IntellioT

New concepts in Smart Health & Care

IntelloT Healthcare perspective

Sphynx Analytics

Background

- Healthcare systems under increased pressure for **high-quality & efficient care**
  - Ageing populations; old-age dependency ratio to **increase from 28.8% to 51.6%** between 2015-2060 in EU-28 *[Eurostat]*

- Chronic diseases account for almost **75%** of all deaths worldwide;
  - **Cardiovascular Diseases** (CVDs) in particular (hypertension, ischemic heart disease, heart failure) are the **number one cause of death globally.**
    - **~17.9 million people died from CVDs** in 2016 (**31%** all global deaths); to reach **~23.6 million by 2030**.
    - **1.8 million deaths in the EU (37% of all deaths), each year**.
    - Significant **economic impact**; EU **~€210 billion a year** in 2015 *[European Society of Cardiology]*
      - *53% (111 billion) healthcare costs, 26% (54 billion) productivity losses, 21% (45 billion) informal care*

IoT and Edge Computing to the rescue?

- Intelligent IoT environments featuring Edge Computing capabilities can collaboratively execute (semi-)autonomous health & care applications
  - Leveraging sensing, acting, reasoning, and control capabilities
    - Medical, purpose-built and/or consumer devices (wearable, smart-home etc.)
  - Human-in-the-loop as an integral part of the system for control & optimization of AI
- Can be leveraged for decentralized health and remote monitoring to:
  - ✓ Improve patient outcomes, safety and comfort.
  - ✓ Lower care costs.
  - ✓ Remotely guide patients through recovery and rehabilitation in their home environment.
  - ✓ Empower patients to become partners in the management of their health.
- **COVID-19 pandemic a transformation catalyst**; acceleration of implementation and adoption of changes in public health interventions
  - Healthcare delivery based on preventive measures, remote care, technological dependence

Consumer (off-the-shelf) devices

- Smartphone
  - Acting as "out of home hub", Location monitoring, Step counter, Distance in meters
- Smartwatch
  - Physical activity tracking (duration of exercise, type of activity), Step tracking (number of daily steps, distance in meters), Sleep tracking (hours of sleep, sleep stages, score), Heart rate (pulse, zones, arrhythmia detection), on-demand ECG
- Smart Blood Pressure (BP) meter
  - Systolic blood pressure, Diastolic blood pressure, Blood pressure variability, Heart rate (HR), ECG-based arrhythmia detection (atrial fibrillation)
- Smart Weight Scale
  - Body weight, Body Mass index, Body composition, changes in weight
- Smart Home devices (i.e., temperature/humidity/motion/light sensors and light bulbs) and integration hub
  - In home conditions monitoring (temp, humidity, light levels), motion sensor, smart lights (regulate brightness, temperature), gateway
- Smart Thermometer
- Smart Oximeter

IntelIIoT Healthcare Use Case
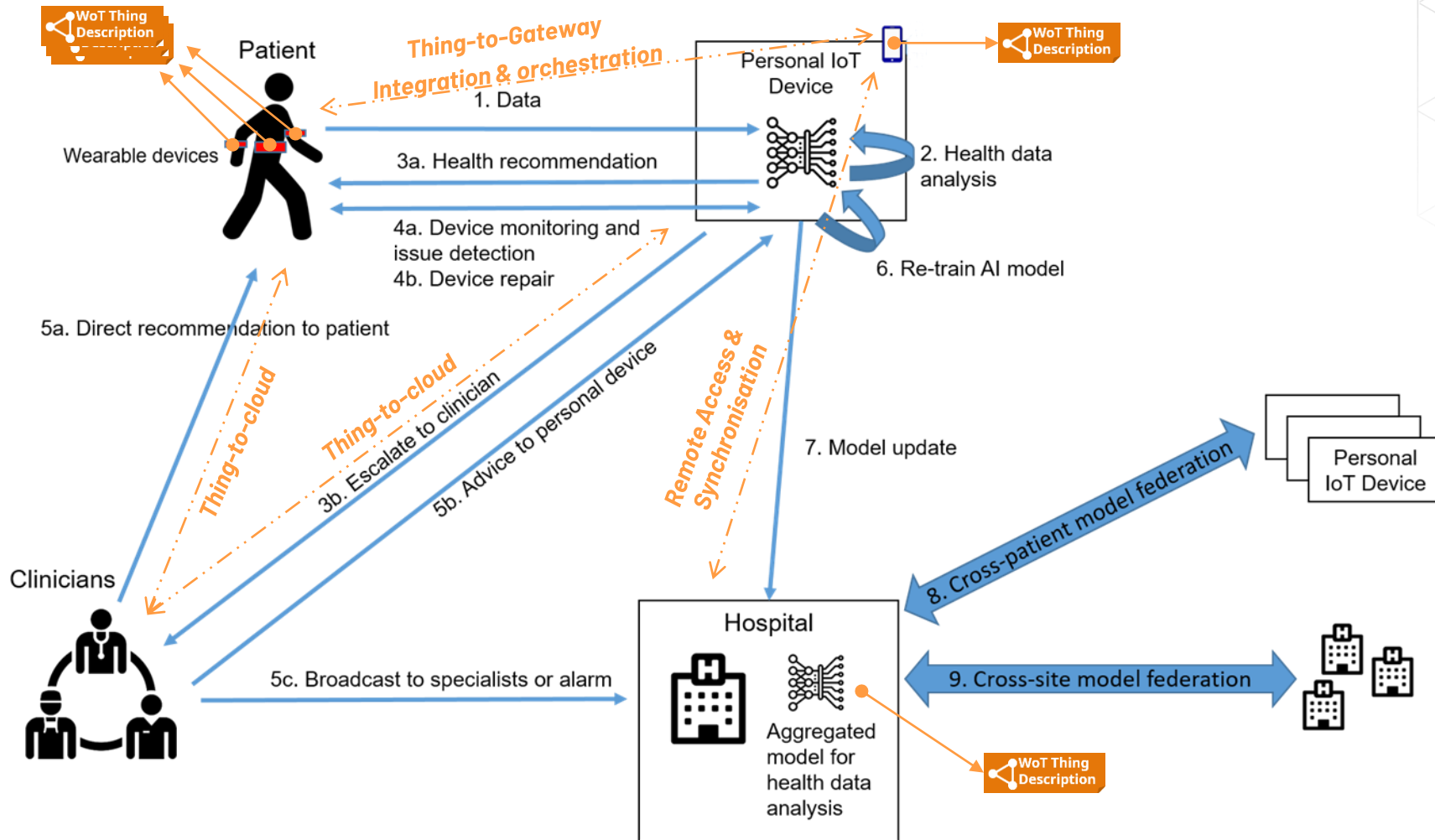
- ✓ Facilitate recovery and rehabilitation – treatment plan, reminders, advice, encouragement, etc.

- ✓ Predict low adherence

- ✓ Model risk of deterioration

- ✓ Identify predictors – variables with predictive value for positive or negative outcomes
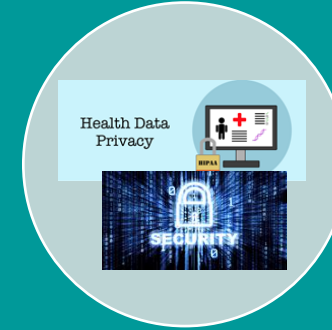
The 3 IntellIoT Pillars

Collaborative IoT

- ✓ Federated & continuous learning
- ✓ FL coordinator & monitoring service on MEC
- ✓ Local model refinement on local data

Human-in-the-loop

- ✓ Clinicians' review of system recommendations & interventions when alerts are triggered
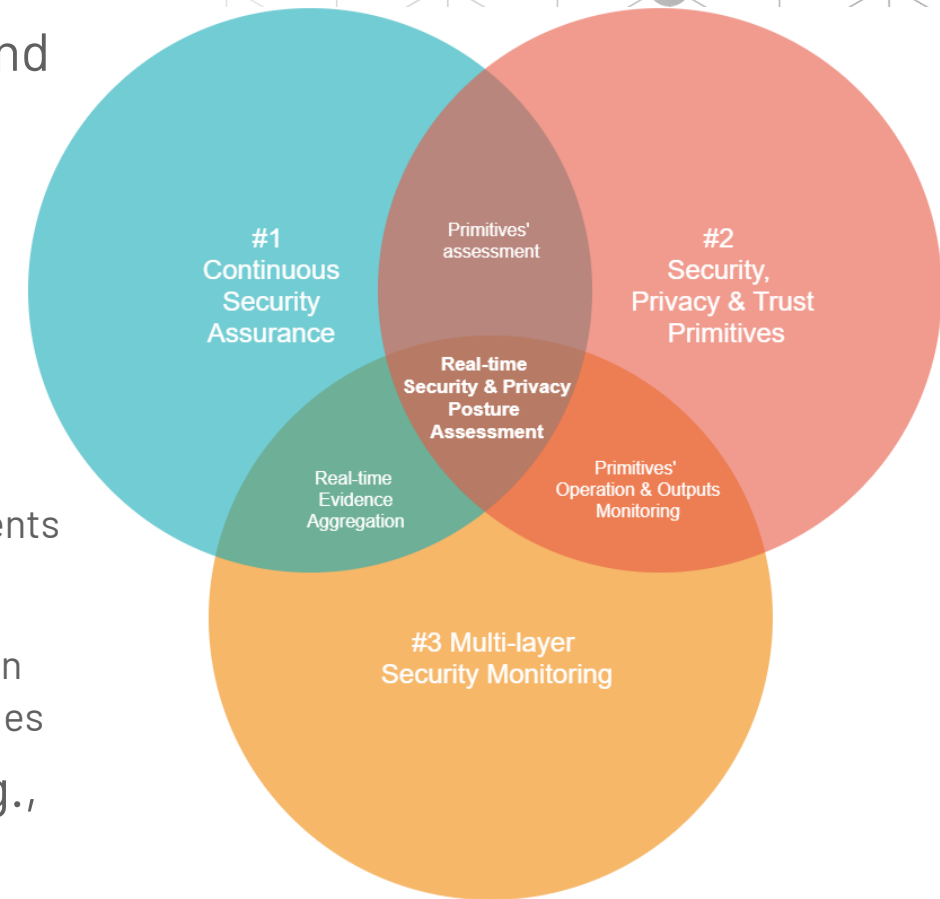- ✓ Seamless & usable feedback on efficacy of interventions

Trustworthiness

- ✓ Trustworthy monitoring & interventions
- ✓ Audit and certification
- ✓ Detection and mitigation of attacks

Building Trust

- Healthcare end users request for (as highlighted in IntellIoT end user workshops):
  - Simple to use applications
  - Reliability & reproducibility of results
  - Transparency

- Ultimately need to build TRUST on NG-IoT healthcare applications

- Technical solutions:
  - Real-time security & privacy assessment and management of IoT environments
  - Distributed Ledger Technologies (DLTs) & Smart Contracts with IoT devices/networks to provide data integrity and trusted communication
  - Trust-based computing mechanisms for secure routing & intrusion detection
  - Mitigation of detected incidents with Moving Target Defence (MTD) techniques

- Bonus: Use trust enablers to create new business models (e.g., model monetisation)

#1 Continuous Security Assurance

Primitives' assessment

#2 Security, Privacy & Trust Primitives

Real-time Security & Privacy Posture Assessment

Real-time Evidence Aggregation

Primitives' Operation & Outputs Monitoring

#3 Multi-layer Security Monitoring

Trust Enablers (1/2)

- The SPHYNX Security & Privacy Assurance Platform
  - Hybrid security & privacy assessments
    - Combining (automated) threat and vulnerability analysis, static analysis, penetration testing & continuous runtime monitoring
  - Interoperability with event captors to obtain monitoring and/or test evidence required for assurance and/or certification assessments, featuring sophisticated event processing capabilities
  - Model-driven customisations enabling realisation of security standards and risk management requirements
  - Advanced & customisable reporting for audit purposes
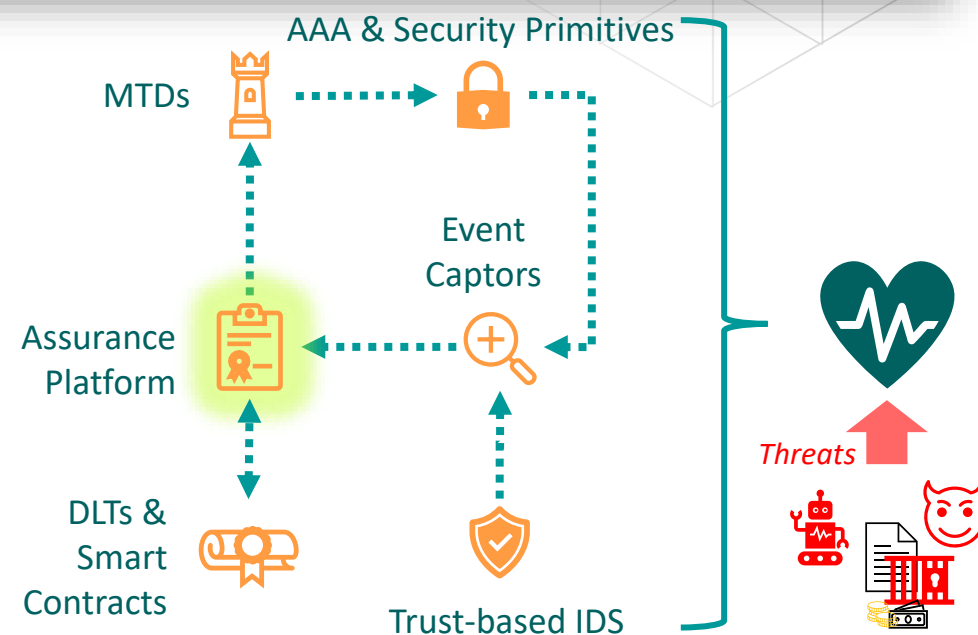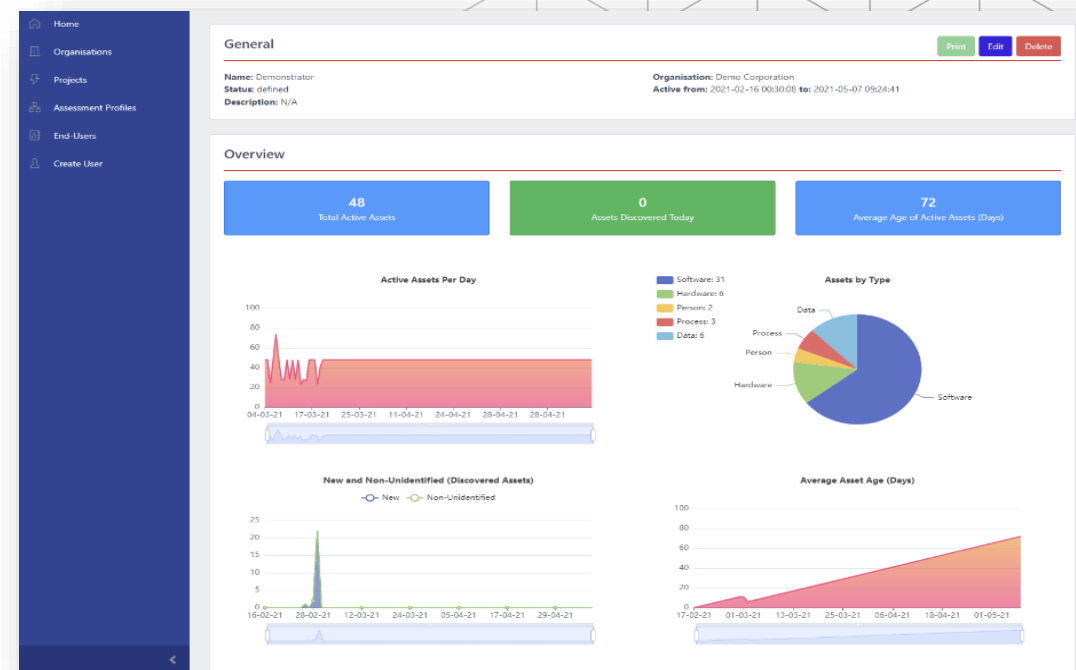
Trust Enablers (2/2)

- DLTs & Smart Contracts
  - DLTs for data handling transparency
    - E.g., encoding data usage agreed terms into smart contracts
  - Blockchain-based ML Model trading
  - Blockchain-based data trading

- MTDs
  - Manages the security configuration of Edge nodes
    - Normal operation: Proactively change the configuration to make it harder to profile devices & increase attackers' effort
    - Ongoing attack: Enforces pre-defined strategies to mitigate the attack

- Trust IDS
  - IoT devices monitors the behaviour of their peers, detecting compromised/selfish ones
  - Assures the legitimacy of IoT devices
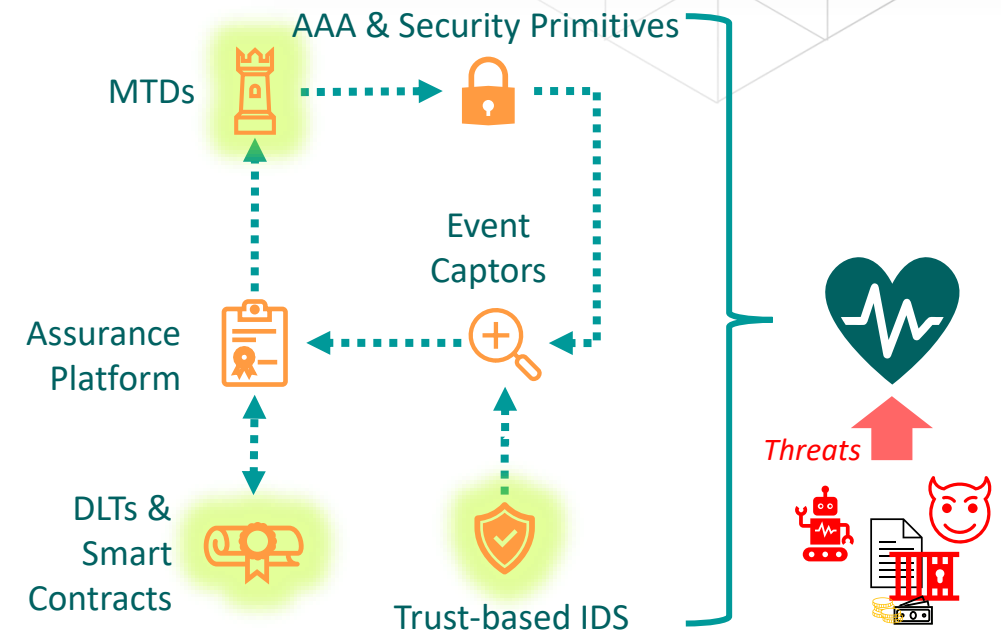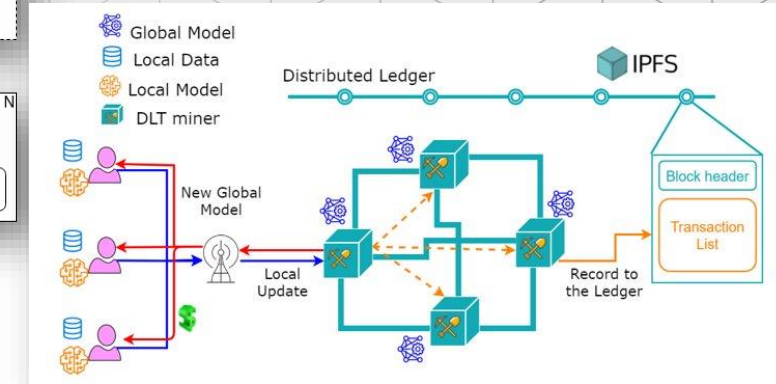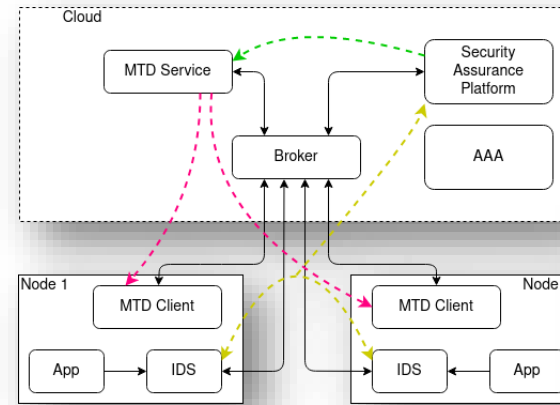
Challenges

- Collaborative IoT
  - Model personalization (per patient), while preserving overall performance
  - Federated learning on constrained resources
  - Leveraging 5G and MEC technologies for the Federated Learning solution – training, validation and model execution

- Human-in-the-Loop
  - Usability and efficiency, while preserving patient safety
    - Filtering and organizing large amounts of data and alerts, to avoid data overload for clinical users
    - Select recommendations for clinicians and patients – automation, again without affecting safety in study
  - Seamlessly embed human intervention in smart health and care workflows

- Trustworthiness
  - Security & Privacy monitoring and protection on resource-constrained, distributed devices
  - Preserve patient data privacy (GDPR compliance) in complex deployments, but providing access to clinicians that need it
  - Provide transparency and, ultimately, build trust with end-users & clinicians

- Other (general) challenges
  - Unobtrusiveness of technologies & patient adherence?
  - Consumer device Interoperability/Openness?
    - Adoption of open specifications/standards - e.g., https://w3c.github.io/wot-usecases/#MedicalDevices – w. extensions e.g., for DLT persistence)
  - Device certification? [Accuracy, but also for cybersecurity]
  - Limited and/or unstructured collaboration among relevant research efforts (e.g., SMART-BEAR)

Thank you for your attention

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