The IntellIoT Architecture
TERMINET Standardisation Workshop
17 January 2024
## IntellIoT Consortium partners

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### Duration:
01.10.2020 – 31.01.2024
(40 Months)

### Overall EU funding:
8 mil €
(incl. 830k € for Open Calls)
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.
IntelliIoT Goal

IntelliIoT 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

Human-in-the-Loop

- AR/VR/MR
- AI re-training

Computation & Communication Infrastructure

- Edge Computing
- Distributed AI
- Distributed Ledger
- 5G
- TSN

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

**Use Cases of Intelligent IoT Environments**

- **Agriculture**
- **Healthcare**
- **Manufacturing**

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Dr. Arne Bröring
Agriculture Use Case

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
1. IoT device collects health data.
2. Local AI application analyzes data.
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.
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
IntelliIoT
High Level Architecture (General Framework)
IntellIoT Architecture

• Five core component groups:
  • **Collaborative IoT enablers:** Components that realize IntellIoT’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 IntellIoT’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 IntellIoT’s Trust pillar. This pillar focuses on privacy, security, and ultimately building trust into the IntellIoT 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.
IntellIoT
High Level
Architecture
- UC1

Including OC #1 Contributions
[iKnowHow & MYW.AI]
IntelliIoT
High Level Architecture
- UC2

Including OC #1 Contributions
VIDAVO & MYW.AI
IntellIoT
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 IntellIoT 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 MAS 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 IntellIoT 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.

IntelliIoT’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.

IntelliIoT’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.

IntellIoT’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) un 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 IntellIoT 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 IntellIoT 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 IntellIoT 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 15/08/2021)
    - Presentation to the 4th EU-IoT Training Workshop: “Next Generation IoT Architectures” (“IntellIoT’s architectural vision in alignment with W3C WoT”)

Konstantinos Fysarakis, SANL
2024. 01. 22.
Thank you for your attention