



HiPEAC Webinar Series: Next-generation IoT insights

TERMINET: nexT gEneRation sMart INterconnectEd IoT



University of Western Macedonia

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Project Identity and Main Challenges

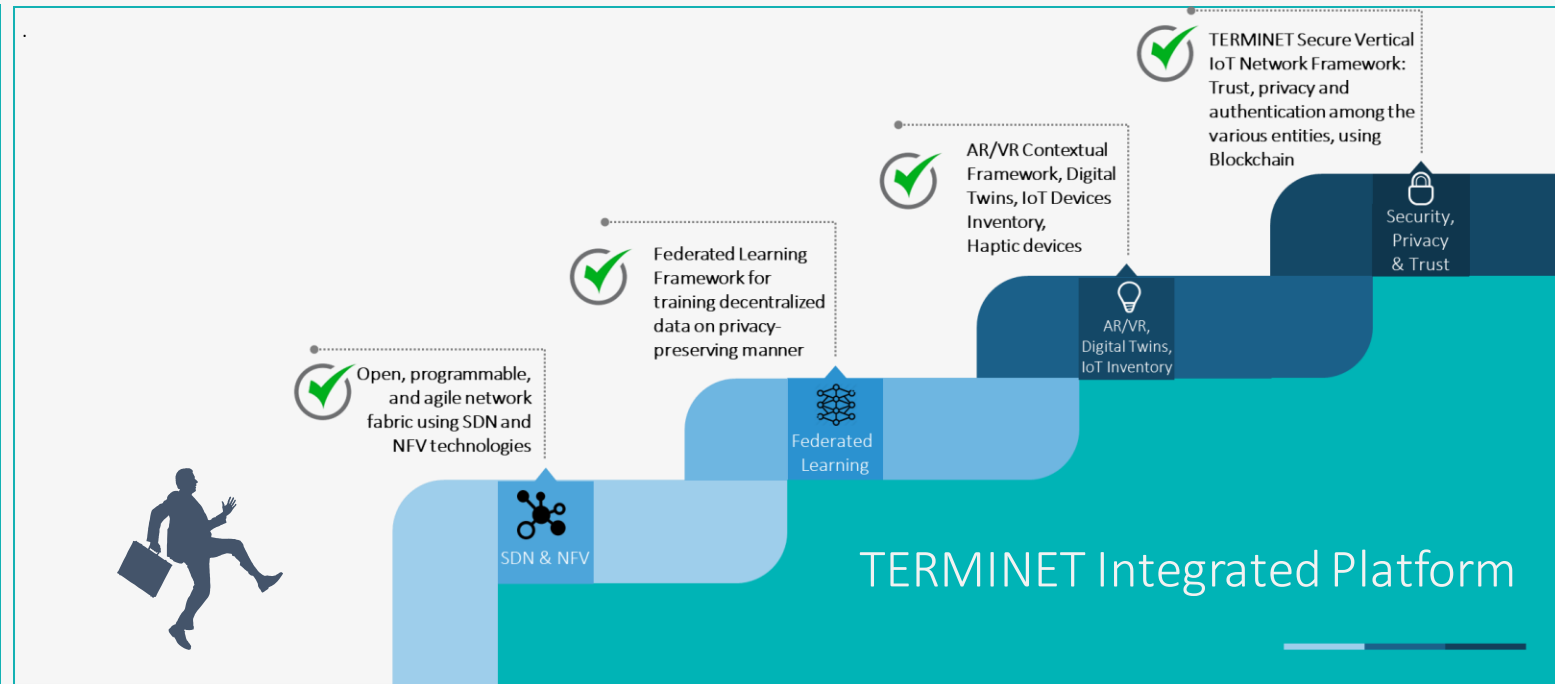
- ✓ Call: H2020-ICT-2018-20
- ✓ Topic: ICT-56-2020
- ✓ Type of action: RIA
- ✓ Total Budget: € 7 998 285,00
- ✓ Active period: 1 Nov 2020 – 31 Jan. 2024



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.**

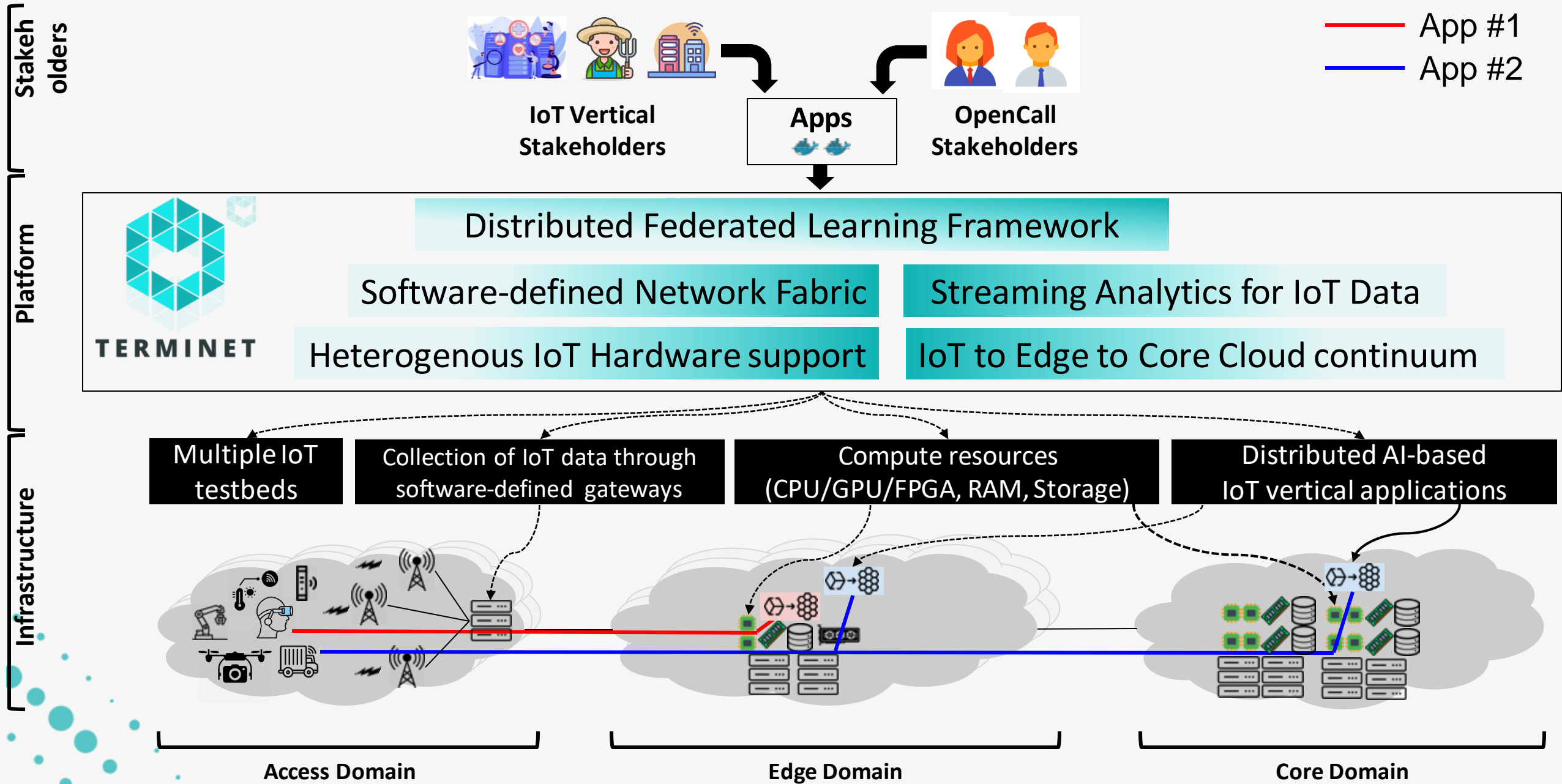


1. UC #1: User-Centric Devices in Smart Farming
2. UC #2: Pathway of Personalized Healthcare
3. UC #3: Smart, Sustainable and Efficient Buildings
4. UC #4: Prediction and Forecasting System for Optimizing the Supply Chain in Dairy Products
5. UC #5: Group Training Surgery Using VR enabled IoT Technologies
6. UC #6: Mixed Reality and ML Supported Maintenance and Fault Prediction of IoT based Critical Infrastructure



<https://terminet-h2020.eu/>



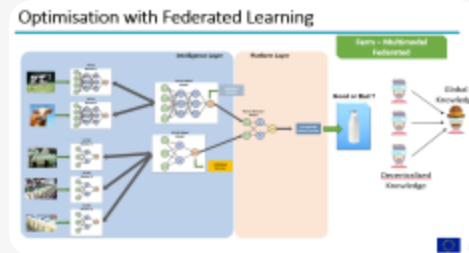




Lessons Learned and Success Stories

Achievements so far

- 57 Scientific publications
- 8 Datasets published
- 3 Whitepapers
- 22 Active PhDs
- 13 Invited talks and keynotes
- 28 Exploitable Items
- 12 Workshops



- The application of state-of-the-art **federated learning procedures** can significantly **improve the quality** of AI models used in the TERMINET use cases, while sustaining reasonable resource containments.
- **Interoperability** through **multi-access distributed edge networks** supported by novel orchestration schemes is found to be applicable in a variety of commercial and industrial applications that TERMINET explores through its use cases.
- Experimental results showed that utilizing **small compound datasets** can achieve measurable results by employing novel **model optimization techniques** accompanied by model **personalisation**.
- Through the correct pathways and channels TERMINET showed that **smooth intrusion in commercial fields**, such as Smart Agriculture and Healthcare by using advanced technological means in a non-obstarkive manner.

AGROMINDS – Qualitative Results

The *three user interfaces* were evaluated by **farmers and agronomists** based on five aspects:

Average Farmer Opinion Scores					
	Ease of Use	Utility	Availability	Responsiveness	Recommendation
Dashboard	4	4,5	4,5	5	4,25
Mobile Dashboard	4,25	4,5	4,75	4,25	4,25
AR Glasses	4,75	4,5	5	4,75	4,75

Success stories:

1. **TERMINET AR-assisted End-to-End Smart Precision and Smart Animal Monitoring Platform (AGROMINDS)**

- Utilised in UC1: User Centric Devices in Smart Farming aiming to provide a complete solution for Smart Animal Husbandry capable of monitoring different kinds of productive animals such as cows, sheep, goats and horses in real – time.
- TERMINET UC1 is the flagship of the project and it was significantly highlighted by Mr. Jan Komarek, Policy Officer of the European Commission, during the Webinar: IoT, Cloud, Edge Computing Continuum From Research to Deployment – AIOTI (<https://aioti.eu/events/webinar-iot-cloud-edge-computing-continuum-from-research-to-deployment/>) that took place online at Nov. 30th 2022.



2. The AGROMINDS tool was a **finalist** in the "Accelerator Program for Start-ups in the Field of Agriculture between China and the Countries of Central and Eastern Europe. - APACCCEEC".
3. **Best Oral Presentation in 10th International Conference on Modern Circuits and Systems Technologies (MOCAS)**: Paper -> T. Sachinidis, A. -A. A. Boulogeorgos and P. Sarigiannidis, "Dual-hop Blockchain Radio Access Networks for Advanced Coverage Expansion," MOCAS, 2021, pp. 1-5, doi: 10.1109/MOCAS52088.2021.9493339.





Contributions to Future IoT (1/3)

- **A new reference NG-IoT architecture model:**
 - Interconnecting ad-hoc IoTs with edge/core processing islands via a *programmable SDN fabric*
 - Managing IoT landscape heterogeneity and data volume via *hardware abstraction and semantic enablement* offered by popular cloud orchestrators
 - *Processing across the Edge-to-Core Cloud Continuum*
 - Ensuring secure orchestration of TERMINET applications on dynamically attested nodes by *employing attestation services*
- Two **policy briefs** including recommendations on NG-IoT standardisation and architectures.
- Investigated the employment of **Federated Learning in a variety of application domains**, achieving **higher accuracy in AI models** and **privacy preserving data exchange**.
 - Produced **novel Federated datasets**
 - Cherry Tree Disease Detection Dataset: doi: <https://dx.doi.org/10.21227/ehfm-9j20>
 - Peach Tree Disease Detection Dataset: doi: <https://dx.doi.org/10.21227/w67n-0q72>
 - Smart house measurements: <https://doi.org/10.5281/zenodo.7628298>
 - Dairy Supply Chain Sales Dataset: doi: <https://dx.doi.org/10.21227/smv6-z405>
 - Virtual Reality Gesture Recognition Dataset: doi: <https://dx.doi.org/10.21227/kyzx-m451>
 - IEC 60870-5-104 Intrusion Detection Dataset: doi: <https://dx.doi.org/10.21227/fj7s-f281>
 - Artificial toolset for forecasting: <https://doi.org/10.5281/zenodo.10517711>



Contributions to Future IoT (2/3)



Contribution to SDN-enabled container network interfaces (CNIs) in cloud environments. **Based on the open-source project Kube-OVN:**

<https://github.com/kubeovn/kube-ovn>



Contribution to **SDN control plane and data plane interfaces for managing OpenFlow-based networks accommodating IoT traffic** (Derived from the TERMINET MPP deployment)



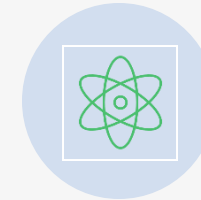
Adoption of emerging SDN technology: A **RINA library (RINAsense) implementation for FreeRTOS:**
<https://github.com/Fundacio-i2CAT/rinasense>



Participate to the **ETSI TeraFlowSDN** open-source project for **aligning the TERMINET SDN activities** with this software development group



Contribution **to application onboarding and placement**, as well as **application lifecycle management** based on TMForum, "Introduction to Open APIs", Available:
<https://www.tmforum.org/oda/about-open-apis/>



Contribution to **Federated Learning standards** such as IEEE Federated Machine Learning (P3652.1), W3C Federated Learning CG, ISO/IEC JTC 1/SC 42 and ETSI GS MEC 003 - Multi-access Edge Computing (MEC) Framework and Reference Architecture



Release of an **Orchestration of Intelligent UAVs Swarm in the premise of UC1:**
<https://github.com/wcipAUTH/AV-orchestrator>



Contribution to the **development of APIs for high-performance Virtual Reality (VR) and Augmented Reality (AR)** in the browser.



Releasing a **QR-scanner-for-AR-Application** in the premise of UC6: <https://github.com/Eight-Bells-Ltd/QR-scanner-for-AR-Application>

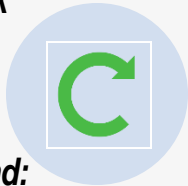




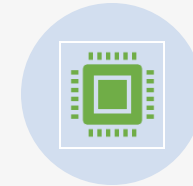
Contributions to Future IoT (3/3)



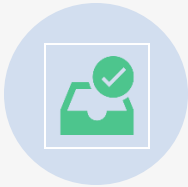
A **reference architecture combining network softwarization and message-oriented middleware technology to provide explicit support for quality-aware Digital Twin technology in I4.0 environments and beyond:**
<https://datatracker.ietf.org/doc/draft-bellavista-semantic-sdn-mom/>



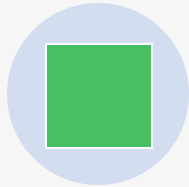
Contribution to **time-sensitive communication in virtualized environments** based on KuberneTSN: containerized TSN scheduler for Kubernetes Overlay Networks: <https://github.com/MMw-Unibo/KuberneTSN>



Contribution to Kubernetes Network Plumbing Working Group. Multus CNI:
<https://github.com/k8snetworkplumbingwg/multus-cni>



Contributing **IoT security support for logging and authorization to Hyperledger Fabric technology**



Contribution **to remote attestation techniques, Lightweight Crypto Primitives (LCP), Control Flow Attestation.** An **Attestation patent** has been filed in the premise of the project by NEC.



SHCN's **New Generation of RTU device – Prototype**



Releasing the **IloT-MDW (middle-ware) enabling the open-source community to interact with the TERMINET Intelligent IoT Devices Inventory (IloT-DI):** <https://gitlab.com/futureintelligence/terminet-iiot-di-middleware>





Thank you for your attention!



TERMINET website : <https://terminet-h2020.eu/>



LinkedIn: <https://www.linkedin.com/company/terminet/>



Twitter: https://twitter.com/Terminet_H2020

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