










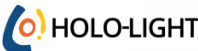




IntelloT

The IntelloT Architecture

TERMINET Standardisation Workshop

17 January 2024

IntelloT Consortium partners

#	Name		Country	Type
1	Siemens AG		DE	Industry
2	EURECOM		FR	Research
3	Aalborg University		DK	Research
4	University of Oulu		FI	Research
5	TTControl GmbH		AT	Industry
6	Telecommunication Systems Institute		GR	Research
7	Philips Research		NL	Industry
8	Sphynx Analytics Ltd.		CY	SME
9	University of St. Gallen		CH	Research
10	HOLO-Industrie 4.0 Software GmbH		DE	SME
11	AVL List GmbH		AT	Industry
12	Startup Colors UG		DE	SME
13	University General Hospital of Heraklion		GR	Industry
14	Vidavo S.A.		GR	SME

Duration:

01.10.2020 – 31.01.2024
(40 Months)

Overall EU funding:

8 mil €
(incl. 830k € for Open Calls)

(Reminder) IntelloT Motivation

Today, **IoT cloud platforms** are central points of data collection and processing.



This **cloud-centric IoT** model however **has limitations**:

- (i) **unreliable cloud connectivity** impedes dependable end-to-end applications,
- (ii) **limited bandwidth** restricts the amount of data that can be processed,
- (iii) **high round-trip times** prevent real-time operation,
- (iv) **high cost of data transport and intake**, and
- (v) **privacy and trust concerns**.
- (vi) **lacking *self-awareness* of individual subsystems** hinder use cases with dynamically changing context due.

(Reminder) IntelloT Goal

IntelloT develops:

a reference **architecture** and **framework**

to enable *IoT environments* for **(semi-)autonomous IoT applications**

endowed with intelligence that evolves with the **human-in-the-loop**

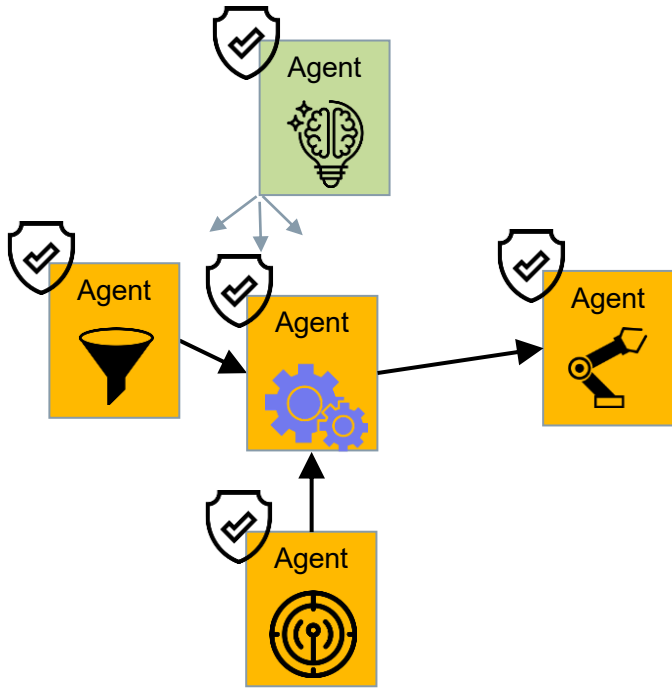
based on an efficient and reliable **IoT/edge-** (computation) and **network-** (communication) **infrastructure**

that **dynamically** adapts to changes in the environment and

with built-in and assured **security, privacy, and trust.**

Concept

Collaborative IoT Applications



- Multi-Agent System
- W3C Web of Things

Deployment

Expertise

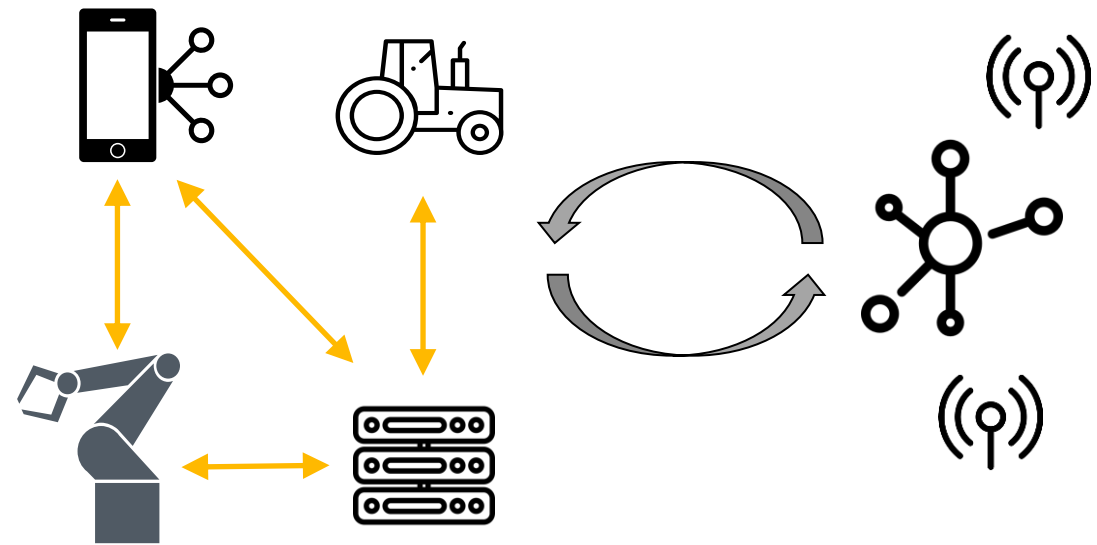
Trust

Human-in-the-Loop



- AR/VR/MR
- AI re-training

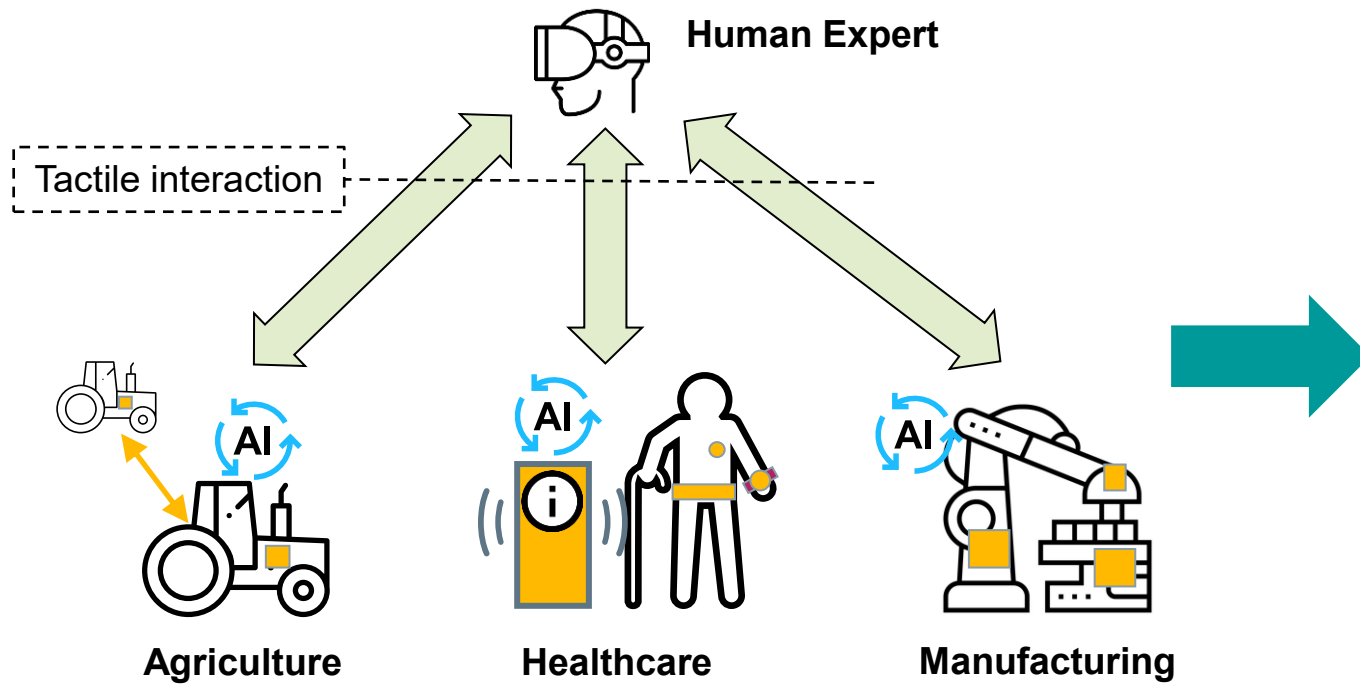
Computation & Communication Infrastructure



- Edge Computing
- Distributed AI
- Distributed Ledger

- 5G
- TSN

Use Cases of Intelligent IoT Environments



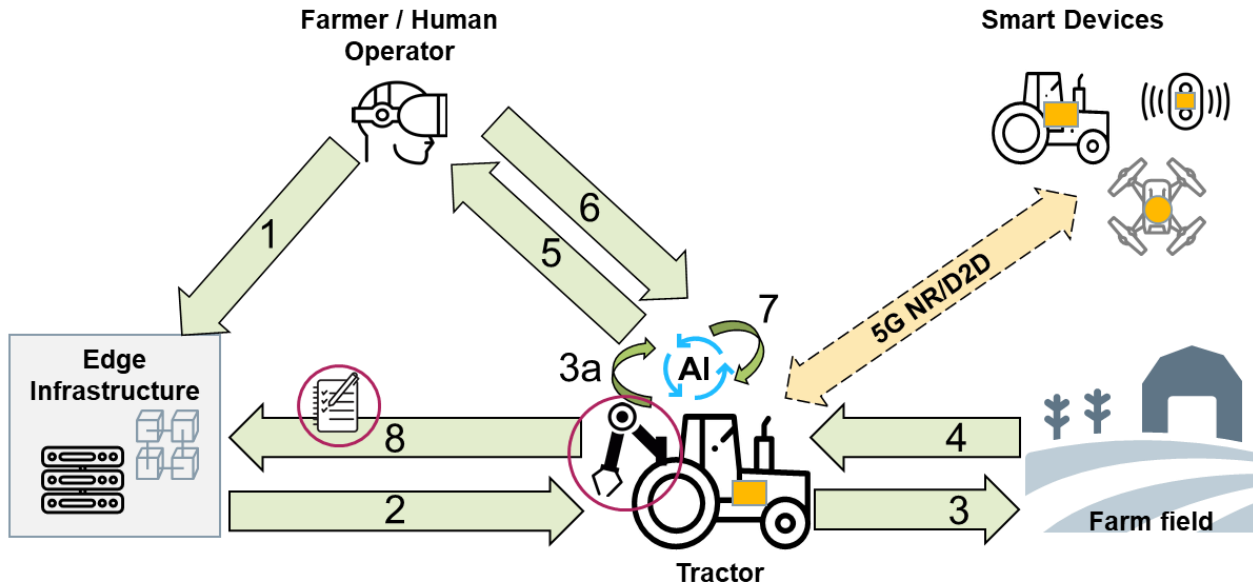
Enable *local*, intelligent IoT environments
with **de-centralised AI** applications
interacting with the **human-in-the-loop**.



■ IoT Device

Agriculture Use Case

TTControl
HYDAC INTERNATIONAL

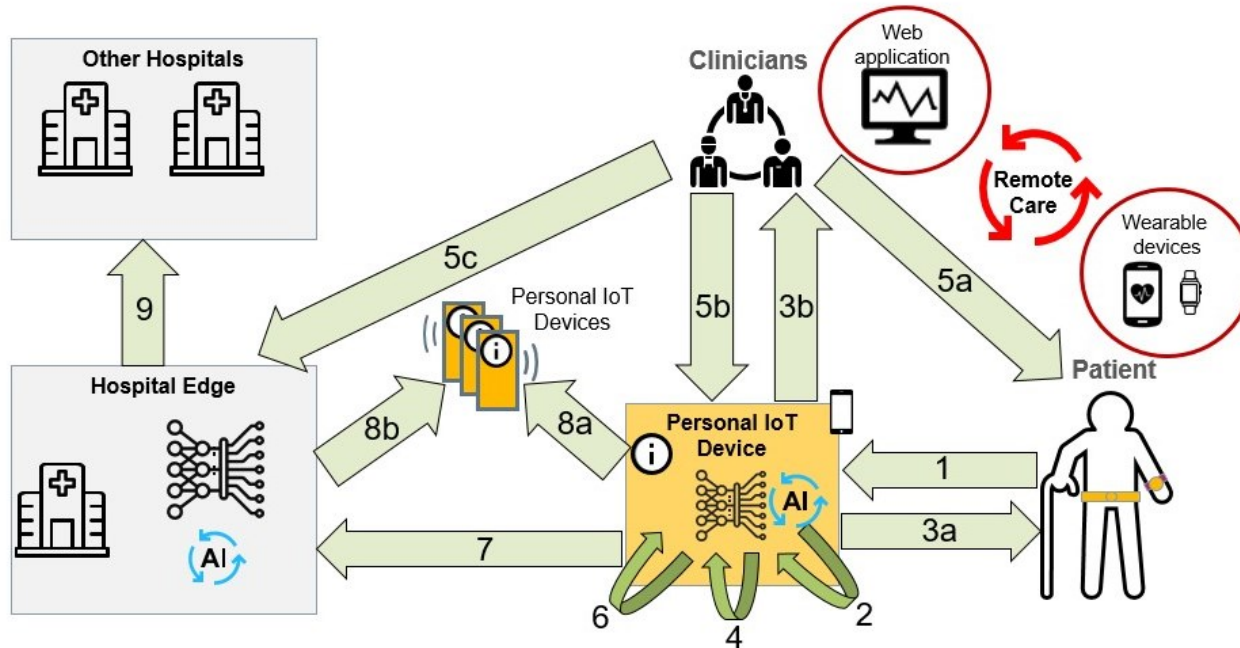


1. Define goal
2. Functionality deployment
3. Environment perception
- 3a. Autonomous operation
4. Unknown situation

5. Request take over
6. Remote control of vehicle / manipulator
7. Update AI model
8. DLT/Logbook access

- Farmers defines to goal
- HyperMAS identifies available resources
- Tractor performs assigned activities
- AI is used to overcome unknown situations
- Tractor interacts with other entities in the field
- Human is brought into the loop, where AI is not confident enough
- Human operates tractor remotely
- AI learns from interaction for future situations
- 5G ensures communication with guaranteed QoS for vehicles and humans

Healthcare Use Case PHILIPS

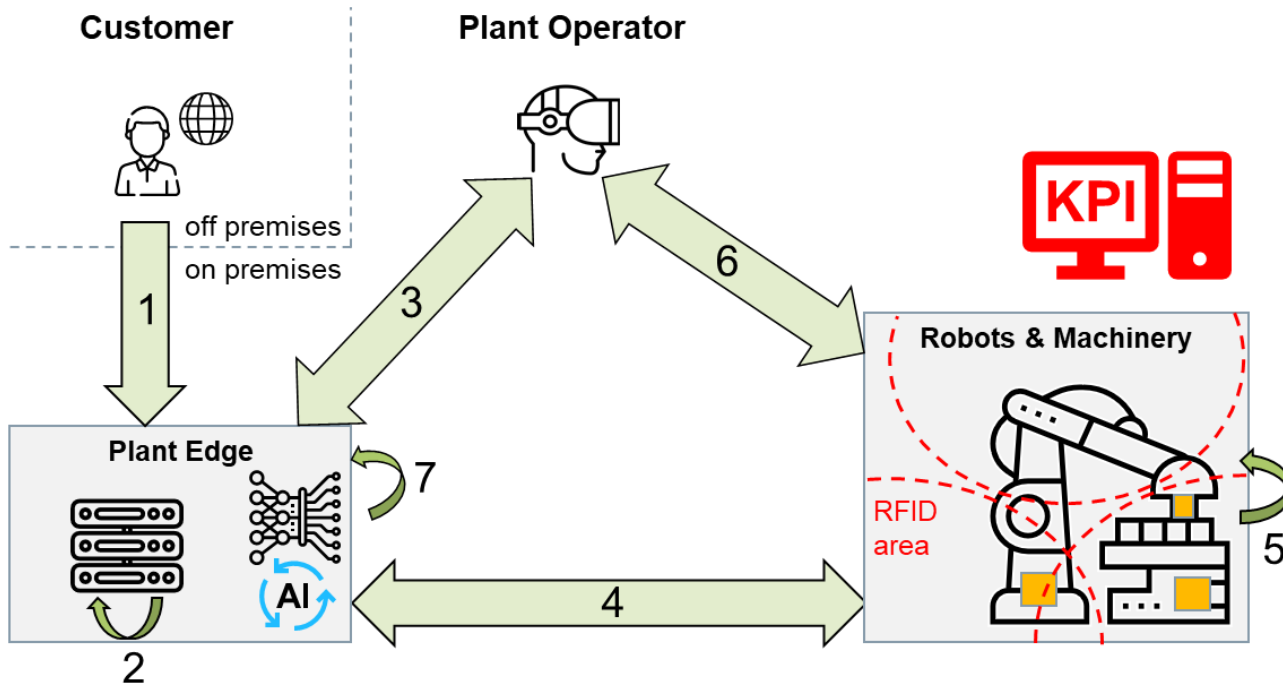


- 1. Health data
- 2. Data analysis
- 3a. Health recommendation
- 3b. Escalate to Clinicians
- 4. Device monitoring and diagnostics
- 5a. Direct recommendation

- 5b. Advice to personal device
- 5c. Broadcast to specialists or alarm
- 6. Re-train AI model
- 7. Model update
- 8a/b. Cross-patient model federation
- 9. Cross-site model federation

1. IoT device collects health data.
2. Local AI application analyzes data.
3. System sends: a) patient recommendation, b) physician notification.
4. Optionally, monitor technical issues.
5. Physician: a) contacts patient, b) sends notification back, c) raises alarm.
6. Local AI model is validated and re-trained.
7. Global AI application aggregates models.
8. Global AI application distributes new model.
9. Global AI applications at multiple sites share models.

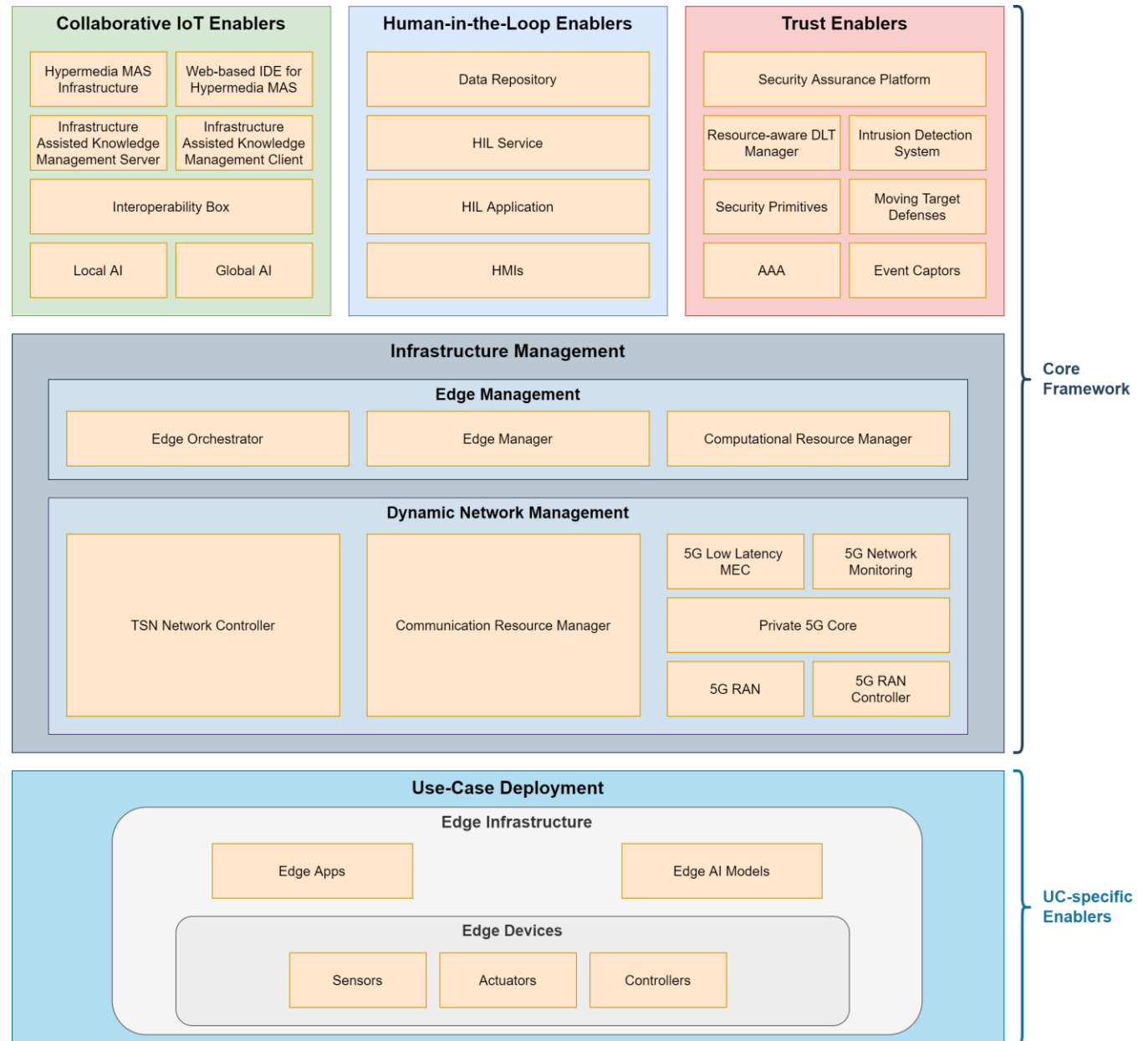
Manufacturing Use Case **SIEMENS**



- | | |
|---|--|
| 1. Define manufacturing goal | 5. Robot movement & workpiece handling |
| 2. Process planning & machine orchestration | 6. Get human help and guide robot |
| 3. Support process planning | 7. Learn from human help |
| 4. Transport commands and Production data | 8. Capture spatiotemporal data |

- Customer defines goal, means she describes the desired product
- Edge orchestrator places applications on resources in edge environment
- Agents within the HyperMAS collaborate to reach the goal
- Artificial Intelligence is used to adapt to different workpieces (lot size one)
- Human is brought into the loop, where AI is not confident enough
- 5G and TSN ensure communication with guaranteed QoS for machines and humans
- Derive KPIs from spatiotemporal information

IntelloT High Level Architecture (General Framework)

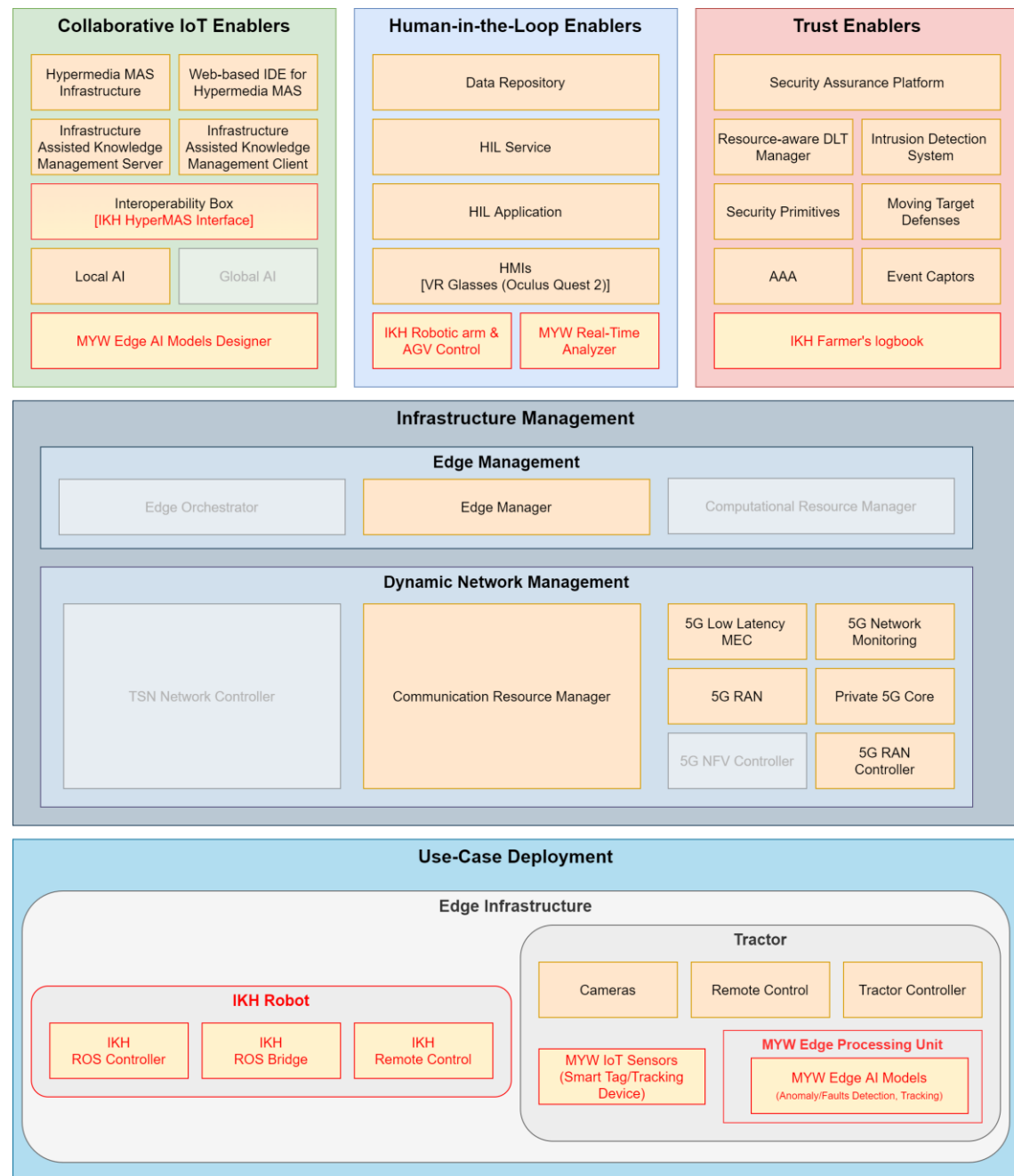


IntelloT Architecture

- Five core component groups:
 - **Collaborative IoT enablers:** Components that realize IntelloT's Collaborative IoT pillar, focusing on the cooperation of various semi-autonomous entities to execute IoT applications.
 - **Human-in-the-Loop enablers:** Components involved in IntelloT's Human-in-the-Loop (HIL) pillar, which focuses on involving the human in the process; e.g., to solve complex situations.
 - **Trust enablers:** Components that are part of IntelloT's Trust pillar. This pillar focuses on privacy, security, and ultimately building trust into the IntelloT framework.
 - **Infrastructure management:** The computation & communication infrastructure and its management capabilities, enabling the deployment and management of edge applications.
 - **Use-Case deployment:** Components which are UC-specific, (i.e., pertaining to the use case environment deployment), such as edge devices, edge apps, and edge AI models.

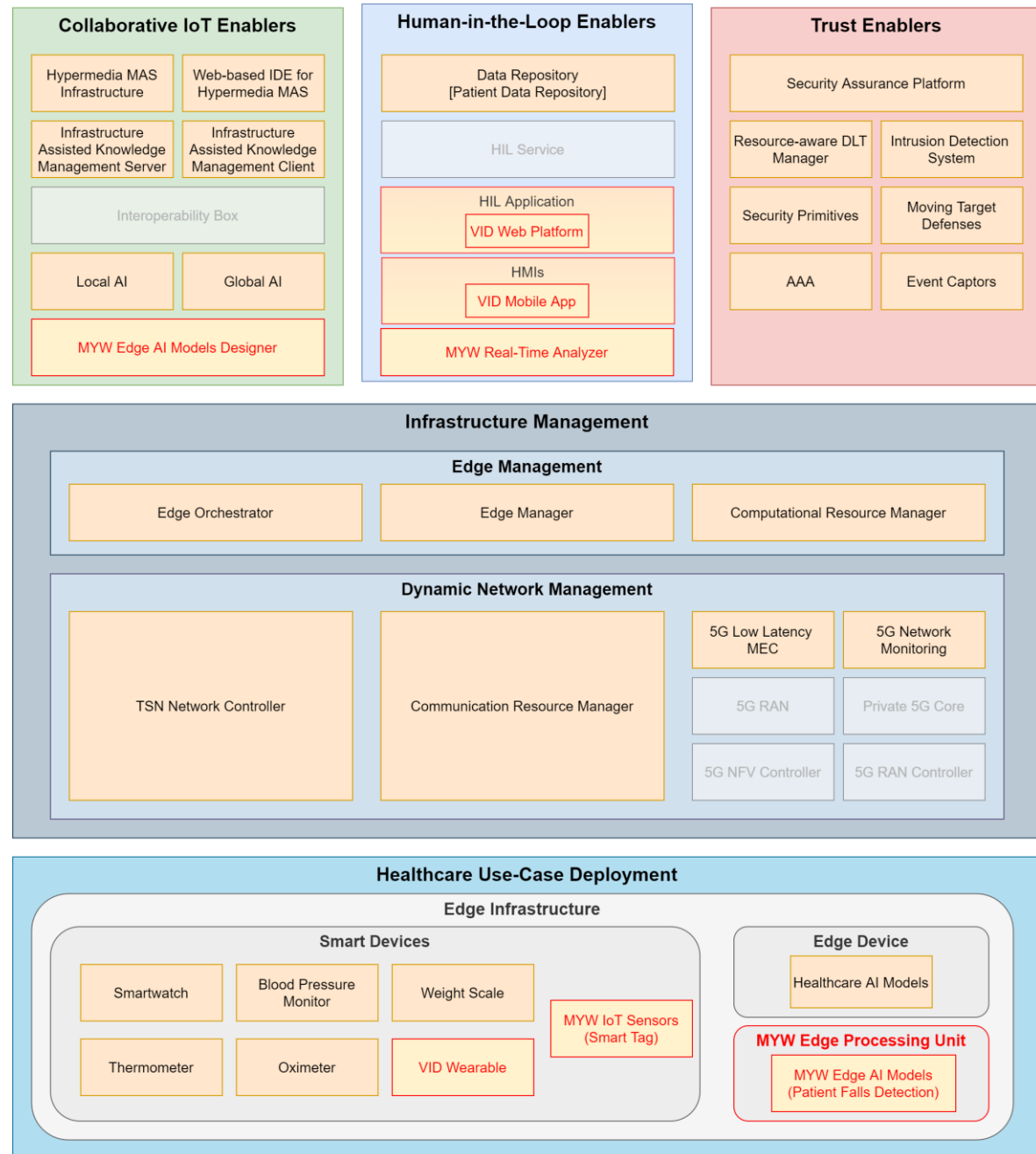
IntelloIoT High Level Architecture - UC1

Including OC #1
Contributions
[iKnowHow & MYW.AI]



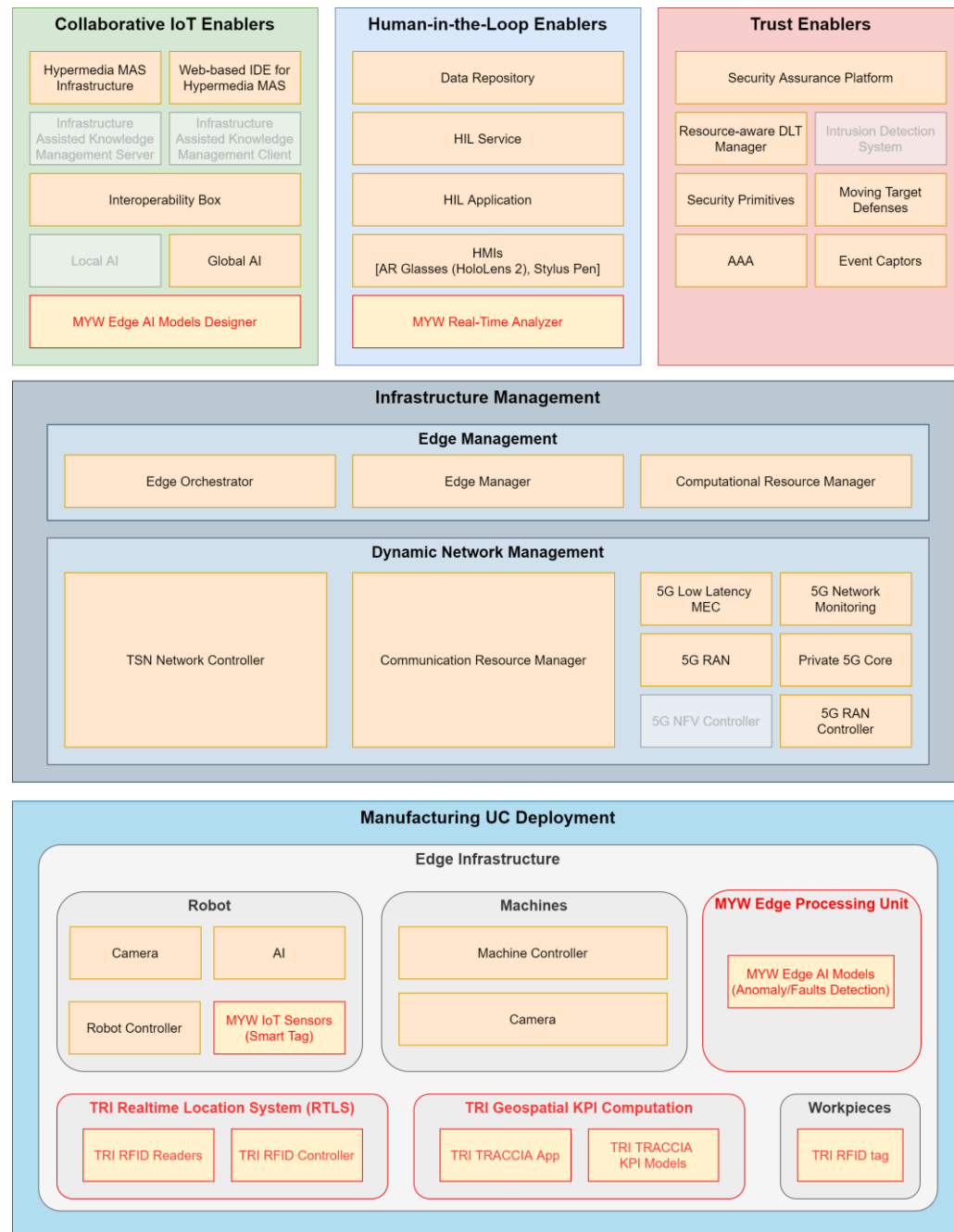
IntelloIoT High Level Architecture - UC2

Including OC #1
Contributions
[VIDAVO & MYW.AI]



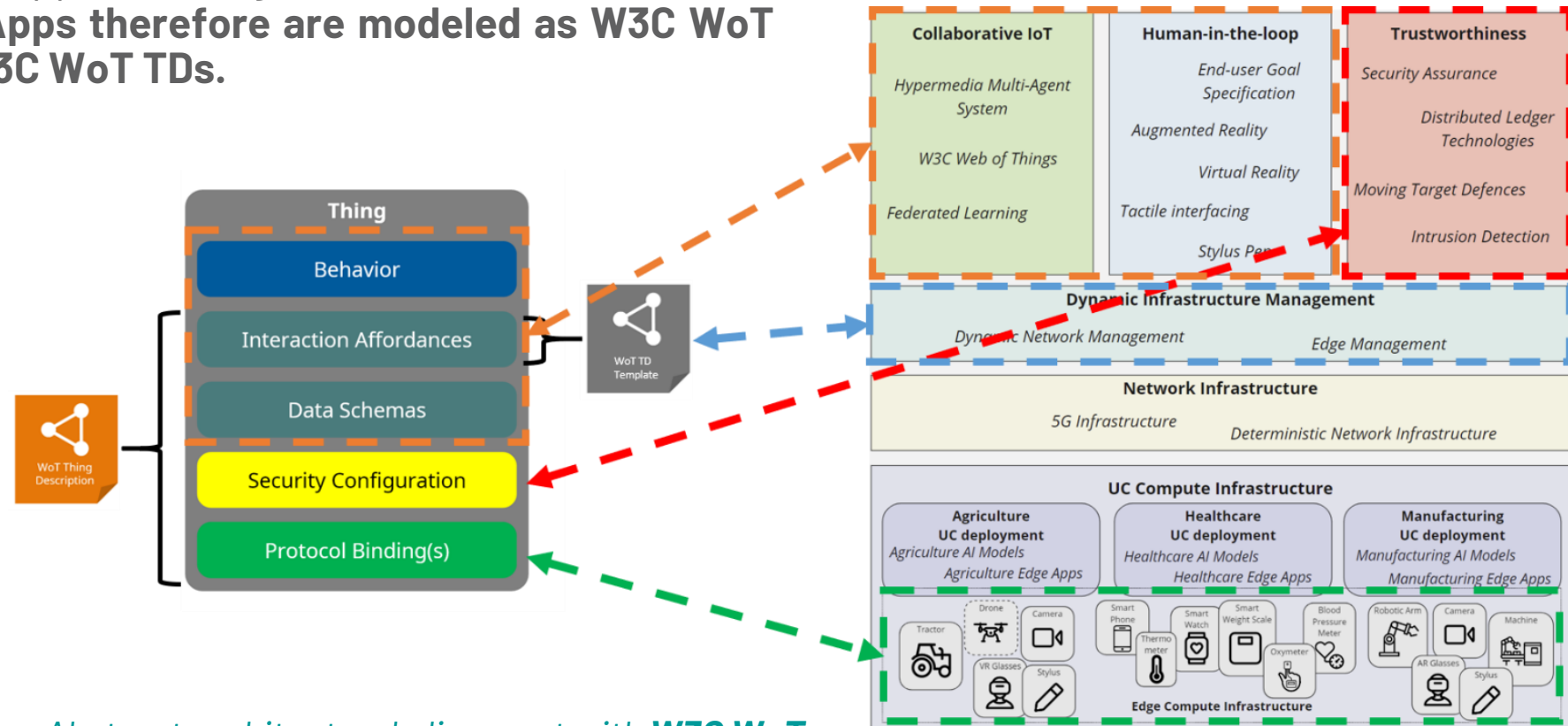
IntelloIoT High Level Architecture - UC3

Including OC #1
Contributions
[Trilogis & MYW.AI]



Relation to IoT Architectures – W3C WoT

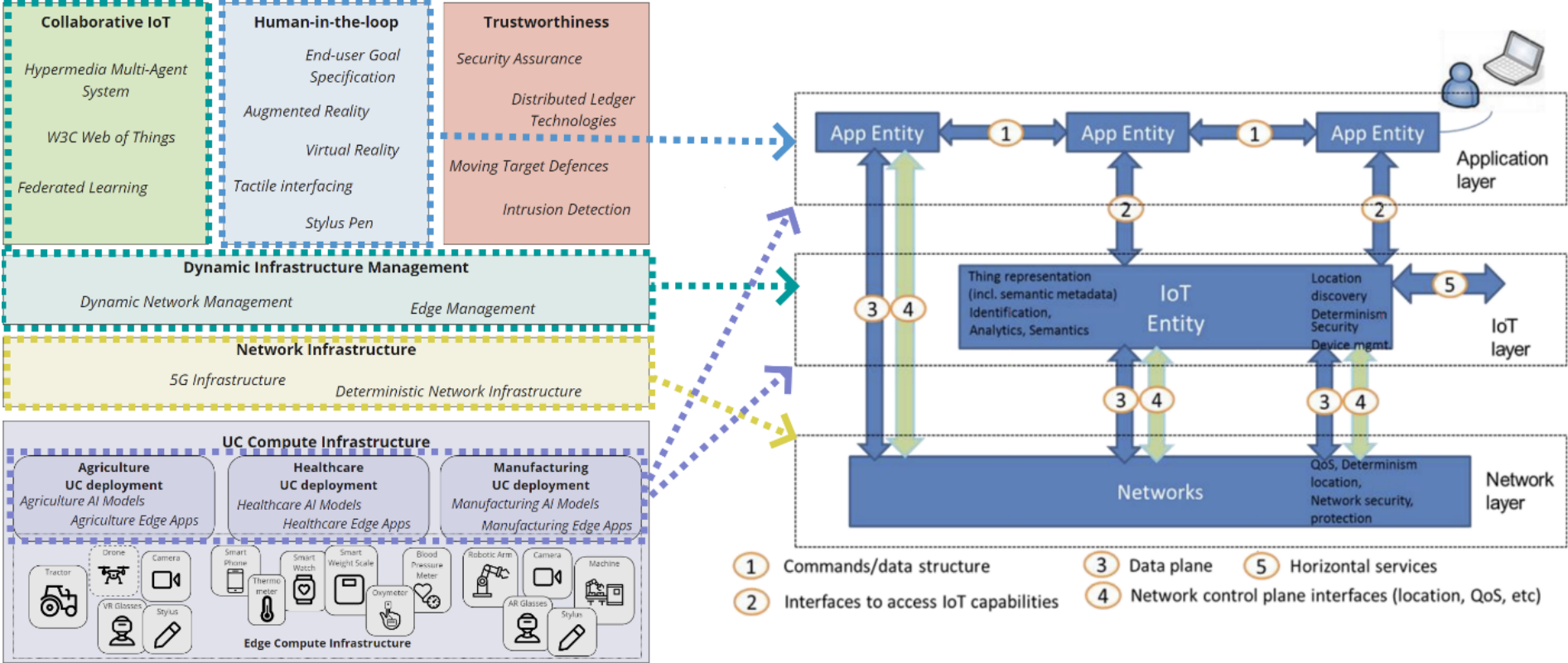
- All services that might be used by consumers in IntelloIoT are encapsulated within Edge Apps – in alignment with the W3C WoT Architecture, **these Edge Apps therefore are modeled as W3C WoT Web Things and provide W3C WoT TDs.**
- Hypermedia Infrastructure provides **affordances** that allow consumers to create Agent environments & workspaces and to add other W3C WoT Web Things to workspaces. The main service consumers in IntelloIoT are Agents (W3C WoT Consumers) that live in the Hypermedia MAS Infrastructure



Abstract architectural alignment with **W3C WoT**

Relation to IoT Architectures – Other

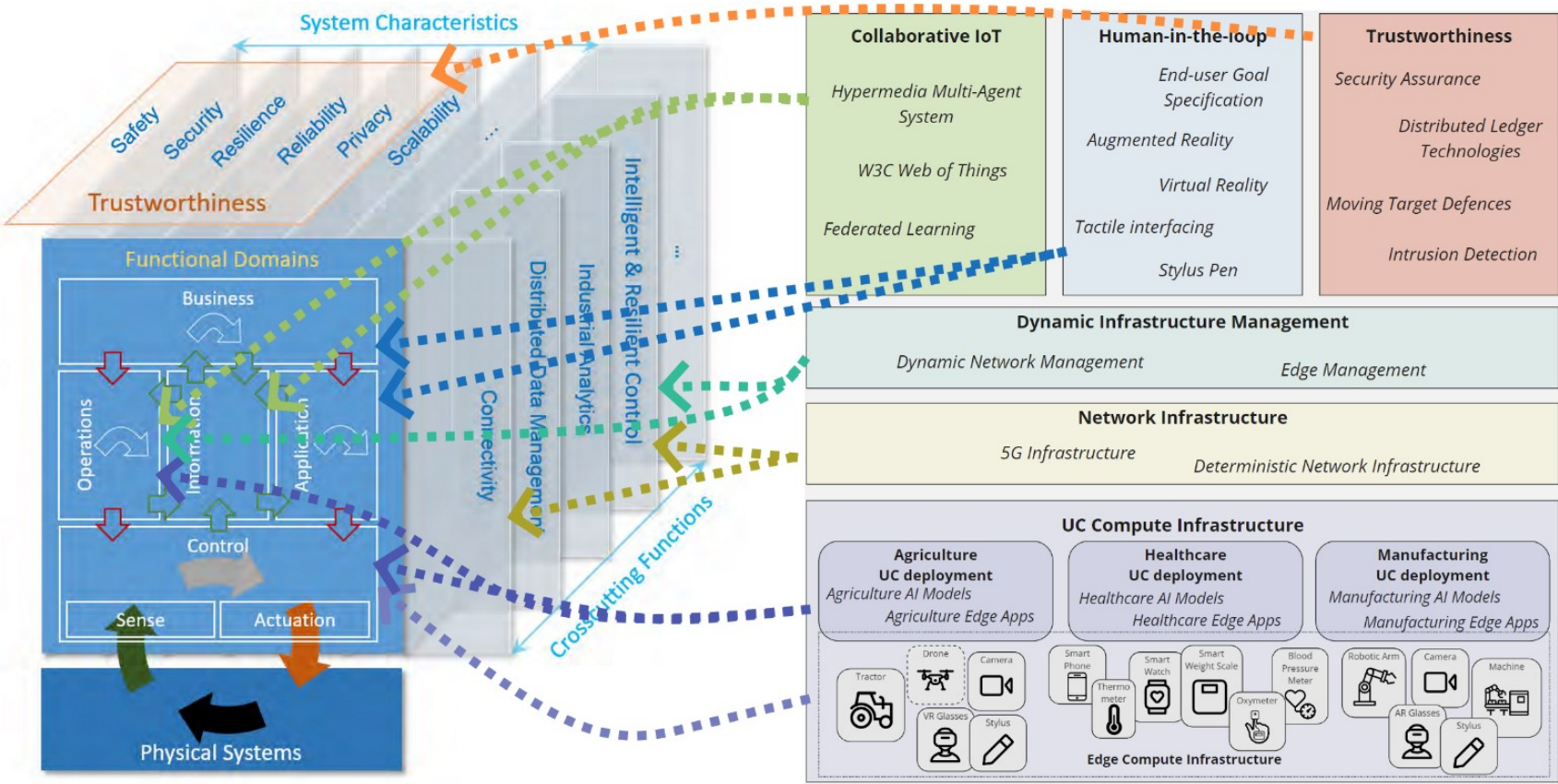
Mapping to additional established IoT “Reference Architectures” has been studied as well.



IntelloT's high level architecture (left) mapped to AIOTI's High Level Architecture (HLA) functional model (right)

Relation to IoT Architectures – Other

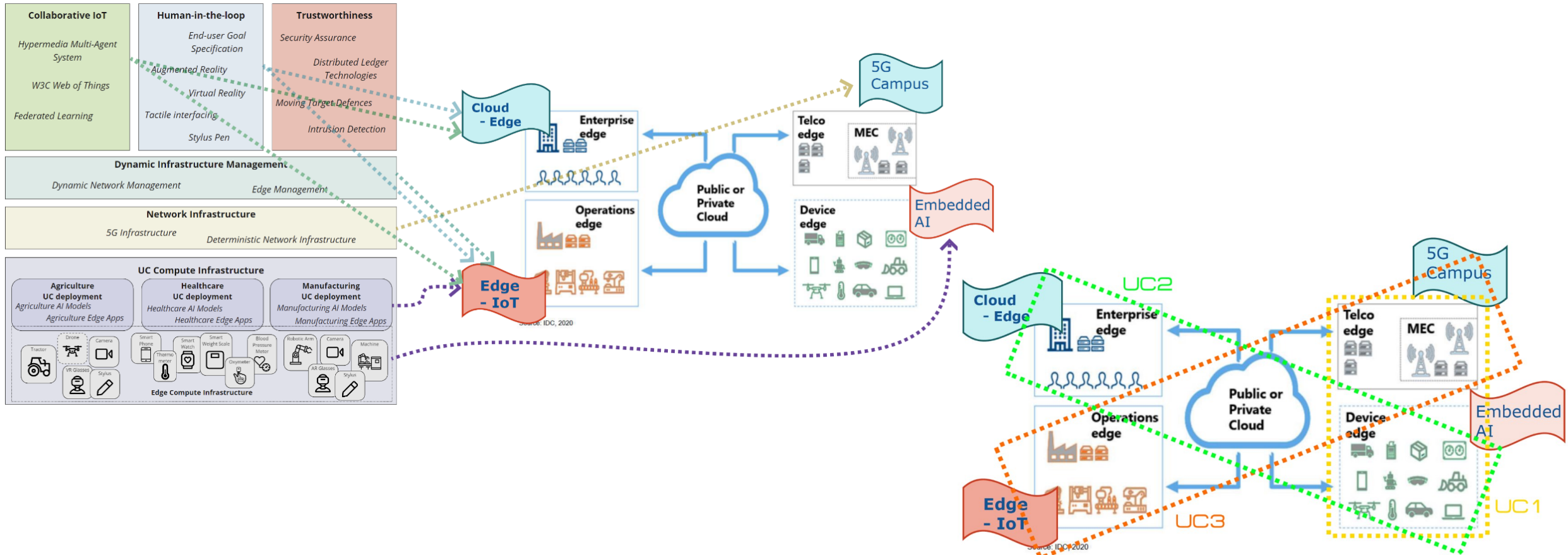
Mapping to additional established IoT “Reference Architectures” has been studied as well.



IntelloT's high level architecture (right) mapped to **Industrial Internet Reference Architecture (IIRA)** Functional Domains, Crosscutting Functions and System Characteristics (left)

Relation to IoT Architectures – Other

Mapping to additional established IoT “Reference Architectures” has been studied as well.



IntelloT’s high level architecture and the project’s Use Cases mapped to the **Edge Taxonomy (IDC & European Commission)**

Standards – Main areas of contributions (1/2)

- 5G ACIA (5G Alliance for Connected Industries and Automation)
 - SIEMENS and EURECOM contributed to the activities of the 5G ACIA standardization group with use cases for Edge computing in a 5G environment of a manufacturing shop floor as well as distributed AI
 - Siemens contributed with a 5G requirements for AR with remote control
- 3GPP
 - EURECOM listing 3GPP RAN, Core and Application work items related to IntellioT
 - Following & adopting relevant extensions & use cases
 - Ultra-Reliable Low Latency in 5G RAN and 5G Core Networks
 - Vehicle-to-Everything Extensions
 - AI/ML integration in 5G Systems
 - Industrial Internet-of-Things (IIoT)
 - Contribution to 3GPP RAN WI on 5G NR Sidelink (D2D) unlicensed spectrum, as well as wakeup signals for low power 5G IoT devices
- AIOTI WG Standardisation TF
 - IntellioT use cases have been presented by EURECOM
 - IoT Relation and Impact on 5G particularly of interest
 - Contributions prepared to the AIOTI landscape maintenance & standardisation Task Force (TF)
 - Contributed as input to the AIOTI survey Edge Computing OSS with EURECOM's OpenAirInterface platform

Standards – Main areas of contributions (2/2)

- W3C WoT WG

- Contributions to the validation of W3C WoT TDs in use cases, the creation of tooling & libraries around W3C WoT TDs, and the extension of W3C WoT TD
- Presentation of IntelloT use cases to W3C WoT Working Group
 - As a follow up, an overview of the use cases sent for listing at - <https://www.w3.org/TR/wot-usecases/>
- Conceptual advancements of W3C WoT proposed
 - W3C WoT Thing Models for Late Binding in Edge Orchestration
 - W3C WoT TD-based Journaling of Interactions
 - Exposure of W3C WoT TDs via a Hypermedia MAS Infrastructure
 - W3C WoT TD-based No-Code Development for Domain Experts
 - Investigation of Affordance Theory in the Context of W3C WoT TDs
- Contribution to the Creation of a W3C Community group on Autonomous Agents on the Web

- OASIS CACAO Specification

- SANL's solutions integrated within IntelloT one of the first to adopt the specification; Continuous interaction with members of the OASIS Collaborative Automated Course of Action Operations (CACAO) TC, providing feedback & lessons learned from applying CACAO in practice within IntelloT and its use cases.

- ...as well as active participation in relevant EU efforts

- NGIoT Thematic Workshop: Health and Care (Siemens/EURECOM Presentation of 5G MEC/Edge Architecture for Smart Health & Care)
- EU-IoT support
 - EU-IoT project webinar on standardization and open source (Participation on 15/09/2021)
 - Presentation to the 4th EU-IoT Training Workshop: "Next Generation IoT Architectures" ("IntelloT's architectural vision in alignment with W3C WoT")

Thank you for your attention



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