5G-enabled Next Generation Internet of Things

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Presentation Outline

- ITHACA Lab
- Next Generation - Internet of Things (NG-IoT)
- NG-IoT Trends
- 5G/B5G & NG-IoT: Enabling Technologies
- Radio Access Networks
- Edge Computing
- Software Defined Networking & Virtualization
- 5G Base Station Prototyping
- Toward 6G Networks: Vision, Requirements, and Research Directions

Panagiotis Sarigiannidis

- *Full Professor*
  Department of Electrical and Computer Engineering
  University of Western Macedonia, Kozani Greece
- *Director of ITHACA lab (https://ithaca.ece.uowm.gr/)*
- *Co-founder of the 1st spin-off of the University of Western Macedonia: MetaMind Innovations P.C. (https://metamind.gr)*

✓ 21 Members
✓ 10 PhD Students
✓ 2 Post Doc researchers
✓ 8 H2020 & HE projects

✓ 17 Projects in total
✓ 350+ Publications
✓ Over 4.1 million € in total budget

✓ 7 projects coordinated
✓ 9+ awards
✓ Over 100 collaborating partners

TERMINET: nexT gEneRation sMart INterconnectEd ioT

https://terminet-h2020.eu/

iTHACA
https://ithaca.ece.uowm.gr/

- ✓ Call: H2020-ICT-2018-20
- ✓ Topic: ICT-56-2020
- ✓ Type of action: RIA
- ✓ Total Budget: € 8.000.000,00
- ✓ Active period: 1 Nov 2020 – 31 Jan 2024

TERMINET

TERMINET aims at providing a novel **next generation reference architecture** based on cutting-edge technologies such as Software Defined Networking (SDN), multiple-access edge computing (MEC), and virtualisation for next generation IoT. In addition, TERMINET introduces **new, intelligent IoT devices** for low-latency, market-oriented use cases. Finally, TERMINET intends to bring more **efficient and accurate decisions to the point of interest to better serve the final user**.

Consortium

This research received funding from the European Union's Horizon Europe Research and Innovation programme under Grant Agreement No. 957406 (TERMINET). Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.

NANCY: An Artificial Intelligent Aided Unified Network for Secure Beyond 5G Long Term Evolution

https://ithaca.ece.uowm.gr/

- ✓ Call: HORIZON-JU-SNS-2022-STREAM-A-01-06
- ✓ Topic: Trustworthy and Reliable End-to-end connectivity Software platforms
- ✓ Total Budget: € 6.447.428,75
- ✓ Active period: 1 Jan 2023 - 31 Dec 2025

https://nancy-project.eu/

NANCY aims to develop a novel, intelligent, and secure Radio Access Network architecture for improved network efficiency and performance for Beyond-5G wireless networks. The NANCY solution will use AI and blockchain technologies to boost safety, improve data management technologies, and develop new solutions for increased efficiency, communication, and resource allocation and management.

Consortium

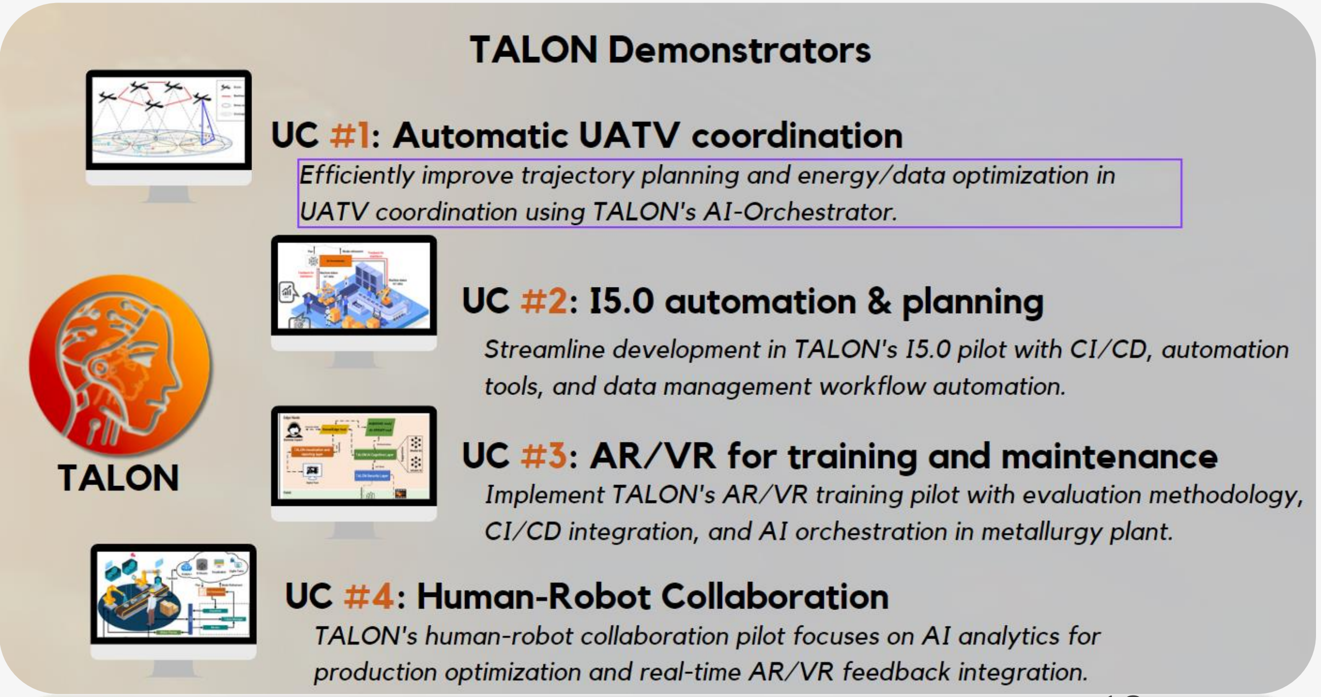
This work has received funding from the Smart Networks and Services Joint Undertaking (SNS JU) under the European Union's Horizon Europe research and innovation programme under Grant Agreement No. 101096456 (NANCY). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the SNS JU. Neither the European Union nor the granting authority can be held responsible for them.

TALON: Autonomous and Self-organized Artificial Intelligent Orchestrator for a Greener Industry 4.0

https://talon-project.eu/

Call: HORIZON-CL4-2021-HUMAN-01
Topic: HORIZON-CL4-2021-HUMAN-01-01
Type of action: RIA
Total Budget: € 3.769.382,50
Period: 36 Months

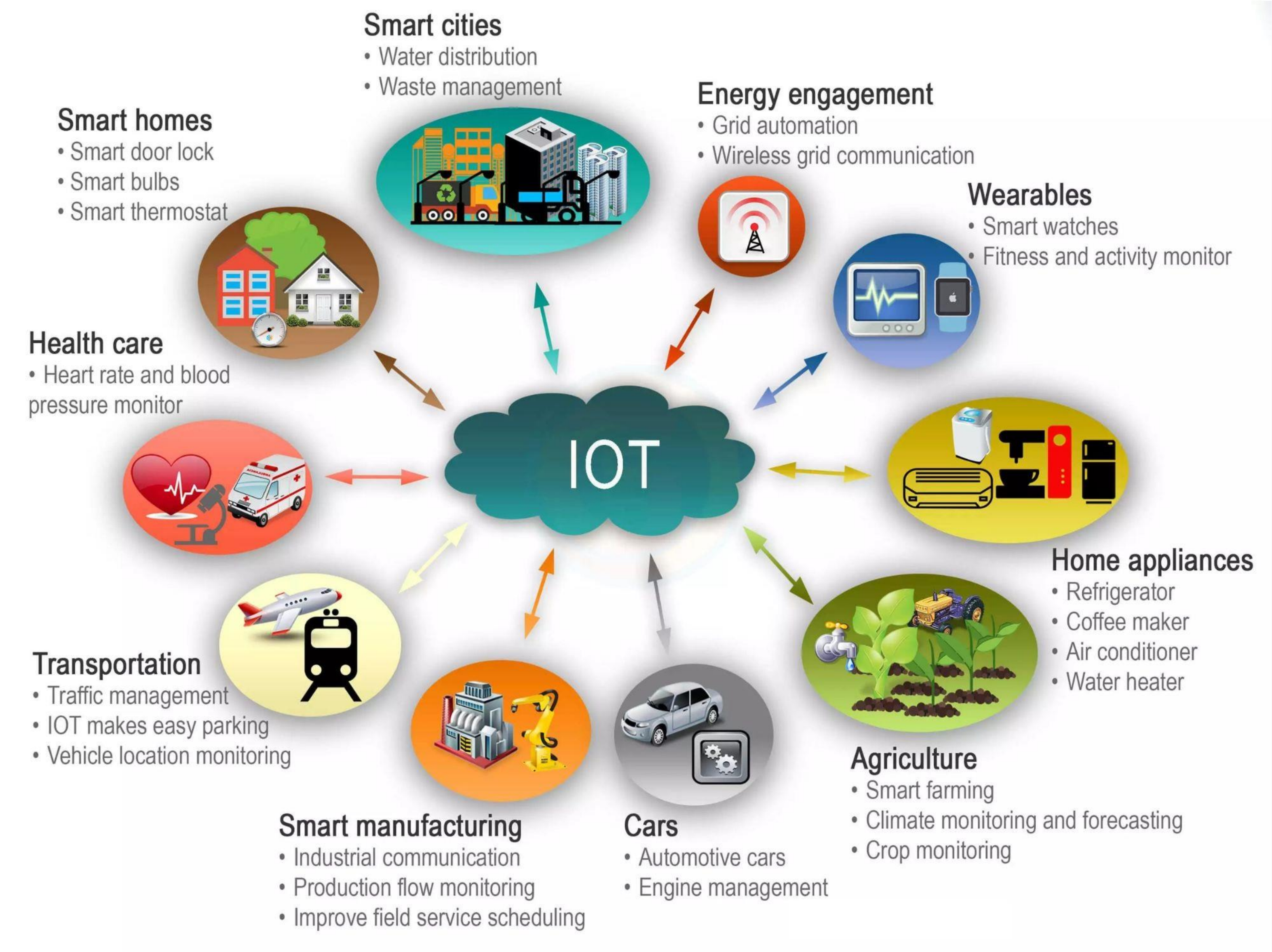
- AI orchestrator for autonomous and dynamic scalability as well as greener AI networks
- Distributed blockchain for high-security, privacy and trust in a heterogeneous application environment
- Flexible E2C deployment for "almost-zero latency" and high-computational capabilities near sensors
- DTs and HIL to boost AI explainability, trust-worthiness and transparency



This research received funding from the European Union's Horizon Europe Research and Innovation programme under Grant Agreement No. 101070181 (TALON). Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.

Next Generation - Internet of Things (NG-IoT)

IoT Initiatives leading to….



From IoT to NG-IoT

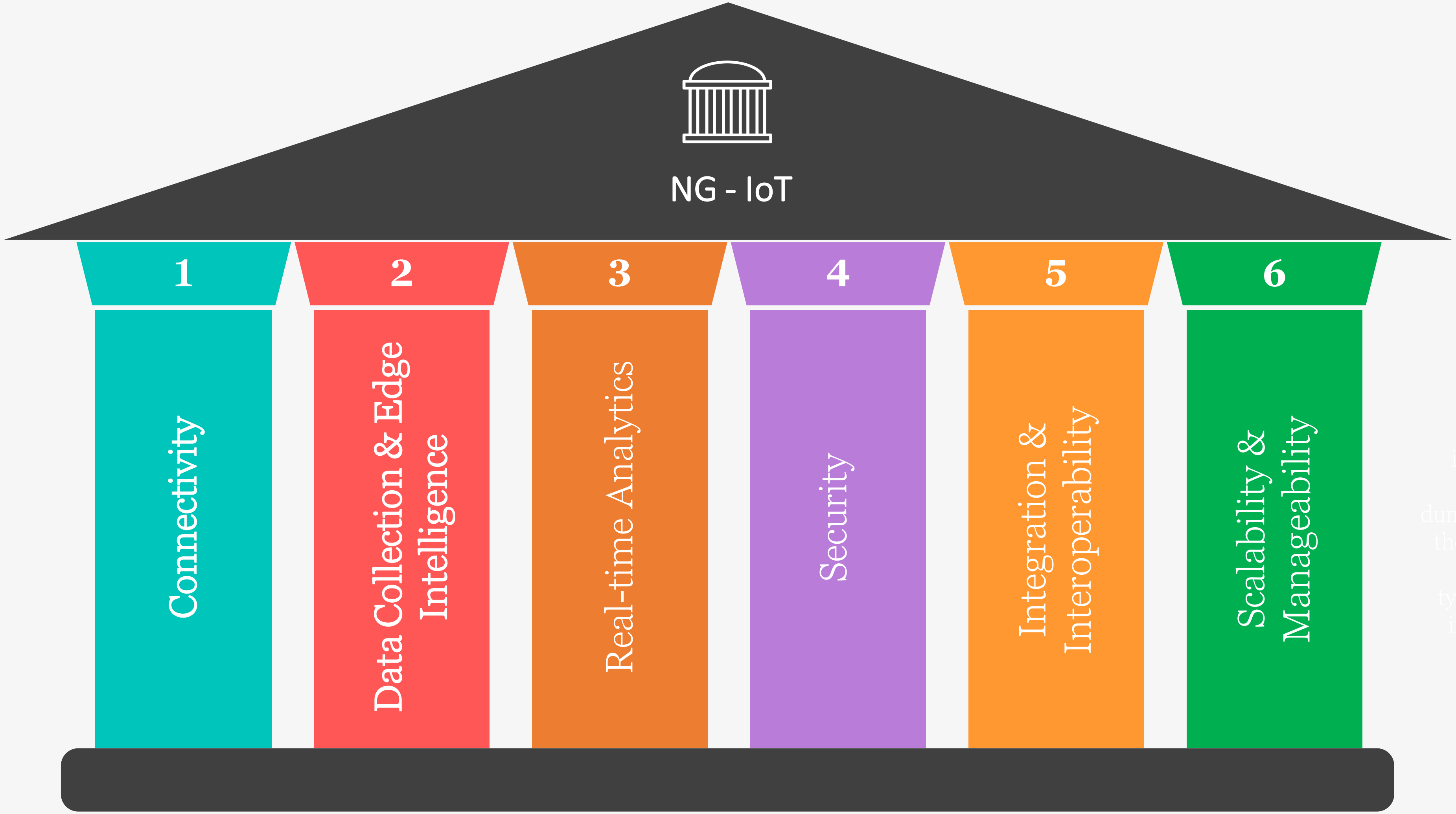
➔ Current networks can't meet the user requirements:

- **22 bn**. new IoT devices by 2025;
- **75%** of data will be processed outside of a centralized data center by 2025;
- **90%** of vehicles will be associated with the IoT by 2030;

➔ Next Generation IoT (NG-IoT) offers distributed intelligence at the edge:

- Ultra-high data rates;
- Increased reliability and coverage;
- Improved resource utilization;
- High security;
- Better cost efficiency;
- Adaptability;
- Scalability;

The Pillars of NG - IoT

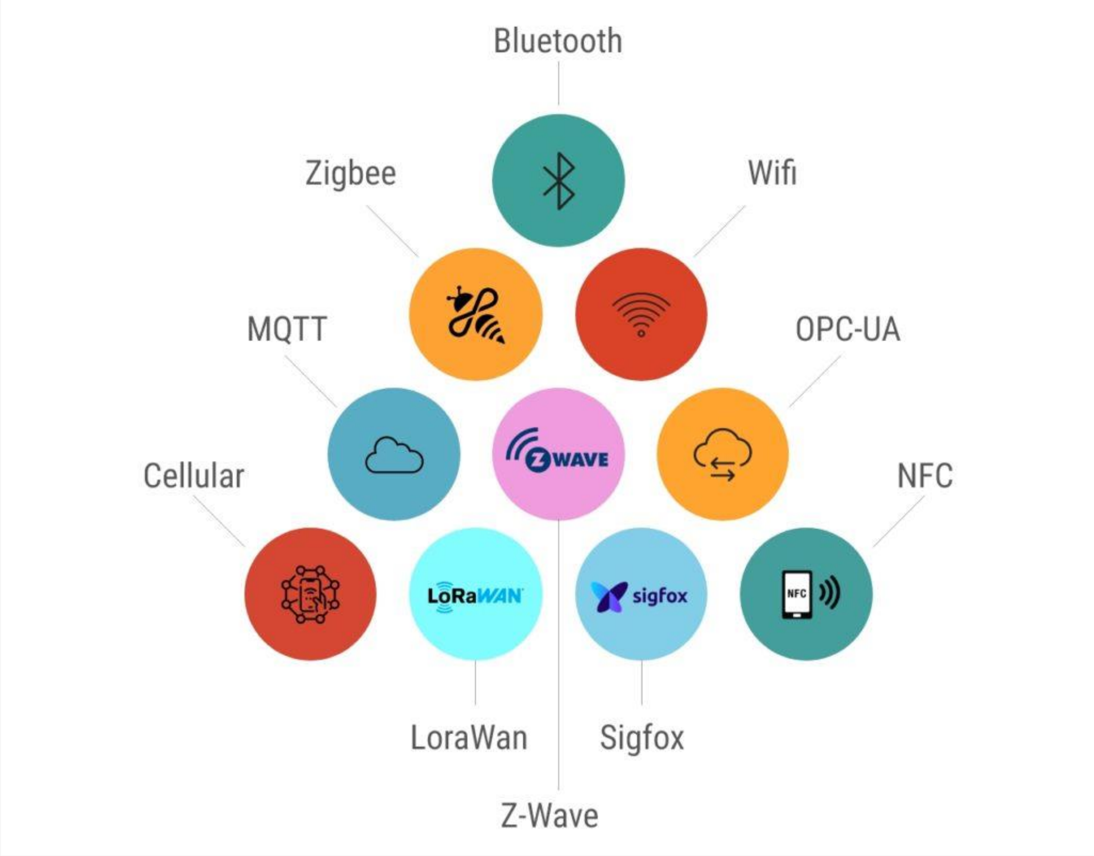


7

Lorem ipsum is simply dummy text of the printing and typesetting industry.

Connectivity

- ➔ Enables seamless communication between devices and the exchange of data
- ➔ Devices can transmit and receive information

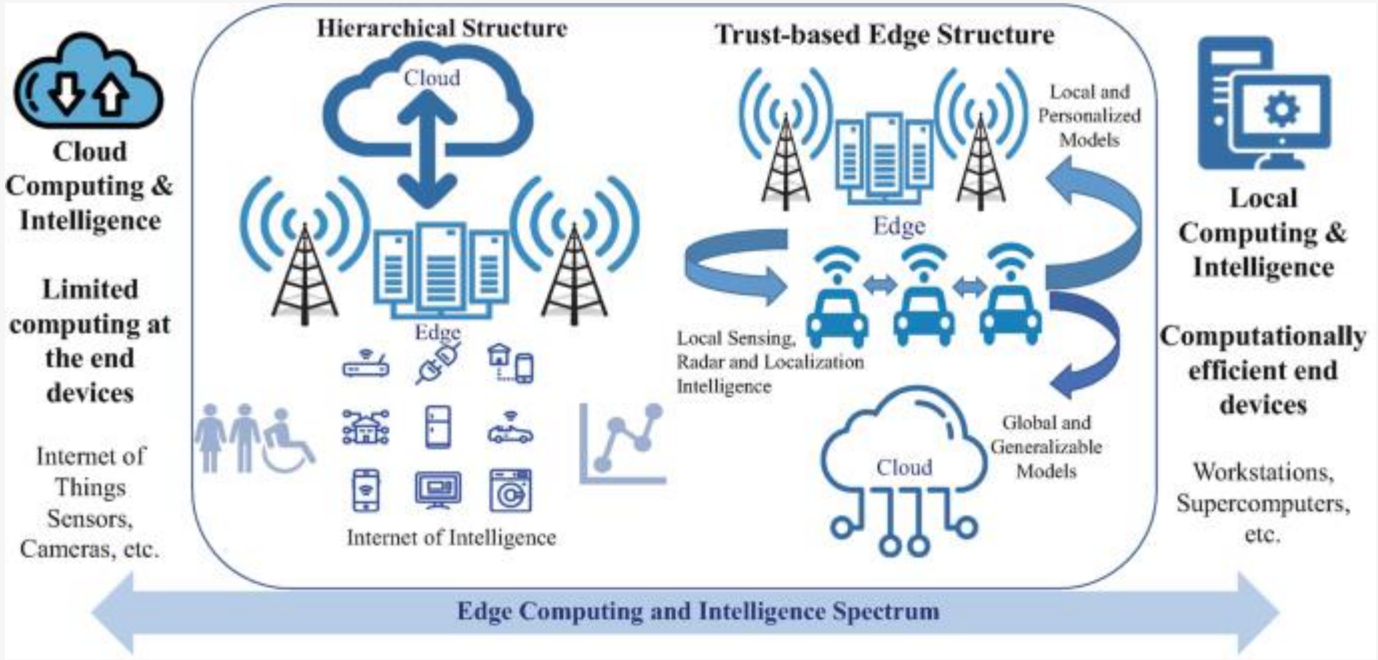


Data Collection & Edge Intelligence

Data collection enables IoT systems to gather insights and make informed decisions, leading to improved efficiency, productivity, and customer experiences

Accurate sensor readings ensure reliable data inputs, reducing the chances of false alarms, errors, or incorrect actions being triggered

Precise sensor readings help in detecting anomalies, identifying patterns, and forecasting trends, thus facilitating predictive maintenance and optimized resource allocation



Source: https://link.springer.com/chapter/10.1007/978-3-030-72777-2_12

Real-time Analytics

- ➔ It enables organizations to derive actionable insights from the immense volume of information generated by connected devices
- ➔ It contains:
  - *Data processing strategies*
  - *Real-time analytics*
  - *Predictive analytics*

Security

Protect IoT devices against physical and cyber threats that can compromise the privacy and safety

Malware, hacking, and data breaches can lead to the misuse of personal information

Unauthorized access to IoT devices can enable attackers to control connected devices

Physical threats, including tampering or theft of devices, can impact the functionality of IoT systems and pose security risks to users

Unsecured IoT devices can also be leveraged as entry points into broader networks,

Integration & Interoperability

Simplifying device integration

Interoperability allows devices from different manufacturers to communicate and work together seamlessly

Enhancing user experience

Various devices can seamlessly interact and share information, users can enjoy a unified and streamlined experience

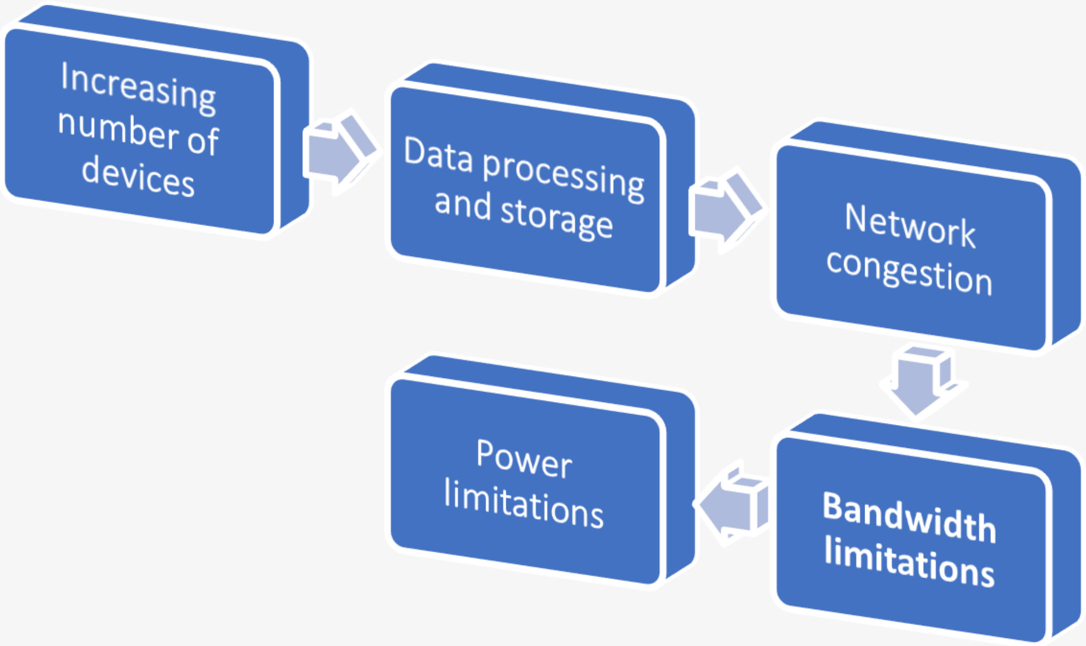
Enabling scalability

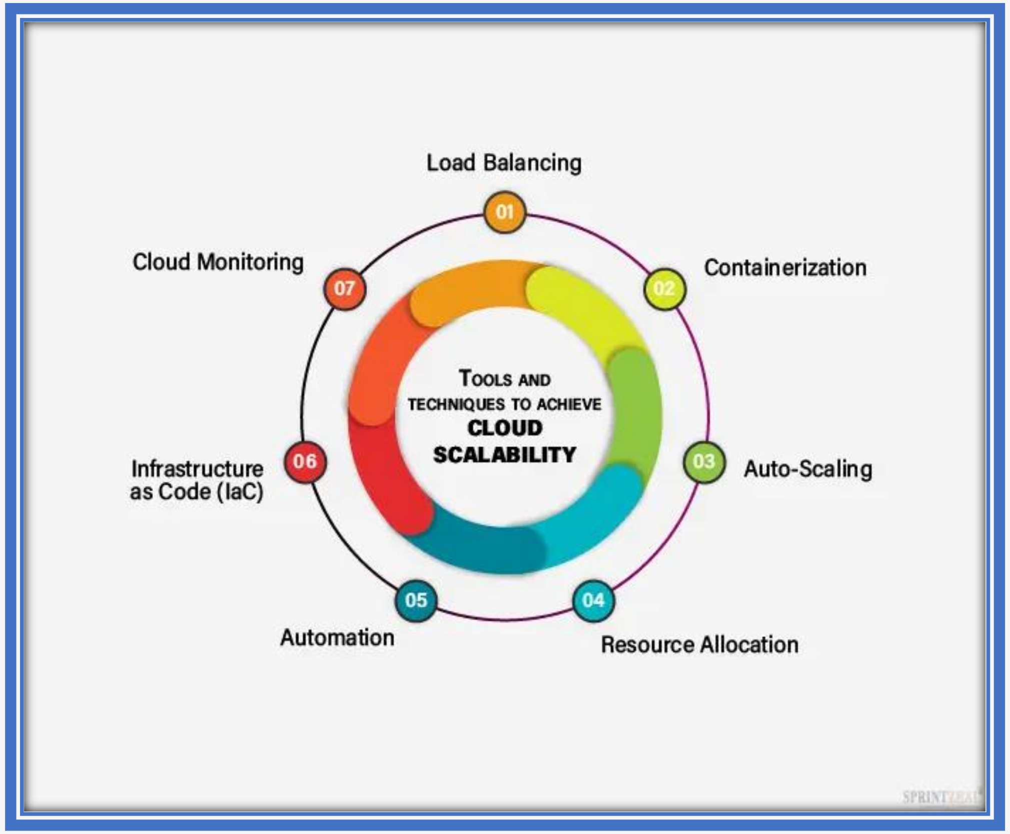
With interoperable devices, businesses can expand their IoT networks without facing compatibility issues or the need to replace existing devices

Driving innovation

When devices and platforms can communicate using standard protocols and interfaces, developers have the flexibility to create new applications and services

Scalability & Manageability





NG-IoT Challenges

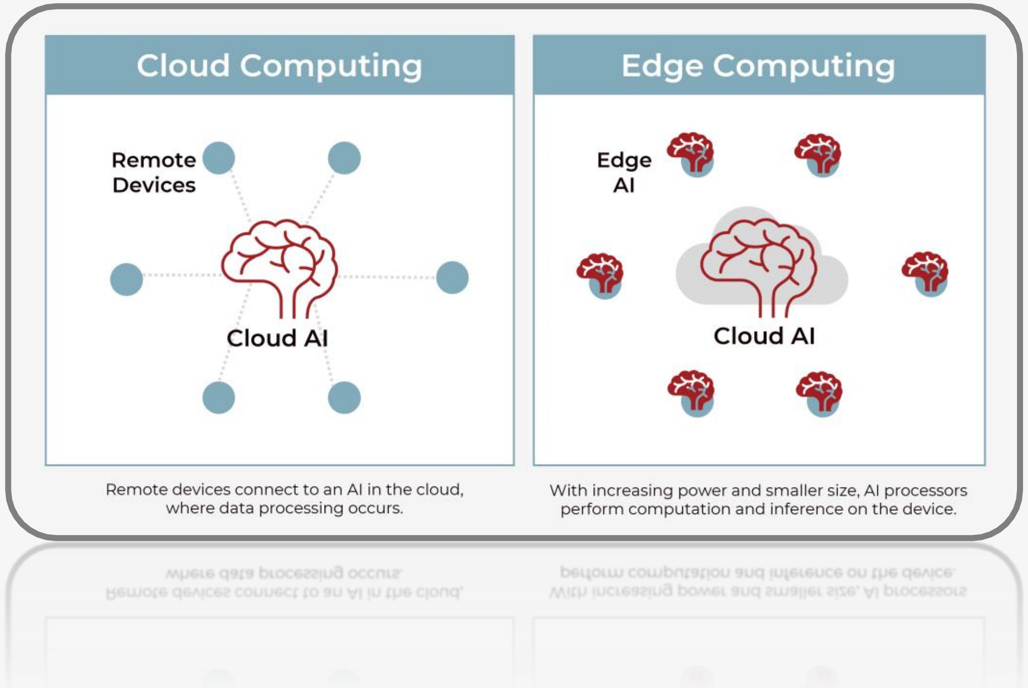
Source: https://www.collidu.com/presentation-iot-challenges

NG-IoT Trends

Trends – Moving to the edge^1/7

➢ Moving to the edge

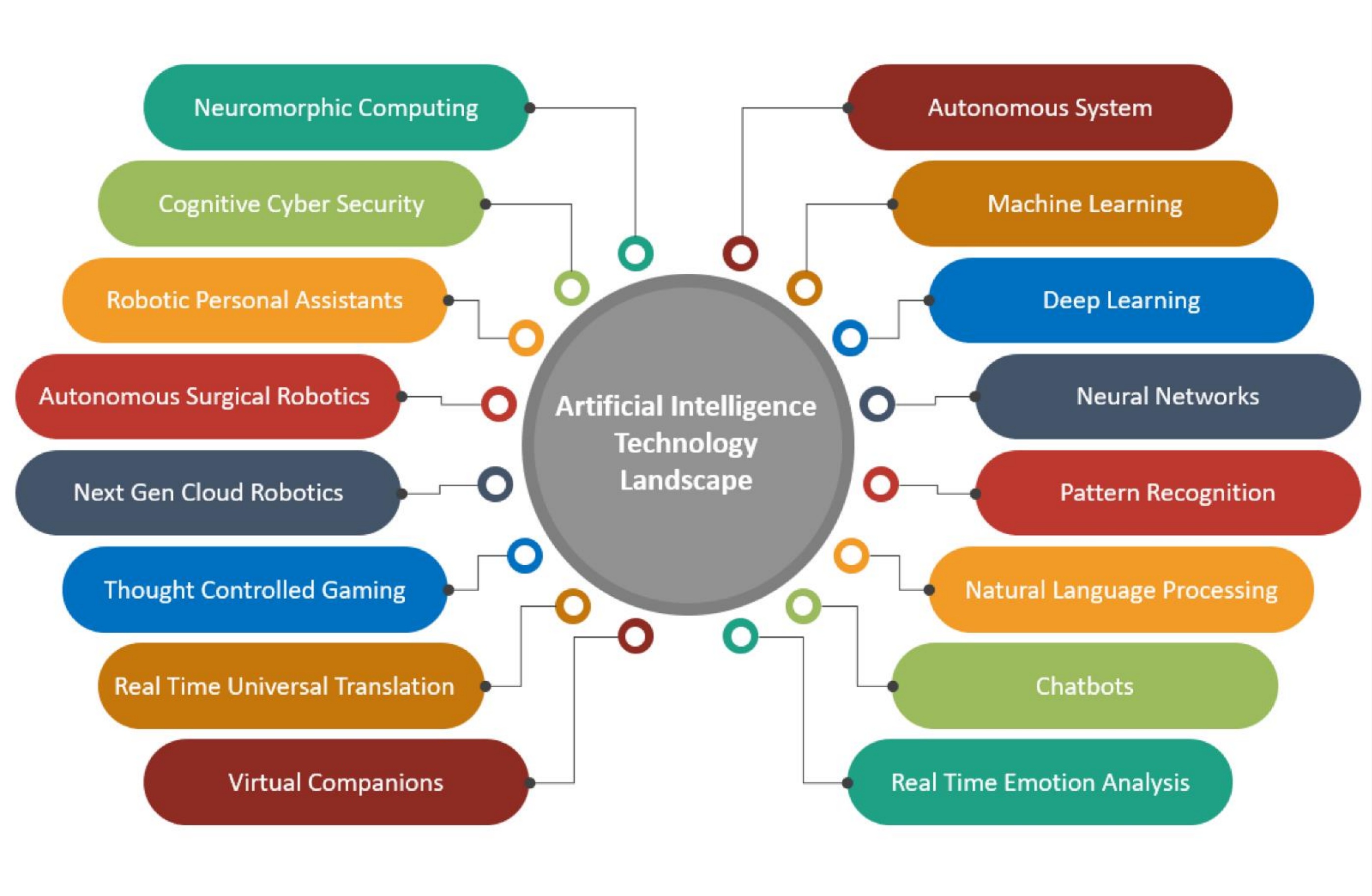
- ➢ Moving from 80% of processing within the cloud and 20% at the edge, to **80% of processing at the edge and 20% in the cloud**, is a unique opportunity;
- ➢ Developments in **meta operating systems** for the edge, environments and tools for swarm intelligence and an AI-enabled continuum;
- ➢ Compete in the **new data economy** and at the same time maintain technologically sovereignty for critical applications;



Source: https://www.cardinalpeak.com/wp-content/uploads/2021/12/cloud-ai-vs-edge-ai-blog-figure2.png

Trends – What about AI?[2/7]

- **Fair and explainable AI**
  - **Personalised** data driven services;
  - Running the **analytics at the edge**;
  - **Privacy by design** approach;
  - Datasets, datasets, datasets…

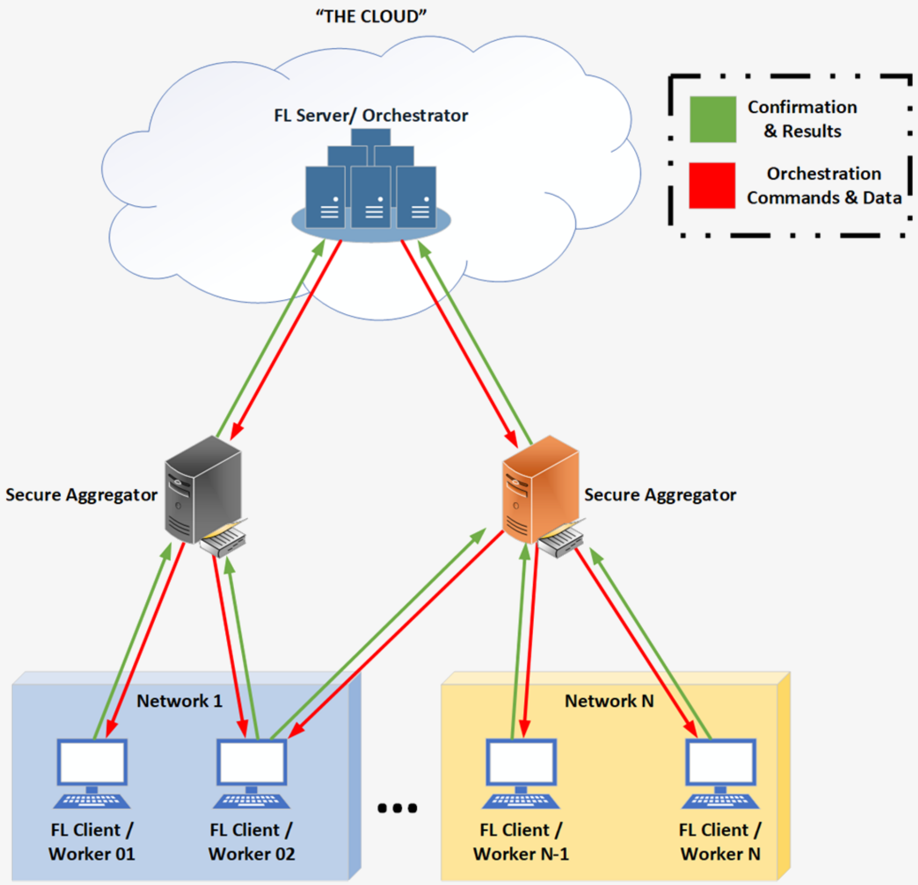


https://blog.portlandai.io/articles/1693562688109-0f2feee547964e11af021ec54729894b/

Trends – Federated Cloud Continuum3/7

➢ Federated Cloud Continuum

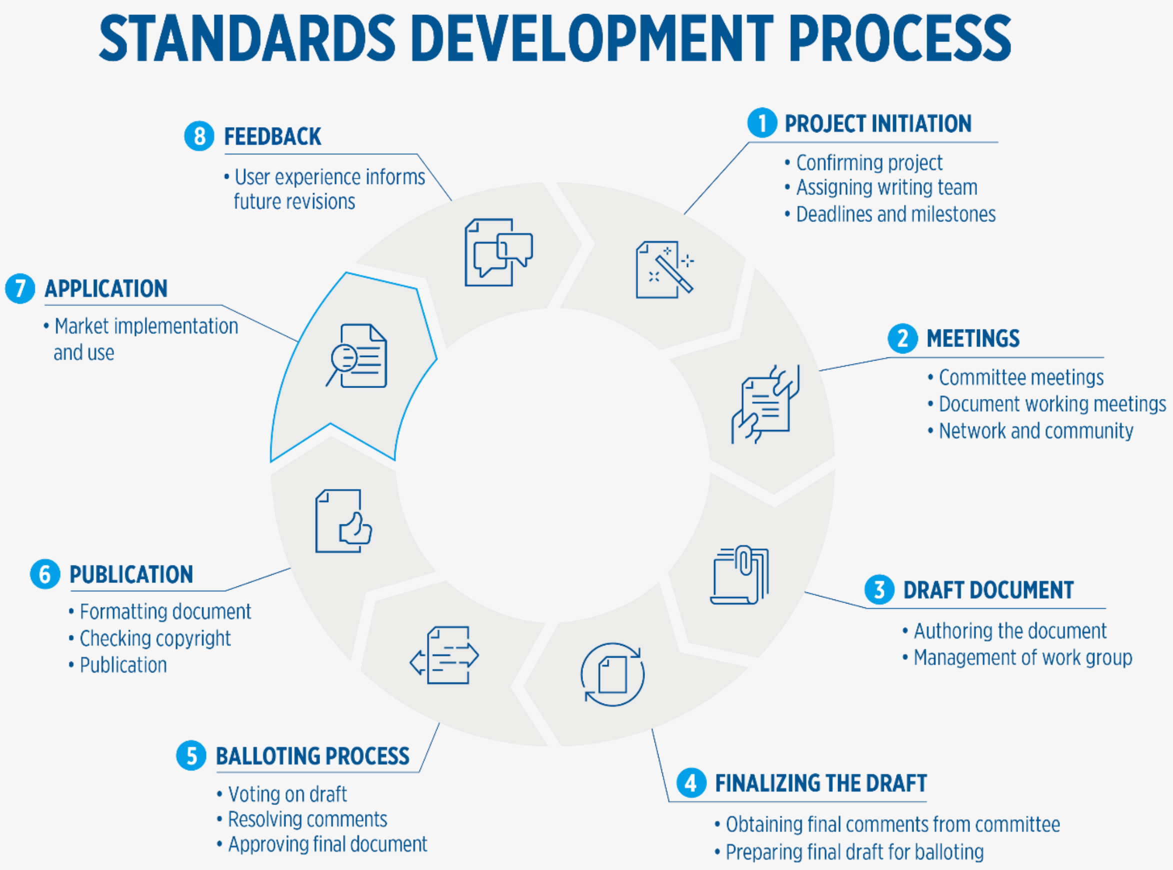
- ➢ Need to address **security, energy efficiency, portability, standards and contract conditions**;
- ➢ Move to a **decentralised data processing ecosystem** which is closer to the user;
- ➢ In future there will be a greater ability to **collect and analyse data close to activity** which can be used to make processes more efficient;



Trends – Silos of the past[4/7]

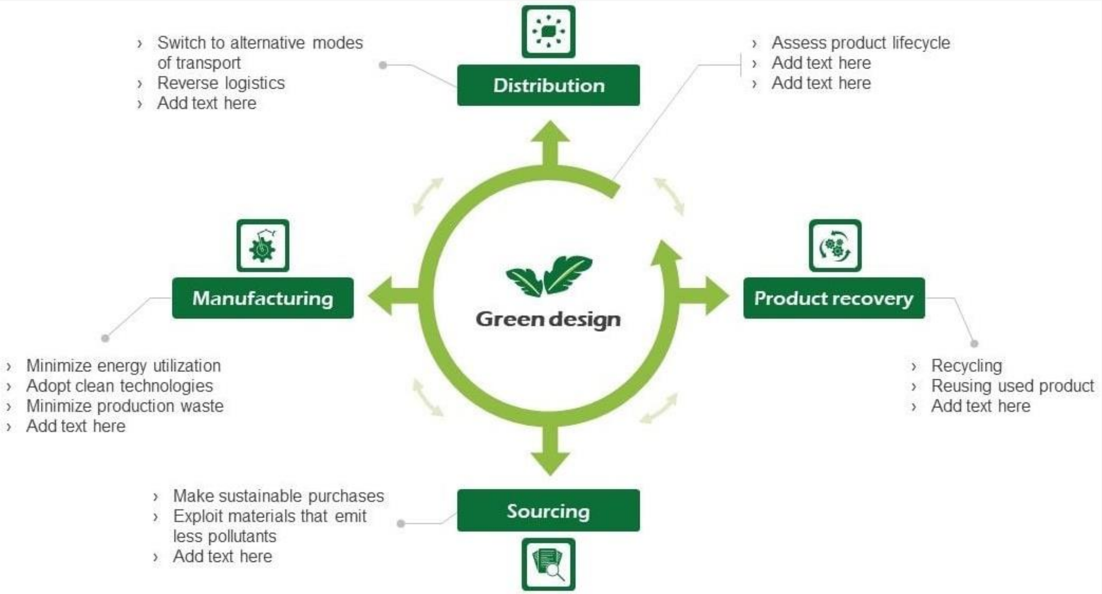
➢ Work horizontally

- ➢ **Open standards** create the market and applications are driven by latency, resiliency, privacy and regulation;
- ➢ It is important to work across sectors and **not build on silos**;
- ➢ Customers need to **trust the system** and want **control of their own data**;



Trends – Recycling 5/7

- Green supply chain management in manufacturing
  - Reduce the **carbon footprint** and **waste** while increasing **resource use efficiency;**
  - **Renewable energy** sources, waste reduction programs, and **water conservation systems;**
  - **Reduces costs;**
  - **Energy-efficient equipment;**



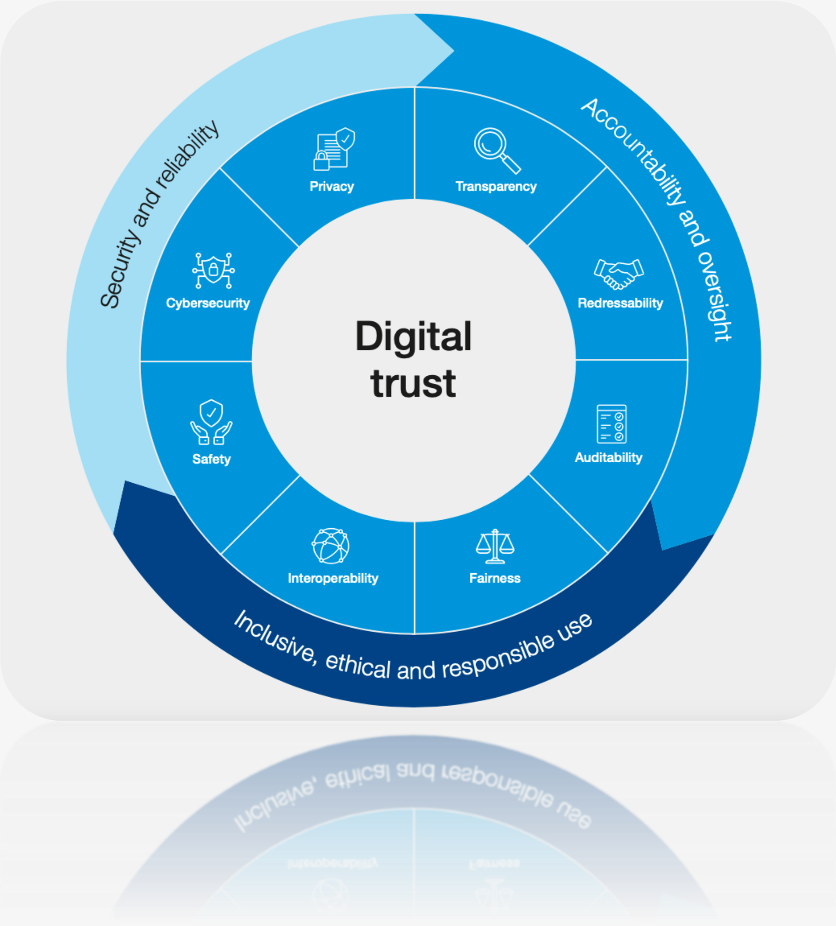
Source:https://www.slideteam.net/green-supply-chain-management-strategies.html

Trends – Trust[6/7]

$$\text{Trust} = \frac{\text{Consistency}}{\text{Time}}$$

➢ Trust and Trustworthiness

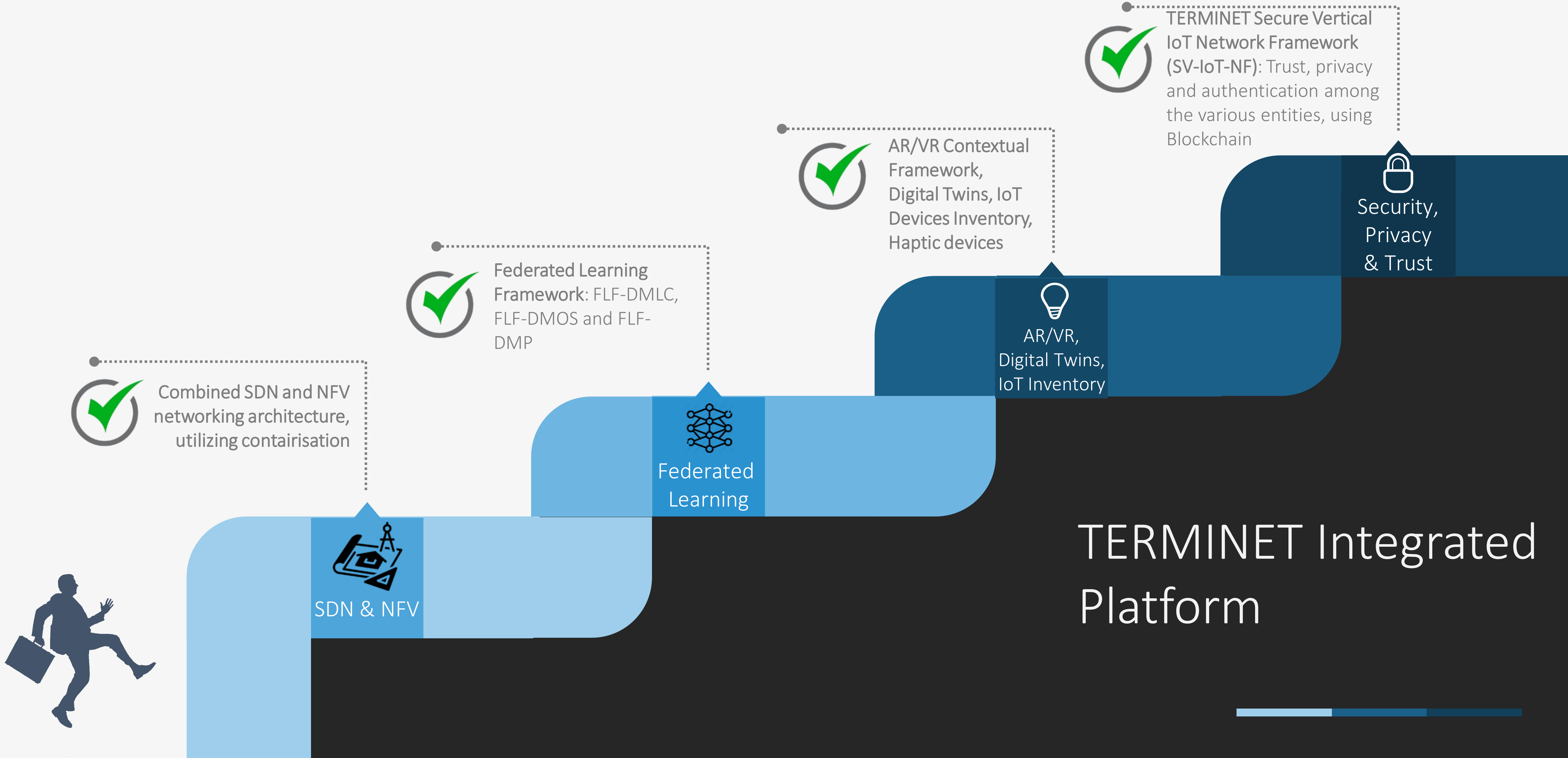
- ➢ **Trusted IoT and Edge Computing Platforms and Orchestration Mechanisms** are needed to accompany digitisation;
- ➢ A **trusted environment** agreed across industrial actors would create benefits in the data economy, and **encourage businesses** to share data;
- ➢ Trustworthiness has been identified as a **core characteristic of AI**;
- ➢ Trustworthiness can be considered to be a **business value and a unique selling point**;



Trends – Need for professionals 7/7

- Need for skilled professionals and citizens
  - To support the ambitions of Digital Decade Communication we need **skilled professionals and citizens**, secure infrastructures, and technologies such as 5/6G, microprocessors, etc
  - Need to support the Digital Transformation of businesses, especially **SMEs, who need assistance and guidance**;

TERMINET Business Logic



KPIs & Achievements

- *42 scientific publications*
- *7 datasets published*
- *3 whitepapers*
- *22 active PhDs*
- *12 invited talks and keynotes*
- *29 exploitable Items*
- *1 Patent: attestation gateway*
- *1 Protype: new generation RTU device*
- *1 Best Oral Presentation*

- TERMINET was represented by the American Farming School and the University of Western Macedonia in the 29th Agrotica Event.
- During the event, the smart farming solution developed in Use Case 1 was presented via a live demonstration of the TERMINET smart glasses application.

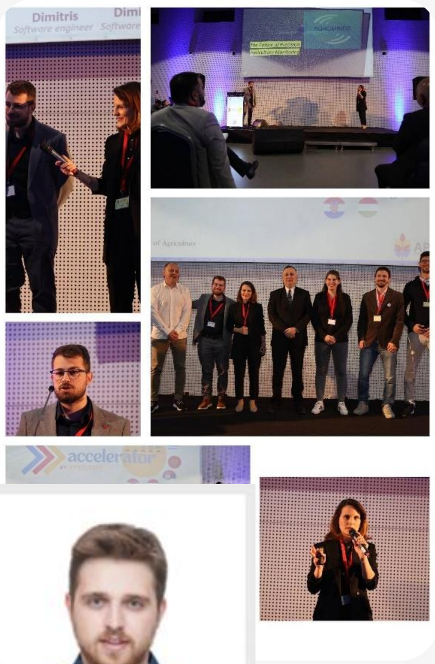
Advancing at the Edge of Convergence - Future Trends, Challenges and Standards with the Next Generation Internet of Things (NGIoT)

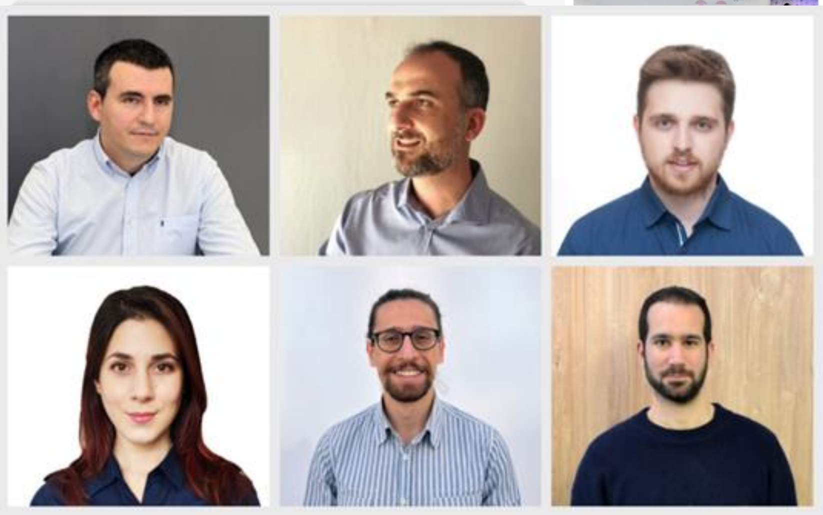
ERIAFF (The Network of European Regions for Innovation in Agriculture, Food and Forestry)

IoT solutions world congress 2022

MetaMind Innovations

https://metamind.gr/





MINDS

Est.

Established in May 2021, MetaMind Innovations is the ***1st spin-off of the University of Western Macedonia***

Projects

Currently MINDS is involved in 10 HORIZON R&D Projects while it is active in developing a variety of commercial tools.

Company

Co-founded by Prof. Panagiotis Sarigiannidis, Director of ITHACA Lab, together with PhD students and academic colleagues

Objectives

MINDS strives to deliver smart and custom solutions for critical infrastructure and Internet of Things ecosystems in the Industrial, public and private domain.

Datasets

CHERRY TREE DISEASE DETECTION DATASET

Citation Author(s):	Christos Chaschatzis Ilias Siniosoglou Anna Triantafyllou Chrysoula Karaiskou Athanasios Liatifis Panagiotis Radoglou-Grammatikis Dimitrios Pliatsios Vasiliki Kelli Thomas Lagkas Vasileios Argyriou Panagiotis Sarigiannidis
Submitted by:	Panagiotis Sari...
Last updated:	Tue, 10/04/2022 - 11:37
DOI:	10.21227/ehfm-9j20
Data Format:	*.zip; *.tif; *.jpg; *.xlsx; *.csv; *.txt
Link to Paper:	Detection and Characterization of Stressed Sweet Cherry Tissues Using Machine Learning
License:	Creative Commons Attribution

377 Views

Categories: Artificial Intelligence, IoT, Machine Learning, Sensors, Image Processing

Keywords: precision agriculture

☆☆☆☆☆ *0 ratings - Please login to submit your rating.*

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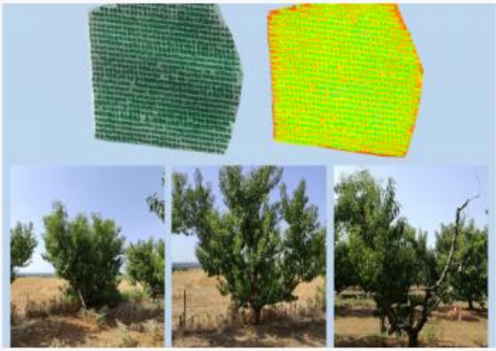
https://ieee-dataport.org/documents/cherry-tree-disease-detection-dataset

Datasets

Standard Dataset

PEACH TREE DISEASE DETECTION DATASET



Citation Author(s): Christos Chaschatzis, Ilias Siniosoglou, Anna Triantafyllou, Chrysoula Karaiskou, Athanasios Liatifis, Panagiotis Radoglou-Grammatikis, Dimitrios Pliatsios, Vasiliki Kelli, Thomas Lagkas, Vasileios Argyriou, Panagiotis Sarigiannidis

Submitted by: Panagiotis Sari...

Last updated: Wed, 11/23/2022 - 14:34

DOI: 10.21227/w67n-0q72

Data Format: *.zip; *.tif; *.jpg; *.xlsx; *.csv; *.txt

Link to Paper: A compilation of UAV applications for precision agriculture

License: Creative Commons Attribution

62 Views

Categories: Artificial Intelligence, IoT, Machine Learning, Sensors, Image Processing

Keywords: precision agriculture

☆☆☆☆☆ *0 ratings - Please login to submit your rating.*

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https://ieee-dataport.org/documents/peach-tree-disease-detection-dataset

Datasets

Standard Dataset

DNP3 INTRUSION DETECTION DATASET

DNP3 Intrusion Detection Dataset ITHACA

Citation Author(s): Panagiotis Radoglou-Grammatikis, Vasiliki Kelli, Thomas Lagkas, Vasileios Argyriou, Panagiotis Sarigiannidis

Submitted by: Panagiotis Sari...

Last updated: Tue, 11/22/2022 - 13:03

DOI: 10.21227/s7h0-b081

Data Format: *.csv; *.pcap

Link to Paper: Risk Analysis of DNP3 Attacks

ACCESS DATASET | CITE | SHARE/EMBED

Categories: IoT, Machine Learning, Smart Grid, Security, Communications

Keywords: IDS Packet dataset

ABSTRACT

In the digital era of the Industrial Internet of Things (IIoT), the conventional Critical Infrastructures (CIs) are transformed into smart environments with multiple benefits, such as pervasive control, self-monitoring and self-healing. However, this evolution is characterised by several cyberthreats due to the necessary presence of insecure technologies. DNP3 is an industrial communication protocol which is widely adopted in the CIs of the US. In particular, DNP3 allows the remote communication between Industrial Control Systems (ICS) and Supervisory Control and Data Acquisition (SCADA). It can support various topologies, such as Master-Slave, Multi-Drop, Hierarchical and Multiple-Server. Initially, the architectural model of DNP3 consists of three layers: (a) Application Layer, (b) Transport Layer and (c) Data Link Layer. However, DNP3 can be now incorporated into the Transmission Control Protocol/Internet Protocol (TCP/IP) stack as an application-layer protocol. However, similarly to other industrial protocols (e.g., Modbus and IEC 60870-5-104), DNP3 is characterised by severe security issues since it does not include any authentication or authorisation mechanisms. This dataset contains labelled Transmission Control Protocol (TCP) / Internet Protocol (IP) network flow statistics (Common-Separated Values - CSV format) and DNP3 flow statistics (CSV format) related to 9 DNP3 cyberattacks. These cyberattacks are focused on DNP3 unauthorised commands and Denial of Service (DoS). The network traffic data are provided through Packet Capture (PCAP) files. Consequently, this dataset can be used to implement Artificial Intelligence (AI)-powered Intrusion Detection and Prevention (IDPS) systems that rely on Machine Learning (ML) and Deep Learning (DL) techniques

DATASET FILES

- DNP3_Intrusion_Detection_Dataset_Final.7z (185.40 MB)

LOGIN TO ACCESS DATASET FILES

DOCUMENTATION

DNP3_Intrusion_Detection_Dataset_Readme.pdf (488.3 KB)

QUESTIONS?

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https://ieee-dataport.org/documents/dnp3-intrusion-detection-dataset

May 2, 2023

Dataset Open Access

TERMINET eHealth post-operation complications synthetic dataset

Lekka, Danae; Pnevmatikakis, Aristodemos; Kanavos, Efstathios; Gottardelli, Benedetta; Tudor, Andrada Mihaela; Cornacchione, Patrizia; de Angeli, Martina; Bellieni, Andrea

1. Introduction

Older adults with cancer often need to undergo operations. Post-surgery complications may arise, and Real-World Data (RWD) collected from such patients during a pre-operation monitoring period of two weeks can help identify risk for post-surgery complications. The involved RWD span behavioral data (measured or reported) as well as clinical data (collected during clinical tests). This dataset is synthesized by Innovation Sprint, using actual data collected from eligible Fondazione Policlinico Gemelli patients participating to the SUPERO study. The clinical data is collected by the hospital, while the behavioral is collected using Healthentia, a medical decision support software developed by Innovation Sprint, facilitating the collection, analysis and presentation of behavioral data.

2. Dataset description

The provided TERMINET eHealth post-operation complications synthetic dataset contains 10,000 synthetic patients, provided in an equal number of rows in the CSV file containing the dataset. The different attributes of the dataset are organized in columns.

The attributes are summarized as follows:

- 6 columns of step data statistics
- 20 columns of clinical attributes
- 2 columns of demographics attributes
- 12 columns of questionnaire attributes
- 1 column of outcome attribute

2.1. Step statistics

Step data is collected per day of the pre-hospitalization period. The final two weeks of that period are used to derive the step statistics. For each of the weeks, the mean, standard deviation and slope of the linear regression of the step data is reported, 3 attributes per week, 6 attributes in total.

Publication date:
May 2, 2023

DOI:
DOI 10.5281/zenodo.7886727

Keyword(s):
eHealth, Real-World Data, Behavioral data, Clinical data

Grants:
European Commission:

- TERMINET - nexT gEneRation sMart INterconnectEd ioT (957406)

https://zenodo.org/record/7886727

zenodo

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February 10, 2023

Dataset | Open Access

Smart house measurements

Georgios Stavropoulos; Dimosthenis Ioannidis; Charilaos Kaliakatsos; Chrysovalantis Kontoulis

Load Forecasting Dataset

Readme File

VARLAB – The Centre for Research & Technology, Hellas [CERTH] - Informatics and Telematics Institute [ITI] - https://varlab.iti.gr/

Authors: Chrysovalantis-George Kontoulis, Georgios Stavropoulos, Dimosthenis Ioannidis

Publication Date: February -, 2023

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreements No. 957406 (TERMINET).

1.Introduction

This dataset features information from a smarthome located at Greece, which features the Mediterranean climate. The building is utilized as a modern workplace that is being used for various every day activities. It is equipped with numerous smart devices and appliances, from smart lights to smart a elevator, while also featuring PVTs.

Indexed in

OpenAIRE

Publication date:
February 10, 2023

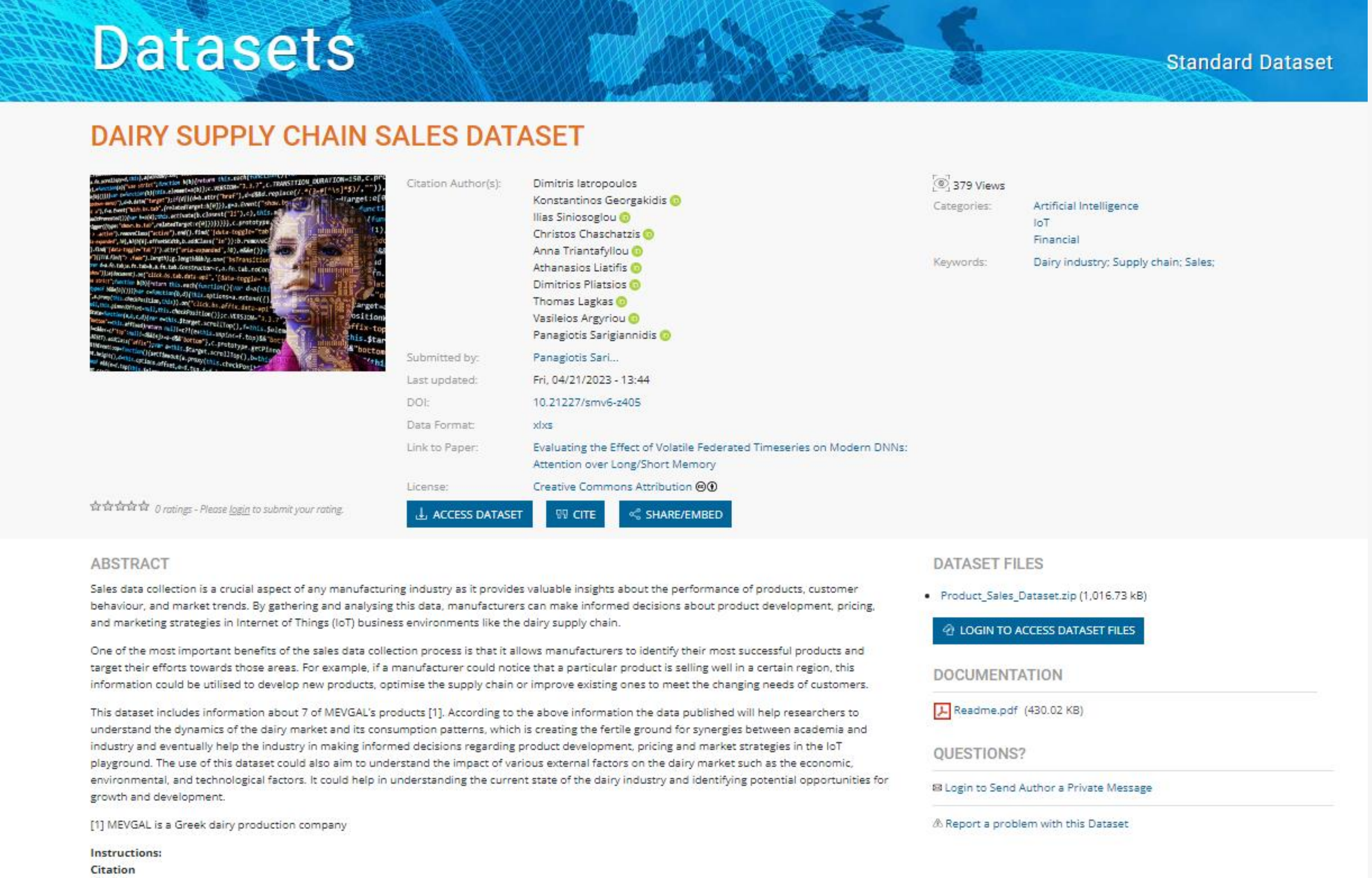
DOI:
DOI 10.5281/zenodo.7628298

Keyword(s):
smart house | energy monitoring

Grants:
European Commission:
- TERMINET - nexT gEneRation sMart INterconnectEd ioT (957406)

Communities:
H2020 TERMINET Project

https://zenodo.org/record/7628298


Datasets

Standard Dataset

DAIRY SUPPLY CHAIN SALES DATASET

Citation Author(s): Dimitris Iatropoulos, Konstantinos Georgakidis, Ilias Siniosoglou, Christos Chaschatzis, Anna Triantafyllou, Athanasios Liatifis, Dimitrios Pliatsios, Thomas Lagkas, Vasileios Argyriou, Panagiotis Sarigiannidis

Submitted by: Panagiotis Sari...

Last updated: Fri, 04/21/2023 - 13:44

DOI: 10.21227/smv6-z405

Data Format: xlxs

Link to Paper: Evaluating the Effect of Volatile Federated Timeseries on Modern DNNs: Attention over Long/Short Memory

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379 Views

Categories: Artificial Intelligence, IoT, Financial

Keywords: Dairy industry; Supply chain; Sales;

ABSTRACT

Sales data collection is a crucial aspect of any manufacturing industry as it provides valuable insights about the performance of products, customer behaviour, and market trends. By gathering and analysing this data, manufacturers can make informed decisions about product development, pricing, and marketing strategies in Internet of Things (IoT) business environments like the dairy supply chain.

One of the most important benefits of the sales data collection process is that it allows manufacturers to identify their most successful products and target their efforts towards those areas. For example, if a manufacturer could notice that a particular product is selling well in a certain region, this information could be utilised to develop new products, optimise the supply chain or improve existing ones to meet the changing needs of customers.

This dataset includes information about 7 of MEVGAL's products [1]. According to the above information the data published will help researchers to understand the dynamics of the dairy market and its consumption patterns, which is creating the fertile ground for synergies between academia and industry and eventually help the industry in making informed decisions regarding product development, pricing and market strategies in the IoT playground. The use of this dataset could also aim to understand the impact of various external factors on the dairy market such as the economic, environmental, and technological factors. It could help in understanding the current state of the dairy industry and identifying potential opportunities for growth and development.

[1] MEVGAL is a Greek dairy production company

Instructions:
Citation

DATASET FILES

- Product_Sales_Dataset.zip (1,016.73 kB)

LOGIN TO ACCESS DATASET FILES

DOCUMENTATION

Readme.pdf (430.02 KB)

QUESTIONS?

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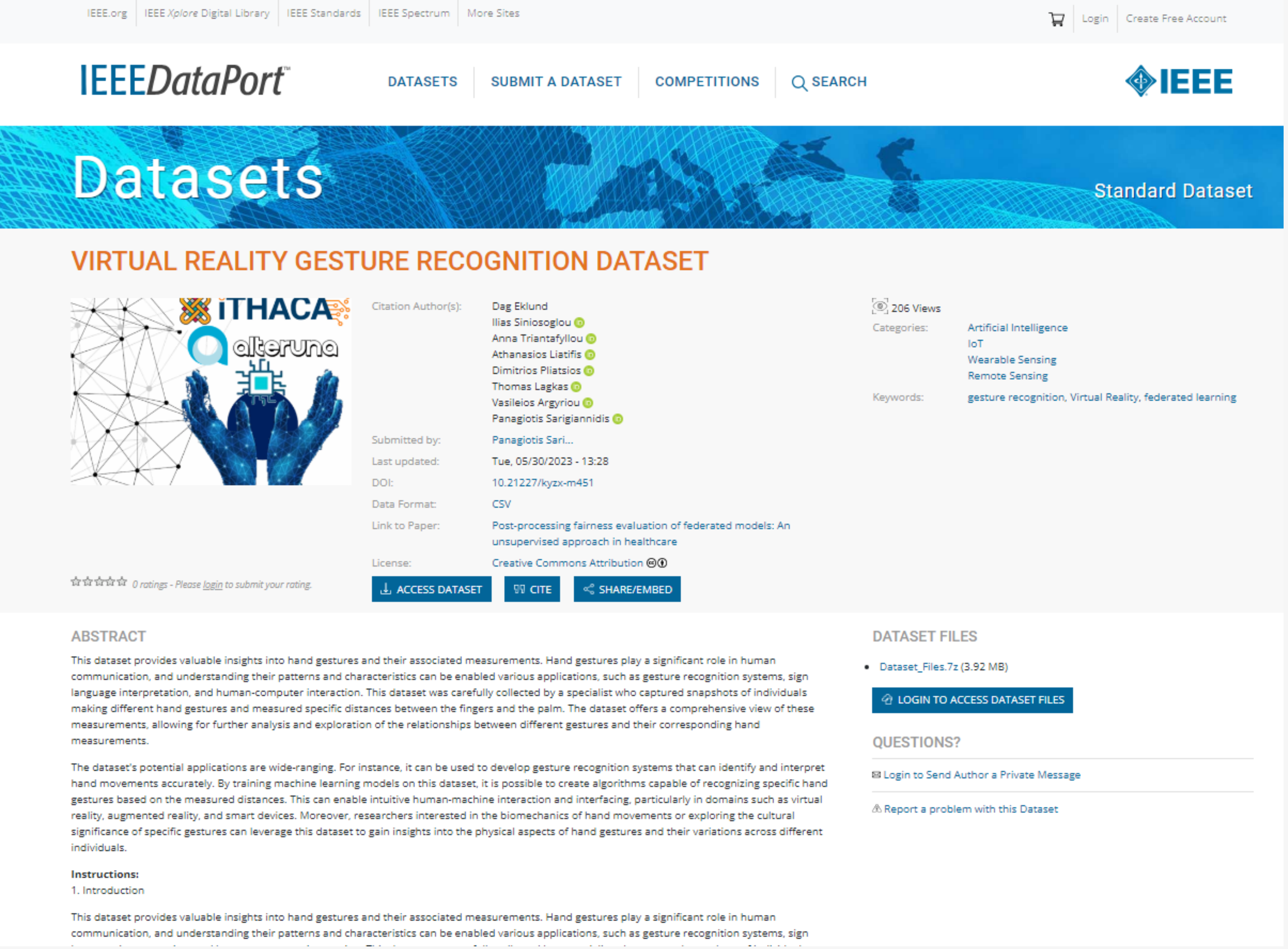
Report a problem with this Dataset

https://ieee-dataport.org/documents/dairy-supply-chain-sales-dataset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Datasets

Standard Dataset

VIRTUAL REALITY GESTURE RECOGNITION DATASET

Citation Author(s): Dag Eklund, Ilias Siniosoglou, Anna Triantafyllou, Athanasios Liatifis, Dimitrios Pliatsios, Thomas Lagkas, Vasileios Argyriou, Panagiotis Sarigiannidis

Submitted by: Panagiotis Sari...

Last updated: Tue, 05/30/2023 - 13:28

DOI: 10.21227/kyzx-m451

Data Format: CSV

Link to Paper: Post-processing fairness evaluation of federated models: An unsupervised approach in healthcare

ACCESS DATASET | CITE | SHARE/EMBED

Categories: Artificial Intelligence, IoT, Wearable Sensing, Remote Sensing

Keywords: gesture recognition, Virtual Reality, federated learning

ABSTRACT

This dataset provides valuable insights into hand gestures and their associated measurements. Hand gestures play a significant role in human communication, and understanding their patterns and characteristics can be enabled various applications, such as gesture recognition systems, sign language interpretation, and human-computer interaction. This dataset was carefully collected by a specialist who captured snapshots of individuals making different hand gestures and measured specific distances between the fingers and the palm. The dataset offers a comprehensive view of these measurements, allowing for further analysis and exploration of the relationships between different gestures and their corresponding hand measurements.

The dataset's potential applications are wide-ranging. For instance, it can be used to develop gesture recognition systems that can identify and interpret hand movements accurately. By training machine learning models on this dataset, it is possible to create algorithms capable of recognizing specific hand gestures based on the measured distances. This can enable intuitive human-machine interaction and interfacing, particularly in domains such as virtual reality, augmented reality, and smart devices. Moreover, researchers interested in the biomechanics of hand movements or exploring the cultural significance of specific gestures can leverage this dataset to gain insights into the physical aspects of hand gestures and their variations across different individuals.

Instructions:

1. Introduction

This dataset provides valuable insights into hand gestures and their associated measurements. Hand gestures play a significant role in human communication, and understanding their patterns and characteristics can be enabled various applications, such as gesture recognition systems, sign

DATASET FILES

- Dataset_Files.7z (3.92 MB)

LOGIN TO ACCESS DATASET FILES

QUESTIONS?

Login to Send Author a Private Message

Report a problem with this Dataset

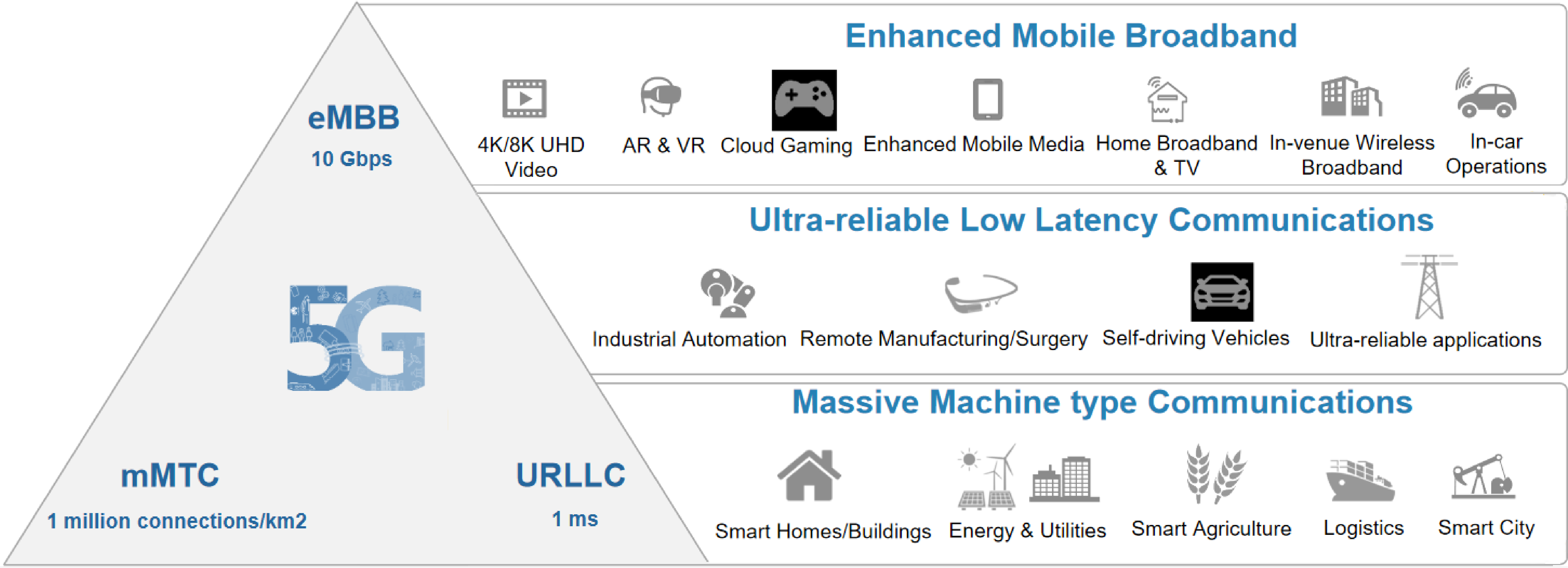
https://ieee-dataport.org/documents/virtual-reality-gesture-recognition-dataset

5G/B5G and NG-IoT

5G & NG-IoT

- 22 billion IoT devices are expected to be deployed by 2025
- The 5th Generation of Mobile Networks is a key technology enabler for the Internet of Things
- 5G and IoT will provide new value to business and society
  - Manufacturing and Connected Products
  - Smart Cities
  - Connected Vehicles
  - Ubiquitous Healthcare
  - Smart Agriculture

5G Requirements Classes



Source: Recommendation ITU-R M.2083

Enabling Technologies

Enabling Technologies

- New frequency spectrum
- Massive Multiple Input Multiple Output (MIMO)
- Non-Orthogonal Multiple Access (NOMA)
- Grant-Free (GF) Access
- **Open Radio Access Network (O-RAN)**
- **Edge Computing**
- **Software Defined Networking (SDN)**
- **Virtualization**

Open Radio Access Network

Radio Access Network

The Radio Access Network (RAN) is a critical component of wireless communication systems

Includes the infrastructure and wireless technologies for providing wireless connectivity to mobile devices

Serves as the interface between mobile devices (such as smartphones, tablets, IoT devices) and the core network

RAN Evolution

Traditional RAN:

- Each base station covers a small area
- A base station consists of the Remote Radio Head (RRH) and the Baseband Unit (BBU)
  - RRH → Radio transceiver, the physical air interface
  - BBU → Baseband signal processing
- Each base station processes and transmits signals from/to UEs

Open-Radio Access (O-RAN) Network:

- RRH and BBU are decoupled
- RRHs transmit “raw” signals to a centralized BBU, which is virtualized and hosted in the cloud
- Enables scaling for low-cost dense small cells
- Optical fiber, 10+ Gbit Ethernet, or mmWave can be used as physical channels

O-RAN Vision

Specify an open, virtualized, and intelligent RAN architecture to deliver a completive, interoperable, and multivendor ecosystem

Enable an autonomous network capable of self-management, self-optimization, and self-healing

Implement network components as flexible network functions that can be dynamically scaled to address the network and user requirements

O-RAN Benefits

Mitigate Vendor Lock-in

Increase Interoperability

Enhance Flexibility and Scalability

Improve Performance

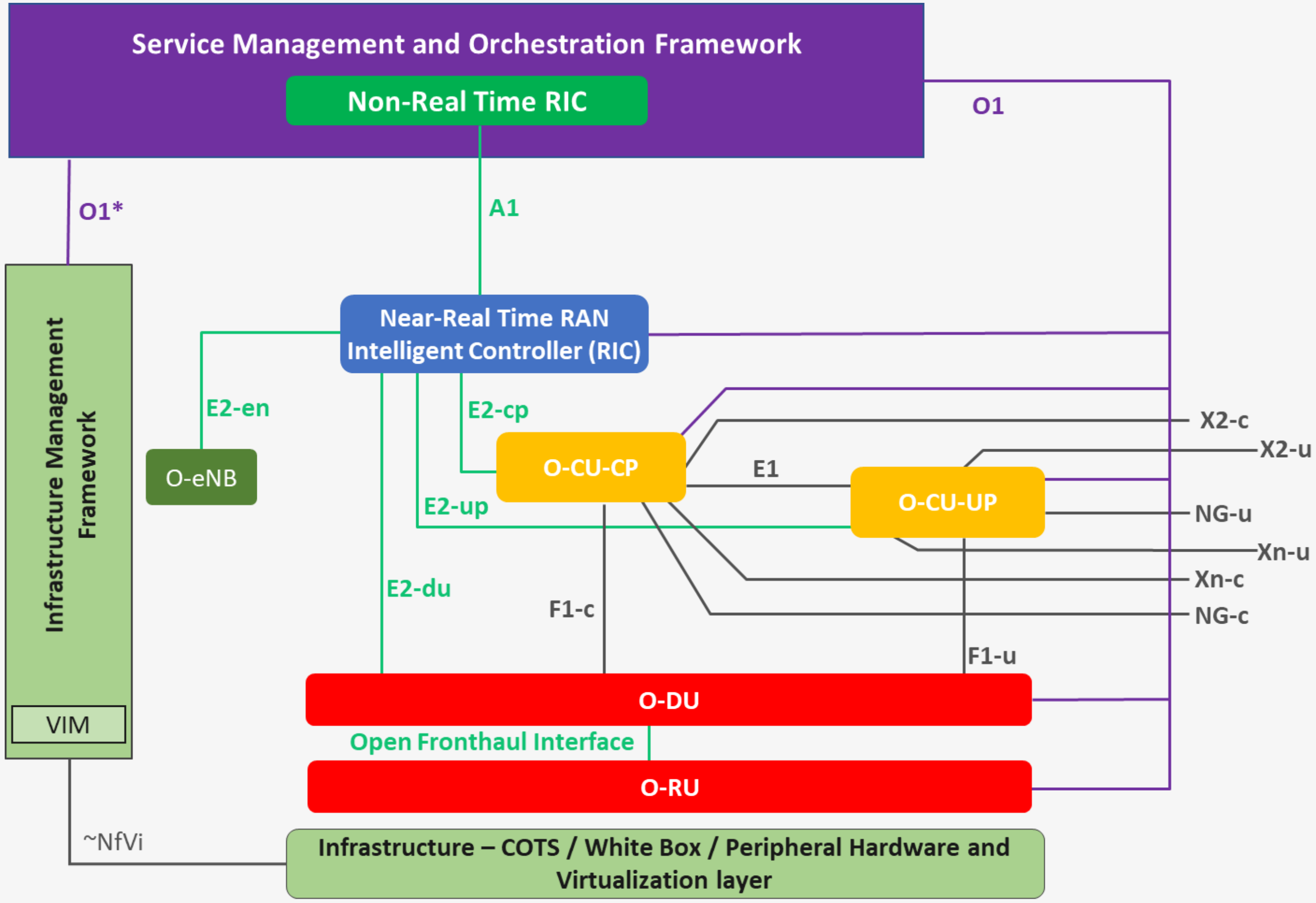
Reduce Deployment Costs

Foster Innovation

Facilitate Research & Development

O-RAN Reference Architecture

- **Non-Real Time RAN Intelligent Controller (RIC):** Provides non-real-time control and optimization of RAN elements and resources
- **Near-Real Time RIC:** Provides near-real-time control and optimization of O-RAN
- **Infrastructure Management Framework (IMF):** Provides cloud resources to manage Network Functions (NFs) and bridges RAN to CORE through the Virtual Infrastructure Management (VIM)
- **O-eNB:** Backward compatibility with 4G networks
- **O-RAN Centralized Unit-Control Plane (O-CU-CP):** Hosts the RRC and the control plane part of the PDCP protocol
- **O-RAN Centralized Unit-User Plane (O-CU-UP):** Hosts the user plane part of the PDCP protocol and the SDAP protocol
- **O-RAN Distributed Unit (O-DU):** Main processing unit responsible for the PHY, MAC, and RLC protocols
- **O-RAN Radio Unit (O-RU):** Performs the actual radio communication

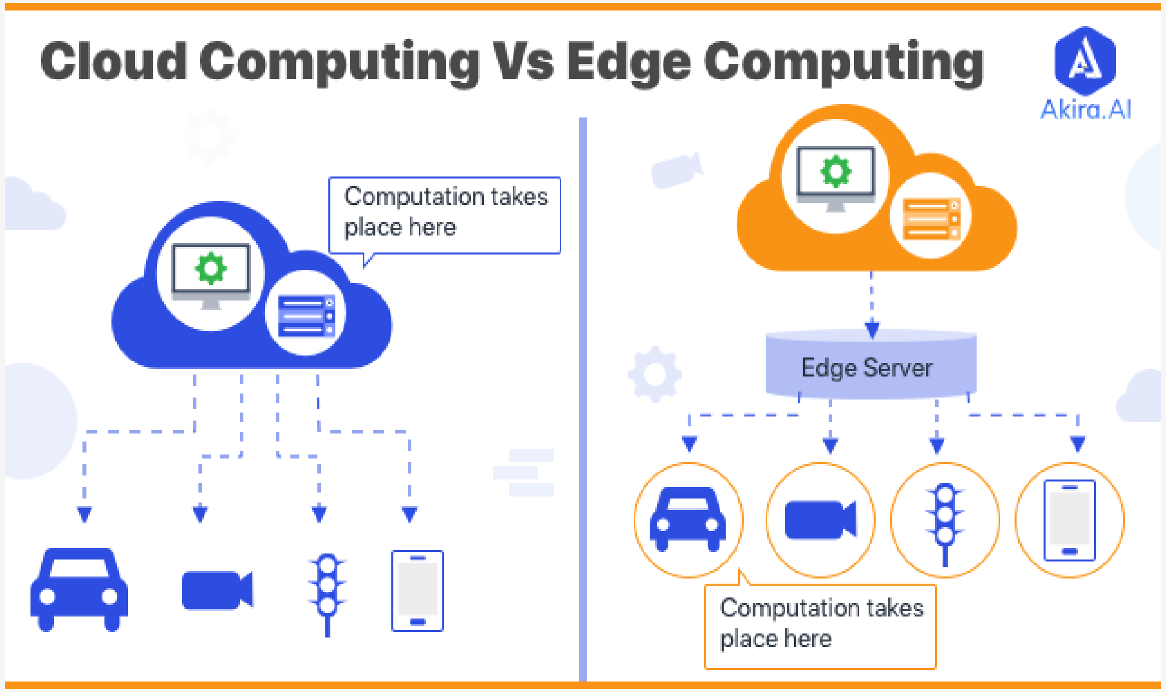


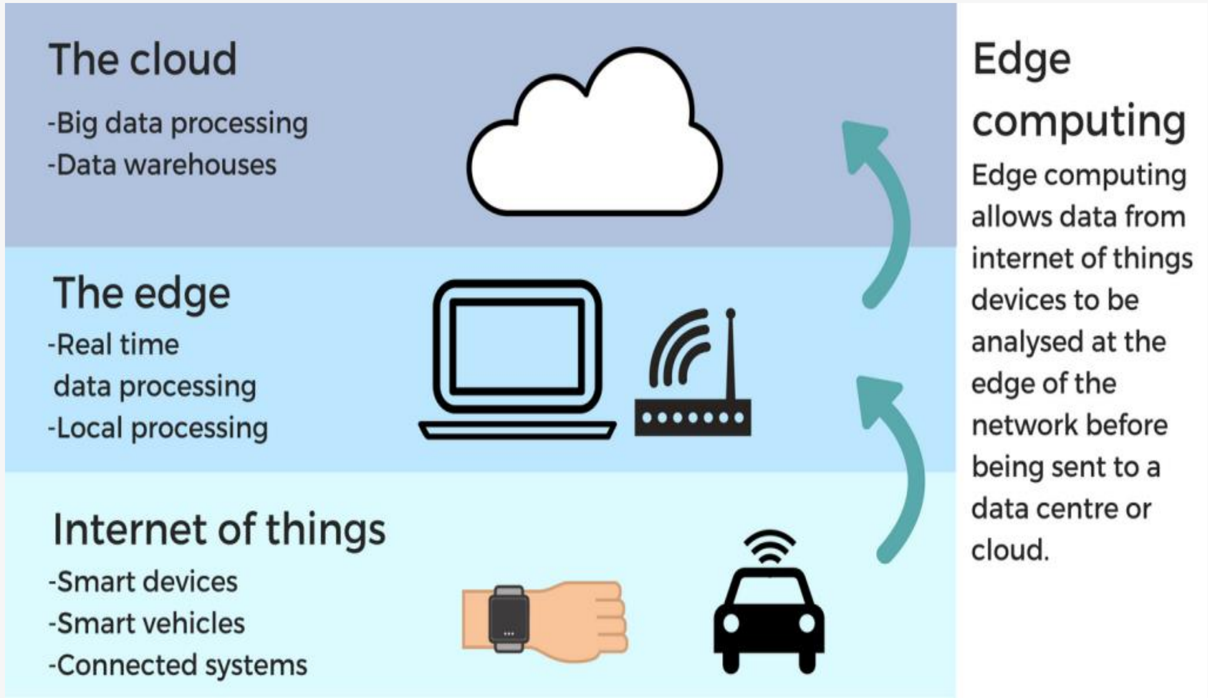
Source: O-RAN Software Community

Edge Computing

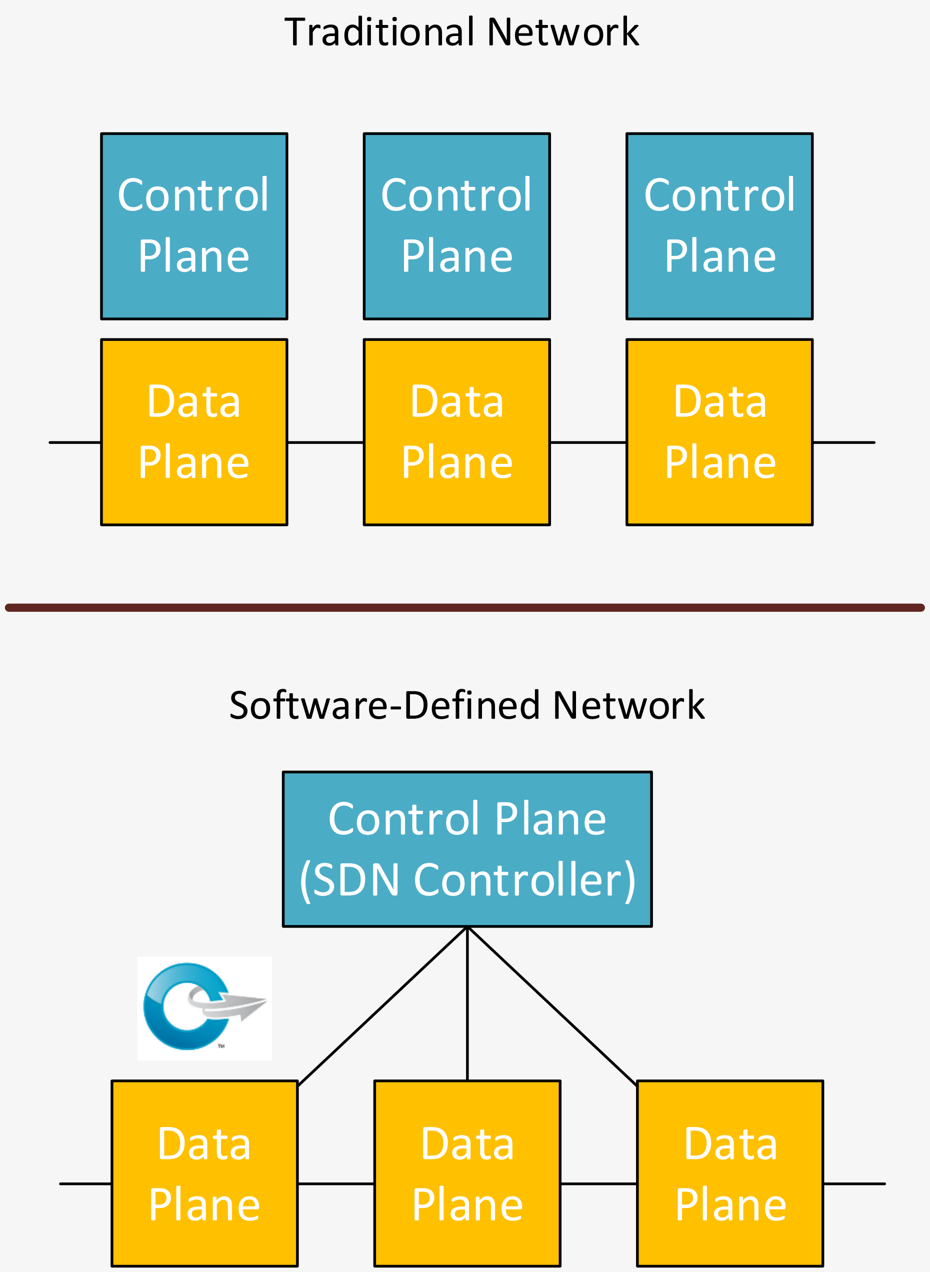
Edge Computing

- Edge computing is a paradigm of **processing data** at the edge of the network **close to the end devices**, where the data is generated, instead of sending the data to the cloud for processing.





Software Defined Networking & Virtualization



SDN Architecture

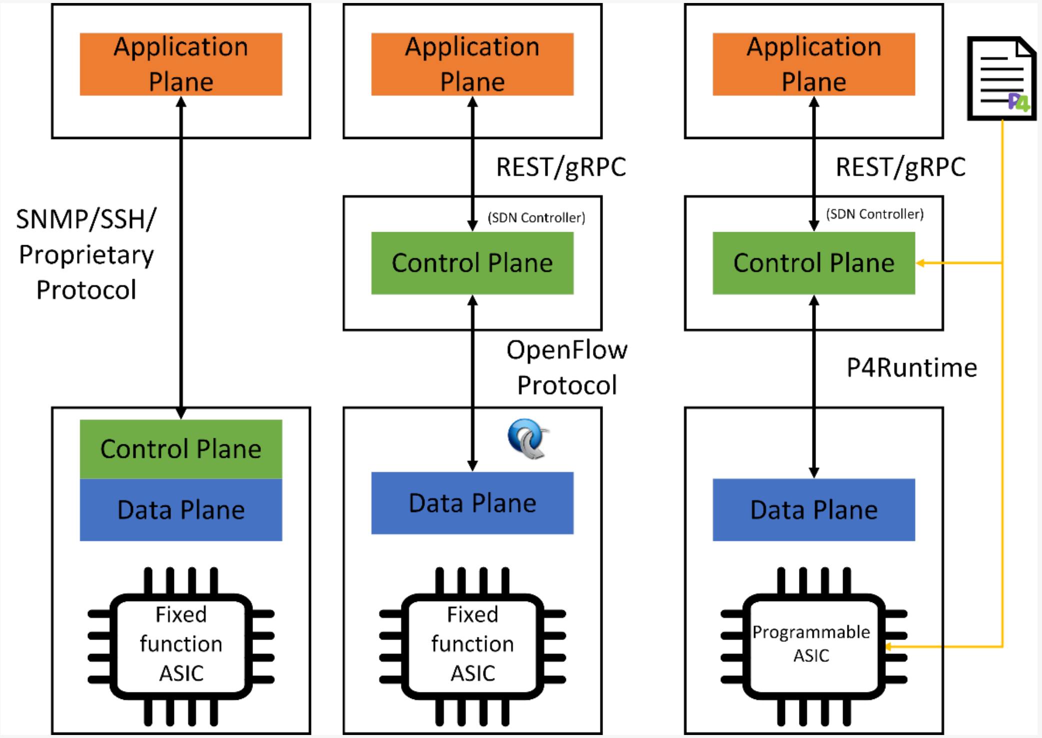
- SDN changes radically the traditional network architecture by decoupling the architectural planes:
  - Control plane has been decoupled – can run on a server as a VM
  - The control plane can be written from scratch
  - Decoupled Control Plane = SDN Controller
  - The Control Plane can instruct the Data Plane what to do with each incoming or outcoming frame

SDN Controllers

- SDN Controller undertake flow control for improved network management and performance
- SDN Controllers utilize CPSIs to interact with network devices (e.g., OpenFlow)
- Most of them are Python or JAVA based

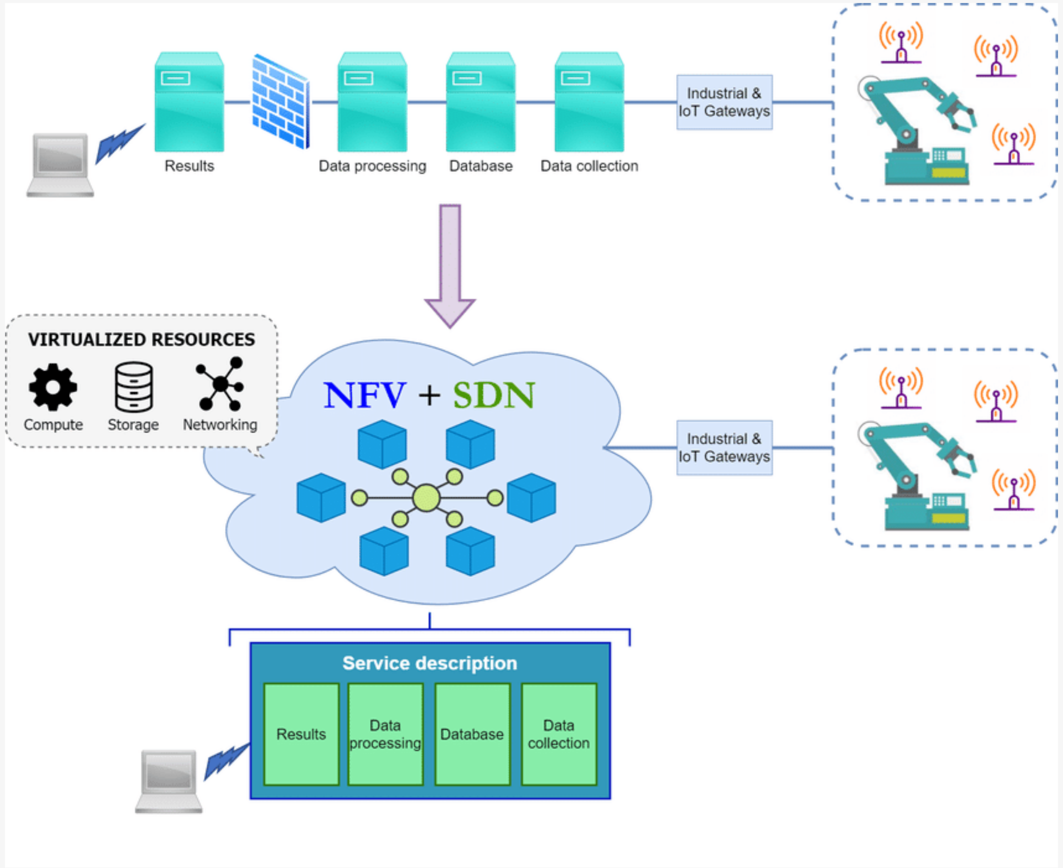
P4 Language

- Introduced in 2014
- P4 is a high-level domain specific language for defining the behavior of programmable data planes
- Data plane ↔ Control plane communications through the OpenFlow → P4Runtime
- So far only one controller (ONOS) supports P4
- P4 also specifies the behavior of the data plane



Liatifis, A., Sarigiannidis, P., Argyriou, V., & Lagkas, T. (2023). Advancing sdn from openflow to p4: A survey. ACM Computing Surveys, 55(9), 1-37

Network Function Virtualization (NFV)



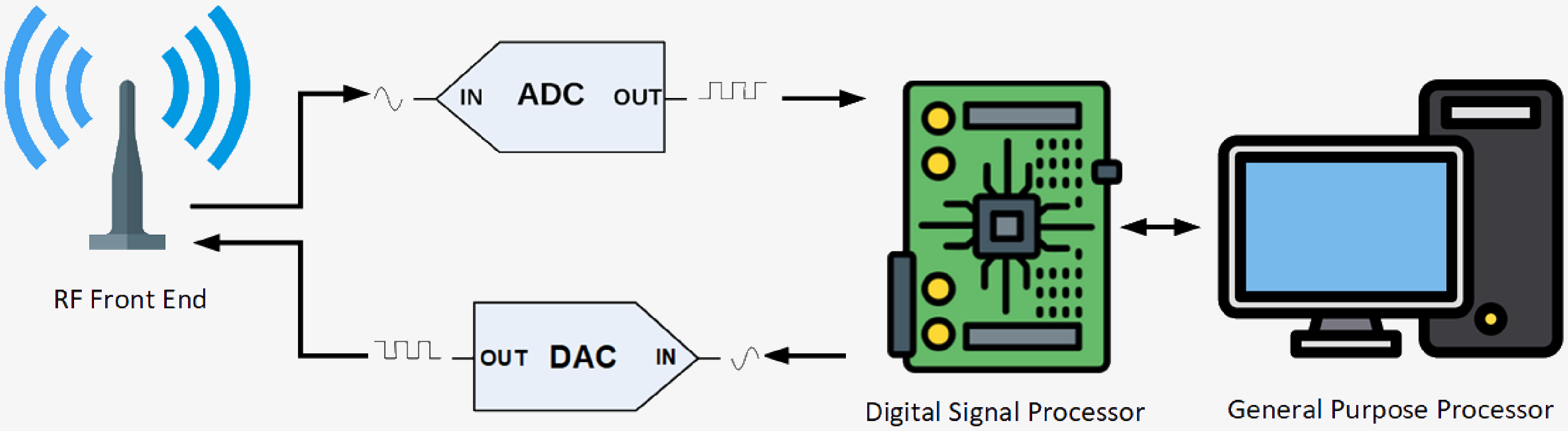
J. Sasiain, A. Sanz, J. Astorga, and E. Jacob, "Towards Flexible Integration of 5G and IIoT Technologies in Industry 4.0: A Practical Use Case," Applied Sciences, vol. 10, p. 7670, Oct. 2020

- NFV is the decoupling of network functions from proprietary hardware appliances and running them as **software in virtual machines** (or containers)
- Various networks functions, like firewalls, traffic control and routing, are called **Virtual Network Functions** (VNFs)
- The European Telecommunications Standards Institute (ETSI) defined a **high-level architectural framework** and design philosophy to foster the adoption of virtualization
- Offers scalability, automation, reduced cost, flexibility.

5G Prototyping using SDR – NANCY Testbed

SDR Components

- Digital Signal Processor (DSP)
  - Responsible for signal processing and implementing the radio functions in software.
- General-Purpose Processor (GPP)
  - Handles the non-real-time aspects of the radio, such as user interface and networking functions.
- Analog-to-Digital and Digital-to-Analog Converters (ADC/DAC)
  - Convert digital signals to analog for transmission and vice versa for reception.
- RF Front End



Hardware Equipment

A. 2x Ettus Research USRP B210

- 70 MHz – 6 GHz Radio Frequencies
- Up to 2x2 Multiple Input Multiple Output
- 56 MHz Real-time Bandwidth

B. Quectel RM520N-GL 5G Module

- Mounted in a USB adaptor

C. SIMCom SIM8200EA-M2 5G Module

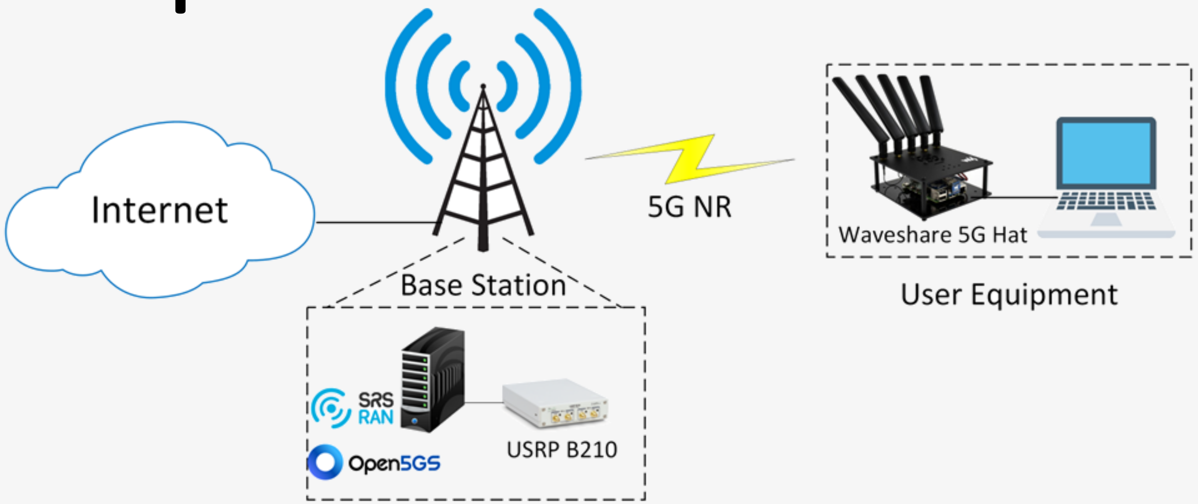
- Mounted in Waveshare 5G Hat

D. sysmocom Programmable SIMs

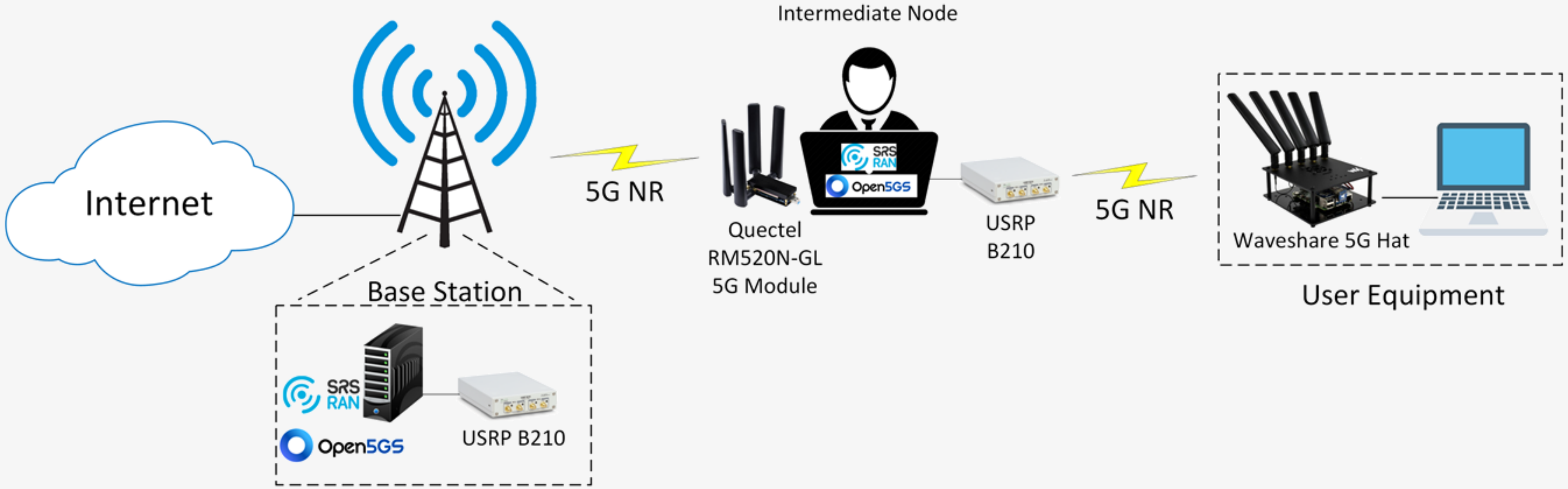
Software

- **srsRAN** (https://www.srsran.com/)
  - Deploys a 5G Base Station using SDR devices
  - Supports 5G Non-Standalone (NSA) and 5G Standalone (SA)
- **Open5GS** (https://open5gs.org/)
  - Provides 5G Core Network Functionalities
- **FlexRIC** (https://gitlab.eurecom.fr/mosaic5g/flexric)
  - Serves as Radio Access Network Intelligent Controller

Coverage Expansion Scenario

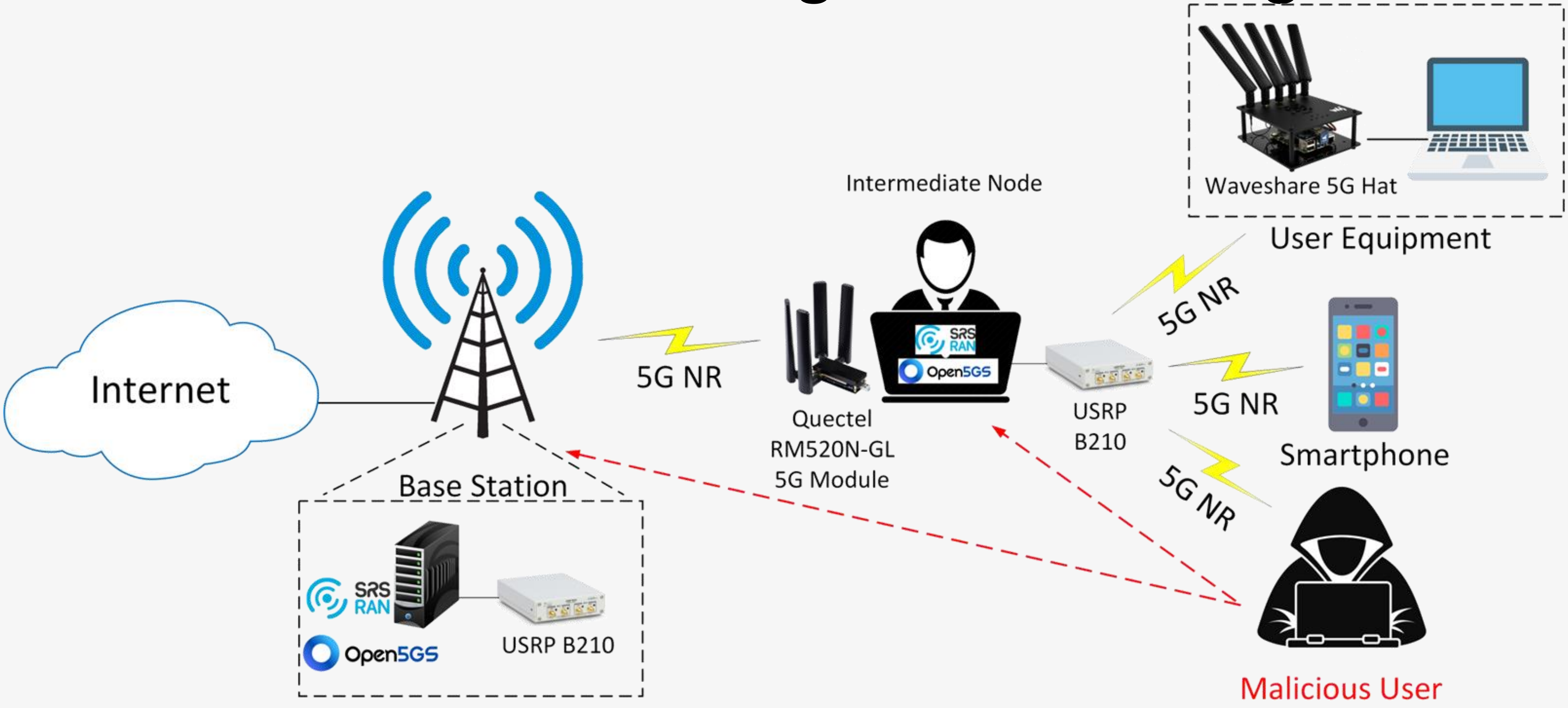


Topology A

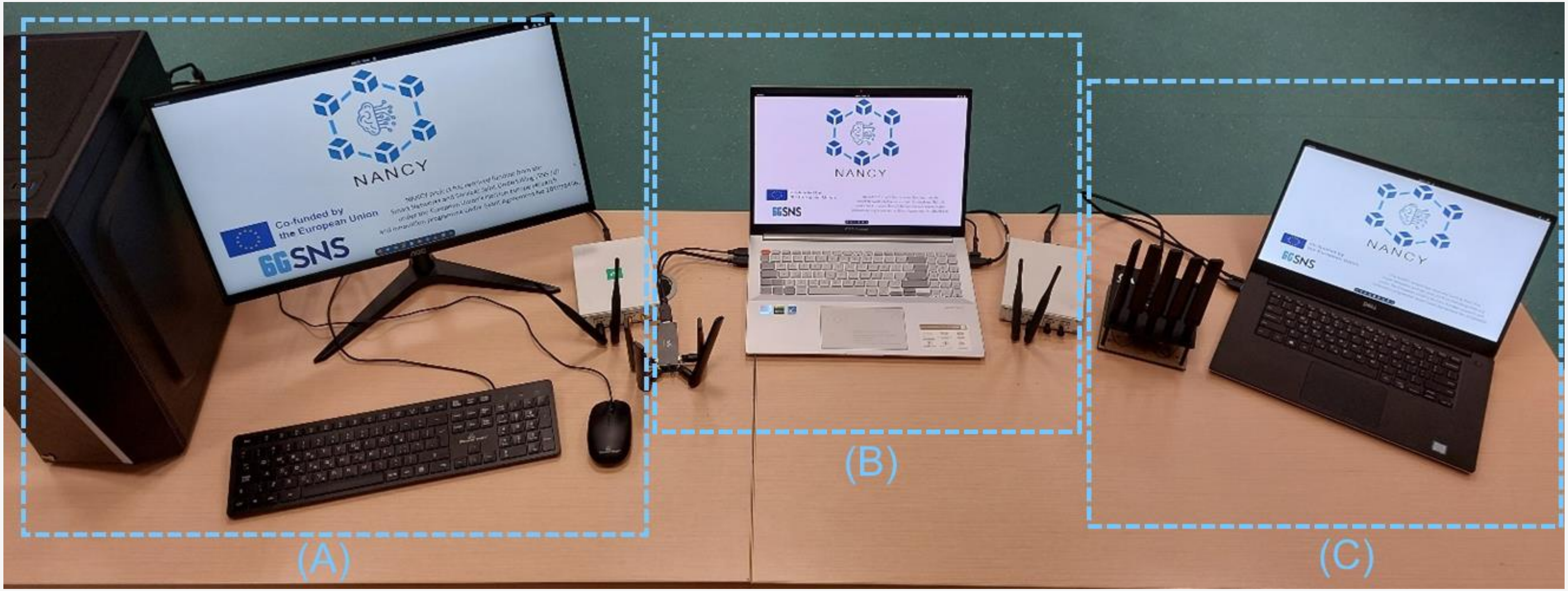


Topology B

Threat Detection using Artificial Intelligence



Laboratory Deployment



(A) Main Base Station

(B) Intermediate Node

(C) User Equipment

Radio Configuration Parameters

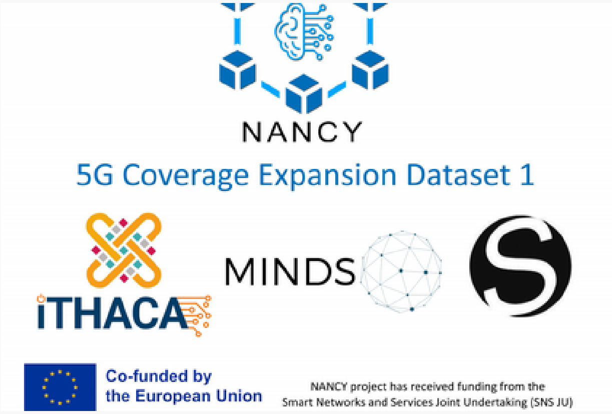
Parameter	Main Base Station	Intermediate Node
Device	Ettus Research USRP B210	Ettus Research USRP B210
5G NR Band	n78	n77
Frequency	3489.39 MHz	4050 MHz
Duplexing	Time Division Duplexing (TDD)	
Bandwidth	40 MHz	
Subcarrier Spacing	30 KHz	
Modulation	256 Quadrature Amplitude Modulation (256-QAM)	
Antenna Configuration	Single Input Single Output (SISO)	

Performance Evaluation Scenarios

- **iPerf3**
  - TCP and UDP Modes

- **VLC Media Player Streaming**
  - 720p - High definition (HD) with a resolution of 1280x720
  - 1080p - Full high definition (FHD) with a resolution of 1920x1080
  - 1440p - 2K resolution of 2560x1440
  - 2160p - 4K resolution of 3840x2160

NANCY SNS JU PROJECT - 5G COVERAGE EXPANSION DATASET 1



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Data Format: *.json; *.pcap

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441 Views

Categories: Wireless Networking, IoT, Communications

Keywords: 5G Mobile Communications; 5G New Radio; Cellular Measurements; Coverage Extension; Packet Capture; Video Streaming; Wireless Communications

IEEE DataPort: http://ieee-dataport.org/12120
Zenodo: https://zenodo.org/records/10442969
DOI: https://dx.doi.org/10.21227/vm3z-ww28

Threat Detection using Artificial Intelligence

Network Traffic Collection (tcpdump)

↓

Conversion to CSV-formatted Network Flows (CICFlowMeter)

↓

Dataset Pre-processing (Pandas)

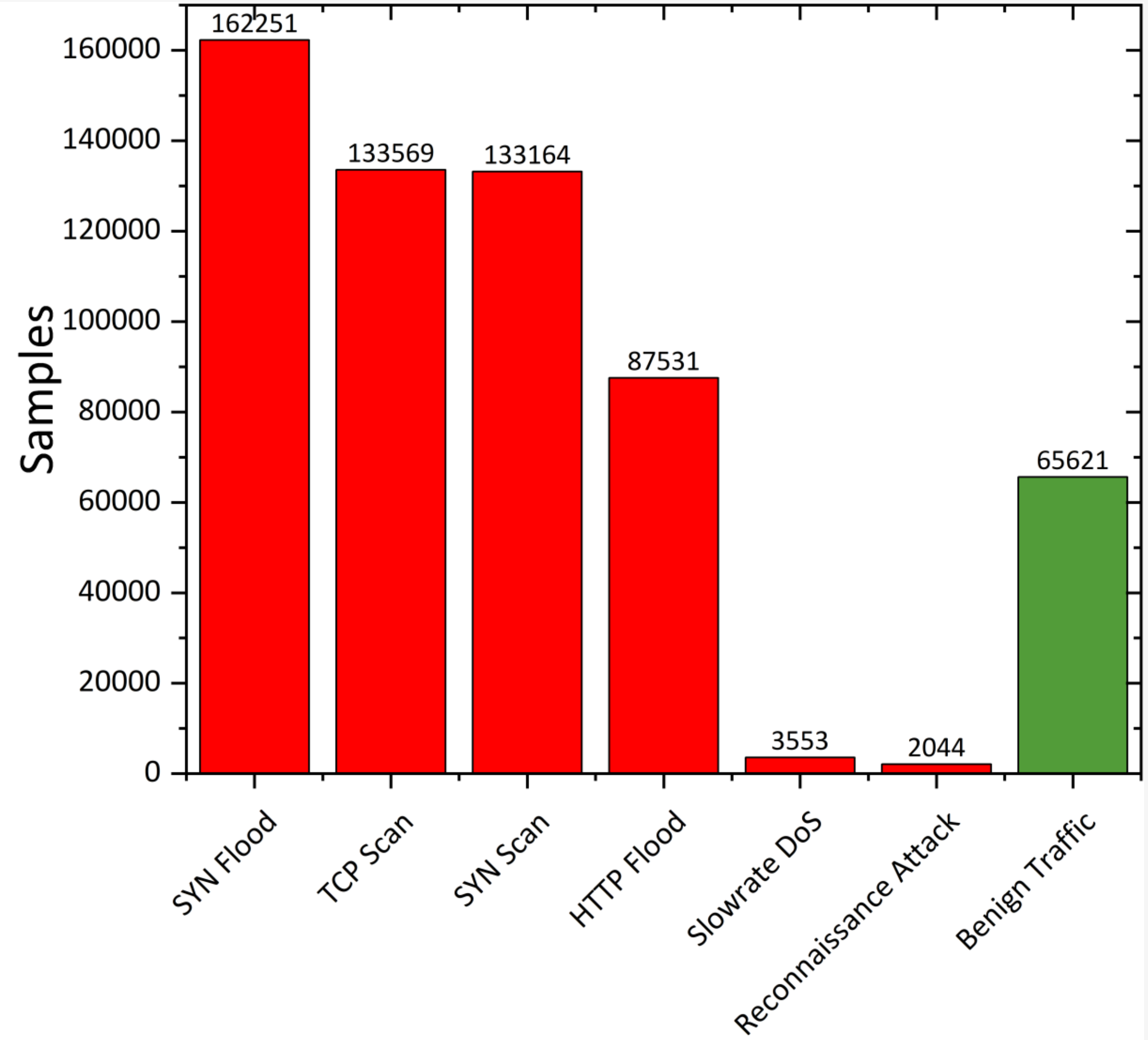
↓

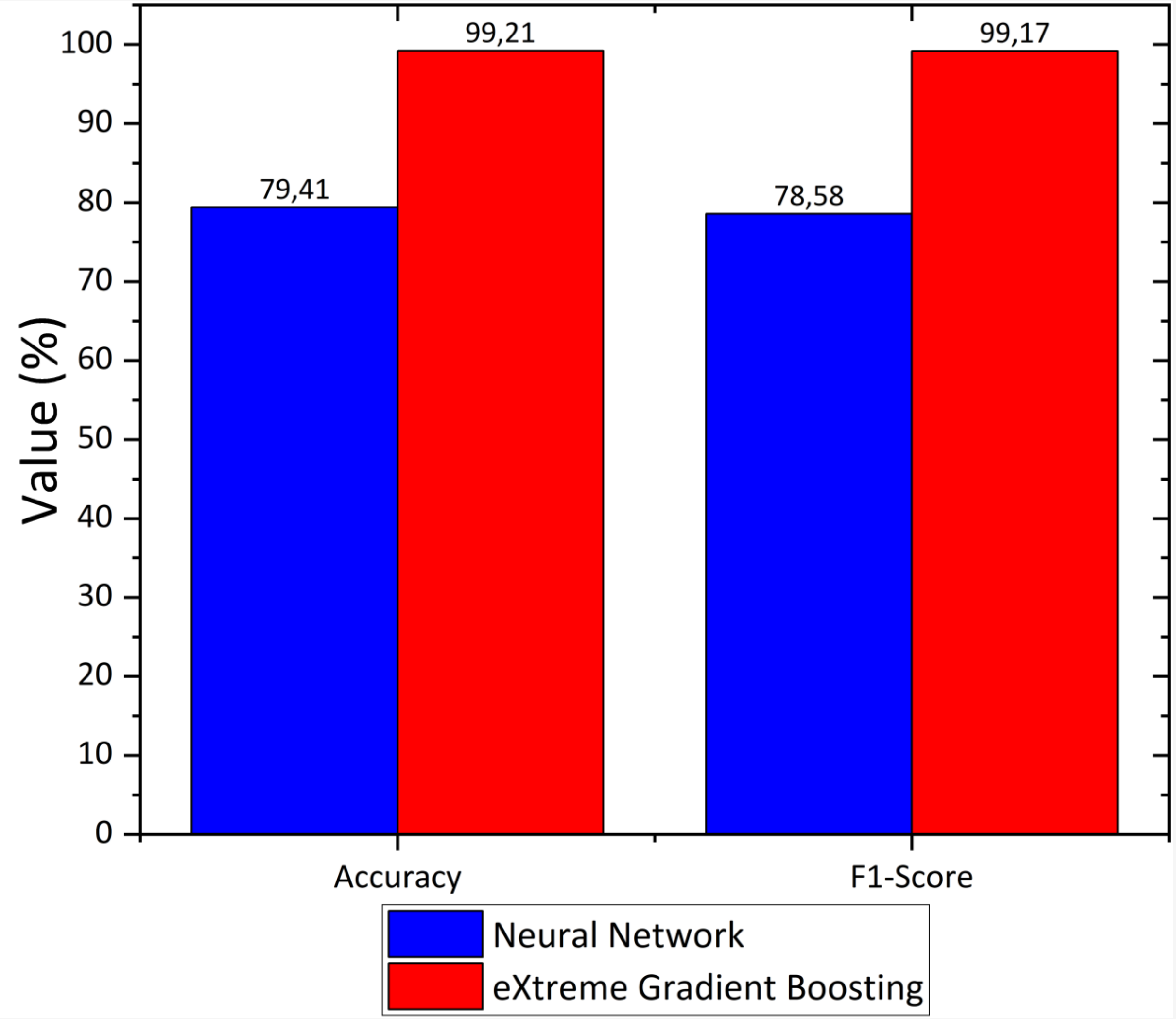
Training/Testing of AI Algorithms (Scikit-learn)

↓

Deployment/Inference

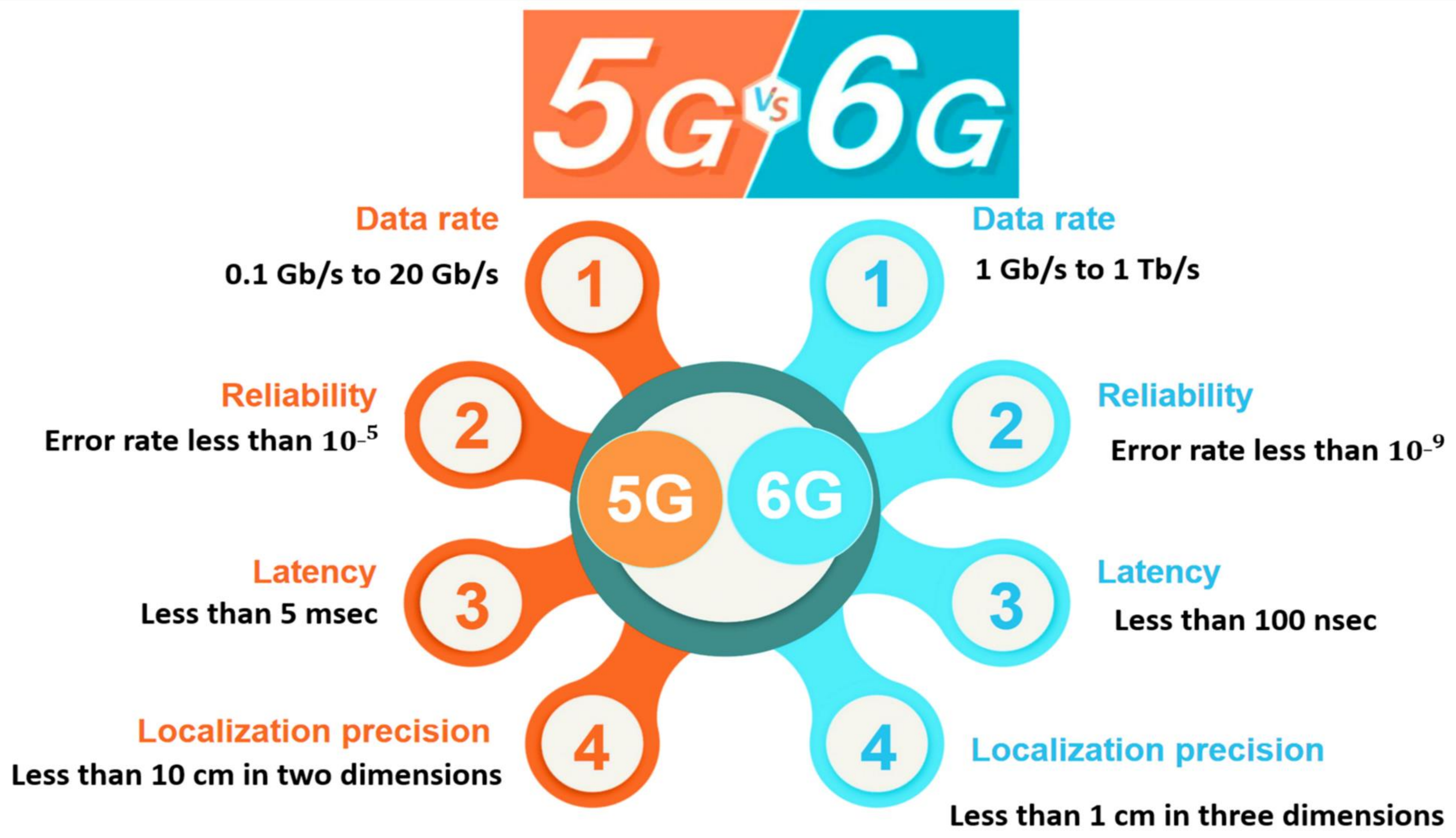
Dataset Size	Features	Classes
587733 Samples	84	7





Toward 6G Networks

5G - 6G Comparison



S. A. Abdel Hakeem, H. H. Hussein, and H. Kim, “Security Requirements and Challenges of 6G Technologies and Applications,” Sensors, vol. 22, no. 5, p. 1969, Mar. 2022

Conclusion

https://www.youtube.com/watch?v=NYHvIG1pJ6w&ab_channel=ITHACALab

Thank You & Q/A

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Thank You

Q/A

iTHACA