoT/Edge Meta-level Operating system discussions will emerge. Due to increasing complexity, collaborative platforms are needed.

Where is the potential for Europe?

Cloud infrastructure as a service is in the hands of US and Chinese digital giants. The paradigm shift from Cloud to Edge brings opportunities for Europe. Europe is strong in industrial applications, in sensors, in cyber physical systems and can, by this paradigm shift, regain competences and market share, reinforcing its place between the US and China. Europe needs autonomy in sectors it is leading and master the value chain, especially the digital part. Europe also need a broad approach to IoT, not just a focus on connectivity but bringing the Microelectronics, Photonics, IoT, SW and Systems, data analytics, data fusion, 5G and beyond and Operating systems together. Europe needs platforms, Large Scale Piloting and partnerships to address these complexities. Speed is crucial to stay ahead competition.

Presentation of the workshop's programme

This workshop discusses NGIoT from various perspectives:

- Application needs
- Cross cutting issues
- Technology and hardware
- Enabling technologies.

2 SETTING THE SCENE

***Rolf Riemenschneider**, Head of Sector, IoT, DG CONNECT, European Commission*

***Martin Brynskov**, Coordinator, Next Generation IoT (NGIoT), Director, Centre for Digital Transformation in Cities and Communities, Aarhus University, DK.*

***Parm Raeewal**, Chair, Alliance for IoT Innovation (AIOTI) Steering Board, Vodafone*

Summary

This workshop on IoT and Edge Computing was primarily technology driven and open. It invitated the sharing of views and co-shaping of future agendas, especially under Horizon Europe Cluster 4 and related initiatives, such as KET, Smart Networking and Services, as well as AI policies.

The workshop looked into several key issues, such as monetization. Today, more than 70% of IoT revenues are Cloud-native. The question is whether this will continue in the future? What are the enabling technologies and where do we see a paradigm shift from the application, from the system, or from enabling technologies like microelectronics or key digital technologies?

IoT is a core strategy for Europe. Europe is striving to reinforce its position between China and the US. Human centricity, inclusiveness and democratic resilience is crucial for the European approach to IoT. We have seen examples of the world fallen apart, when this focus is not included. IoT is when the digital takes place in a very physical sense, when it hits the ground. We need to focus on technology and on industry, but also on our economy. IoT is thus also about inclusion and democratic resonance, about prosperity beyond economics. A quarter of the economic activities is spent in cities. Thus, it is important to understand public-private interactions.

According to AIOTI, a holistic end-to-end approach is critical for the socio-economic success of digitization across the value chain. A responsive network connectivity to allow the devices and humans controlling and manipulating objects in real reversal environments is essential as well.

Key takeaways

- IoT is a key strategy for Europe, and Europe should strive for reinforcing its position between the US and China by focusing on its core strengths.
- IoT as a European core strategy has to be human-centric, inclusive, and democratic, striving for prosperity beyond economy, as well as strategic resilience.
- Future research challenges cover open distributed Edge computing architectures, wireless communication and networking, Edge computing for IoT and built-in end-to-end distributed security, trust and privacy controls.
- Artificial Intelligence is a key technology, as it enables IoT in an Edge computing environment, uncovering meaningful insights and informing decision making.

3 TOGETHER ON THE EDGE

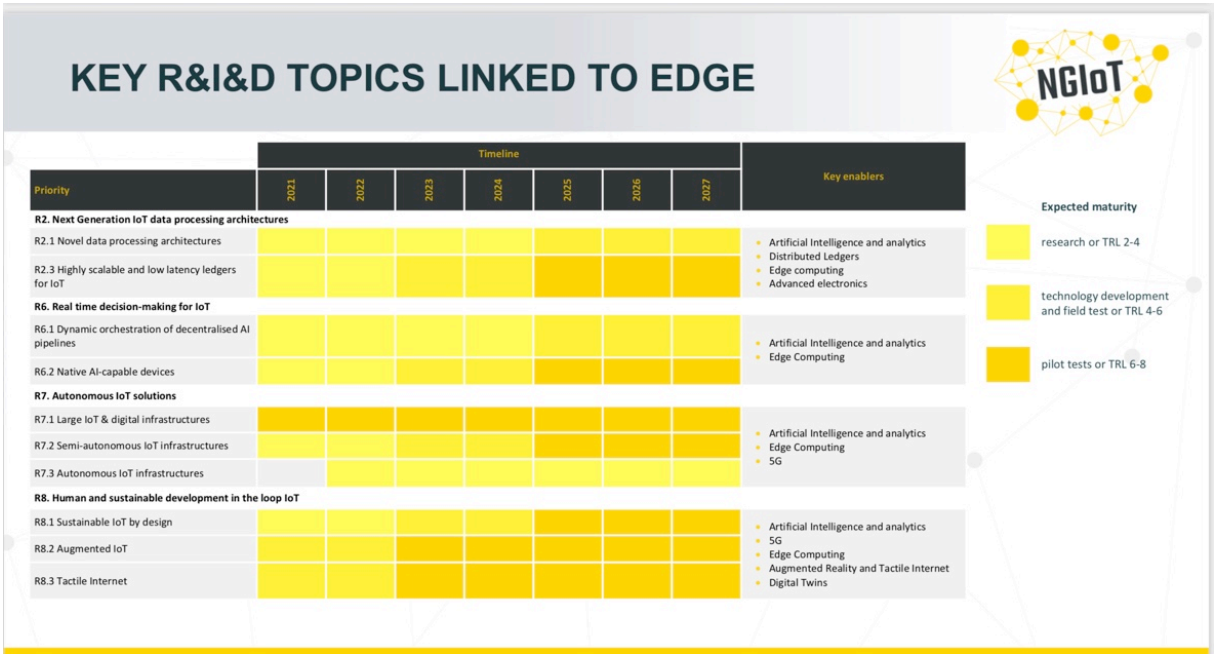
Together on the Edge

Monique Calisti, CEO, Martel Innovate & NGIoT

The Edge is the area where data, IoT, AI, Cloud, Cybersecurity, 5G/6G are converging. How to tackle this complexity is the big question. Many examples of Edge computing are already a part of our everyday life and this will only increase, as communicating and transporting data from where they are produced and gathered is becoming too costly. Many current and future applications will not allow for the time it takes to gather, store, process and analyse data in the Cloud. This means that we need smarter sensors, more intelligent devices that are capable to gather, collect and process data close to where they are used.

This workshop explored IoT and the Edge from different directions: On the one hand, from market pull trends; requirements of several market segments and, on the other hand, from the technology side: technological push factors. In addition, the regulatory, standardization and legal aspects were addressed.

The project NGIoT has already published a number of Research, Innovation and Deployment priorities, which can be accessed in the project's report **D3.1 – IoT research, innovation and deployment priorities in the EU White Paper**, published on the NGIoT website.[2]



[2] www.ngiot.eu

4 FIVE YEARS FROM NOW – KEY SCENARIOS AND EMERGING NEEDS IN EDGE IOT

Connected Road Infrastructure

Thomas Jell, Programme Manager for Shared Autonomous Mobility at Siemens

This presentation addressed shared autonomous mobility and the requirements for IoT, by presenting a case study from Siemens Shared Autonomous Mobility unit. Many companies do self-driving cars. One of the key challenges of autonomous mobility is to ensure safe and fluent traffic for self-driving vehicles in all weather conditions and in complex traffic situations. Siemens works with self-driving shuttles, which is different from other self-driving vehicles, as emergency stops are not possible. Usually, people do not wear belts or other protection systems in shuttles, so an emergency break would result in injured passengers. Siemens sees a potential market in developing additional safety features.

Setting up infrastructures will allow guidance systems for shuttles. There are many situations where infrastructures, through sensors, can look around the corner, can detect dangerous situations where cars normally do not have the overview.

Siemens' systems are largely running in the Cloud, in the back-end: all the strategic elements, the route management, the changes, the regulations given to the cars are in the Cloud. But it is not feasible to have calculations done in the Cloud when information needs to be fast, and needs to reach the cars in only a couple of milliseconds. In these instances, Siemens has Edge Computing in place, the Traffic Cell Computer, the TC3, comes together with a roadside unit which does the communication with the car. The current system works with both 5G and WiFi and Siemens supports both.

Key take aways: Cloud and Edge

Information that is not time critical is in the Cloud, while all the security and time critical information next to the road is at the Edge. It is a bi-directional communication between the car and the infrastructure, as the car also returns feedback to the system and to the roadside unit. The system is already in place. Test beds in relevant environments are OTS in Munich, HEAT in Hamburg, testbeds in Singapore, the Airport Munich, as well as KoRa9. Siemens is testing which infrastructure works best and how to decide how to reduce infrastructures to critical areas, as well as to reduce to only a few sensors.

Smart Energy

Oliver van der Mond, Co-Founder & CEO Lemonbeat

Lemonbeat is a provider of IoT technology with a focus on applications in the energy space.
Lemonbeat's presentation addressed Smart Energy, and specifically: What are the particularities in smart energy applications?

When it comes to energy utilities, the main focus is on the energy grid. This means a very large infrastructure with many largely distributed devices, monitoring various assets in the grid. For large grid operators, this means millions of devices. Currently, we see the attempt to enable traditional scala systems and connect them to the Cloud. This is still happening within industrial IoT. But with this

approach, most of the logic still sits within large controllers, which is now supported by some further intelligence in the Cloud. Lemonbeat is not convinced that such large infrastructures can become smart with this approach. A real IoT-based approach needs to increase the intelligence in the grid, and a push in two directions can be identified: a push towards the Cloud, as many industrial IoT applications still are a retrofit of existing scala systems (which means putting a Cloud connection on top and consider this to be IoT). With time, for larger applications, this will become difficult to deploy, as it is too cost inefficient and the technology cannot cover the large number of devices and data. The other push is to the Far Edge: Not just gateways, but really intelligent devices.

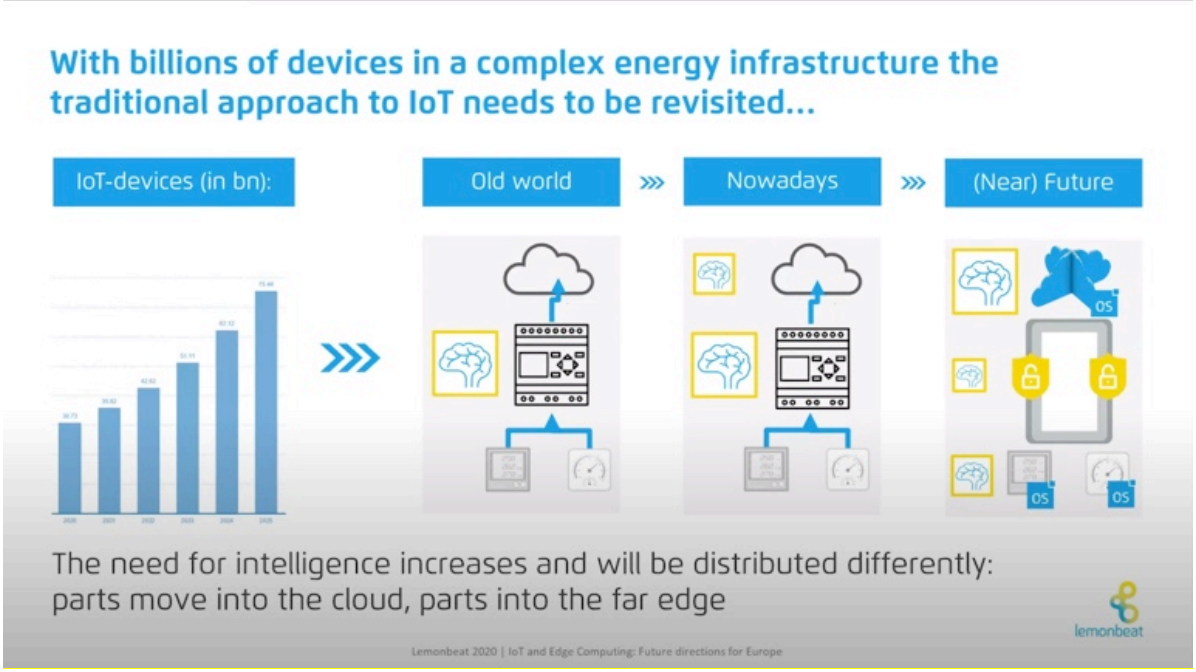
An important requirement for this to happen is to build a solid infrastructure between the Far Edge and the Cloud, where the intelligence will sit. Lemonbeat calls this an IoT communication backbone, which goes far beyond connectivity and is thus not just a 5G question.

Key elements of the IoT communication backbone:

1. It is about device integration, the hardware interface to bring a device into the IoT system;
2. Supporting use cases depend on suitable connectivities and gateways;
3. Flexibility is key, allowing for the connection of different Cloud infrastructures, depending on where the data and information is needed. This will heavily depend on the use case. An additional element is that there is not one, but there are several IoT platforms that can meet special requirements;
4. Everything is at hand to ensure that the established network of devices can be managed properly. This is often underrated with the retrofit solutions, where you cannot really access the Edge, only monitor the network to some degree, but not to the Far Edge to the device level;
5. Across the whole backbone, an integrated security architecture should ensure that the system cannot be compromised.

Key takeaways

1. With billons of devices in a complex energy infrastructure, the traditional approach to IoT needs to be revised.
2. A solid infrastructure between the Far Edge and the Cloud, where the intelligence will sit needs to be built: An IoT communication backbone.
3. To build this IoT communication backbone, and ensure flexibility regarding hardware as well as high security, we need to rely on European players. This is an important industry for Europe. Lemonbeat is a strong supporter of the Zephyr project of the Linux Foundation, which they consider the most successful and active community at the moment.
4. Europe should strive for independence in standards and protocols. Assets in the energy space have a life span of 30-50 years. Dealing with existing protocols in the field is necessary. Rather than a silver bullet solution that can cover everything, we need to adopt a more agile approach and agree on standards for various levels, as it will be too large an investment to constantly replace protocols.
5. Europe needs to focus on interoperability and adopt an open approach.
6. For the most critical parts of the energy infrastructure a reserved radio frequency @450Mhz is superior to other cellular networks.



Food and Farming

Harald Sundmaeker, SmartAgriHubs

This presentation highlighted scenarios and emerging needs, based on the experience gained in more than 80 initiatives from the IoF2020[3] and SmartAgriHubs projects[4]. As a major difference to other areas, such as Smart Cities and Communities or Manufacturing, the Food and Farming domain is challenged by the lack of fast fibre optic or 5G mobile networks in rural areas. In addition, investments are challenged by long payback periods, low profit margins and heterogeneous stakeholders that benefit differently from required investments. Efforts for a successful digital transformation of the Food and Farming sector need to involve a diversity of stakeholders from farm to fork, with a direct involvement of ICT experts, public authorities and policy makers. Such an inclusive approach can realise new scenarios from farm to fork. Acquired data can be transformed into knowledge that will facilitate control of farming activities (e.g. health control, feeding, growth) as well as enable an autonomous control of processes and activities along the agri-food chain.

Key scenarios for Edge IoT in Farming:

- Automation
- Tracking and Tracing (how are we monitoring animals' health, welfare, location, origin, etc.)
- Predictive analysis (implementation of automating to reduce labour costs)
- Supply and Demand (Real time control of environmental conditions).

[3] https://www.iof2020.eu

[4] https://smartagrihubs.eu/portal/open-call

Key scenarios for Edge IoT in Food:

- Smart Trays
- Intelligent Logistics
- Balancing Supply
- Process Control
- Augmented Reality

Key takeaways

Experience gained in the IoF2020 and SmartAgriHubs projects indicates that support for digital innovation through experimentation can guide the way towards a sustainable integration of Edge IoT in the supply chain from farm to fork. But barriers, such as battery lifetime, bandwidth, costs of devices as well as accuracy of sensors need to be overcome. Also, focus should be on the implementation of security, privacy and trust. In addition, a change of mindset among consumers leading to a greater appreciation of farmers' work, could increase the willingness to invest in future Edge IoT based solutions. New business models should be developed to move forward.

Smart Communities

Davor Meersman, CEO of Open & Agile Smart Cities

Open & Agile Smart Cities network (OASC) is a network that connects 150 member cities and communities from 30 countries worldwide to learn from each other and exchange digital, data-driven solutions based on *Minimal Interoperability Mechanisms*. There are three formally adopted mechanisms – Context Information Management, Common Data Models and Marketplace. New MIMs adopted as work items for 2020 are Personal Data Management and Fair Artificial Intelligence. OASC will publish a catalogue of interoperable and operational applications and products for and by cities and communities in October 2020.

OASC main activities

- Two new MIMs: Personal Data Management and Fair Artificial Intelligence to be further developed and adopted in 2020;
- 20+ operational deployments worldwide;
- Free online OASC academy in areas as technology governance, pilots and innovation, open urban platforms;
- The OASC Digital Festival for 48 hours with local and physical chapter events is planned for January 2021.

- Living-in EU[5] is a European initiative, where governments are encouraged to adopt a series of financial, societal and technological measures to increase the uptake and scale of digital solutions, helping cities and communities to increase life quality, and meet climate targets.

Key takeaways

For cities and communities, knowledge gap, vendor lock-in and investment risk are crucial issues due to the fast advancement of technology. OASC helps reducing this gap through building communities of learning and strengthening the demand side through collaboration in order to create a market for Smart Cities and Communities and IoT across sectors and borders.

[5] https://www.living-in.eu

CROSS-CUTTING ISSUES

Cross-cutting issues: Data spaces, processing and networking

Nuria de Lama & Aurora Ramos, Atos

Part 1 – The convergence on IoT and AI –Nuria de Lama, Atos

This presentation addressed cross-cutting issues and thus established links between different technologies and disciplines, specifically with Dataspaces. Convergence of technologies is key, as between AI and IoT. Thierry Breton, European Commissioner for Internal Market and Former CEO Atos, has stated that Europe has everything it needs to lead the technology race. The US has nevertheless been most successful in the platform economy, as they have been able to establish large data lakes, especially in industrial data. So, access to data has tremendous value. Most of this data comes from IoT devices, but it is through the technologies Machine Learning and AI that economic impact is achieved. The value of the European data economy is in 2020: 4% of Europe's overall GDP. The European data hub will be the foundation of a European AI. In 2025, smart sensors in our cities, hospitals, factories or connected vehicles, etc. will create nearly 90% of humanity's data and by 2025, 80% of data will be generated and processed at the Edge, and only 20% in the Cloud.

IoT is key for the generation of data and can be considered as a mature technology with a large economic and societal impact. However, there are still unsolved issues, which we need to address in future agendas, even though moving to the Edge might be a step in the right direction:

- platform interoperability
- data integration
- security and privacy

Moving to the Edge: Transforming data into intelligence

Smart devices need to become smarter, which means giving them more functionalities and bringing in AI. We can start with Machine Learning: detecting patterns and behaviours from data that is gathered from the IoT devices, so the more data you have collected, the better patterns you can discern.

The challenge is how to deal with heterogenous sources of data. In addition, hardware performance, energy efficiency and connectivity issues still need to be solved.

Avoiding fragmentation through collaboration is crucial and partnerships are a key instrument. An example is the AI, Data and Robotics Partnership[6], which is one of the candidates for European Partnerships in digital, industry and space in Horizon Europe. The partnership has identified five cross sectoral AI technology enablers: Sensing, measurement and perception are the relevant enablers for this workshop. This is then the vision not only of Atos, but of the crowd.

[6] https://ai-data-robotics-partnership.eu/

There are particular challenges around sensing, measurement and perception enablers, which still need to be solved:

1. **Trustworthiness**: transparency of algorithms, data processing and management, traceability, privacy, integrity, and accountability;
2. **Capacity**: connectivity coverage, quality, and capacity for carrying large volumes of data, Edge capacity and security to cope with decentralized big data and AI processing, energy consumption by physical sensors;
3. **Heterogeneity**: handling of the heterogeneity of data sources, formats, collection mechanisms, access methods, flows, and meta-data, as well as coping with diverse environmental conditions (physical, technical, human);
4. **Effectiveness**: research and development of measuring mechanisms, methods, and criteria to assess key metrics to evaluate progress, quality, and adoption of sensing-enabled technologies and services;
5. **Scale**: the still insufficient scale of publicly available, quality data (real or synthetic) needed to adequately model the required complexity that represents the physical world(s).

Part 2 – Cross-cutting issues: Edge Computing, IoT ang 5G/6G connectivity –Aurora Ramos, Atos

Moving to the Edge has the following benefits:

1. It brings computation and storage closer to the source of the data, ensuring that the results of analytics and other processing are rapidly available and highly accessible.
2. It addresses latency issues, conserves bandwidth and reduces privacy and security risks by eliminating unnecessary network transmission.
3. It lightens the load of centralized Cloud servers.
4. It is expected to enable a broad spectrum of use cases and applications for which traditional Cloud computing is not sufficient.

Moving network processing to the Edge and higher Edge computing capabilities will be a fundamental technology not only as part of IoT but also in the next 6G mobile infrastructure. The high increase of devices in a hyper-connected world will require that the convergence between mobile 5G/6G and IoT is a must towards 5G-IoT. Future communication services should also offer higher reliability and flexibility in an autonomous way in a changing environment and connectivity will have to involve even more high data intensity for AI based network management, besides the data for AI execution at the Edge. Current and future work needs to integrate mobile connectivity and computing with core Cloud, and AI-based automation.

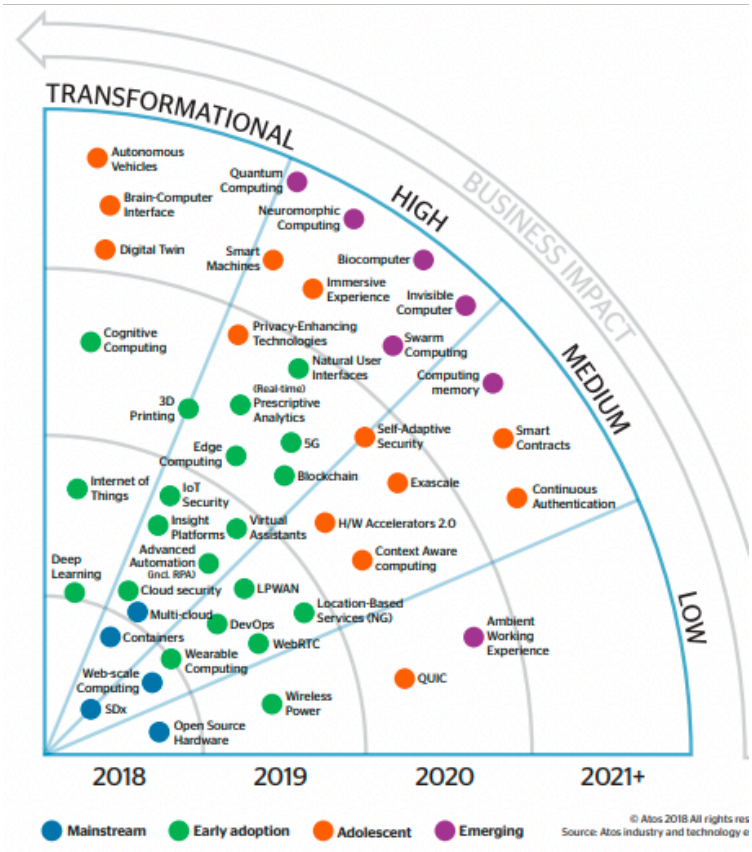
Already joint efforts are underway with:

- ETSI NFV: focused on general architecture for core Cloud resources where the network functions are deployed; now moving to Cloud-native orchestration - easier technical link with MEC.
- ETSI ENI: provide interfaces specification for the inclusion of AI for predictive management.

Edge computing is currently being tackled by multiple fora and standardization bodies from different perspectives (5G mobile management, Data processing and IoT, Cloud computing), and an effort to find technical synergies and converge should be carried out to avoid fragmentation.

Edge computing can be seen as an evolution of Cloud Computing:

- **Edge Management and heterogeneity**: Management of potentially thousands/millions of small diverse devices and sensors will require new management styles, potentially decentralized and able to scale to degrees that nowadays are unprecedented in existing Cloud architectures.
- **Across Edge execution orchestration**: Edge set-ups are envisaged to spread covering wide geographic areas. For serving applications and services that make use of these distributed set-ups, mechanisms for deployment, provisioning, placement and scaling service instances across execution zones are necessary.
- **Edge Workload management**: Considering different types of workloads (monolithic or interactive) as well as the different processors types where these workloads can be computed, the final encapsulation solution may vary. Systems able to deal with different encapsulation approaches (VMs vs. Container) will be encompassed and mechanisms capable of balancing between high-performance processors and low power processors according to the final objectives of the workload should be taken into consideration.
- **Data abstractions**: There is a need for data intensive applications able to manage more data coming from distributed and heterogeneous sources. Tools are required that enable data management scattered on a heterogeneous and distributed environment dealing with the underlying complex infrastructure composed by smart devices, sensors, as well as traditional computing nodes.
- **Admission control**: Considering the volatility of resources not traditionally considered in Cluster and Cloud computing.
- **Off-loading optimization**: off-loading workloads across diverse Edge/Cloud infrastructures.



Key takeaways:

- Edge computing is a key technology for IoT and 5G/6G to support applications with more stringent requirements, zero-latency, higher capacity and massive connected devices.
- Edge computing is currently being tackled by multiple fora and standardization bodies from different perspectives (mobile comm, IoT, Cloud), an effort to find technical synergies and converge should be made to avoid fragmentation.
- Key current challenges for Edge computing are: decentralized management, distributed setups, data intense heterogeneity, volatility of resources and integration with connectivity.
- But, not all traffic can be taken to the Edge! – limitation of resources, cost, energy consumption a-trade-off - integration with core Cloud.
- Expected future evolution of Edge computing: Swarm computing, brings a lot of potential combining connectivity and Edge computing together with multi-Cloud computing, based in a collaborative environment.

Architectures, interoperability and orchestration

Omar Elloumi, AIoTI and Nokia

The presentation *Architectures, interoperability and orchestration* addressed challenges in building Edge infrastructure in conjunction with mobile networks. Nokia is a network provider. Motivations for Mobile Network Operators (MNO) to go to Edge Cloud are about demand on the one side, with industrial IoT application (IIoT), V2X, Gaming, and AR/VR applications. The Mobile Network Operators have also huge opportunities in terms of the points of presence that they can leverage right away in order to build infrastructures for Edge computing, including Far Edge and Deep Edge preceptors. This can be done up to 5 km proximity to the users and even closer.
Additionally, 5G is just around the corner: Features in 5G such as Ultra-Reliable Low Latency Communications (URLLC) and massive Machine Type Communication (mMTC) call for complementary Edge computing capabilities to realize the full market potential of 5G. The market ingredients are there to build massively distributed Edge Cloud infrastructure with time to market.

The question is: If Cloud computing has existed for so many years, why does deploying Cloud at the Edge make things any different? Looking at the evolution of the Cloud, it started with building virtual machines, then applications, a move to container, followed by orchestration clusters. With these clusters, you get certain capacities, and that comes with attributes, like horizontal scalability, no single point of failure, high availability, high through-put, low latency, etc. An extremely important point for IT developers is that, once you have an application with market demand, you can build your Cloud infrastructures with only 5-10 engineers. In the past you needed 100s of engineers to build scalable IT applications with high through-put. This brings a huge innovation potential, as also garage start-ups can start building IoT applications. Things are now moving serverless, where there is no need to care for scaling up and scaling down.

Thus, the entry point for developing applications in the Cloud becomes lower and accessible for all developers. It is key to start to have commercial grades of software which is open source that can be used ‘off the shelf’, accessible to all.

Challenges that need to be solved in an Edge computing environment and particular in MNO.

- Discovery of, and optimal (re)-routing to an Edge Cloud capable of serving application clients (running on devices). When an application client wants to reach a server application, there is a need to discover the optimal Edge Cloud, one which runs instances of the server application, has the necessary resources (CPU, GPU, etc.) and provides the lowest network latency.
- Service continuity: when mobility occurs, it will be beneficial to seamlessly transfer the context from a stateful application instance in an Edge Cloud to an instance of the same application in a target Edge Cloud, e.g. one that provides a lower latency.
- Smart application placement to allow the optimized deployment of applications at the Edge infrastructure based on criteria such as available resources, geographical areas, cost and latency requirements.
- Cloud applications would enhance the user experience if they could leverage services offered by the network: accessing information and services provided by the Edge services such as the device location or QoS are key to enhance the user experience.
- Edge federation across multiple MNOs: allowing MNOs to offer to the developers/customers the possibility to deploy their software across multiple domains and ensure service continuity when roaming on alternative networks.
- Europe needs to advance on standards, as we have multiple stakeholders and providers that need to work together across systems and sectors.

Demand, supply and regulators

Ilkka Lakaniemi, Business Development at Combient

Combient (Combined Entities) is a Nordic industry network. Combient provides a collaborative platform for the industry around digitalization and surrounding ecosystem enabling industrial digital transformation. Combient acts as a trusted advisor and facilitator of knowledge sharing and co-innovation/experimentation.

Combient's work is user and business case driven rather than technology based. The starting point is the identification of technologies that make the most sense for a specific purpose. Talking about the implementation of technologies in companies, the perspective of skills is often lacking. Combient focuses on the capacities and the maturity of companies to implement data driven new businessmodels or pilots. Skills development is key to guide the existing work force in use new technologies, customised to the companies where it makes most sense from their perspective.

SESSION 3: TECHNOLOGY: HARDWARE, SOFTWARE, SYSTEMS

Smart Sensors and Systems

Gerald Fritz, Senior Manager Innovation Projects and Funding at TTTech Computertechnik

TTTech Group presented their insights into the automotive industry and the challenges they are facing in autonomous mobility experience. The ultimate challenges are increased complexity and thus costs. The American approach relies heavily on cameras, while the European approach relies on sensors. The number of sensors is very high and to analyse the data and integrate is highly challenging. The interoperability of subsystems in the car to work together is crucial for having the functionalities available also for future extensions of functionalities.

Bridge to Edge and Cloud

For the future, having the application in the car integrated with the sensor information, you also need the connectivity up to the higher-level Edge infrastructure. As well as the Cloud infrastructure to update functionalities regarding the sensors or autonomous functionalities in the car. The sensors are not just data providers for raw data, but they are smart sensors. These sensors have models behind them, learned models, based on a huge amount of data. These models are to be improved in the future and enhanced with the data of the individual cars to get better results, based on the number of cars on the road.

So, the question is how to establish a data centre, where all this data of multiple cars can be processed together. Key competences are: Connectivity to Edge backend, and to Cloud backend. This needs to be technology-ready so you can rely on the functionalities. A necessary feature is cross border service continuity.

Key messages and recommendations:

Revolution in the automotive industry could be seen in three changes:

- from dedicated HW appliances to software platform,
- source best in class solution elements,
- faster innovation cycles.

Neuromorphic Sensing – Extreme Edge AI

Ilja Ocket, Program Manager at iMec

We need massive datasets for deep learning, building intelligent systems. However, this does not scale very well. One approach is going to be neuromorphic technologies. The challenge is to let these neuro-networks learn with very little data. Automation is a clear example, where current approaches are hitting a bottleneck. Adding more sensors will not necessarily bring better systems. So, we need a technology breakthrough: Neuromorphic sensing is the marriage between neuroscience and semiconductor technology. This means using the principles of the brain and leveraging semiconductor

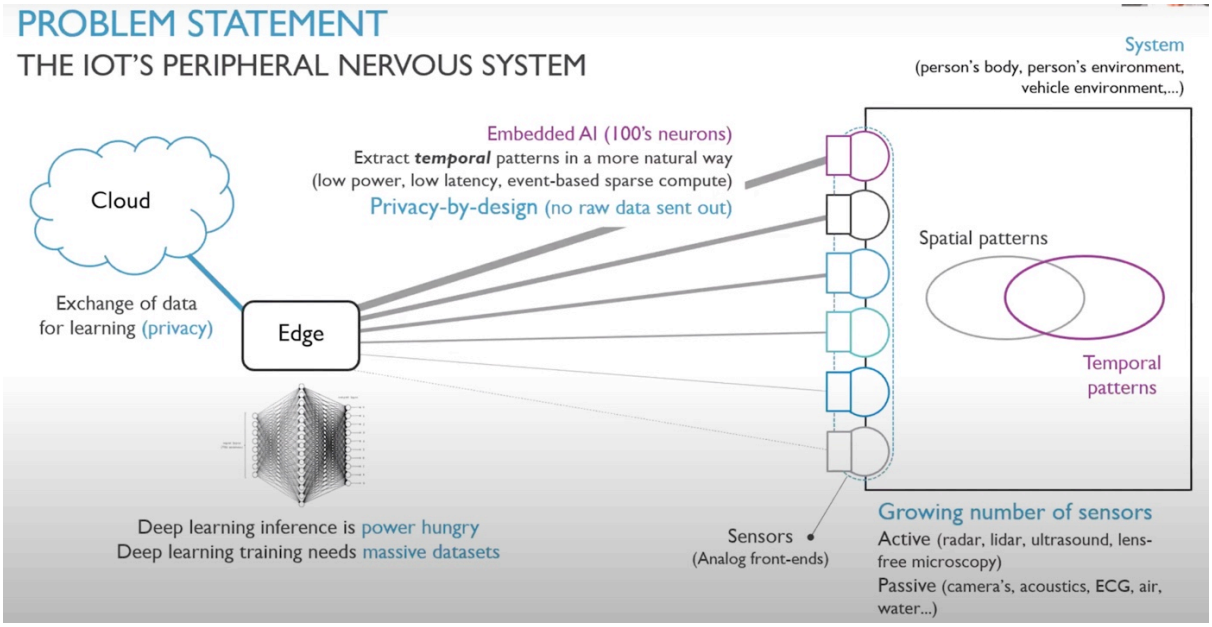
technology to create neuromorphic (mixed signals) architectures for which we can develop algorithms to solve real-world sensing problems. Data is used but it is mostly a matter of developing the right algorithms to determine what kind of architectures we build in silicon.

Inspiration from neurological principles, brains use:

- feedforward and feedback
- time (spikes) to compute
- sparse distributed representations
- hierarchies to construct complex concepts
- do not use backpropagation to learn.

With the right type of neurons and the right type of algorithms, you can reach the same kind of accuracy levels as the traditional algorithms.

The goal is not to do all the decision making in the Cloud but close to the Extreme Edge



Energy Grid and Edge Computing

Henrik Madsen, Energy Center Denmark, Technical University Denmark

This presentation focused on how to use IoT and Edge technologies in the energy grid in order to progress towards the green transition. The challenges the Danish energy system is facing is to get rid of the fossil fuels and only have renewables was also featured. Currently approx. 50 percent of the Danish energy is derived from wind energy. At times this is more than 100 percent, so flexibility is need. The central hypothesis is that by intelligently integrating current distinct energy (heat, power, gas and biomass) and water components using AI, IoT, Edge, Fog, Cloud computing, we can unlock the flexibility needed to balance very large shares of renewables - and consequently obtain substantial reductions in CO2 emissions.

Orchestrating the Edge

Marc Duranton, CEA HiPEAC

The vision for the future of the evolution of the Web and IoT was presented. Web 1.0 was a one way road. What was new was that the user could upload data to the server. The web is now a more specialized hub for services.
The added value of IoT is in moving across the verticals. We see a movement towards more horizontal platforms that still can keep up with the complexity of the sensors. Programmes are executed in the continuum, part at the Edge, part locally or in the Cloud. This digital continuum is dependent on collaboration between various stakeholders.

Challenges in the continuum

- Fragmentation: We need to overcome the fragmentation of vertically oriented closed systems. Thus, move towards open platforms and standards.
- Heterogeneity/interoperability. How to handle the numerous types of devices, protocols, standards and non-functional requirements?
- Scalability. How to handle the big number of connections/big data coming from millions of devices.
- Dynamicity. Plug & Play, self-configuration, self-management, self-matchmaking.
- Privacy issues

The core of the proposal is the notion of advanced orchestrators, which we call “Guardian Angels”, loyal to their “users” and being at the interface of the physical and virtual world.

5 INTERACTIVE SESSION ON ENABLING TECHNOLOGIES

Interactive session on enabling technologies

Ovidiu Vermesan, Chief Scientist, SINTEF

The convergence of technologies is extremely important. IoT and end applications get support from other technologies, such as AI, Edge Computing, Distributed Ledger Technologies, Wireless and cellular 5G and beyond, Digital Twins, and at the same time, IoT applications reinforce these technologies and further develops them, bringing new features to these technologies. Edge computing is filling the gap between centralized Cloud and the need for decentralized processing continuum medium for IoT and industrial IoT and for using Edge computing in vertical and horizontal IoT platforms.

Edge computing paves the way for IoT intelligence, connectivity and AI convergence. Edge computing will contribute to the evolution of IoT, moving from the Cloud-centric solution to decentralisation, and, in the next decade, a fully distributed computing architecture. In this evolution, the other technologies converge in bringing the features that are needed to move to distributed architecture with federated learning, which brings AI models close to the Edge. With this role of the Cloud, that can lead to a federation aggregation role and collaborative work for IoT devices and discovery. We see a shift from Cloud-centric processing and intelligence to more distributed IoT architectures. The development of the technologies is supported by the development in AI based components. AI will become part of the IoT devices and components.

Key message

Convergence of technologies is key. There is a technology push which will evolve IoT from centralised to more decentralised computing architectures in which other technologies converge to bring features close to the edge. Accordingly, the developments of technologies are supporting this transition from centralised to decentralised architectures with the development of AI-based components and devices and of intelligent IoT/IIoT Edge ecosystem devices to platforms.

Short interventions/presentations from the audience floor

IoT, Edge Computing and AI Technologies and its future impact on the next generation of IoT nodes

Antonio Skarmeta, University of Murcia

This presentation focused on the interaction between IoT, the Edge, and AI. It addressed the question of how the next generation of IoT nodes will behave based on the new capabilities generated via new technologies. One of the technologies, perhaps somewhat overseen, is the impact that 5G is providing to the current paradigm shift. Not only because of the communicational element, but because of the capabilities that it is offering to have a very distributed processing scenario.
This paradigm shift brings new opportunities and challenges:

- IoT devices and the emergence of 5G in our daily lives are bringing new data-driven and increasingly autonomous scenarios.

- Possibilities of hugely distributed processing capacities from IoT-Edge-Cloud in a continuum:
  - New services require efficient and effective management of computing and networking resources.
  - The means to deal with huge amounts of data and at different levels of the future NG infrastructure.
- Need for configuration, architecture and coordination of processing nodes at different levels: end-device -Edge-Cloud and beyond.
- Need for intelligent methods to offload processing operations to the proper levels of the computing network to meet e.g. delay and processing constraints, security.
- Support heterogenous processing infrastructures offering decentralized and adaptive coordination of virtual resources that accommodate QqE, mobility and security requirements.

Identified research and innovation opportunities

- Tactile internet & AI to control objects remotely.
- Intelligence methods to optimize the offload process in operations to the proper level of the computing continuum.
- Distributed model for assigning computing resources.
- Increase the embbeded intelligence of the devices.
- Contextual management and reactive adaptation.
- Active and adaptive security within IoT lifecycle and mobility and transition of the devices.
- ML techniques can be key for a more effective detection and mitigation of security and privacy attacks.

Conclusions

- AI within devices is just the first step towards the development of completely intelligent and evolutive systems.
- Evolutive Artificial Cognitive Capabilities (EAAC) mechanisms will open the door for designing devices and systems with a superior intelligence that will permit them to meta-learn from new situations and environment.
- Security VNFs can be timely and dymanically orchestrated through policies to deal with heterogenity demanded by these distributed IoT deployments, than can be deployed either at the core of at the Edge, in VNF entities , in order to rule the security in IoT networks.
- Dynamic and intelligent reactive provisioning of services and resources with the Edge of the network can enhance scalability, necessary to deal with IoT scenarios.

The role of Cloud – Edge scenarios for applying distributed ledgers solutions in an energy related context

Artemis Voulkidis, Synelixis

The energy sector represents a critical infrastructure that is facing challenges. The energy sector is also particularly critical as it is related to other critical infrastructures and the increased renewable penetration is causing instabilities to the power grid. Intelligence control leaves the door open to automation. Cyberattacks are thus always a potential and form a high risk. This is where Blockchain as example of distributed ledger can come in. Smart grid control largely depends on timing monitoring.

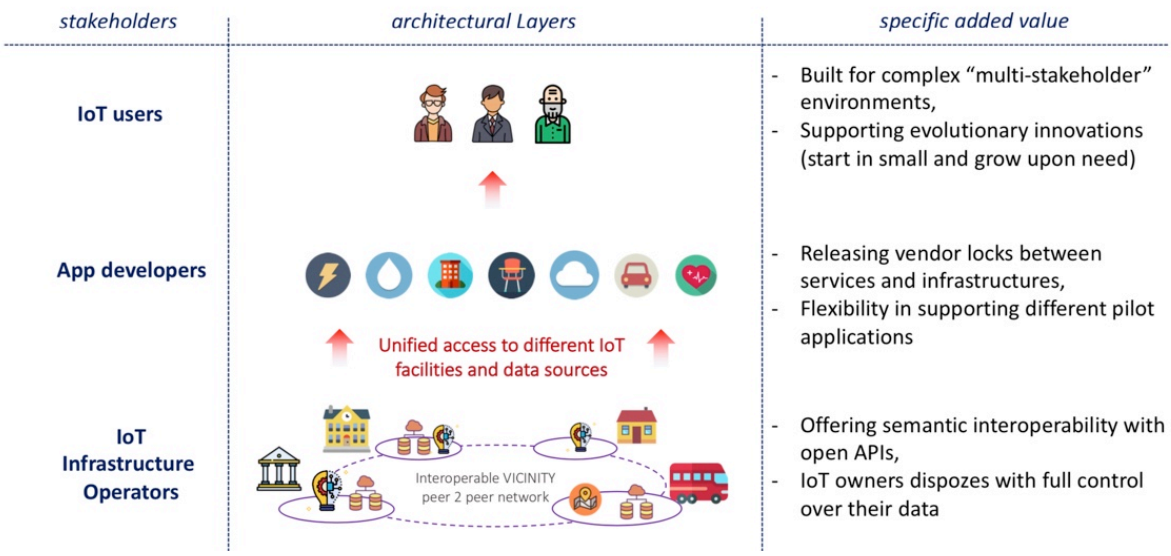
Blockchains are stellar examples of distributed ledgers which can be used in the energy sector to solve data security and confidentiality as a key issue. The necessity for Cloud-Edge approaches in the scenario where Blockchain-related operations are integrated, represents computationally intensive operations.
Transactive energy approaches are the future of renewable integration in the current grid.

- Data security and confidentiality are key factors that can partially be addressed by keeping the local data at local level (Edge) and by ensuring data sovereignty.
- The role of Cloud Edge architectures and 5G is crucial to offload computationally intensive operations to the Edge instead of the Cloud.
- Cloud Edge architectures with 5G communications empowers blockchain-powered energy networks.
- Digital twins could be used for mitigation issues: lower communication latency, faster development lifecycle (faster evolution of services), increased resilience, local data keepers.
- AI-powered Cloud-trained digital twins operate better at the Edge: with low latency and closed-loop integration of analytics and local control.
- Cloud-Edge architectures coupled with 5G communications actually empower blockchain-powered energy networks.

An option for decentralized interoperability

Nathalie Stefan Vanya, AIOTI

The Vicinity project provides decentralized interoperability as a service, as a peer-to-peer architecture with open APIs. It offers to connect existing platforms. This approach makes the sevices independent from IoT infrastructures.



Still certain challenges in a decentralized environment are: protecting users' privacy at metadata level, lack of business models in decentralized ecosystems and convincing data owners to share their data.

Edge-based solutions for Energy Systems

Antonello Monti & Alberto Dognini, RWTH Aachen

This presentation presented results of a few projects, e.g. the Horizon 2020 project SOGNO - *Service Oriented Grid for the Network of the Future*.
To solve the challenges in the electricity grid, several ingredients need to be brought together:

- the need of low-cost sensors that provide high accuracy;
- visualization at the Edge, create a standard architecture for the Edge, where we can plug in several services;
- the application of 5G for the data position and Edge management;
- data analytics and deep learning.

Across sectors

- To support sector coupling and to move into Smart Cities and Communities, energy platforms need to open up.
- As example, FIWARE offers a solution to break down the silos and bring data together.
- In general, Cross- domain approach (Energy, Agriculture, Manufacturing and Healthcare) is used by Open-DEI to detect gaps, encourage synergies and support.

AIoT and TinyML : The low-power compute revolution at the very Edge

Csaba Kiraly, Digital Catapult UK

Computing needs to move closer to the Edge. How close is the key question, depending on capabilities. We are facing a new computer revolution: during the last two years, AI has become a first-class citizen in the micro-computiong space. The largest initiative is TinyML: ultra-low power (>mW) Machine Learning technology enabling battery-operated on-device analytics at the very Edge.

What is driving this change? There is fast progress on enabling technologies:

- Model compression (quantization, pruning, etc.) to <250 KBytes
- Hardware architectures
  - Near-memory, in-memory, on-sensor AI
- Software frameworks and toolsets are evolving.

Even more important is the change in the programming of embedded devices.
Powerful data-driven programming for embedded devices:

- Enabling new **use cases.**
- Enabling wider **developer ecosystem.**

The future of compute is Tiny:

- MCU based Things are everywhere
  - >250 billion microcontrollers in the world today
- MCUs and SoCs are getting cheaper
  - 0.50$ Average MCU Selling Price in 2020
- No good data should be left behind
  5 Quintillion bytes of data produced every day by IoT, *Source: Cisco*
- MCU compute is now cheaper than comms
  32x32 Image classification @ 0.15 mJ per inference
- LPWAN image transfer @ 10-100 mJ per image

Early adopters

PIR and People counting
© GreenWaves
Autonomous Drones
© ETH Zürich
Always-on Voice Commands
© Synthiant

Research and Innovation priorities - a look ahead

What we do to encourage innovation

- - Performance benchmarking: Tiny MLPerf.

- - Encourage innovation to improve the state-of-the-art low-power ML.
- - Accelerate progress in TinyML via fair and useful measurement.
- - Accelerator programmes for start-ups and scale-ups.

The big picture

- - Enable data-driven innovation in previously untapped domains.
- - Research directions.
- - Sustainable energy-neutral deploy-and-forget devices.
- - Thing-to-Cloud orchestration of compute and communication resources.
- - From inference to low-power learning (not yet here) at the very Edge.

Virtual panel discussions

What is the added value of integrated IoT, Industrial IoT and Edge computing solutions?

The added value of having Edge computing processing huge volumes of data in the industrial sphere is predictive maintenance, to add quality assessment to images, and different kinds of sensing techniques.

Vertical farming has many complexities in the management of subsystems that need to be coordinated, and is costly. The capability to provide decision making that is close to the actuators, distributed computation and intelligence to know what to do in different spaces.

From the energy perspective, moving to the Edge is a necessity. We are moving from a situation where we previously had a few large powerplants, we now need to orchestrate millions of devices. So, it is not a question of value but it is an enabling technology.

We need to build new infrastructures on the Edge. We have to build additional infrastructures not only at the media level but in the Cloud. We have only limited resources, if we do not build infrastructures at the Edge, we are losing user engagement, flexibility, energy efficiency. Going upstream is just too costly.

Now the world becomes more complex, and we move to smart integration across the verticals. So, the architectures and the role of Edge for the holistic picture is more complex and for the future research area it is there where we need to focus on how we can extend the architectures and how the distributed Edge can have a role.

The Edge has a potential to transform IoT. The Cloud Edge renders IoT Realtime and interactive. The one thing that was missing was, together with 5G, low latency. With the advent of 5G combined with Edge, IoT is not only about monitoring but also about control

Which IoT and Edge Computing enablers do you consider as being key for the future development and integration of these two technologies?

And on the platforms: Which IoT and Edge platforms do you consider for several sectors and how do you envision these platforms for the future?

Digital Twins in the energy domain are great. For the sectors, we do not have a one size fits it all. It is much more complex and depends on the context.

The open platform is what we are having in the future and will be the key enabler in the future.

Orchestration and the use of open platforms that facilitate work on heterogeneous environments are the key enablers.

Two key ingredients: the main learning is that we need open source and a combination of open source solutions, so we do not need to start from scratch. And then a critical factor is the interface and API definition.

For integrating IoT, there is a very good open source platform Open Hub. Besides open source there are Open Source Foundations.

What are the obstacles to build integrated IoT Edge computing systems and applications today?

- Heterogeneous devices and data.
- The lack of standards and interoperability (are the biggest obstacles for integration).
- Costs in case you have large amounts of devices for building solutions.
- Investment and policy cycles.
- Security: how to maintain a certain level of security, when you operate in multidomain realities.
- Connectivity.

Which objectives should be set to improve EU competitiveness?

The EU is well positioned. We see a revolution in the energy sector that is very sustainable and where the US is largely behind. The question is whether we have enough flexibility among the stakeholders to make the changes. The strength of Europe is its diversity, but this is also Europe's drawback. We thus need standardisation and interoperability. Another step is to focus on non-critical sectors, such as gaming and robotics. Security and IoT Cloud Edge is a European strength.
Scaling up is one of the EU challenges. We have plenty of innovation at the start-up level. But harmonization across the Member States is very much needed. Also, the potential, in the energy sector specifically, or cross domain – smart cities and communities, climate change, here we can move faster. The separation of the critical assets and the services that the energy sector can provide is an important consideration We can go faster here with Edge deployment.

6 CLOSING REMARKS

Martin Brynskov, Coordinator NGIoT, DITCOM Aarhus University

A few observations: technology cannot just be pushed out. We need to work collaboratively, across the Quadruple Helix model – the private, public, knowledge institutions, and civil society. The latter has a very strong position in EU policies and strategies. The question is: how much of this vast IoT, needs to be synchronised? Here are many dilemmas to address – Decoupling to increase speed, sovereignty versus economy at scale. Technology, governance and timing are key. NGIoT will continue to work to highlight the priorities that we hear from you, and broadly from Europe, inspired by the world. We will facilitate and mobilise the community and create a roadmap with priorities and timing together with you. We have research, we have the market, society and we have an urgency. So, speed is the essence. So, the timing of what to do when – will be our focus now.

Rolf Riemenschneider, DG Connect European Commission.

IoT is a highly interdisciplinary domain. There is a strong need from the sectors, particularly driven by decentralisation, moving automation and decisions on a decentralised level and keeping information and data on a decentralised level, which globally represents a complete paradigm shift from what we have today. It does not make things easier. It is certainly cross disciplinary – to bring different technologies together from IoT, AI, Cloud data, 5G, Microelectronics.

We see a paradigm shift for IoT. We are moving from monitoring and connecting things to outcome driven and automation processes. Much of the data is increasingly processed locally, transformed into knowledge and information. We have seen a trend towards more intelligent sensors, emerging mobile Edge. We have seen different flavours of architectures from Deep/Far Edge.

The European Commission wants to avoid new islands or silos, so we need to ensure interoperability and keep an eye on federated learning, energy consumption, energy in the context of decentralised architectures, deep learning, especially in development and advances in AI and Edge.

We need to define what we mean by orchestration between Cloud, Edge, on the one hand, and computing, virtualisation and meta operating systems. At the same time, to keep the strong attention on innovation and development on the device level; keeping end-to-end security, looking at new standards, open software, open hardware; and to see what is added value for the European industry; what are the business models, what sort of investments are needed to support the infrastructures, and what can we do on the regulatory side, on the side to bringing public money into the game, and bringing stakeholders together, partnerships and drive innovation that gain speed and adoption.

Max Lemke, Head of Unit IoT, DG CONNECT, European Commission

The presentations show that moving from Cloud to Edge is two directional: We see more intelligence at the Edge, but we also see the federation of Edge resources to support the Cloud. There is a demand for the movement from Cloud to Edge from applications in industry, manufacturing, Smart Cities and Communities, Food and Farming, a push for decentralization and a need for intelligent sensors and intelligent devices.

The question is – how quick will that go? And how can we, as we are good in the Edge or in the applications, how can that help Europe to position itself better? And what can we, as the Commission do to strengthen our EU players in terms of research, innovation, platform building and policy?

POLL RESULTS

Poll Session 1

What are the most challenging aspects related to the Edge IoT Paradigm shift from an application/market perspective?

- Legal aspects.....3%
- Regulatory aspects..... 28%
- Technological aspects..... 49%
- Educational aspects..... 10%
- Other.....9%

Poll Session 2

What are is the way ahead?

- Standardisation.....67%
- Regulation.....9%
- Policy making.....15%
- Other.....9%

Poll Session 3

What are the major complexity factors?

- Smart sensors.....17%
- Smart devices.....61%
- Smart architecture.....22%