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NEC Solutions Innovators (NES) / NEC Laboratories Europe (NLE)

Reliable Cloud-Edge Programming for the Internet-of-Things

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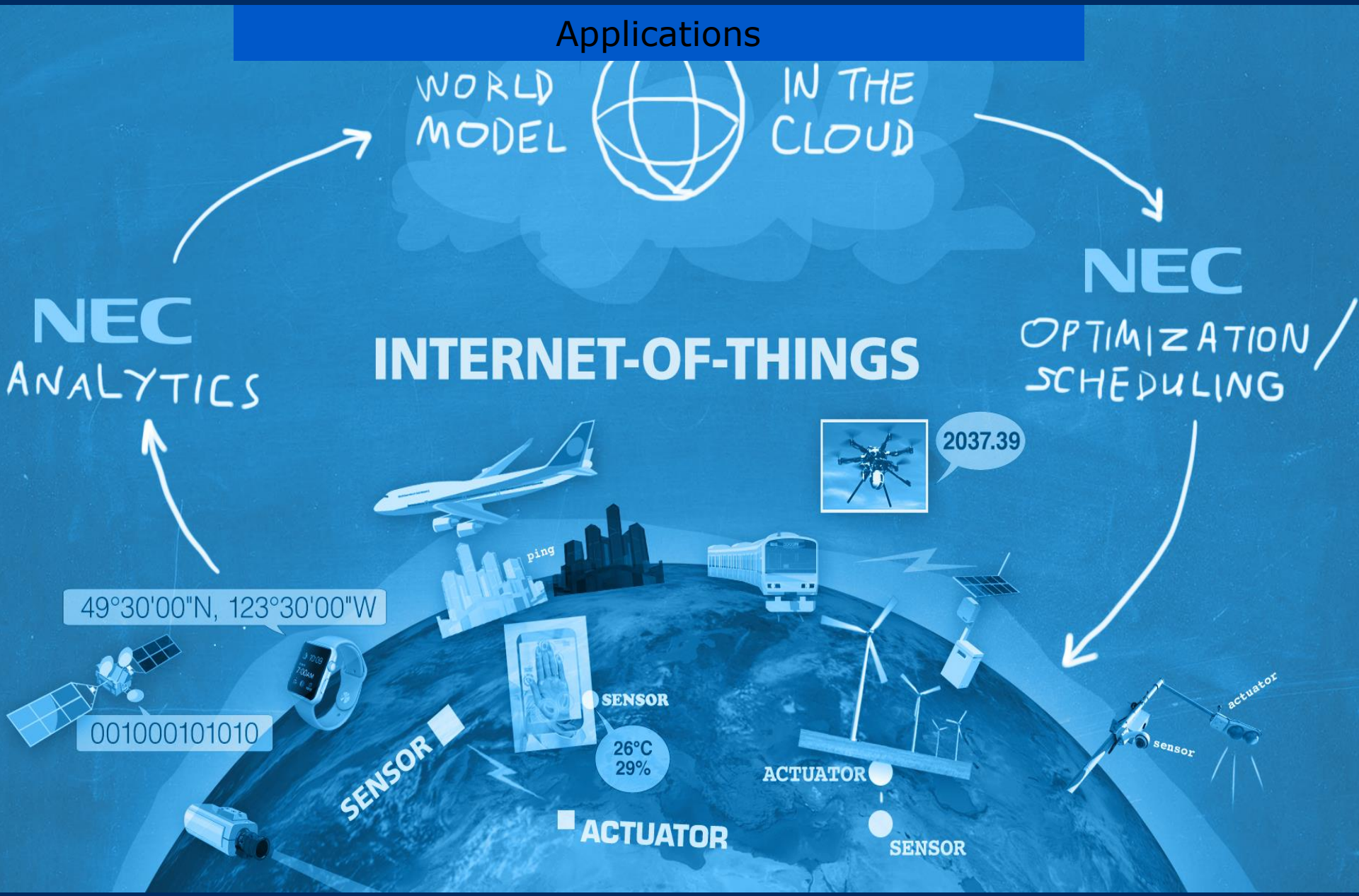
Cloud Services and Smart Things
NEC Laboratories Europe

July 25, 2017

'This activity is based on results achieved within the project CPaaS.io, which has received funding from the European Union's Horizon 2020 research and innovation program

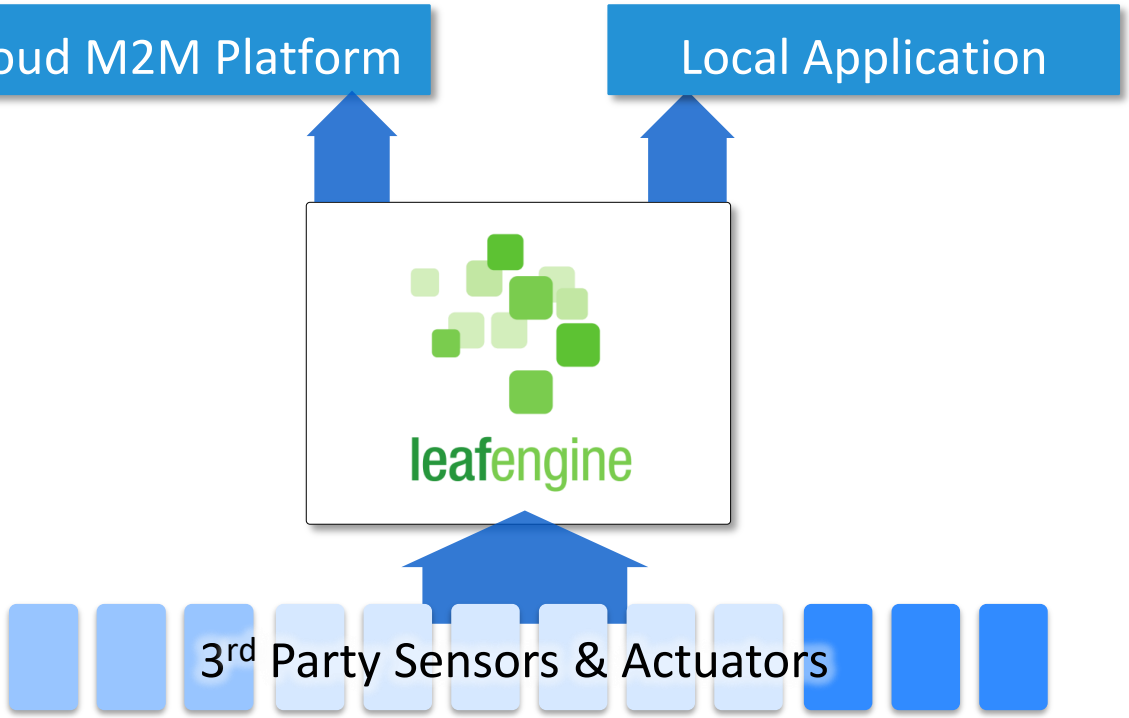
IoT - the Traditional Way

A view of the Internet-of-Things...



leafengine concept: Co-Creation of IoT services

leafengine



Application Creator & Device Manufacturer

Simply add IoT capabilities to your product

leafengine sensors

leafengine

Expert Level Sensors
Ubertooth Bluetooth Scanner
Field Analyst 4

Heavy Duty Sensors
POS-T ePusher v2

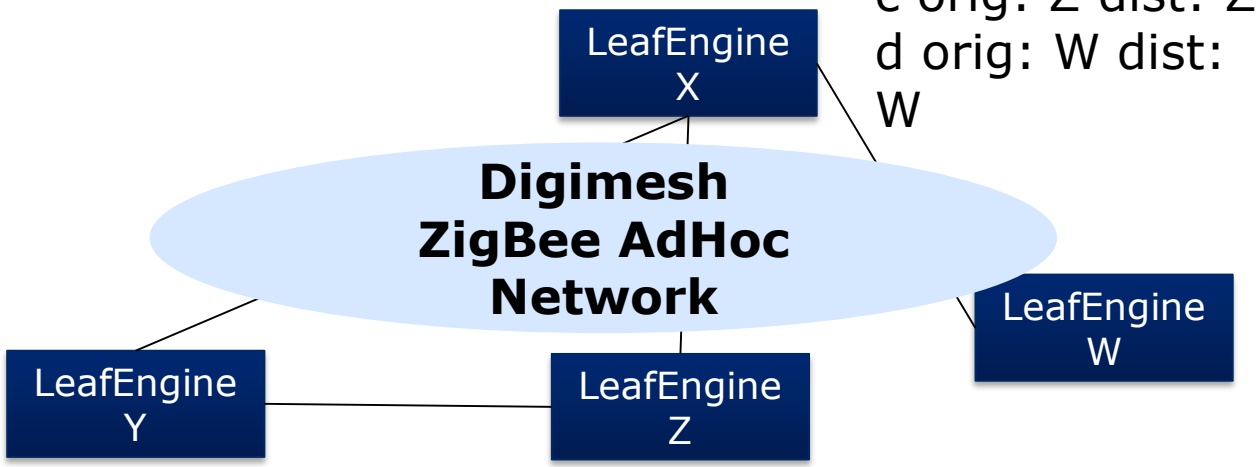
Basic Level Sensors
Vibration Sensor (Wired)
Ultrasound Distance Sensor (Wired)
Touch Sensor (Wired)
Temperature Sensor (Wired)
Sound Sensor (Wired)
Shade Sensor (Wireless)
Remote Control
Rain Sensor (Wireless)
RFID Reader
Property File
NFC Reader
Motion Sensor (Wireless)
Motion Sensor (Wired)

Light Sensor (Wireless)
Light Sensor (Wired)
Infrared Light Barrier (Wireless)
Humidity Sensor (Wired)
Gas Pressure Sensor
Door/Window Open Sensor (Wireless)
Distance Sensor (Wired)
Discontinued - Oak Light Sensor (Wired)
Discontinued - Oak Distance Sensor (Wired)
Controllable Power Plug
CO2 Sensor (Wired)
1D/2D Bar Code Reader
BLE Beacons (Eddystone)
Digimesh Sensors
…

New: leafengine 2.0 [Smart City Edition]

Advanced Technology

- Licensing Schema for Smart Cities
- Remote Management and Mass Deployment
- Dockerized leafengine
- Meshed Network – Digimesh



a
b orig: Y dist: Y
c orig: Z dist: Z
d orig: W dist: W

d
a orig: X dist: X
b orig: Y dist: X
c orig: Z dist: X

b
a orig: X dist: X
c orig: Z dist: Z
d orig: W dist: X

c
a orig: X dist: X
b orig: Y dist: Y
d orig: W dist: X

Aeron: The NEC IoT Broker

Application Layer

Smart Home App

Smart City App

Smart Agriculture App

IoT Broker Layer

Role of Aeron: *Make the IoT do what the applications need.*

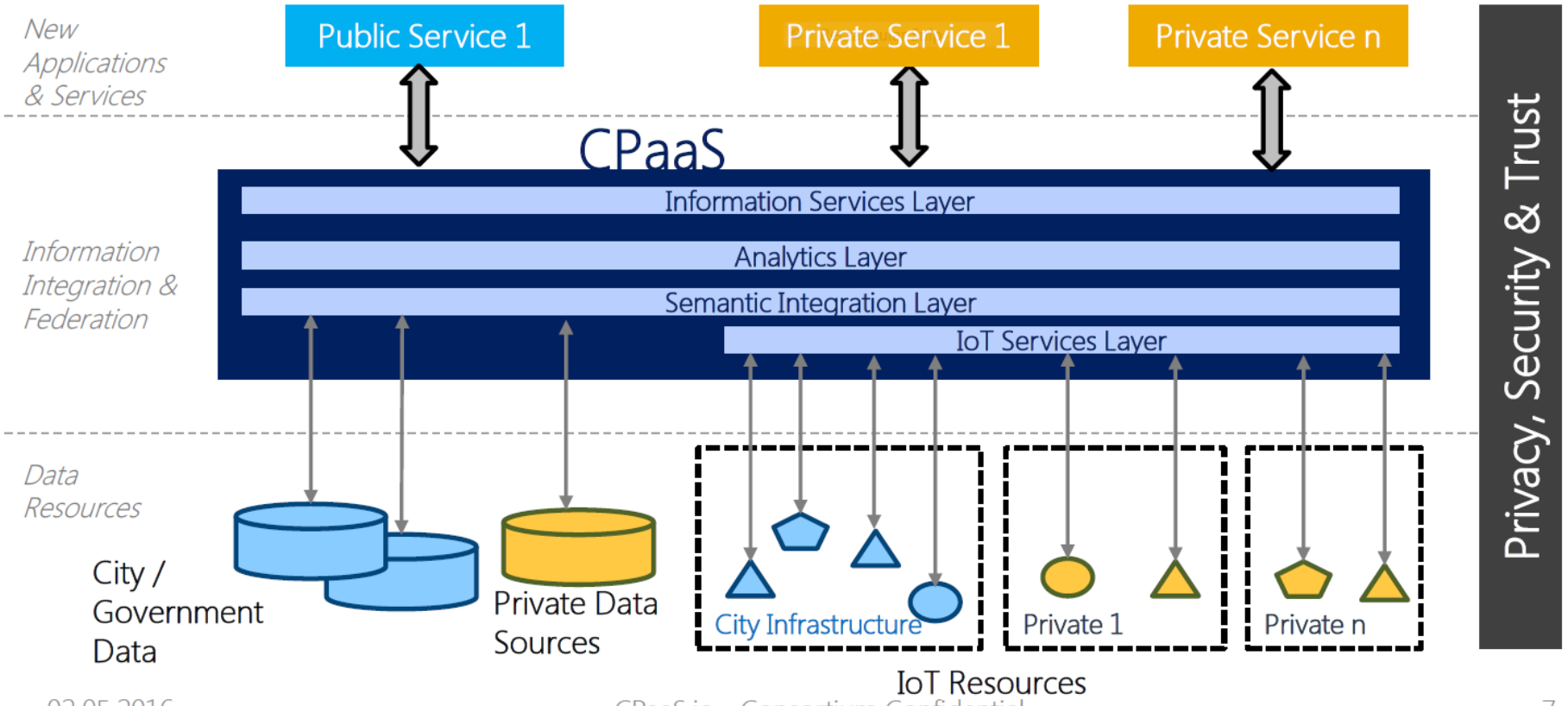
Data
- Entity Model
- Semantic Discovery

Processing
- World-wide Operation
- Federation
- Edge Processing

Meaning
- IoT Analytics
- Contextualization
- Sem. Mediation

IoT Device Layer

Architecture



Customer Values for Smart Cities

Customer Value (I):
Deep understanding of the **city „health"**

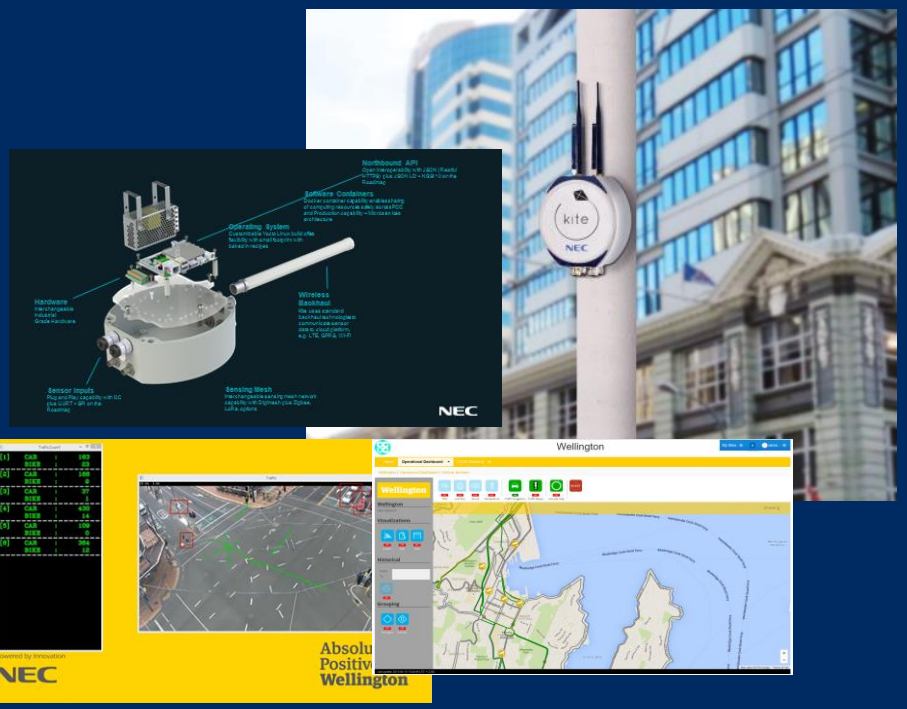
- Key Performance Indicators
- Environment, Traffic, ...
- Real –Time Situation

Customer Value (II):
Enabling **data-driven business** (with open, real-time data)

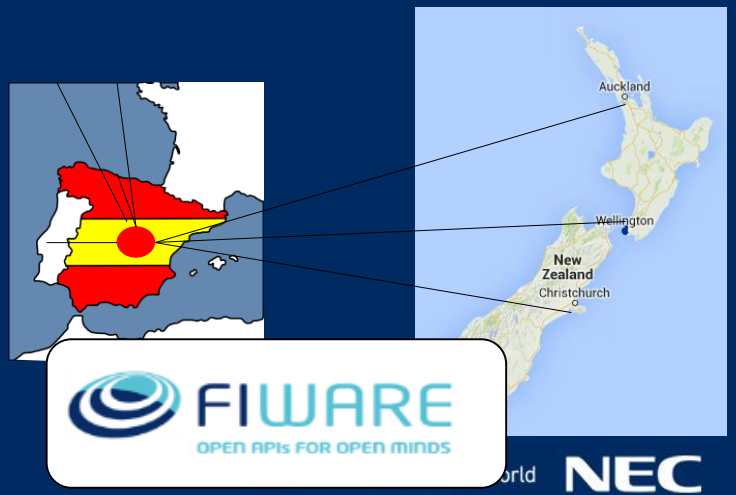
NEC's Technology Strength

- fast and reliable (global) **service creation** and **operations**
- proven and ready-to-deploy **toolchain** for smart cities
- city-wide **analytics**

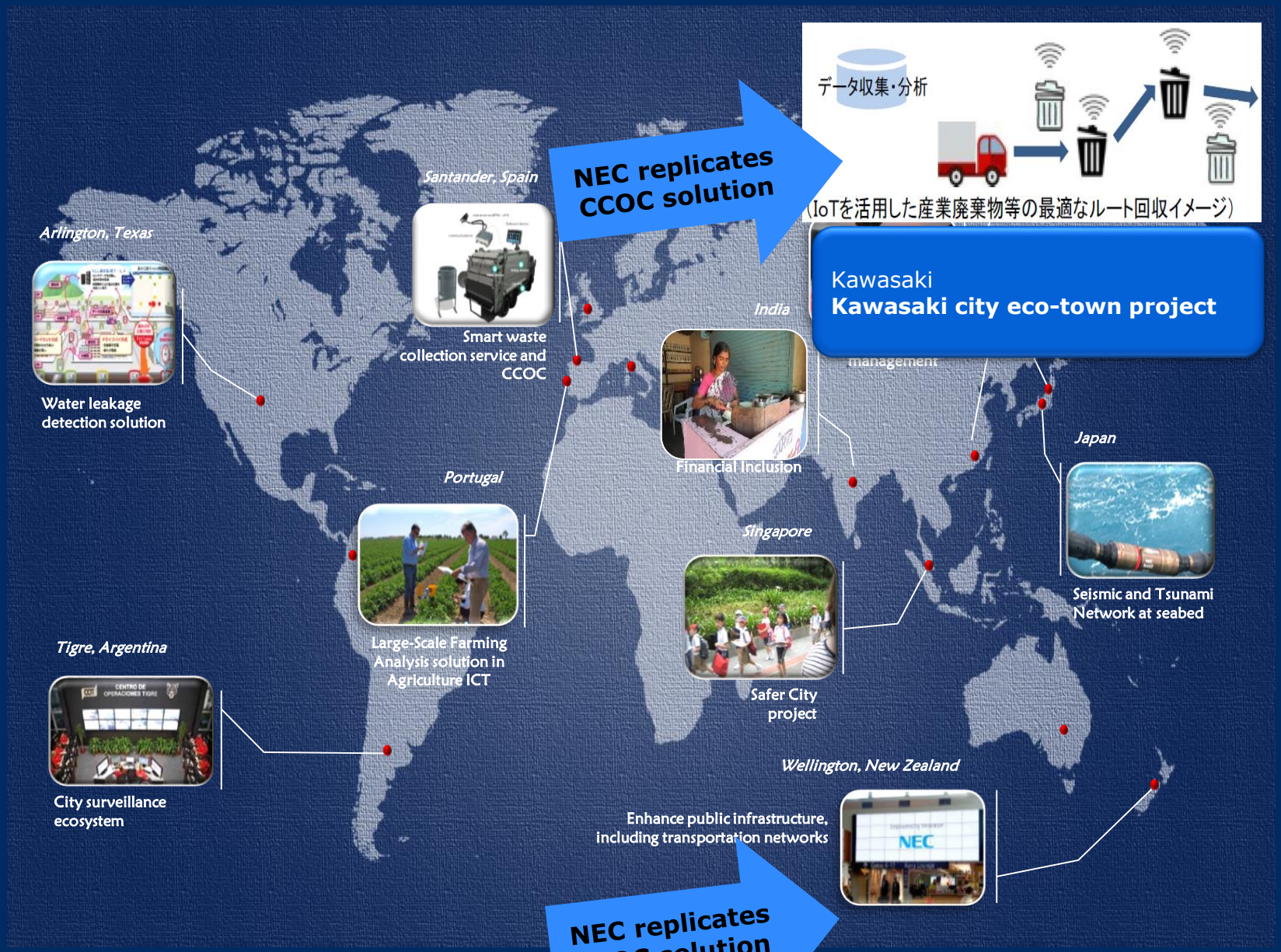
City Monitoring



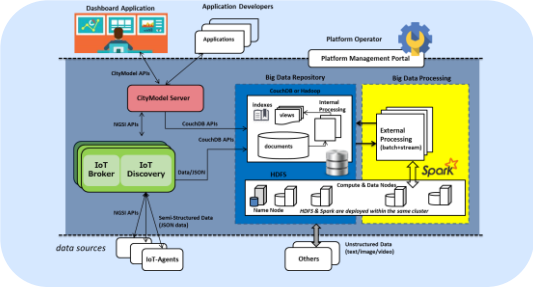
Visualisation

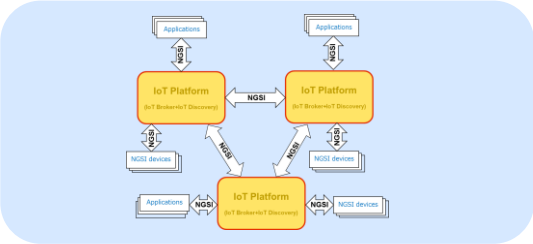


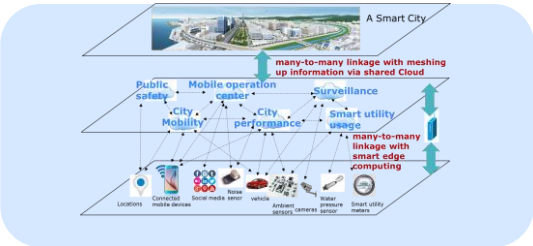
NEC ... Replicating Smart City Solutions

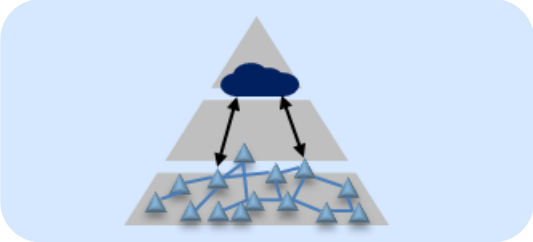


Outlook: Future Technology Trends









Today

IoT Clouds [today state-of-the-art]

- Cloud-based provisioning of IoT services
- NEC product: Cloud City Operation Center

1-3 year

Elastic IoT [emerging]

- From central cloud to federation & brokering: Cloud-of-Cloud, System-of-System
- Edge Computing & automated functional distribution, devops
- IoT network re-configuration

2-5 year

Hyperconnected IoT [Next Gen Discussion]

- Business mode: many-to-many data sharing
- semantic interoperability, multi-source data analysis, semantic context, sharing of control
- massive orchestration

4-6 year

Extreme IoT [R&D starting]

- Massive use: „100-10K IoT objects **per room**"
- IoT & 5G: IoT into every (!) object
  → network impact , advance discovery & contextualized orchestration, tactile control

Advanced IoT Use Cases

Beacon for Smart Displays

Beaconing Technology

- Bluetooth Low Energy (BLE) profile
- Enables information broadcast
- Realizes the Physical Web: things are linked to the Web

Example

- Smart Displays: equipped with beacons
- Broadcasting URLs with additional information about the shown content

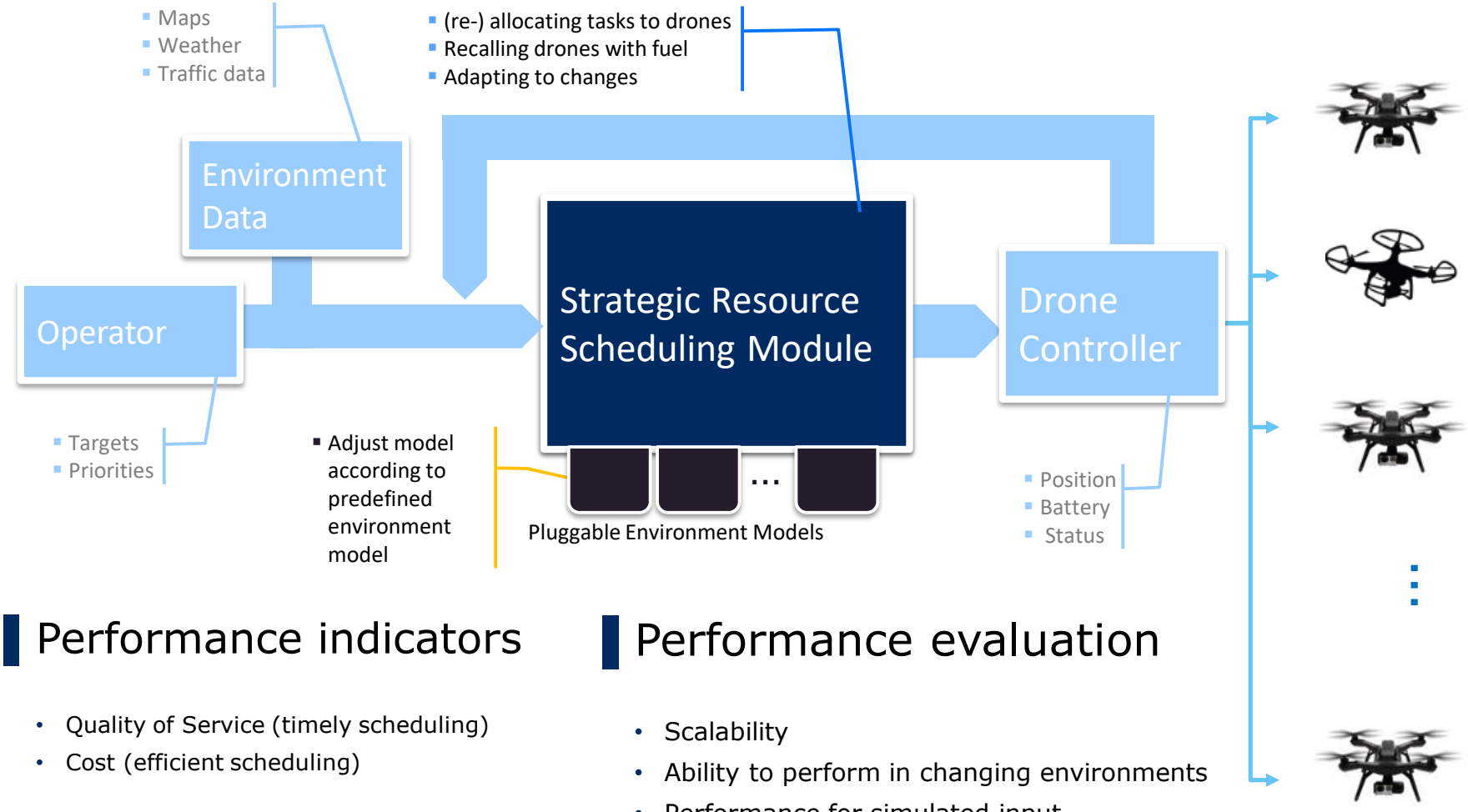
Realization

- Using Raspberry Pi Zero W or NEC Slot-in-PC with BLE dongle (Linux only)

NLE Technology

- iPhone App with calibration for distance
- management software for the beacons (using leafengine)
- entity lookup using the IoT Broker

Swarm Algorithm 1: Real time scheduling module – NITRO - Nature Inspired Task - Resource allocation Optimization



Performance indicators

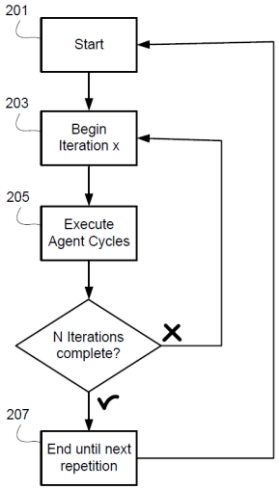
- Quality of Service (timely scheduling)
- Cost (efficient scheduling)

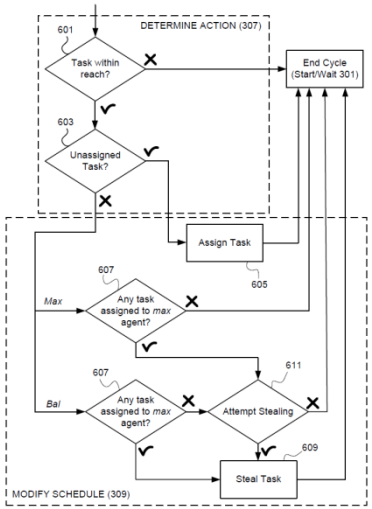
Performance evaluation

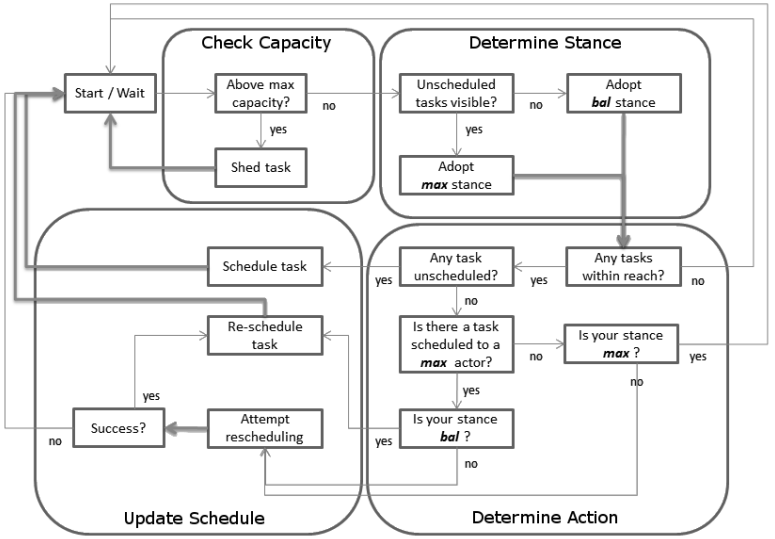
- Scalability
- Ability to perform in changing environments
- Performance for simulated input
- Performance for non-routing applications

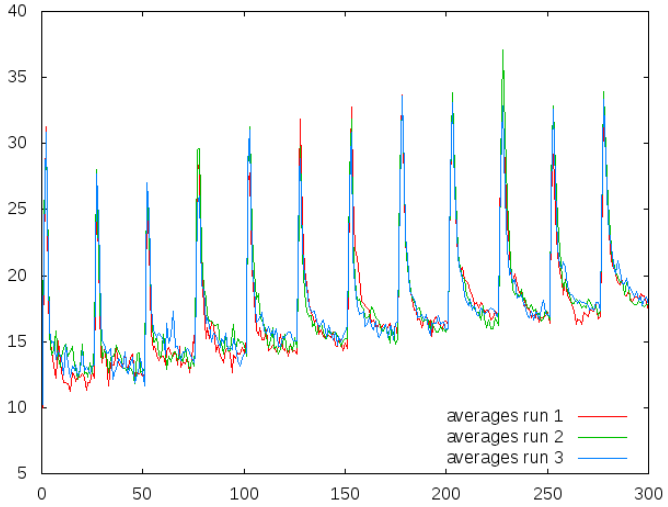
Real time scheduling module – NITRO - Nature Inspired Task-Resource allocation Optimization

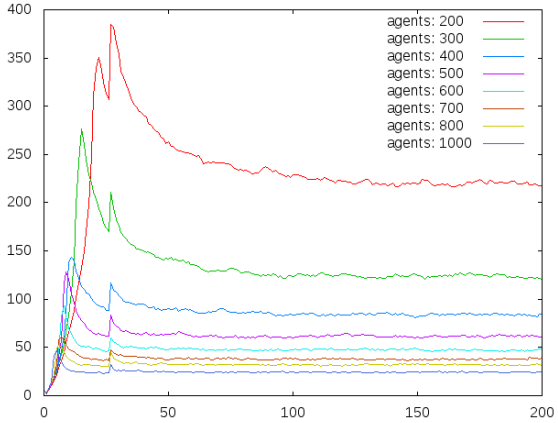
- "Distributed task scheduling using multiple agent paradigms", H. Hildmann and M. Martin

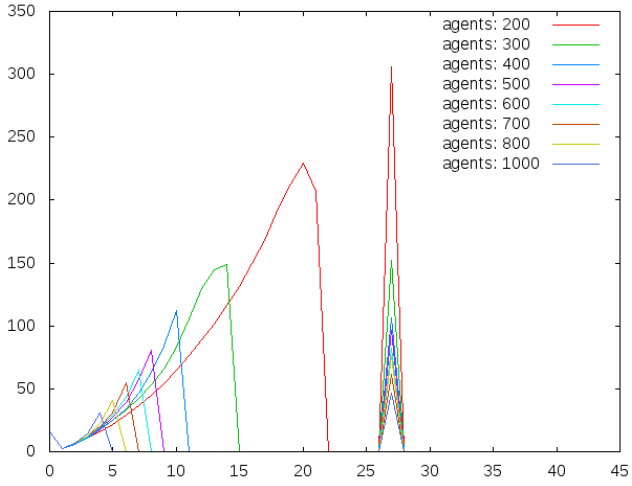




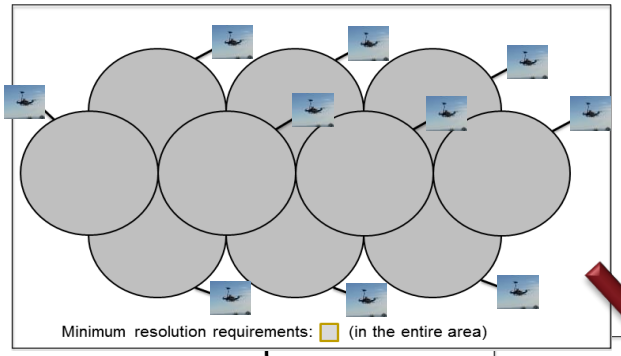








Swarm Algorithm 2: Swarm Surveillance – Adaptive Video Surveillance using multiple Aerial Sensing Platforms Drones)



Algorithm example and system architecture

Fig. 1a – homogeneous coverage

Algorithm improvements

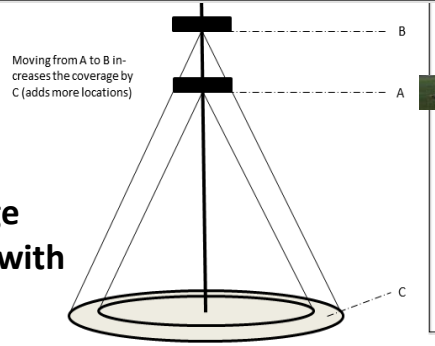


Fig. 2 – Coverage change with altitude

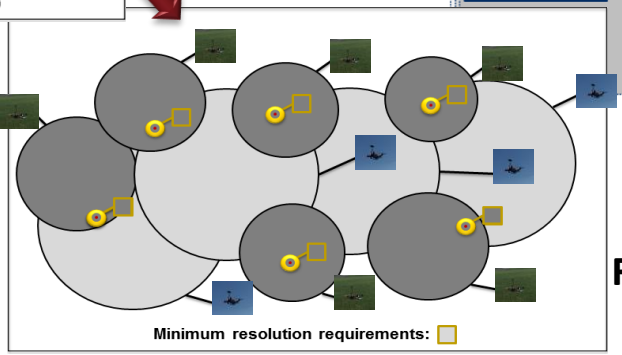


Fig. 1b – optimized coverage

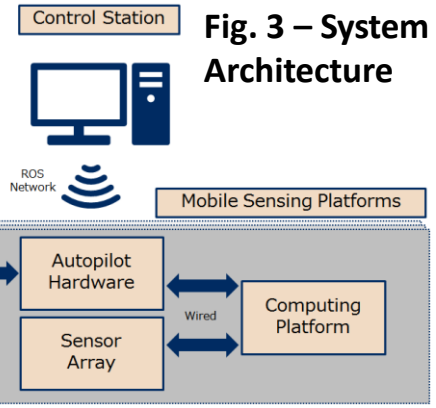


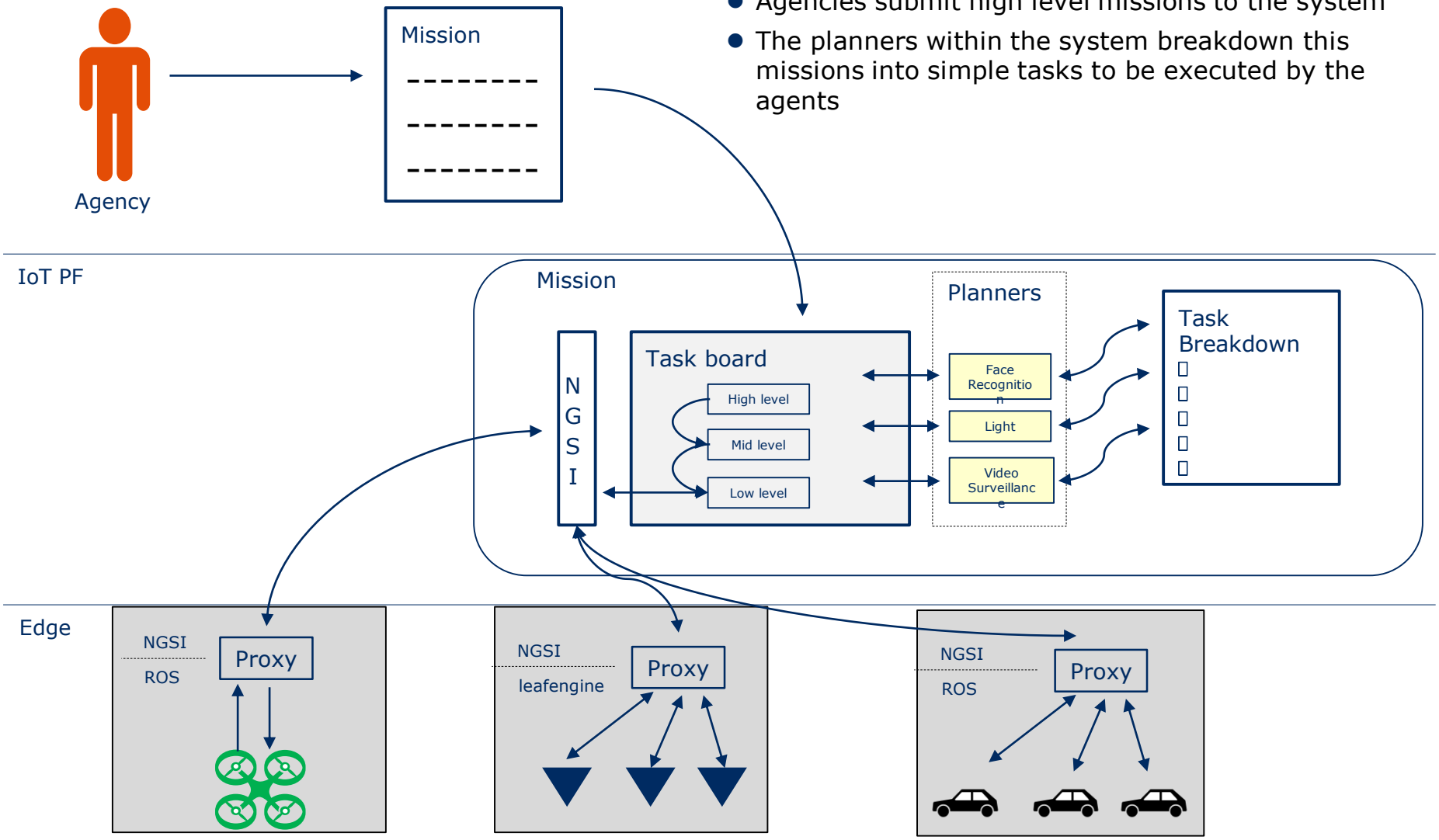
Fig. 3 – System Architecture

The **swarm surveillance algorithms** enable groups of devices to cooperatively execute tasks where one device is not enough, eg, surveying a large area. Devices participating in collective sensing tasks (such as providing **video coverage for an area** or **locating gas leaks**, e.g.) can adjust the quality or the scope of their sensory focus. This enables a swarm of devices to operate on two levels: while **the entire swarm provides blanket coverage** over an area the **individual devices can significantly improve the measurements provided for specific points**. The target customers are companies and units in the public and civil security area such as GSD and NEC NZ, as well as those providing (real-time) advice for e.g. agricultural or mining applications. The method can be applied to devices ranging from cameras to satellites.

Multi-Agent Control System for different systems

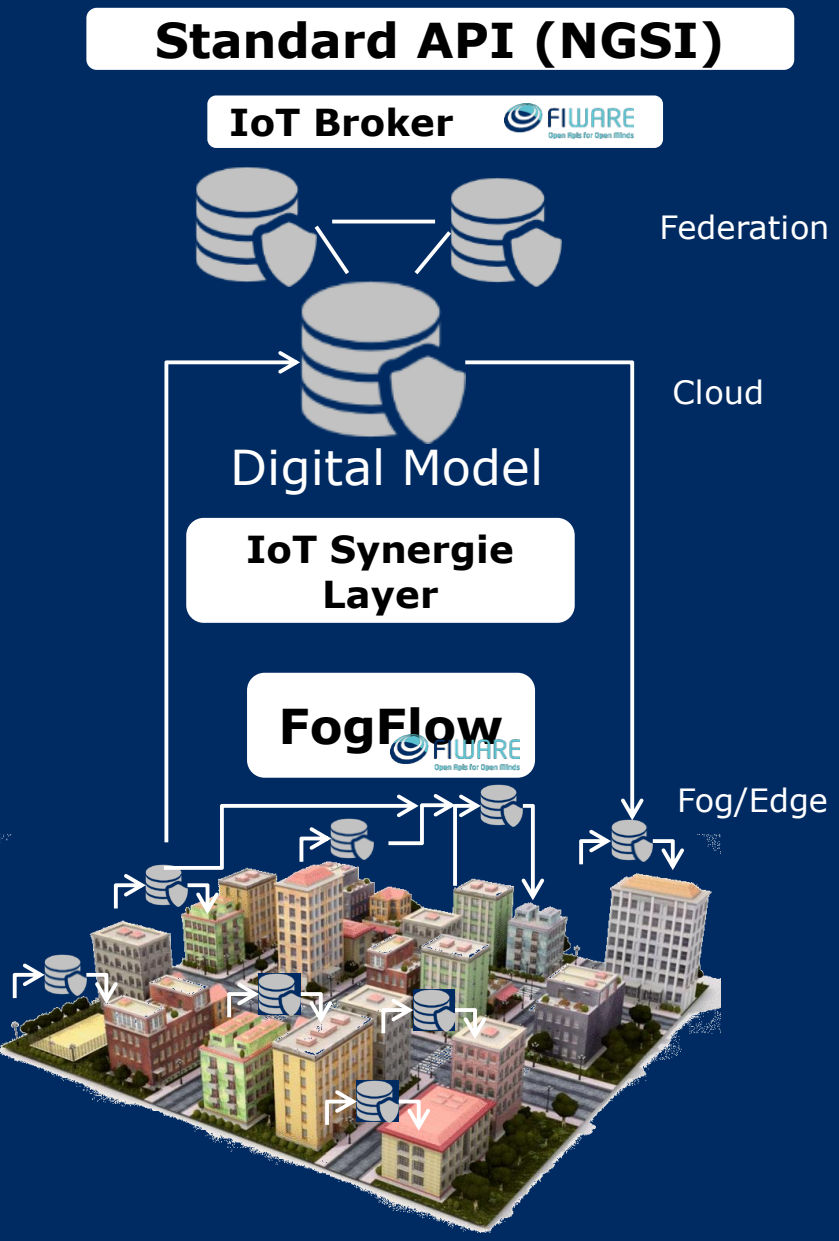
System architecture

- Agencies submit high level missions to the system
- The planners within the system breakdown this missions into simple tasks to be executed by the agents



FogFlow – Reliable Cloud/Edge Execution

Research



Digital Services

- Data Stream Analysis
- Contextualized Services

Data Model / Data Handling

- FIWARE NGSI (supported by100 cities)
- ETSI ISG CIM – Semantic Context Information about Smart Cities

IoT Synergie Layer

- Joint optimization of Edge, SDN and wireless networks

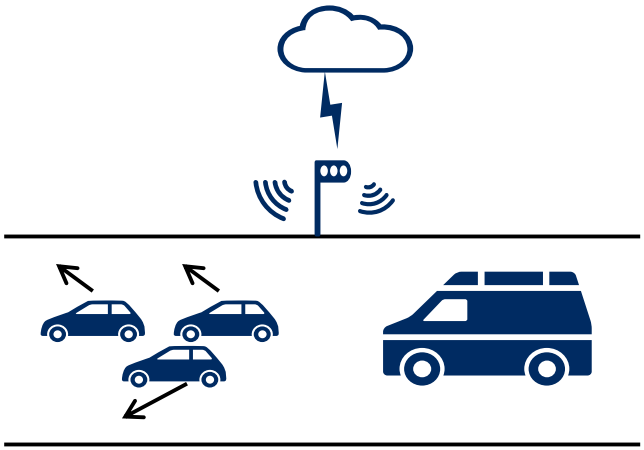
Edge Programming

- Dynamic Edge Programming
- Local Processing Flows
- Communication Optimization (10x higher throughput then ORION)
- FIWARE-based Pub/Sub Model

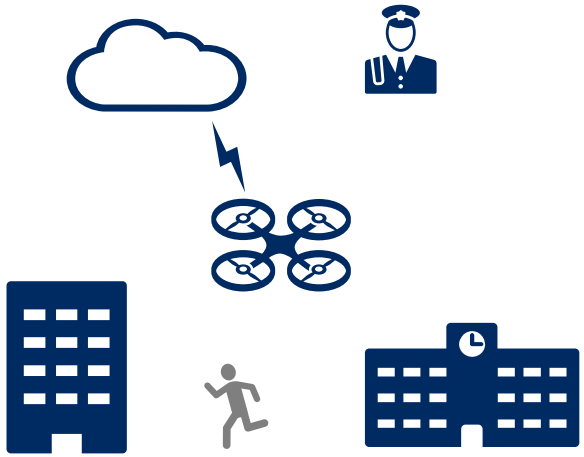
Mission Critical IoT Services

Mission Critical IoT Services – a emerging class of IoT services

- Closed loop: sensing → analyzing → actuating → sensing
- Use case examples
  - Lane preparation for ambulance cars
  - Car accidence avoidance with fast alert in emergency situation
  - Terrorist searching and tracking for public safety
- Top requirements: reliability, time constraint (often low end-to-end latency and fast response time), efficiency, scalability

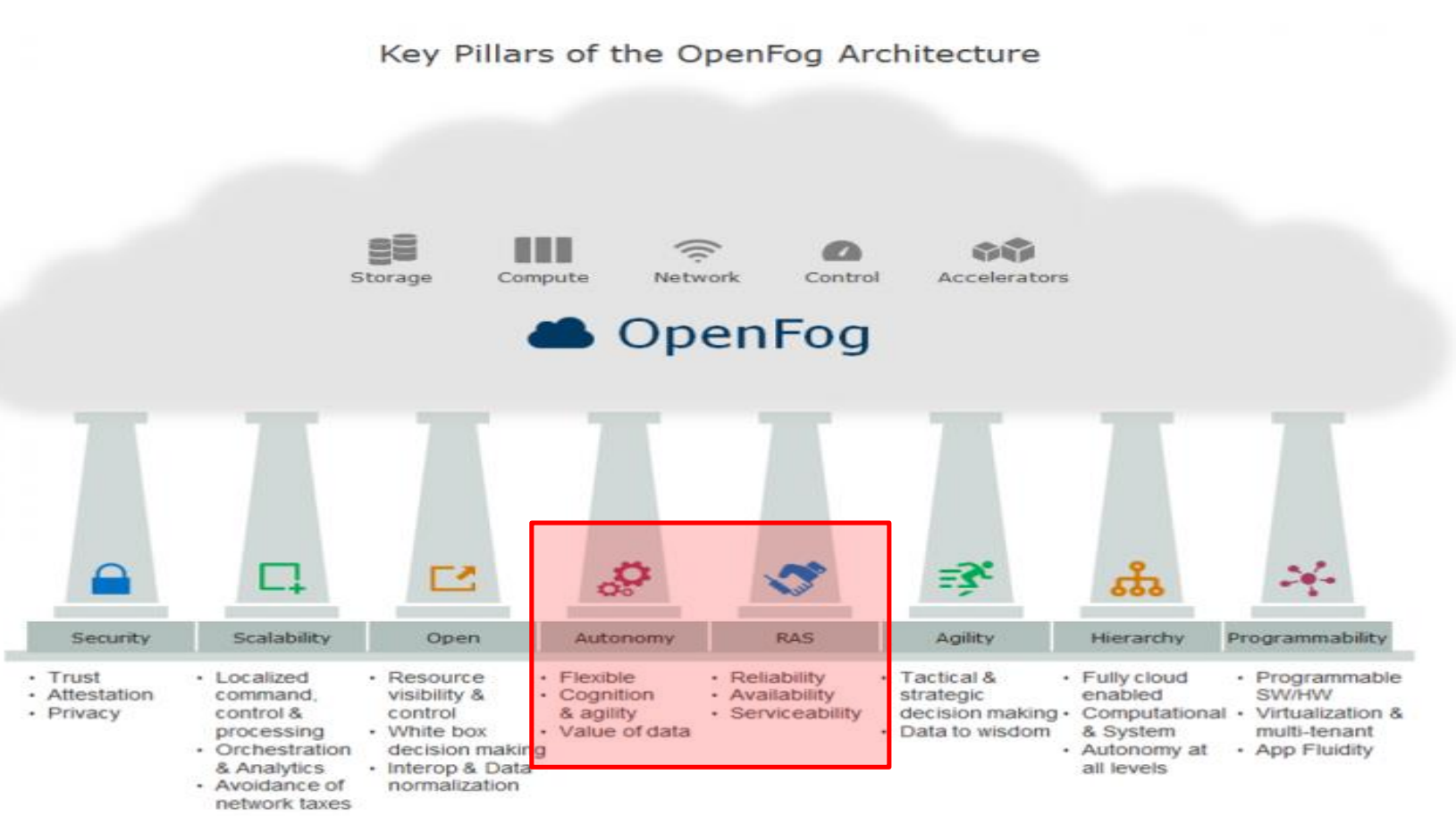


lane preparation for ambulance cars



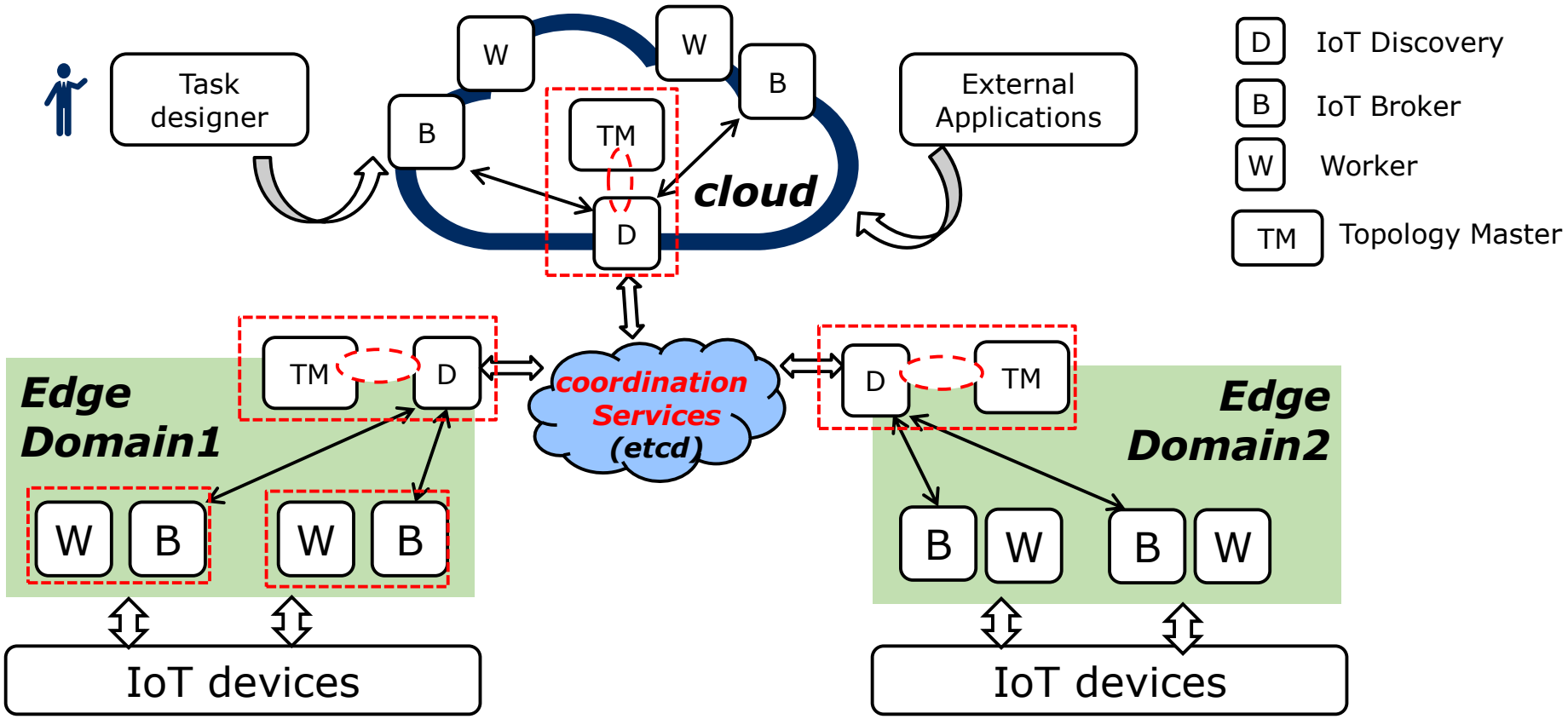
terrorist searching and tracking

Fog Computing



Reliability & autonomy: important criterions for fog computing

FogFlow: Reliable Fog Computing Framework

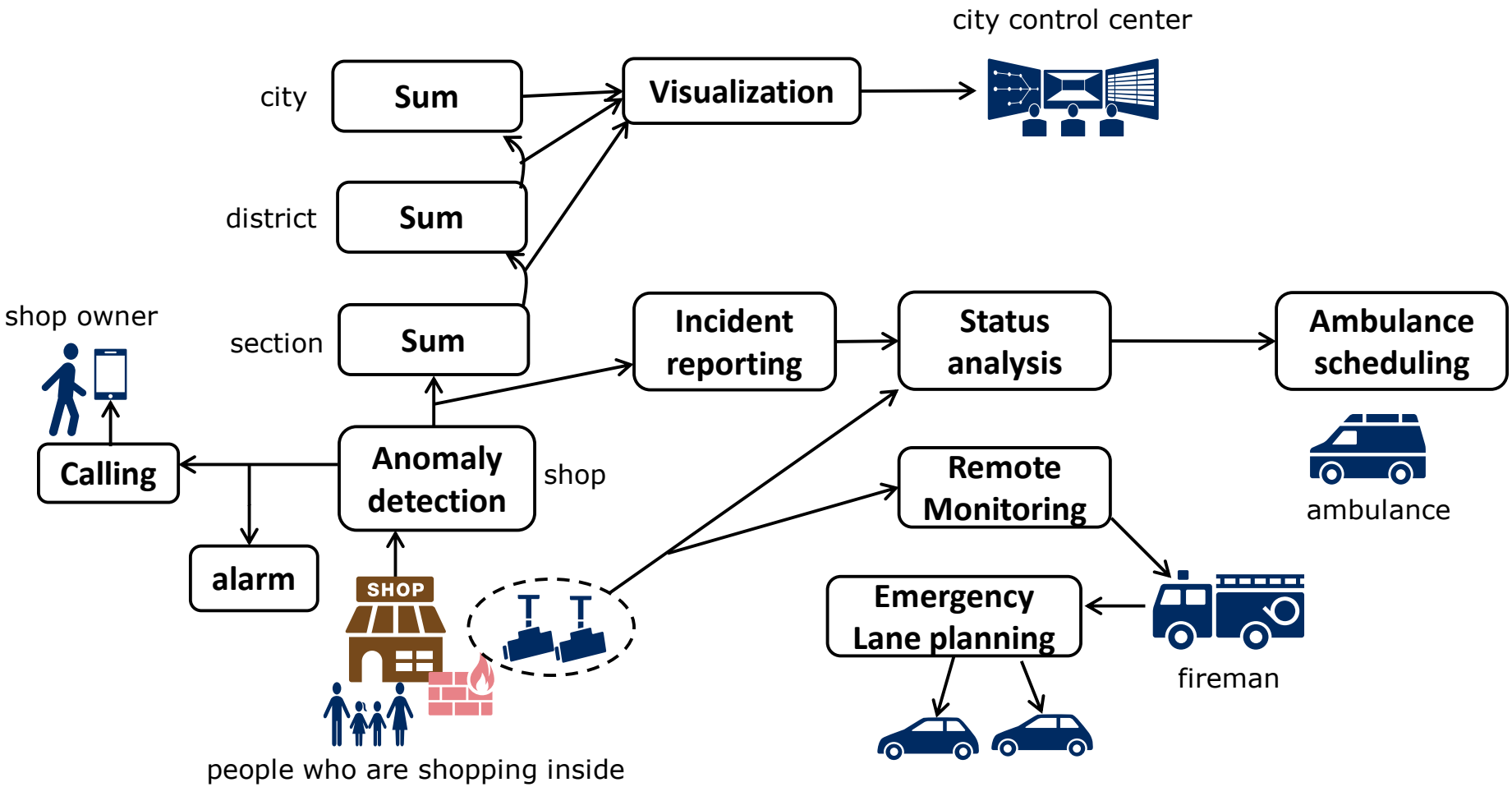


Two big challenges:

1) How to achieve the reliability of system components

2) How to offer the reliability of user-defined services?

Core Ideas: Dynamic Task Orchestration over Cloud-Edges



Triggering dockerized tasks based on the availability of its required input data;
Data processing topology can be constructed dynamically;

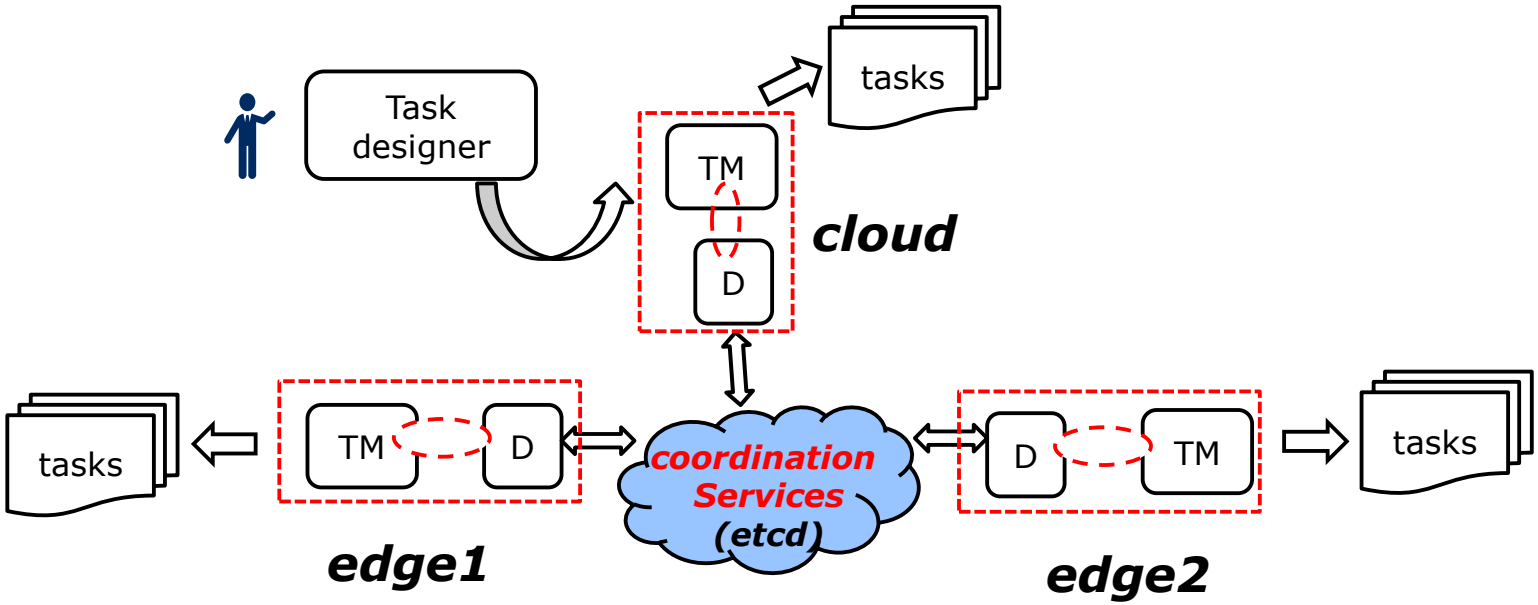
Reliability Issues (1): Reliable Service Orchestration

Distributed orchestration:

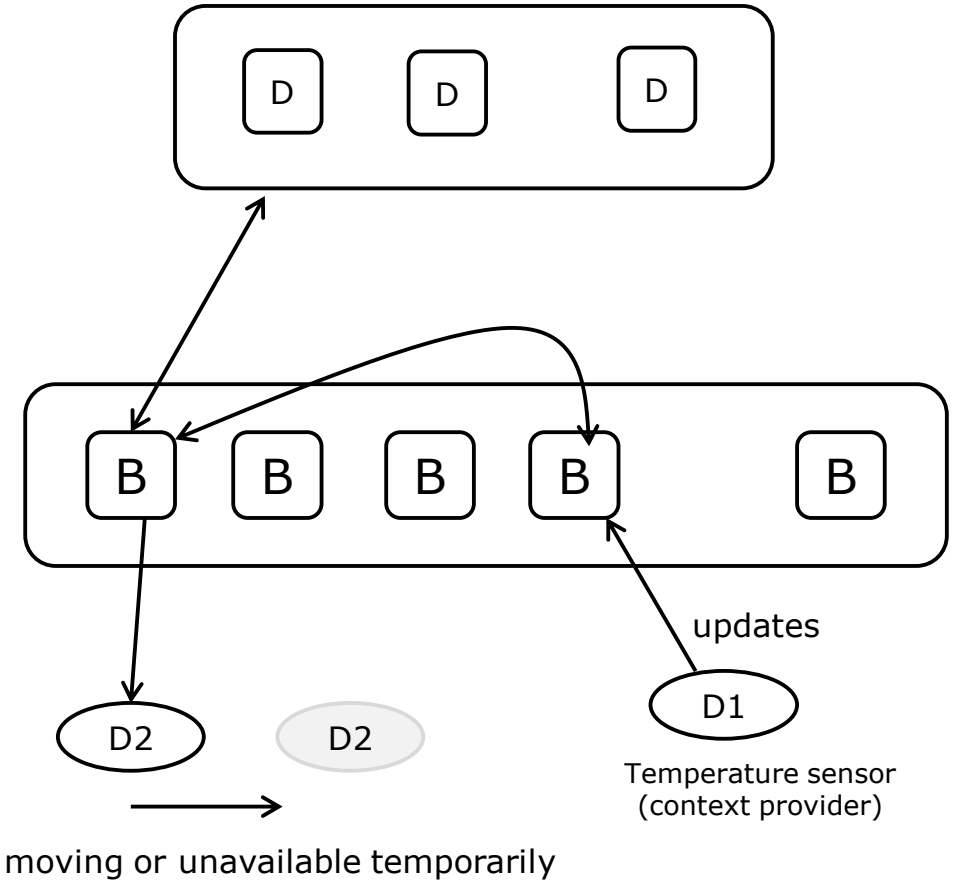
- Turn TM (topology master) from centralized to distributed
- Turn TM (topology master) from stateful to stateless (using reliable coordination services for saving intermediate decisions)

Task Migration

- Migrate tasks from one edge to another edge without losing inputs and internal states



Reliability Issues (2): Reliable Information Delivery



Context Availability
(indexing, discovery)

Context Entities
(information exchanging)

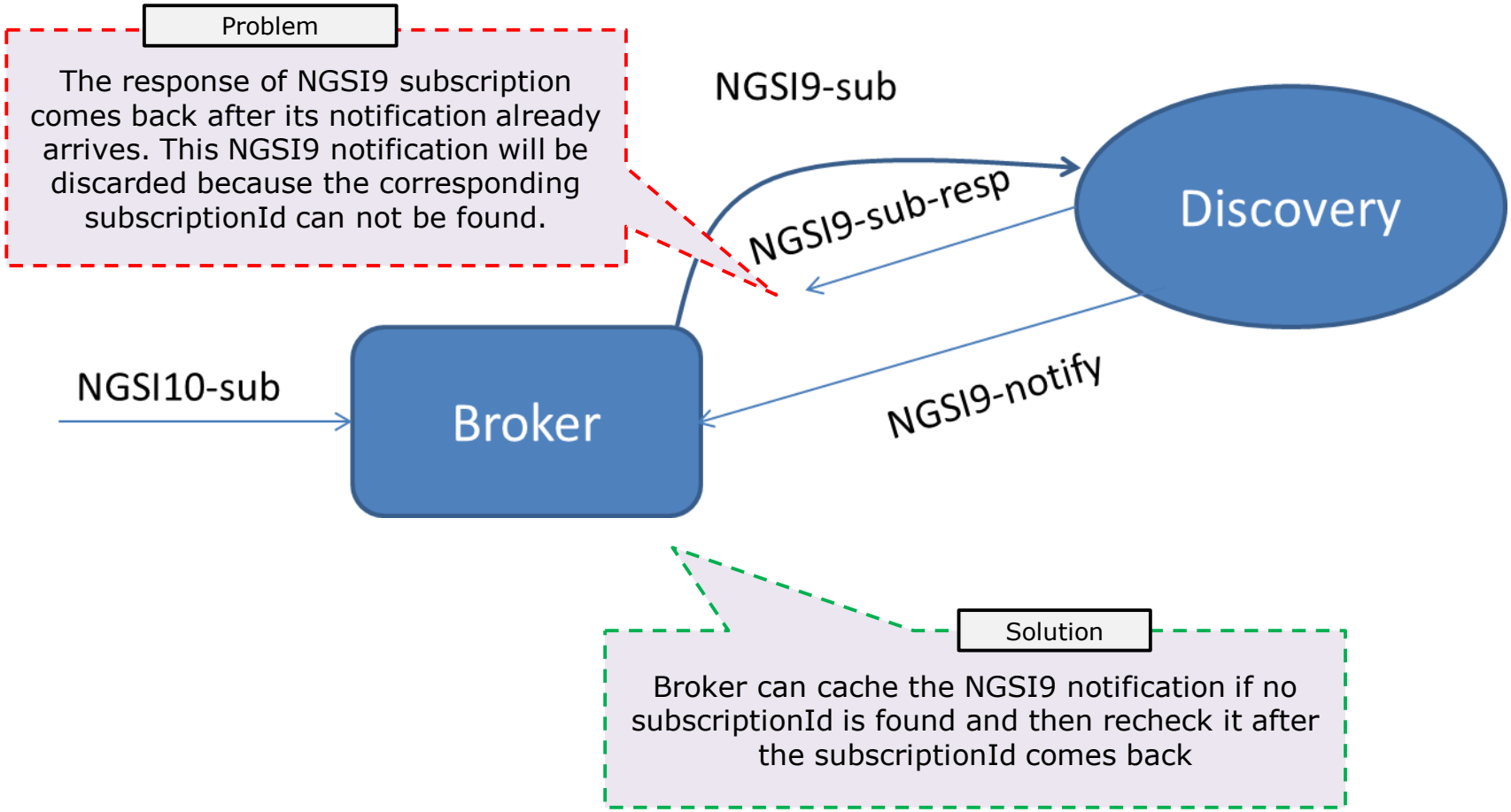
IoT Devices
(provide/consume context)

How to ensure the order and reliable delivery of messages when exchanging context information? (we have enhanced our IoT Broker to provide reliable notify delivery in an optional way)

Concrete Issue related to System Reliability

Enhancement to solve the issues with NOTIFY delivery

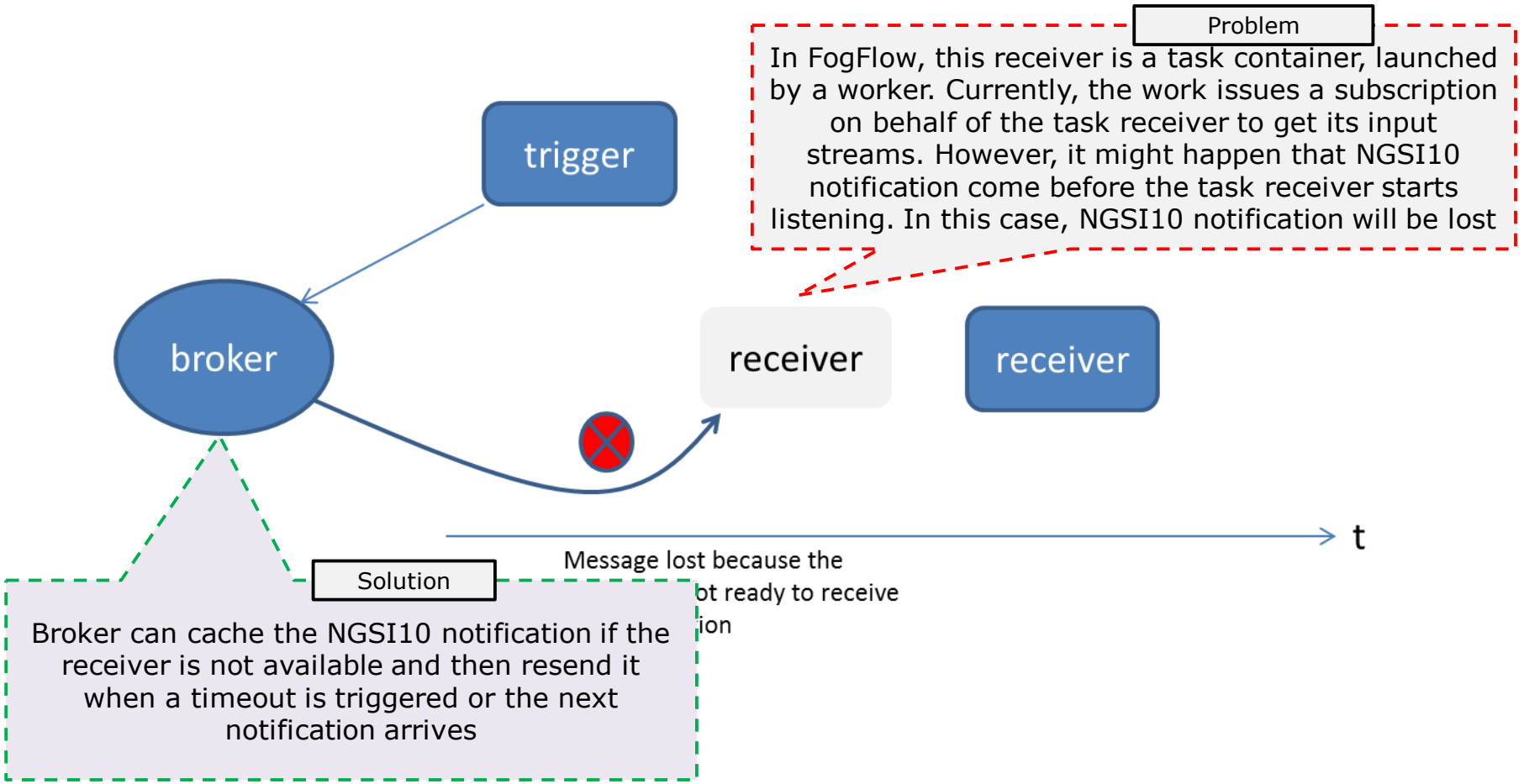
- Disorder of messages between IoT Broker and IoT Discovery



Concrete Issue related to System Reliability

Enhancement to solve the issues with NOTIFY delivery

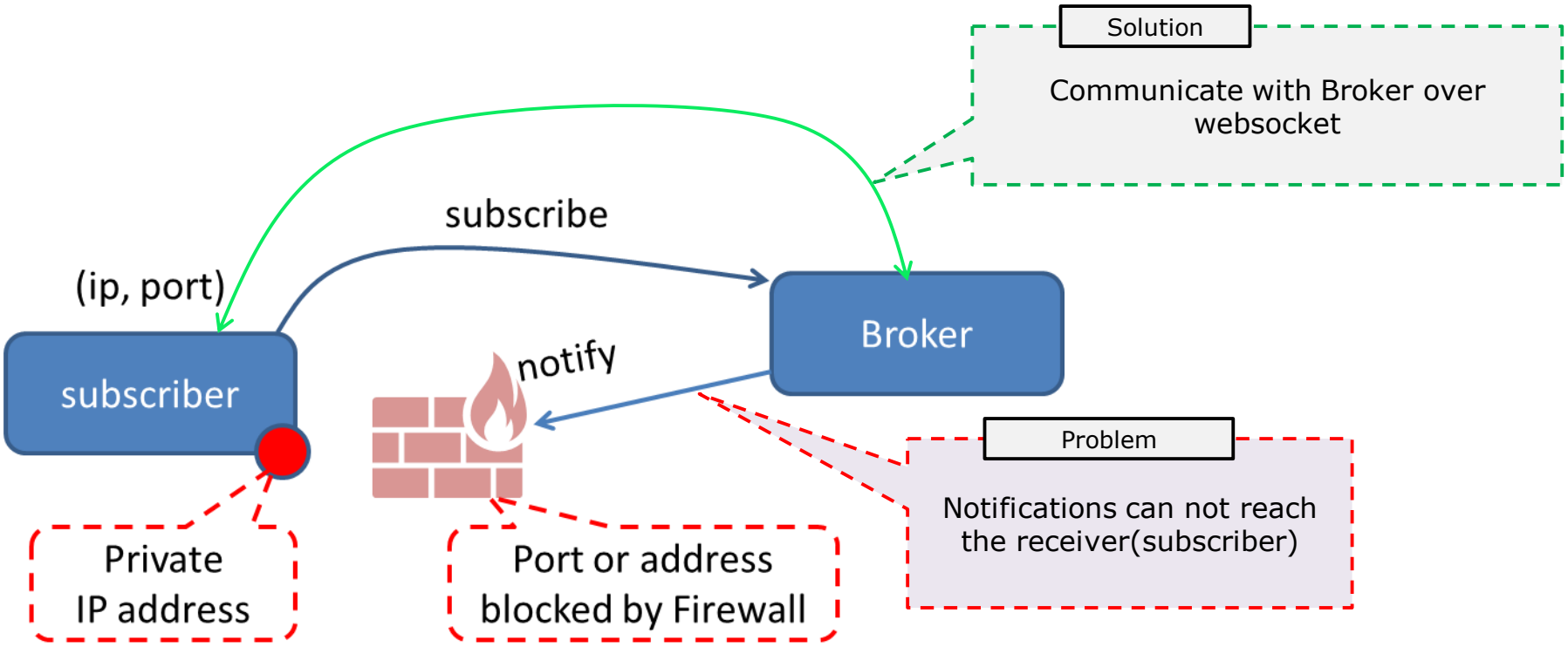
- Lost of NGSI10 notification before the receiver gets ready (start listening)



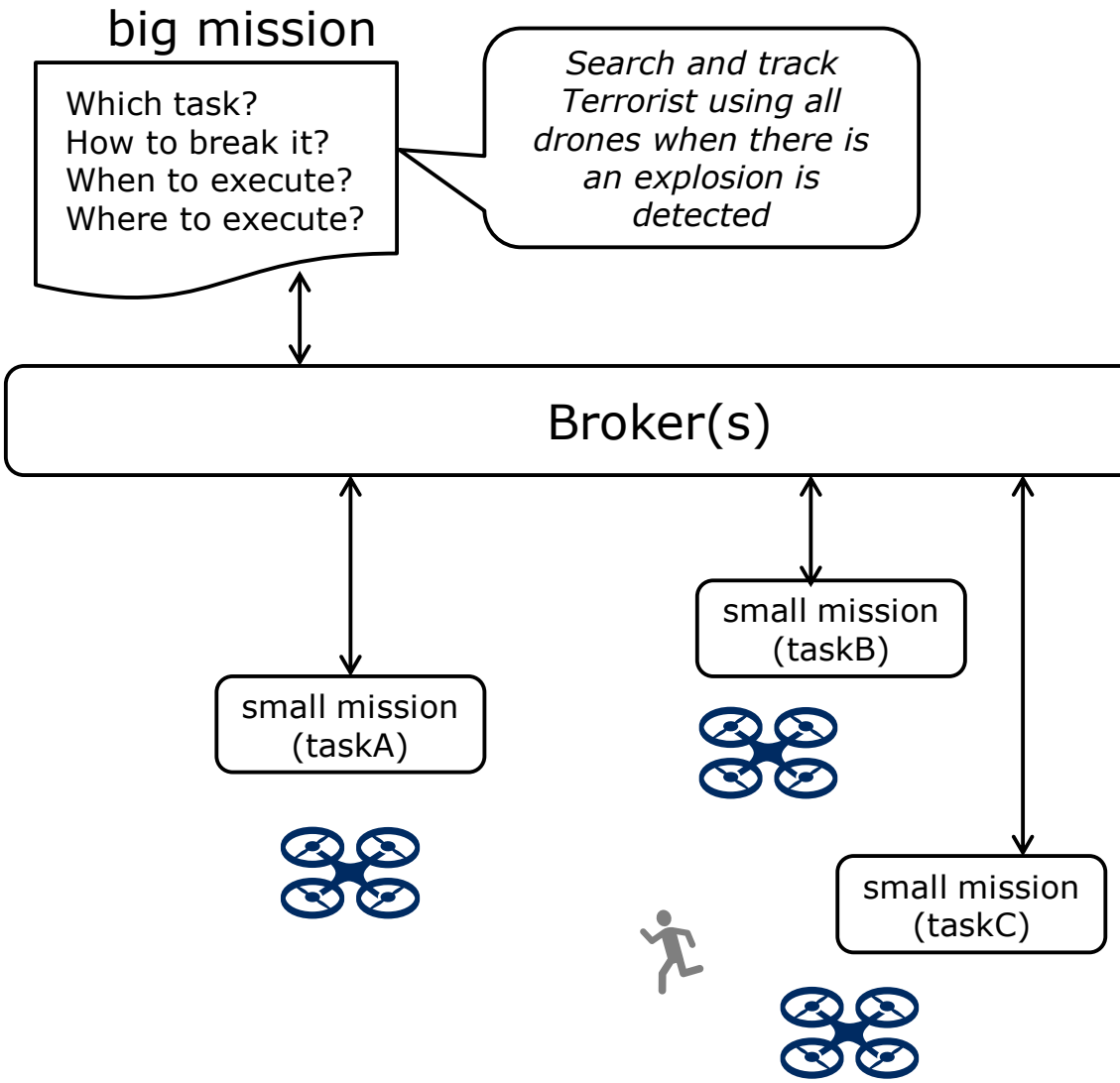
Concrete Issue related to System Reliability

Enhancement to solve the issues with NOTIFY delivery

- Subscriber(receiver) is behind NAT/firewall, no able to receive notifications via a listening port



Reliability Issues (3): Reliable Actuating



Provide proper and easy programming model to define missions and let the framework to handle all complexities

Coordinate all actuators to perform small divided tasks in order to finish the given mission

More importantly, we need the mechanism to ensure each mission has been done (reliable actuating)

Summary

Internet-of-Things

- is evolving into a global infrastructure for data and processes
- is moving to become more elastic and hyperconnected

Edge Computing

- is solving issues of latency, bandwidth, lcoal operation, and disconnection
- is using content-based brokering
- need to be made reliable by updating its internal system mechanisms

Moving On

- IoT is moving towards self-organized ensembles of devices
- needs reliable and stable algorithm for coordination and decision making

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CPaaS.io

City Platform as a Service – Integrated and Open


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