CHARIOT – 3rd Workshop

Thursday 22 October 2020 (online)

IoT Data Security and Privacy Solutions – Challenges and Opportunities for Airports

IoT Privacy, Security and Safety Supervision Engines

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IPSE: IoT Privacy, Security and Safety Supervision Engines

- A set of novel runtime components acting in concert to understand and monitor the cyber-physical ecosystem
  - **Privacy Engine:** privacy by design

    -> handling data encryption policies based on blockchain technologies
  - **Security Engine:** firmware authentication

    -> identification of security vulnerabilities, rule-based filtering and validation with blockchain
  - **Safety Supervision Engine:** safety policies enforcement:

    -> monitoring data streams with machine learning deployed on the edge
- Topology service and IoT Language
  - Enable functionality of the Privacy and Safety Supervision Engines
- Predictive Analytics for anomaly detection

Topology Service and IoTL

IOTL - state definition language

- Define the topology of an IoT system (**IoT State**)
- Define privacy and safety rules and policies
- Share and sync IoT state across Fog Network

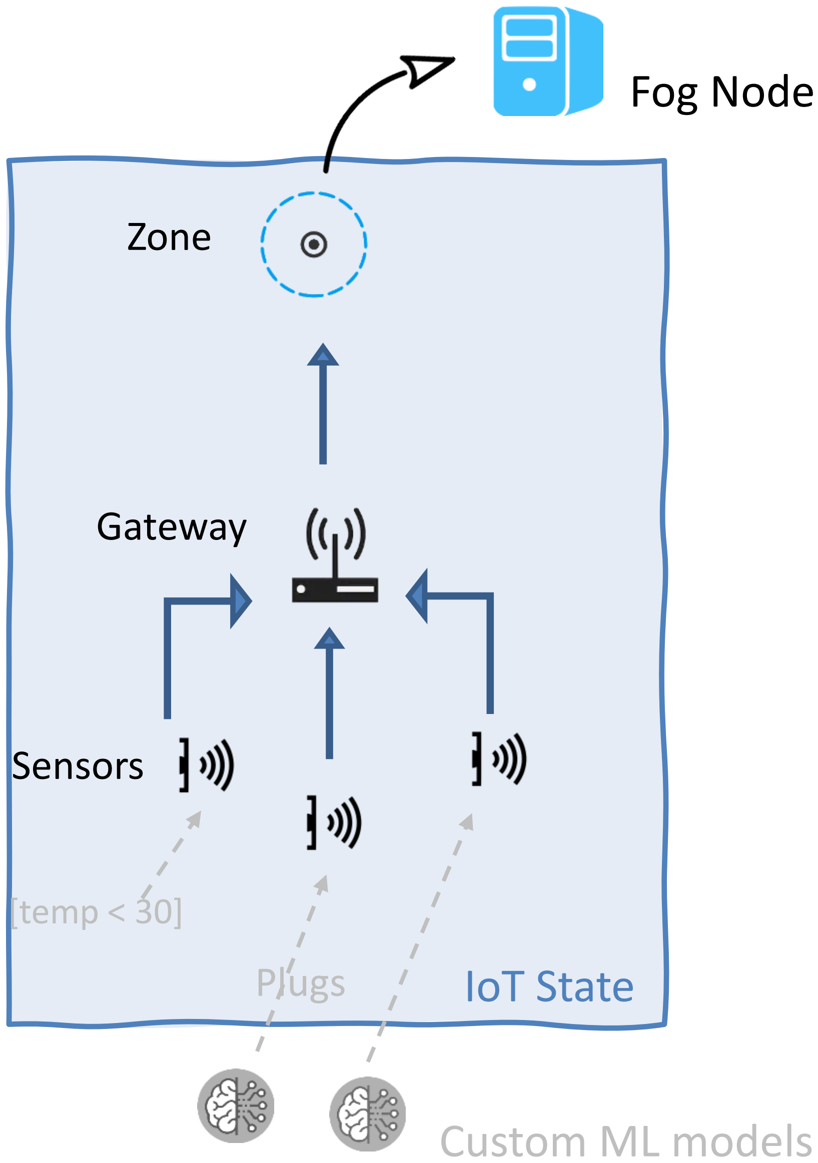
Topology service

- Provide REST services for Chariot Engines
- Implement IoT State
- Handle persistence

IoTL: Efficient tool for communicating IoT state

- Concise but comprehensive representation of current state
- Easy to share across the Fog Network
- Easy to sync to ensure consistent state
- Easy to store and recover
- Easy to interact with via REST interface

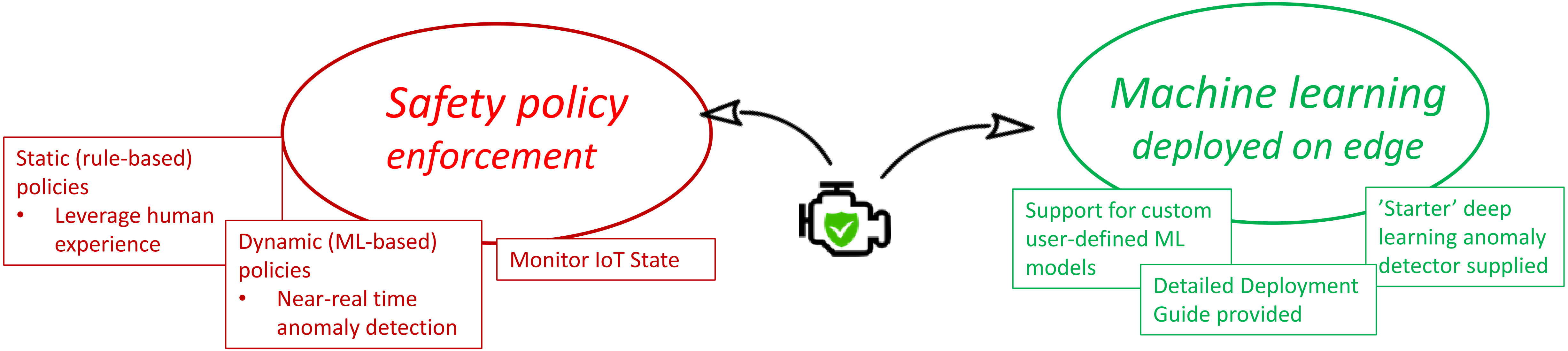
Topology Service and IoTL



CORE SPECIFICATIONS

- **Entities**
  - Zones
  - Gateways
  - Sensors
- **Relations:** Defined between two components in the system.
  - Dependency, correlation, equality, delayed condition…
- **Safety policy definition**
  - Enforcements
  - Plugs
- **Privacy policy definition:**
  - Access Control Lists,
  - Schemas
  - Anonymization

Safety Supervision Engine



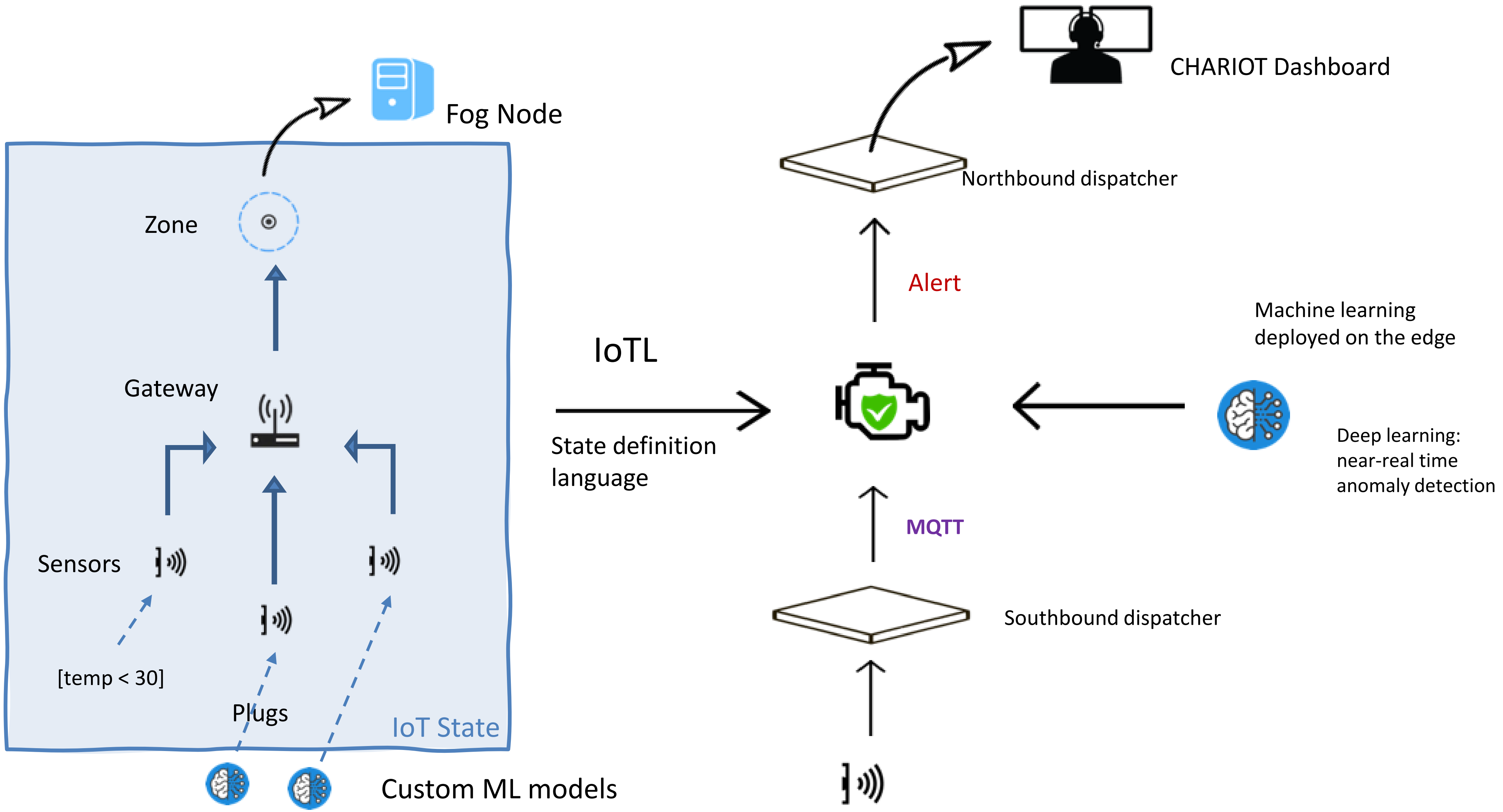
Stream Listener: Monitor, assess and enforce

- Web interface for registering and enforcing safety policies
- Detect & Predict safety policy violations with associated Alert Generation
- Integration of dynamic (ML-based) policies and user-defined rules

Plug & Play Machine Learning: easily upload custom models

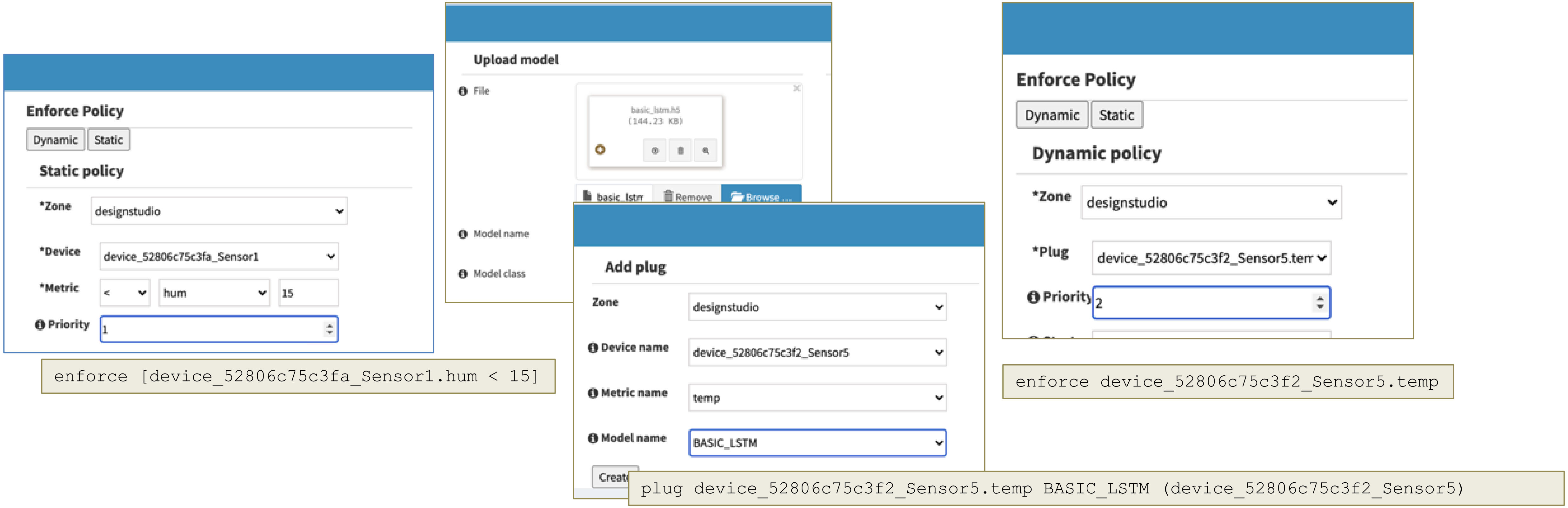
- Safety supervision without manual effort – does not require time or expert knowledge
- Machine Learning deployed on edge
- Of-the-shelf Deep Learning anomaly detector provided

Safety Supervision Engine and Anomaly Detection



Safety Supervision Engine and Anomaly Detection

- **Integration with CHARIOT Dashboard**
  - Complete REST API provided for safety policy management and anomaly detectors configuration
  - CHARIOT Dashboard provides user-friendly GUI
  - Alternatively, safety policies can be managed through IoT Manager UI



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CHARIOT – 4th Plenary Meeting
Wednesday 30 September 2020 (online)

Privacy Engine and Data Encryption

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Privacy Engine and Data Encryption - Intro

Main goals

- Protect private and sensitive data
- Identify types of sensors and services with regards to privacy
- Components communicate without exposing sensitive information

Novel aspects

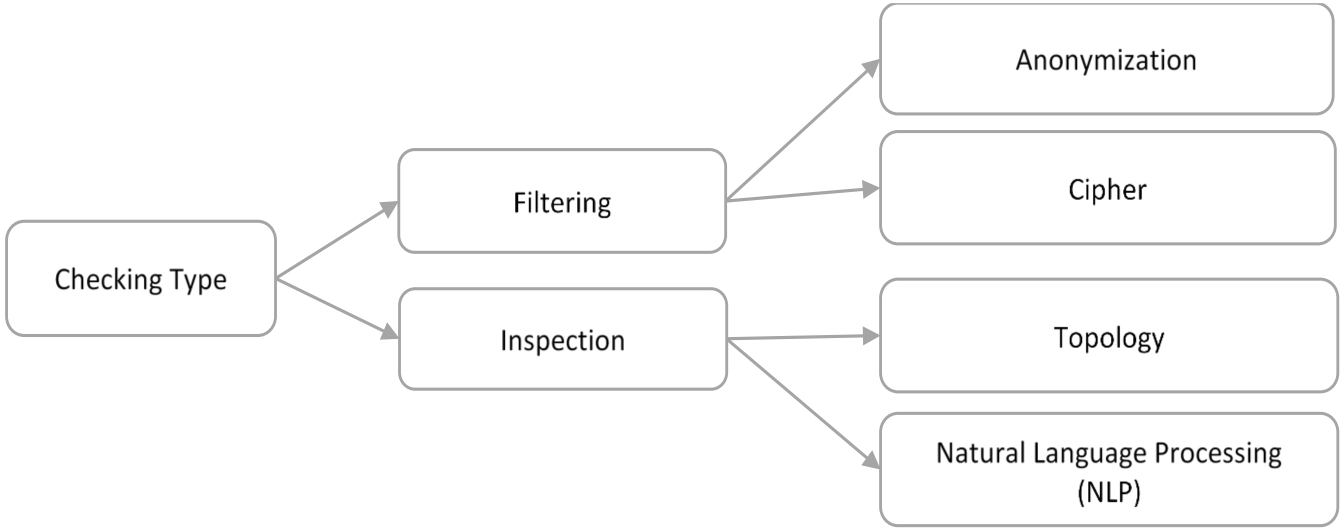
- Anonymization methods
- Cognitive: use machine learning models for disseminating messages
- Provides insight on privacy threats based on topology information
- Self-contained service deployed on a Fog node

Main benefits

- Create value from IoT sensor messages by training specialized dissemination classification models
- A complete framework for managing private data in industrial IoT environments

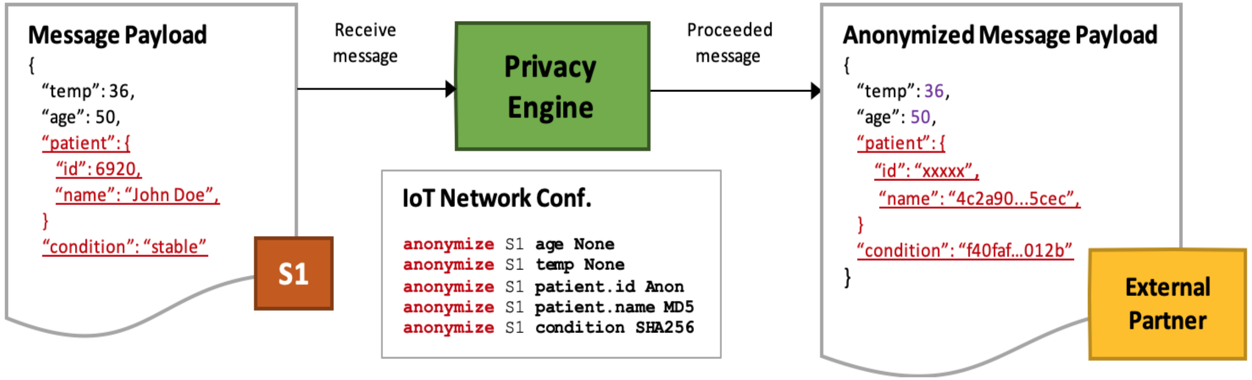
Privacy Engine and Data Encryption

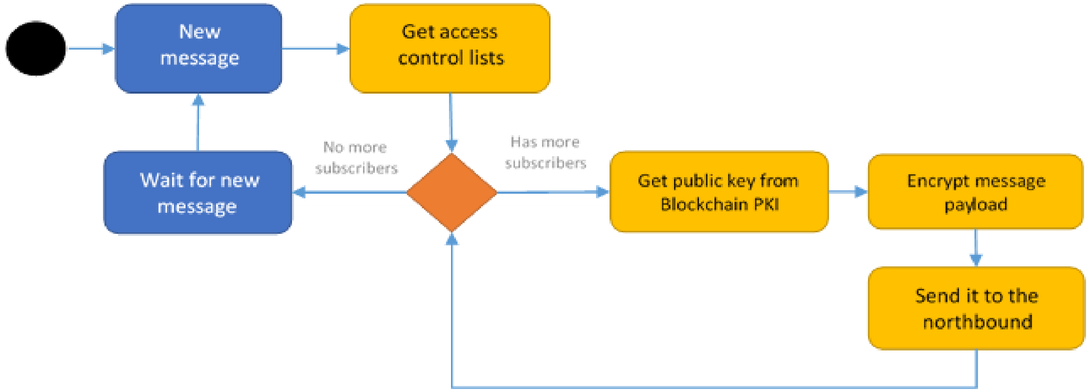
- Two types of checks enables passive and active safeguarding
- Inspection checks helps administrator of IoT network to actively map all privacy related information during configuration setup
- Filtering safeguards information exchange with other parties by encrypting and anonymizing information



IoTL Statement	Description
define SENSOR S1 --params {"privacySensitive": 1.0}	Mark a sensor as privacy sensitive.
acl BMS S2 DENY acl BMS S2 ALLOW	Safeguard access to sensor messages
schema EmployeeID --pattern "\d{4}-\d{4}-\d{4}\d{4}" --private expect S1 EmployeeID	Manually define privacy sensitive formats.
anonymize S1 age SHA256	Enable privacy engine to anonymize age on message originated from S1 Sensor.

Privacy Engine and Data Encryption





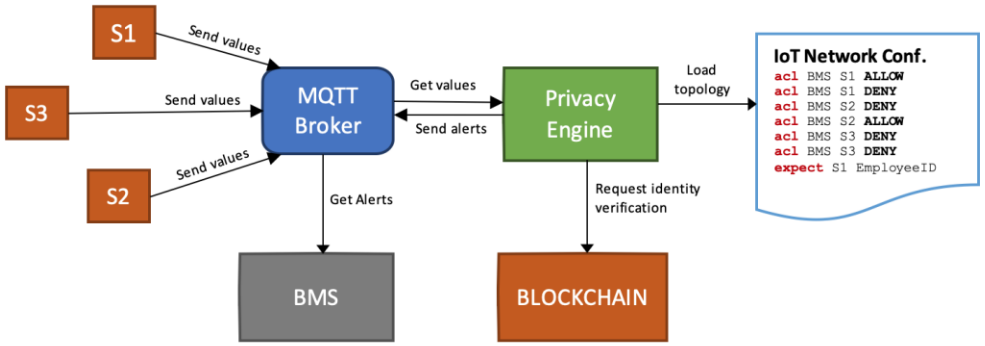
Anonymization

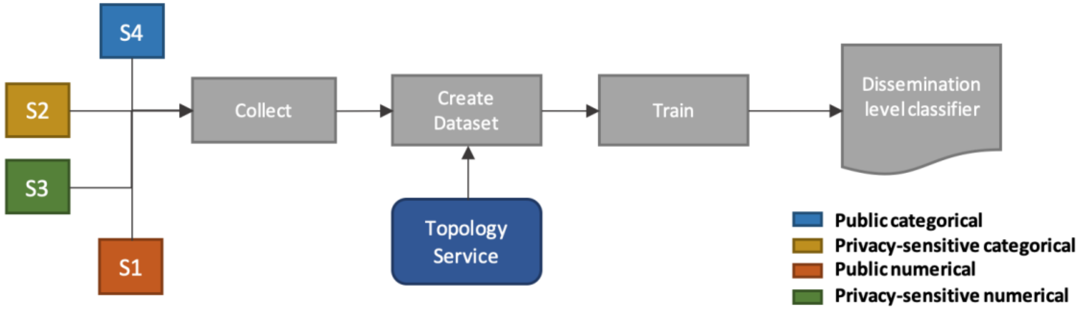
- Administrator defines message fields to be anonymized
- Engine applies anonymization logic on messages originating from specific tables
- Anonymization replaces value with random sized string of '*'
- MD5 & SHA256 pseudo-anonymizes data by returning hashed value

Encryption

- Prevents sensitive information leakage to unauthorized users
- Public Key encryption adds end to end encryption between Fog Node and External services preventing MitM attacks
- Access control lists defined by the CHARIOT by using IoTL guards user data

Privacy Engine and Data Encryption - Standalone





Manual private data guard

- Provides insight on privacy threats based on topology information
- Topology information can be pulled by API
- Information can also be pulled by local file created by Administrator, to achieve standalone functionality (without the platform API)
- This version can be installed in single board Linux PC and connected to external MQTT broker to receives messages per configuration

Cognitive - Detect privacy violation by using dissemination level classifier

- Collection of messages from every sensor is used to produce datasets for model training
- Message types stemming from private sensors are used to compose attributes of training instance
- Machine learning to produce Dissemination level classifier
- Fully automated process, variable reliability

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Predictive Analytics for Out-of-Bounds Behaviour

Kostas Zavitsas PhD
VLTN

Predictive Analytics for Out-of-Bounds Behaviour

- Technical objectives:
  1. Identify sources of variation in a monitored system
  2. Datasets of varying dimensions capturing a stochastic real-world processes
  3. Calculate bounds of normal behavior
- Business objectives:
  - robust/ context – agnostic
  - efficient/ no human intervention

- All 3 Chariot case studies offer ample datapoints and opportunities to train accurate ML based predictive models

Locomotive / Fleet – DMMS

Smart Building/ Technology campus – BMS & Security IoT

Airport – BMS

Predictive Analytics for Out-of-Bounds Behaviour

- Anomaly Detection component pipeline:
  - Part 1: Training
    - Data preprocessing
      - Temporal resampling
    - Normalization and regularization to avoid overfitting to one feature
    - Cross validation algorithm used with k=10
    - Unsupervised machine learning clustering models
      - Elliptic Envelope (EE)
      - Isolation Forest (IF)
      - One Class Support Vector Machine (OSVM), and
      - Density-based spatial clustering of applications with noise (DBSCAN)
    - model evaluation assessed with the Fowlkes-Mallows index (FM)

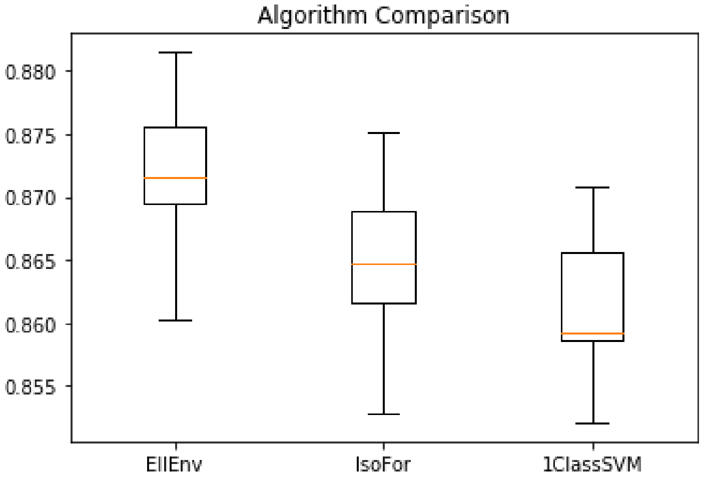
$$FM = \sqrt{\frac{TP}{TP+FP} * \frac{TP}{TP+FN}}$$

    - Update dashboard information
    - Upload model to Security Engine
  - Part 2: Prediction
    - Collect live data
    - Check if out of bounds behaviour

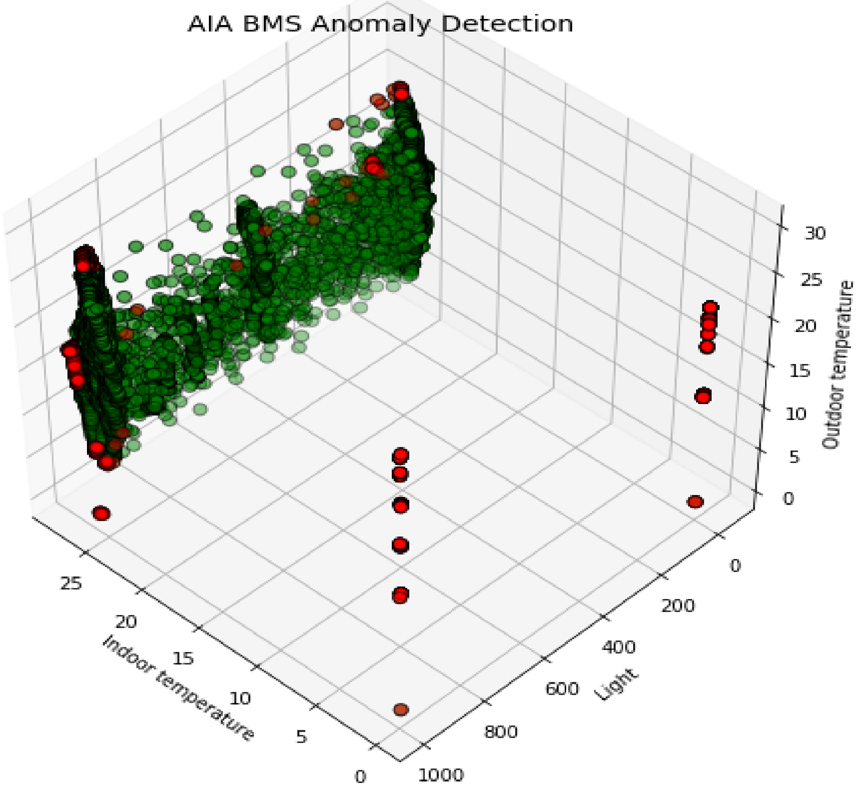
Predictive Analytics for Out-of-Bounds Behaviour

- Unsupervised AD modelling

Airport – BMS



- Best performing model:
  - Elliptic Envelope with 97% prediction accuracy for incorrect Indoor temperature readings



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