

# Project Overview & (meta-) Architecture

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## IoT-NGIN Project Identity Card

- Title: Next Generation IoT as part of Next Generation Internet
- Grant agreement ID: 957246
- H2020 Call: H2020-EU.2.1.1.
  - Funding Instrument: RIA (Research and Innovation action)
- Duration: 36 months
- Starting Date: 1<sup>st</sup> October 2020
- EU Contribution: 7 998 622,50 Euro
- Partners: 19 (Country Coverage (8): France, Spain, Germany, Finland, Luxembourg, Italy, Greece, Cyprus)

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## IoT-NGIN Consortium

<b>M</b>					Logo	Participant organisation name	Short name	Country	
	Atos		ABB	01	Capgemini	Capgemini Technology Services	CAP	France	
Capgemini	AUSS	ERICSSON		02	Atos	Atos Spain S.A.	ATOS	Spain	
				03	ERICSSON 💋	ERICSSON GmbH	EDD	Germany	stry
				04	ABB	АВВ Оу	ABB	Finland	Indu
d			ASM	05	INTRASOFT	INTRASOFT International S.A.	INTRA	Luxemburg	
		BOSCH	ASM Terni S.p.A.	06		Engineering-Ingegneria Informatica SPA	ENG	Italy	
				07	BOSCH	Robert Bosch Espana Fabrica Aranjuez SA *	BOSCH	Spain	Sq
FORUM				08	ASM	ASM Terni SpA	ASM	Italy	g La
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				11	BOS	eBOS Technologies Ltd	EBOS	Cyprus	
		emotion	Α!	12	Privanova -	Privanova SAS	PRI	France	Щ
Synelîxis		C	Aalto University	13	Synel <sup>‡</sup> xis	Synelixis Solutions S.A.	SYN	Greece	SN
	Cumucore			14		CUMUCORE Oy	СМС	Finland	
				15	emotion	Emotion s.r.l.	EMOT	Italy	
				16	A?	AALTO-Korkeakoulusaatio	AALTO	Finland	
<b>I2cat</b>		RWTHAACHEN		17	<i>O</i> i2cat <sup>•</sup>	i2CAT Foundation	I2CAT	Spain	rch
	E.Ok Dongy Insearch Center 1			18		Rheinisch-Westfälische Technische Hochschule Aachen	RWTH	Germany	Resea
				19		Sorbonne Université	SU	France	

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#### I@T-NGIN

## IoT-NGIN in one slide

- Our goal:
  - Bringing the IoT and modern technologies (5G, AI, DLT...) together in an optimal way, towards a sustainable ecosystem of European Technology and System providers
- Offer new tools and ecosystem to enable next-generation IoT
  - New services to existing platforms
  - New platform opportunities
  - New collaboration paradigms
  - New business potential
- Prepare the technology & standardization landscape to manage the demands posed by large-scale IoT deployments

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#### I&T-NGIN

## IoT-NGIN vision and principles



#### I&T-NGIN

## IoT-NGIN Work Organization



- Meta-Architecture & Requirements
   → WP1
- Technology development
   → WP2, WP3, WP4, WP5
- Integration / Validation
   → WP6, WP7
- Impact creation & outreach
   → WP8
- Project Management & OCs
   → WP9

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## IoT-NGIN core technical objectives

#### Patterns-based meta-architecture

- Architectural design language for IoT platforms and services
- targeting mostly next-generation IoT architectures
  - Compatible with existing, legacy IoT architectures
- IoT-NGIN federation approach
  - Privacy preserving federated ML training Distributed AI
  - Inter-DLT technologies for secure and trusted data sharing
  - Zero knowledge proof techniques for ML models verification
  - Meta-level digital twins
  - Ontology-based operations

## IoT-NGIN core technical objectives

- Optimize IoT/M2M and 5G/MCM communications
  - Task offloading (µ-services) onto a secure edge cloud
  - 5G slicing
  - Time Sensitive Networking
  - Research over a 5G network exposure API
- Enable user and self-aware, autonomous IoT systems
  - privacy-preserving federated ML
  - ambient intelligence, with AR support
- Research towards distributed IoT cybersecurity and trust
  - Self-Sovereign Identities
  - Interconnected DLTs
  - ML-based cybersecurity auditing and active protection

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# Standardization / Exploitation outlook

- Thorough inspection of exploitation / standardization / cluster contribution potential
  - 3GPP, 5GPPP, 5G IA, AIOTI, BDVA, GAIA-X, Living.IN-EU, etc





The 5G Infrastructure Public Private Partnership

- Strong industry interest on the project topics
  - On May 2021, Ericsson & CAP have announced a strategic partnership on supporting client 5G innovation

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# Alignment to Standards

• Multifaced, due to depth of the project activities stack

#### Indicative list

- 3GPP stack of standards
- ETSI NSM-AF TS 28.533
- IEEE 802.1 (TSN TG)
- ETSI NGSI-LD
- FIWARE protocol stack
- SAREF
- GS1
- W3 Decentralized Identifiers (DIDs) v1.0



#### Validation 目日日 3 6 Living Labs 6 & Laboratories 12 10 PARTNERS USE CASES Ο 25/11/2021 Project overview and (meta)-architecture 11

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LL 👘	UC #	Title	Objective		
SC	UC 1	Traffic Flow Prediction & Parking prediction	To re-route traffic in case of transport interruption and parking prediction		
SC	UC 2	Crowd Management	<ul> <li>Demonstrate the use of open data, user data and IoT data on traffic fluency at the bottleneck</li> <li>Crowd management of the busy Helsinki- Tallinn cross-border</li> </ul>		
SC	UC 3	Co-commuting solutions based on social networks	Combine IoT data with virtual citizen IoT data from social networks to support co- commuting solutions		
SA	UC 4	Crop diseases prediction, Smart irrigation and precision aerial spraying	<ul><li>Improvement of the prediction of crop disease</li><li>Optimization of precision aerial spraying</li></ul>		

LL UC # Title		Title	Objective		
SA	UC 5	Sensor aided crop harvesting	<ul> <li>Optimization of the crop harvesting process</li> <li>Operational costs' reduction</li> <li>Improvement of quality of services related to harvesting and loading</li> </ul>		
14.0	UC 6	Human-centred safety in a self- aware indoor factory environment (Bosch Aranjuez Factory)	<ul> <li>Improvement of safety parameters inside factories</li> <li>Demonstrate IoT-NGIN contextual IoT sensing to avoid collisions between humans and AGVs</li> <li>Federate and interwork of IoT with 5G and edge computing</li> </ul>		

LL	UC #	Title	Objective
14.0	UC 7	Human-centered augmented reality assisted build-to-order assembly (ABB Helsinki Factory)	<ul> <li>Utilise existing CAD models and wiring instructions to implement AR assisted build-to-order assembly</li> <li>Use digital twins to coordinate the cameras, cabinets and smart tools</li> </ul>
14.0	UC 8	Digital powertrain and condition monitoring (ABB Pitäjänmäki High Power Test Lab)	<ul> <li>Demonstrate the use of wireless communications and federated AI in condition monitoring applications</li> <li>Examine the use of a meta-level digital twin for grouping and managing data gathered from multiple sources</li> </ul>

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L	L	UC #	Title	Objective
S	E	UC 9	Move from reacting to acting in smart grid monitoring and control (ASM Terni)	<ul> <li>Realize a digital twin of the power grid in order to continuously monitor electrical quantities</li> <li>Test Phasor measurements units for distribution grid</li> </ul>
S	E	UC10	Driver-friendly dispatchable EV charging (E-motion, ASM Terni)	<ul> <li>EVs smart charging with renewable energy using smart contracts</li> <li>Test Augmented Reality interaction with charging stations</li> </ul>



## IoT-NGIN meta-Architecture

And IoT-NGIN reference implementation

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## The IoT-NGIN meta-architecture

- The **meta-architecture** takes a higher-level view and collects together architecturally significant choices, patterns, components, viewpoints and quality attributes that need to be considered when designing and implementing individual systems.
  - provides a foundation for the architecture and system design.
- Four main points of view:
  - Domain Horizontal
  - Quality Vertical
  - Architectural Patterns Vertical
  - Element view
    - Artificial Intelligence

## The IoT-NGIN meta-architecture



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## Meta-Architecture: Intelligence

#### The presence of ML & AI is ubiquitous, catalysed by MLaaS

- Delivers automated ML pipelines and services
  - To the project services
  - To third parties
- Arbitrary number of supported technologies
  - Focus on:
    - Privacy Preserving Federated Learning
    - Active/Continuous Learning
    - Deep Learning
    - Model training and polyglot sharing
    - Generative Adversarial Networks



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## The IoT-NGIN meta-architecture



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## The IoT-NGIN meta-architecture



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## The IoT-NGIN meta-architecture

Functional Group	Necessity
Infrastructure	Infrastructure provisioning, bootstrapping and management is necessary for allowing applications to properly operate.
Federation	Granted the (horizontal) scalability requirement stemming from the Quality vertical, support for federated orchestration at compute and data level is deemed necessary.
Workloads	In tandem with the Infrastructure and the Federation functional groups, the workloads functional group represents the necessity to optimally manage the hosted application and data workloads.
Things	The Things functional group functionalities cover the necessity to manage not only the platform- oriented workloads, but also the device ones.
Fog-Edge	The Fog-Edge functional group is necessary to achieve effective communication and secure task offloading (towards lowering the cost and increasing the capabilities of the supported IoT devices)
Automation	Granted the expected rise in the design complexity of the offered IoT platform services, the Automation functional group represents the needs to easily install and dynamically (automatically) manage the provided platform instances.
Analytics	To uncover the value of the underlying platform-collected/generated data, it is important to feature analytics toolboxes.

## Compliance to the IoT-NGIN metaarchitecture

Meta-Architecture view	Compliance baseline
Quality vertical	ALL elements/requirements should be satisfied.
Architectural patterns vertical	At least one should be adopted*.
Element View	All security elements should be present. For each one of the first-level functional groups, at least one element should be adopted.
Underlying ML/AI	Desirable, not necessary.

\* With the exception of the identification of new patterns that have not been (implicitly or explicitly) considered by the relevant work

# IoT-NGIN reference meta-architecture instantiation



#### Layered architecture

- Multiple, semiautonomous layers
- Each living lab features its own instantiation
- Compliant with the requirements of the meta-architecture
- Extensible, open to other interfacing with existing systems, devices and platforms

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#### IOT-NGIN

## 5G Network & Resources Management



#### **Core Objectives**

- Enhance IoT underlying technology offering IoT/5G optimization
- Provide a "by-design" secure edge cloud execution environment to support micro-services' offloading and increase scalability

## 5G Network & Resources Management



- 5G range extention via D2D communications
- IoT MCM Communications
  - Network Slice Manager
    - 3GPP NSM-AF TS 28.533
    - Implementation including IEEE TSN characteristics
- 5G Resource Mgmt API
  - API for unified access to 5G and Edge resources

## 5G Network & Resources Management



- Secure Edge Cloud Framework
  - Edge infrastructure
    - Secure Unikernels
    - Containers
  - ML functionalities
    - Enhanced learning mechanisms
    - Inference services (together with MLaaS)
  - Kubernetes unikernel services

## Enhancing IoT Cybersecurity & Data Privacy



#### **Core Objectives**

 Enhance Iot Cybersecurity against data poisoning and ML-based anomaly detection

• Enforce data sovereignty by making IoT data accessible in a trusted, auditable and controlled way

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### I**⊘T-NGIN**

## Enhancing IoT Cybersecurity & Data Privacy



- IoT Vulnerabilities crawler
  - Report known CVEs identified for IoT-NGIN devices
- Attack detection using federated ML
  - Synthetic datasets of poisoning attacks in IoT
  - Train a Malicious Attack Detector (MAD)
  - Moving Target Defence (MTD) network of Honeypots

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### I**⊘T-NGIN**

## Enhancing IoT Cybersecurity & Data Privacy



- Interledger enables atomic cross-ledger transactions
  - Decentralized bridging interledger
- Privacy-preserving Self-Sovereign Identities for different entities
  - DIDs, VCs, QR codes & GS1 links
- SAREF Ontologies enable interoperability for Meta-level Digital Twins (MLDT)

## Enhancing IoT Intelligence



#### **Core Objectives**

- Big data management and privacy preserving federated ML layer
- Deep learning and reinforcement learning techniques to enhance training processes with adaptive self-learning
- ZK for ML models verification
- Reinforce secure and trusted
   data sharing

# Enhancing IoT Intelligence



- ML as a Service Framework
  - Data acquisition
  - Data preprocessing
  - AI modelling (at the edge)
  - AI model deployment
  - Integration and model operation
  - Model sharing
- Technology highlights
  - Kubeflow, Onnx, IoT gateways
  - MLOps (via ArgoCD & gitlab runners)

# Enhancing IoT Intelligence



- Technical focus
  - Online Learning
    - On top of SKLearn and Wabbit
  - Model optimization
  - Privacy preserving FL
    - For different classes of devices (IoT, Edge, Cloud)
  - Model sharing
    - Polyglot model sharing (onnx)
      - Model conversion, protocol buffers
    - Transfer Learning (SDK)

# Enhancing IoT Tactile & Contextual Sensing/Actuating



#### **Core Objectives**

- PRESS analysis
  - Privacy, data pRotection, Ethics, Security & Societal aspects
- Improve objects recognition using visual/non-visual methods
- Ambient Intelligence access control
- Repository of AR/MR software
   to support 3rd parties

# Enhancing IoT Tactile & Contextual Sensing/Actuating



- Devices recognition
  - Computer vision
  - QR codes
  - RF protocols
- Device Indexing
  - Based on FIWARE loT Agents
- Access Control module
  - AAA considering external factors like proximity
- APIs and tools to interact with IoT-NGIN via using AR/MR/XR frameworks

# Integration and deployment

- Specific tasks for application development
  - On top of the generic IoT-NGIN generic protocol and services task
- DevSecOps connected with CI/CD principles
- Kubernetes-based deployments
- Laboratory validations
  - OneLab, Eurolab
- Verification and replication guidelines



- IoT-NGIN encompasses a very wide range of future and legacy IoT platforms requirements
  - Open meta-architecture
  - Open APIs
  - Open Source
  - Focus on:
    - Interoperability by design
    - Security by design
    - Privacy by design
    - Traceability by design
    - Data sovereignty by design

Project overview and (meta)-architecture

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## More Information

- Web site:
- Email: <u>info@iot-ngin.eu</u>
- Twitter: <u>https://twitter.com/lotNgin</u>

https://iot-ngin.eu

- LinkedIn:
- F6S:

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- https://www.linkedin.com/company/iot-ngin/
- <u>https://www.f6s.com/iot-ngin-1st-open-call</u>



# Thank you for your attention

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