IoT and Edge Computing-Future Directions for Europe

Cross-cutting issues: Data spaces, processing and networking

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Part I

The convergence of IoT and AI

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"Europe has everything it takes to lead the technology race"
Thierry Breton, European Commissioner for Internal market

► The success of big platforms is mainly the result of a homogeneous data market which makes possible to create **very large data lakes, which in turn feed machine learning and artificial intelligence applications**

  – Value of the European data economy in 2020: **4% of Europe's overall GDP**

  – The European data hub will be the foundation of a European AI

► In the world of 2025, these objects – smart sensors in our cities, hospitals, factories or connected vehicles – will create nearly **90% of humanity's data**

► By 2025 **80% of data will be generated and processed at the Edge**, and only 20% in the cloud

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IoT evolution

▶ After more than ten years of research and innovation activities, IoT is now a mature and transforming technology with billions of devices deployed

#interoperability #platform #ecosystem #security #standard #protocols
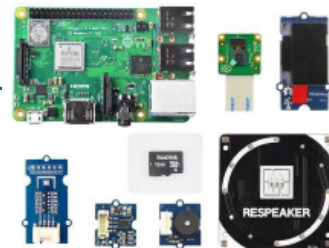#interoperability # interoperability #interoperability

#data

▶ Still not solved the complexity of the landscape and security and privacy issues

▶ Second Phase of IoT, it is time to exploit all the gathered data to turn these pieces of silicon, chips, copper and steel, into a more functional device

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Future

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Transforming data into intelligence*

▶ AI technologies are mature enough to provide us the tools for the required data analysis, in these huge and complex scenarios

▶ **Machine Learning** would be the most suitable for IoT scenarios

- Based on detecting patterns and behaviors from gathered data
- The more data you have, the more past experiences will be analysed, and better patterns would be modelled
- Gathering data is not an issue for IoT.
  - Technologies as image recognition for pictures
  - Data integration is not evident.

▶ Power demanding calculations is an issue for IoT

- **Hardware performance**
- **Energy efficiency**
- **Connectivity issues**

HW with AI capabilities on the edge

https://atos.net/en/blog/artificial-intelligence-second-phase-iot-part-1   AtoS

Have your say on the AI Partnership
https://ai-data-robotics-partnership.eu/

European Partnership on Artificial Intelligence, Data and Robotics

Cross-Sectorial AI Technology Enablers

Sensing Measurement and Perception

Continuous and Integrated Knowledge

Trustworthy Hybrid Decision Making

Physical and Human Action and Interaction

Systems, Methodologies and Hardware

A joint initiative by:

BDV BIG DATA VALUE ASSOCIATION   CLAIRE   ellis European Laboratory for Learning and Intelligent Systems   EurAi   eu ROBOTICS   European Commission

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Data Deep Dive: Technology Enablers – Sensing and Perception (source: SRIDA AI, Data and Robotics Partnership)

► **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)

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Part II

Cross-cutting issues: Edge Computing, IoT and 5G/6G connectivity

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Trends
Convergence Edge Computing, IoT, 5G/6G connectivity

▶ Future networks are expected to provide zero latency communications and high capacity as required by applications as autonomous driving, remote surgery, mission critical/PPDR, etc.

→ 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 an hyper-connected world will require that the **convergence between mobile 5G/6G and IoT is a must towards 5G-IoT**

▶ Future communications services should also offer higher reliability and flexibility in an autonomous way in a changing environment

→ connectivity will have to involves **even more high data intensity for AI based network management,** besides the data for AI execution at the edge.

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Edge computing – different perspectives - fragmentation risk

► Edge computing is being tackled from different technical axis, and therefore across multiple standards and open source fora related to:

- Data processing and IoT
- Cloud computing
- 5G mobile management

Standardization bodies	Open Source Foras	Industrial associations
ETSI	ONAP	5GACIA
TMFORUM	Openstack	5GAA
3GPP	Cloudify	Industrial Internet Consortium
……	Edge Computing group	……
	Openess	
	LF Edge	
	OSM	

► Need to avoid ecosystem fragmentation → to achieve technological convergence

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Edge computing evolution from 5G/6G mobile connectivity perspective

► **Multi-access Edge Computing (MEC)** [ETSI MEC] as natural development in the evolution of mobile base stations and the convergence of IT and telecommunications networking. Considering as use cases:

- video analytics, location services, IoT, augmented reality, optimized local content distribution and data caching

► Current and future work needs to **integrate mobile connectivity and computing with core cloud, and AI-based automation**. Already joint efforts with:

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

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Edge Computing Research Areas as evolution of cloud computing

► **Edge Management and heterogeneity**: **Management** of potentially **thousands/millions** of **small diverse devices** and sensors **will require** of **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 be 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. System able to deal with **different encapsulation approaches** (VMs vs. Container) will be and mechanisms capable to **balance between high-performance processor and low power processor** according to the final objectives of the workload should be taken into consideration.
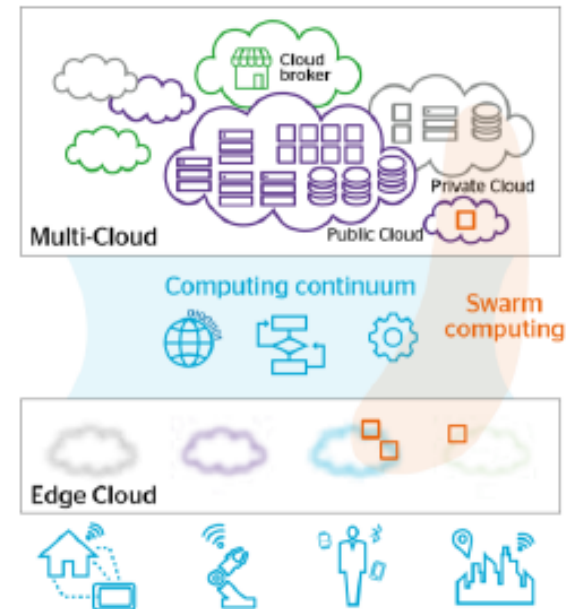
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Edge Computing Research Areas as evolution of cloud computing

▶ **Data abstractions**: need of data intensive applications able to manage more data coming from distributed and heterogeneous sources → Tools that enable managing **data 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 **volatility of resources** not traditionally considered in Cluster and Cloud computing

▶ **Off-loading optimization**: off-loading **workloads across** diverse of **edge/cloud infrastructures**

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The future: Swarm management among IoE, Edge and Cloud Computing

► Swarm computing combines **network** and **cloud principles** in order to create an **on-demand, autonomic and decentralized computing and storage management**

► Swarm computing is the natural evolution of cloud and IoT, while at the same time, being a **combination of complex and diverse typologies of multi-cloud architectures with edge computing**.

► So it will solve two key current challenges:
  • Need for orchestration with core cloud services
  • Integration of connectivity and computing

https://atos.net/wp-content/uploads/2018/12/atos-swarm-computing-white-paper.pdf

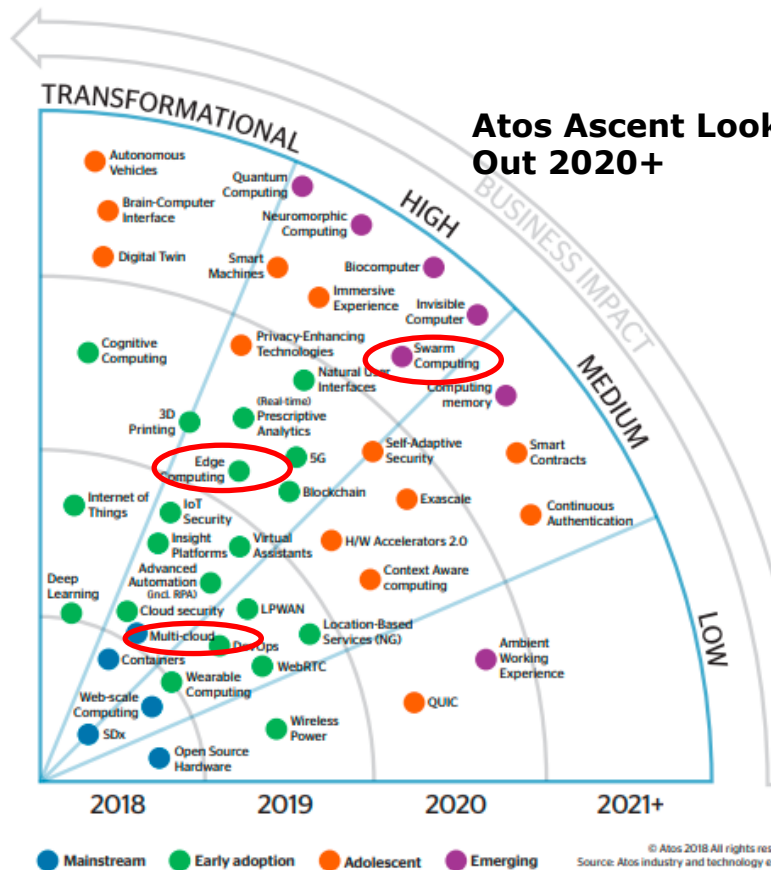# The future: Swarm management among IoE, Edge and Cloud Computing

▶ Dynamic eco-systems of clouds, each adding to the collective capability

▶ Allows operations and interactions to adapt according to context

▶ Improved efficiency and reliability of service provision through:

  – Enabling ad-hoc collaborations, which help built service networks

  – Optimizing delivery schemes and communication patterns, which enable information and services to be shared and exchanged

▶ Provides a significant step toward massively distributed computing models

Advent of fully distributed, opportunistic collaborative environments encompassing complex IoT devices, cyber-physical systems, edge and clouds, each of these adding to the collective capability and insight.

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Wrap-up

- Edge computing **<u>key technology for IoT and 5G/6G</u>** to support applications with more stringent requirements, zero- latency, higher capacity and massive connected devices.

- Edge computing is being currently tackled by multiple fora and standardization bodies from different perspectives (mobile comm, IoT, cloud) , an **<u>effort to find technical synergies and converge should be done to avoid fragmentation.</u>**

- Key current challenges for edge computing: decentralized management, distributed setups, data intense heterogeneity, volatility of resources and integration with connectivity. But, not all traffic can be take to the edge! – limitation of resources, cost, energy consumption → trade-off - integration with core cloud.

- Expected future evolution of edge computing: **<u>Swarm computing,</u>** brings a lot of potential combining connectivity and edge computing together with multi-cloud computing based in a collaborative environment.

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Thanks!

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