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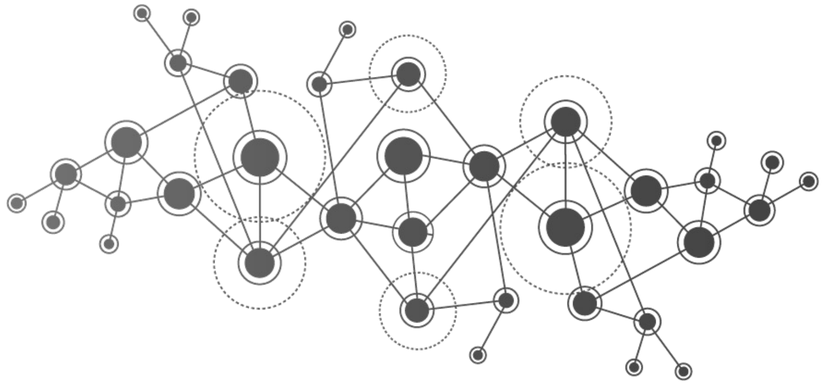

Intelligent Internet of Things

IoT Architectures End to End Design

Prof. Marco Picone

A.A 2022/2023

IoT Architectures End to End Design

- Scenario 1: Personal Health Device
- Scenario 2: Health & Sport
- Scenario 3: Industrial Telemetry
- Scenario 4: Industrial Edge Deployment
- Scenario 5: Smart Building

2023 - Marco Picone, Ph.D. (marco.picone@unimore.it)

IoT Architectures End to End Design

- Scenario 1: Personal Health Device

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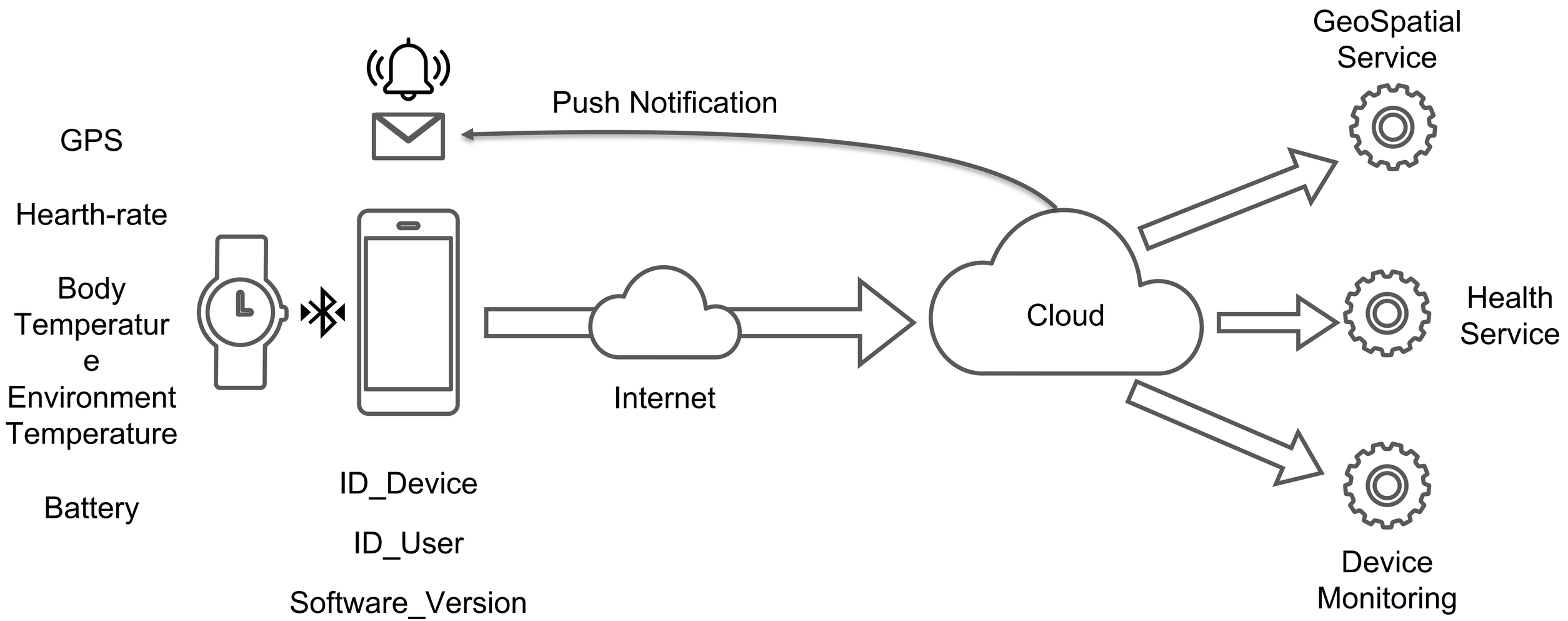
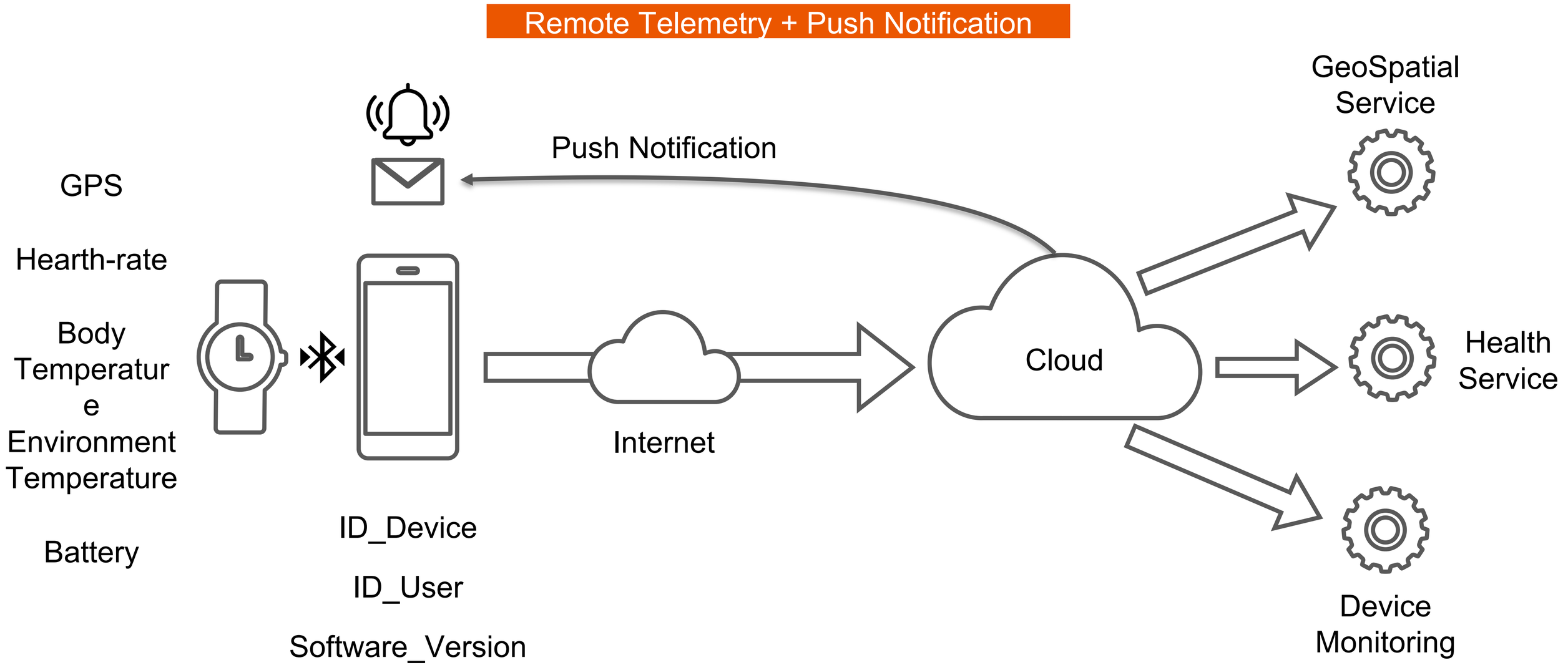
Scenario 1 - Personal Health Device



Scenario 1 - Personal Health Device



Scenario 1 - Data Modeling

GPS

Field	Type
latitude	Double
longitude	Double
altitude	Double
timestamp	Long

Hearth-rate

Field	Type
value	Double
unit	String
timestamp	Long

Body Temperature

Field	Type
value	Double
unit	String
timestamp	Long

Env. Temperature

Field	Type
value	Double
unit	String
timestamp	Long

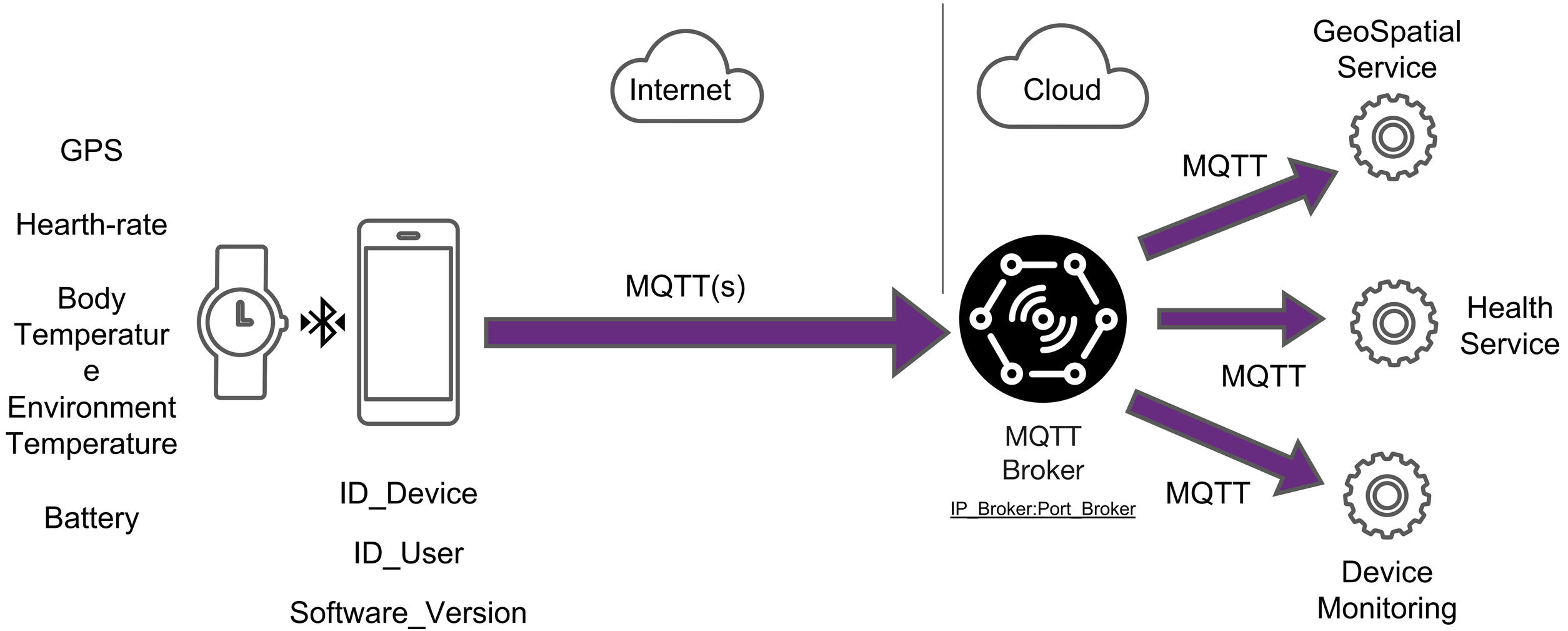
Battery

Field	Type
value	Double
timestamp	Long

Device Info

Field	Type
id	String
user_id	String
software_version	String

Scenario 1 - Protocols & Communications



Scenario 1 - MQTT Topics & Data

Device Info

Field	Type
id	String
user_id	String
software_version	String

/device/<id>/info

/device/**deviceTest0001**/info

*retained message

```
{
  id: “deviceTest0001”,
  user_id: “user0001”,
  software_version: “0.0.1-beta”
}
```

GPS

Field	Type
latitude	Double
longitude	Double
altitude	Double
timestamp	Long

/device/<id>/telemetry/gps

```
{
  lat: 10.12121,
  lng: 44.12121,
  alt: 10,
  timestamp: 15718928192
}
```

Hearth-rate

Field	Type
value	Double
unit	String
timestamp	Long

/device/<id>/telemetry/hr

```
{
  value: 80,
  unit: ”bpm”,
  timestamp: 15718928192
}
```

Scenario 1 - MQTT Topics & Data

Body Temperature

Field	Type
value	Double
unit	String
timestamp	Long

→ /device/<id>/telemetry/bt →

```
{
  value: 36.5,
  unit: ”C”,
  timestamp: 15718928192
}
```

Env. Temperature

Field	Type
value	Double
unit	String
timestamp	Long

→ /device/<id>/telemetry/et →

```
{
  value: 36.5,
  unit: ”C”,
  timestamp: 15718928192
}
```

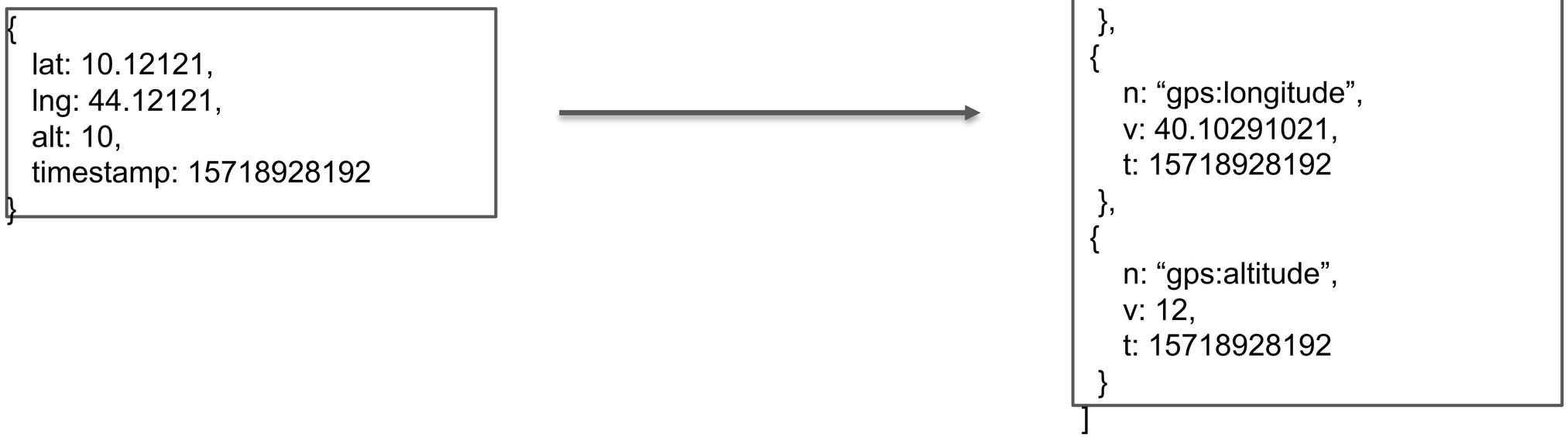
Battery

Field	Type
value	Double
timestamp	Long

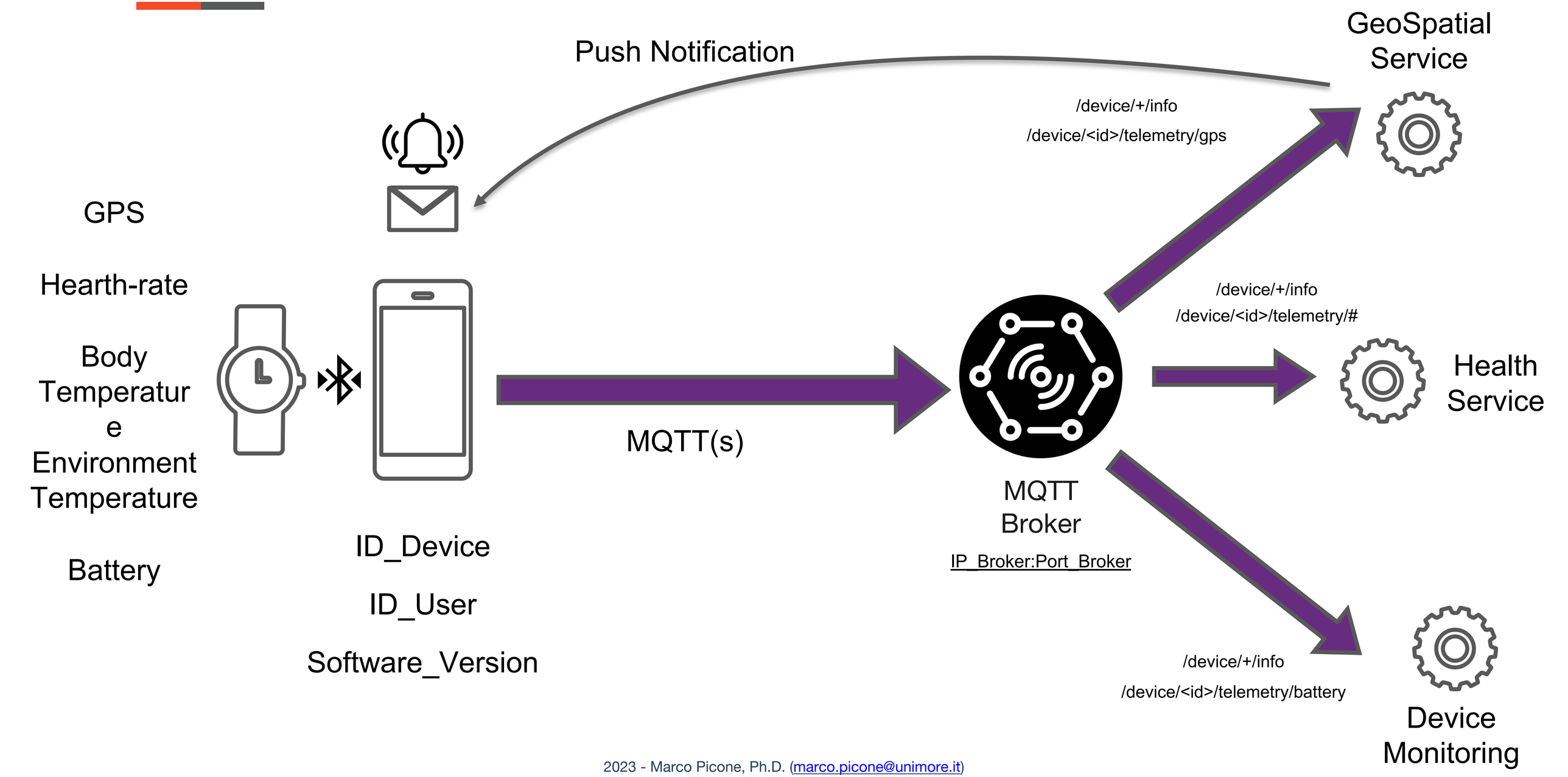
→ /device/<id>/telemetry/battery →

```
{
  value: 98,
  timestamp: 15718928192
}
```

Scenario 1 - SENML + JSON



Scenario 1 - Protocols & Communications



IoT Architectures
End to End Design

- Scenario 2: Health & Sport

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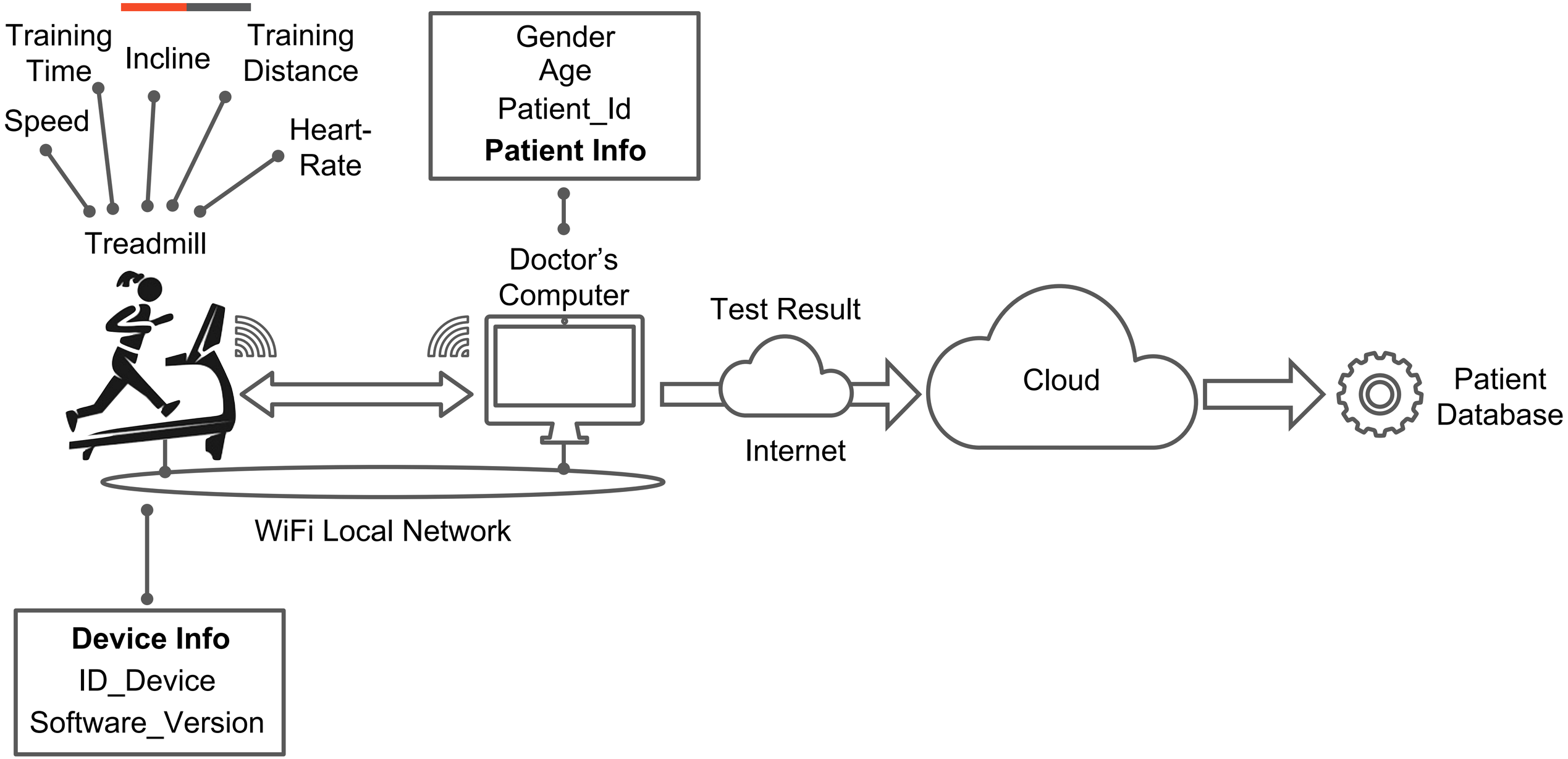
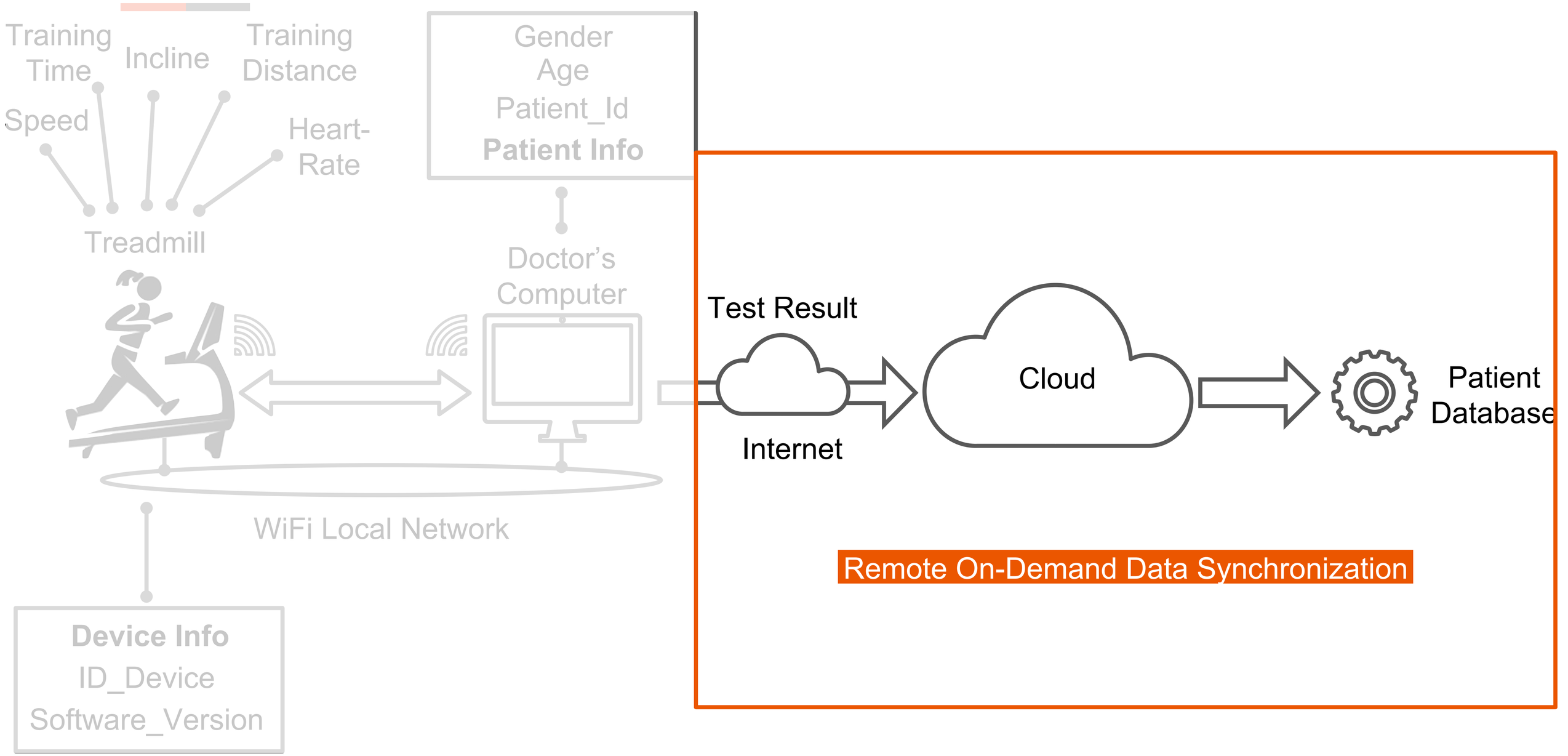
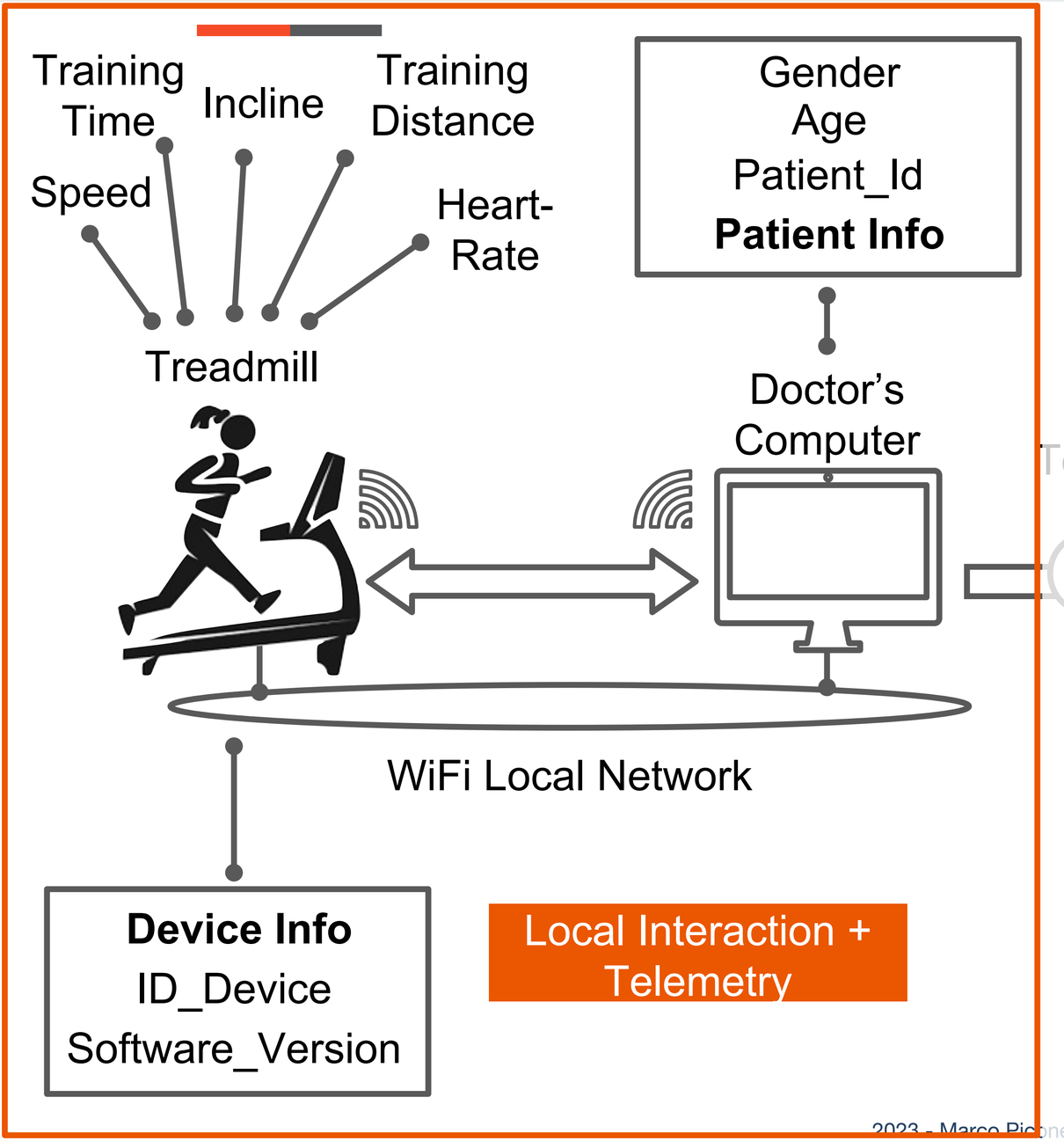
Scenario 2 - Health & Sport

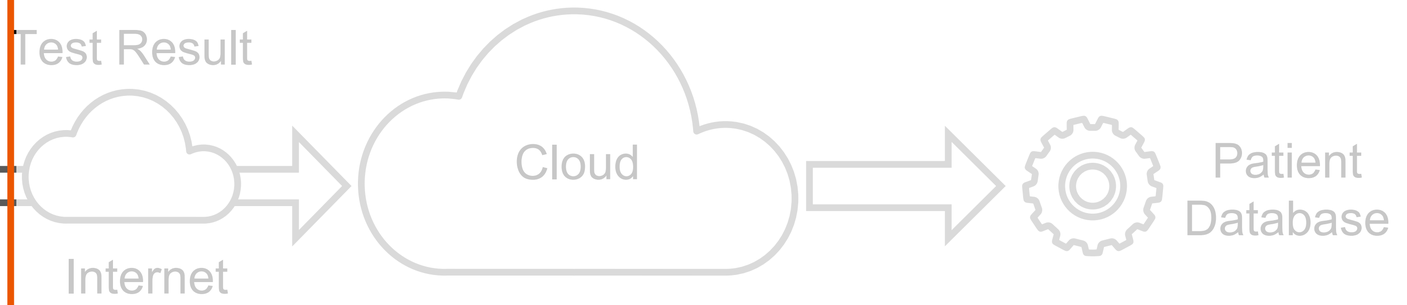


Scenario 2 - Health & Sport

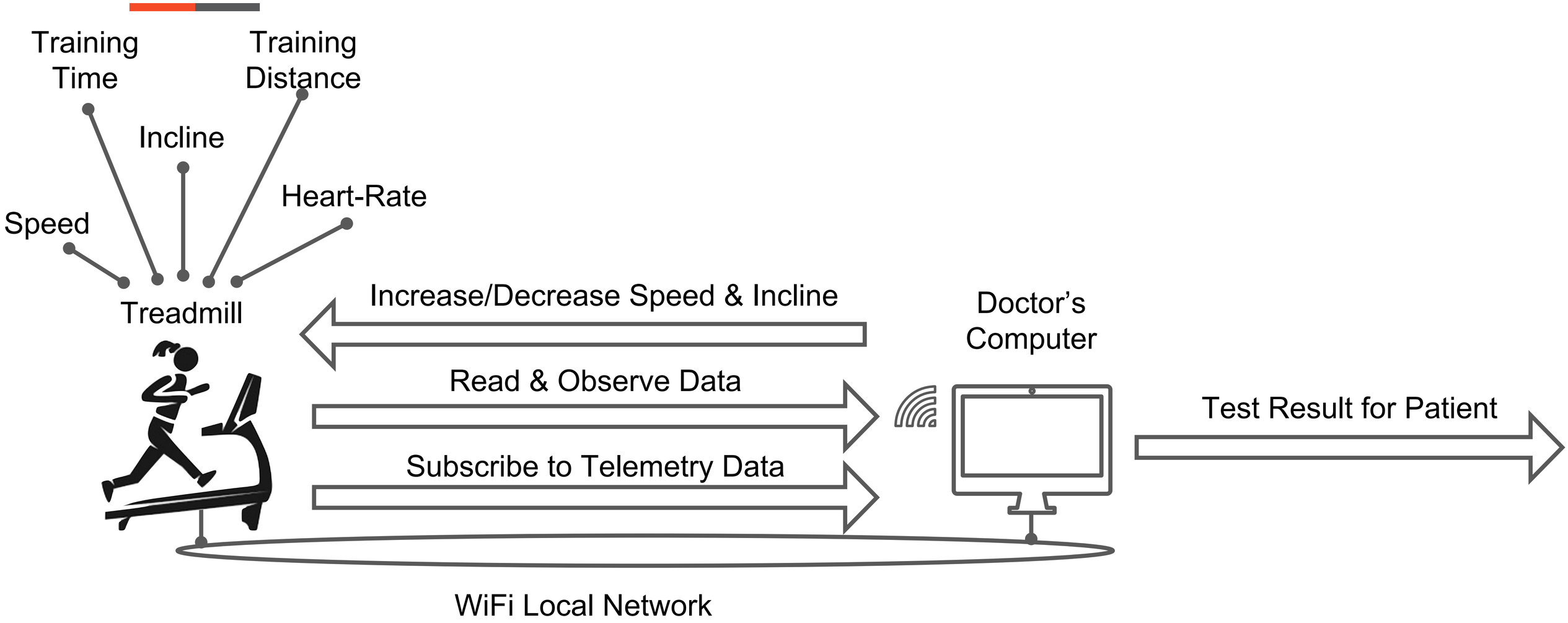


Scenario 2 - Health & Sport





Scenario 2 - Health & Sport - Local Network



Scenario 2 - Health & Sport - Local Network

Treadmill

Doctor’s Computer

Remote Services

Req/Resp

Telemetry

Start Session

START OK

Save New Start Instant
Init data subscription

Sensor Data

Storage &
Filtering

Change Parameters

CHANGE OK

……..

Stop Session

STOP OK

Stop data subscription
Data Processing
Data Entry

“Test Result”

Patient Data
Storage

Scenario 2 - Data Modeling

Hearth-rate

Field	Type
value	Double
unit	String
timestamp	Long

Speed

Field	Type
value	Double
unit	String
timestamp	Long

Incline

Field	Type
value	Double
unit	String
timestamp	Long

Training Info

Field	Type
start_timestamp	Long
end_timestamp	Long
distance	Double
distance_unit	String

Device Info

Field	Type
id	String
software_version	String
manufacturer	String
device_type	String

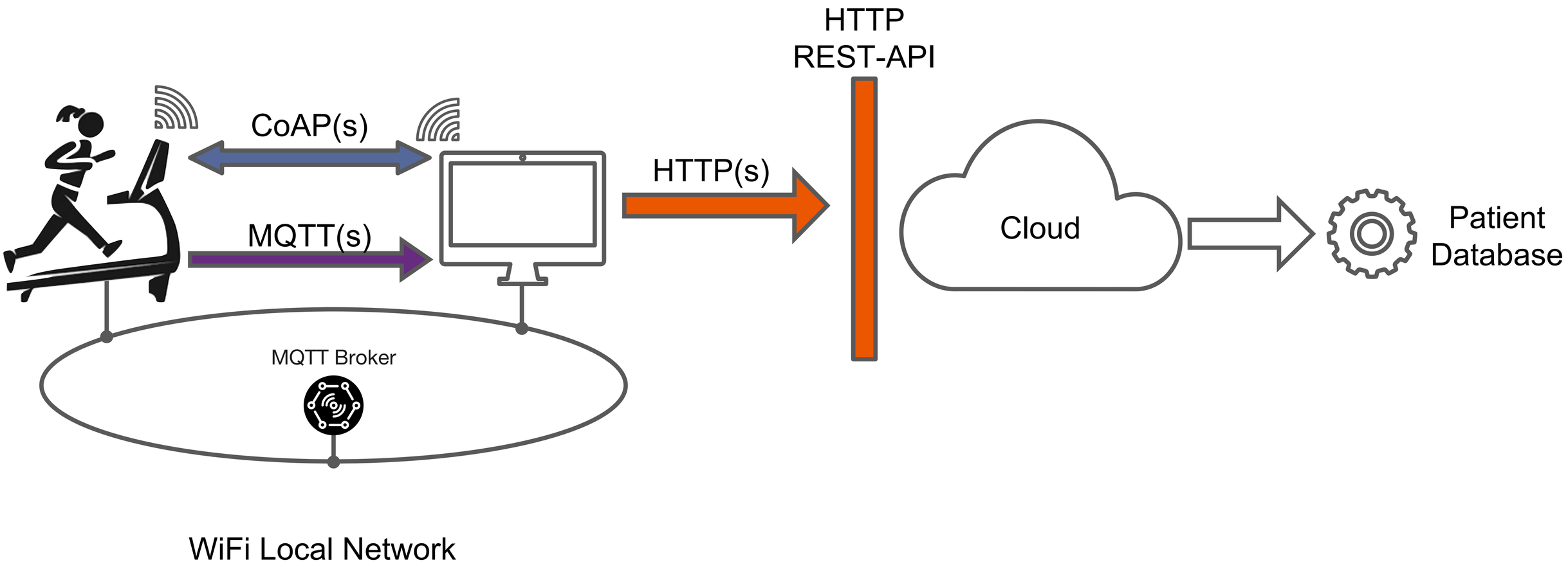
Patient Info

Field	Type
id	String
gender	String
age	Integer

Test Result

Field	Type
id	String
timestamp	Long
avg_hr	Double
is_success	Boolean
hr_graph_data	Array[…]
conf_data	Array[…]

Scenario 2 - Protocols & Communications



Scenario 2 - CoAP Resources & Responses

Hearth-rate

Field	Type
value	Double
unit	String
timestamp	Long

/hr-id
if: core.s
rt: iot.demo.hr.sensor
obs

```
[
  {
    n: “iot.demo.hr.sensor:hr-id”,
    v: 10.21313,
    t: 1577698017
  }
]
```

SENML + JSON

Speed

Field	Type
value	Double
unit	String
timestamp	Long

/speed-id
if: core.a
rt: iot.demo.speed.device
obs

.....

Incline

Field	Type
value	Double
unit	String
timestamp	Long

/incline-id
if: core.a
rt: iot.demo.incline.device
obs

.....

Device Info

Field	Type
id	String
software_version	String
manufacturer	String
device_type	String

/treadmill-id
if: core.p
rt: iot.demo.treadmill.info
obs

.....

Scenario 2 - CoAP Actuators & Requests

Speed

Field	Type
value	Double
unit	String
timestamp	Long

/speed-id
if: core.a
rt: iot.demo.speed.device
obs

POST

Body: Empty
Result: Change Status [Start, Cool-Down, Stop]

PUT

Body: New Speed in Km/h
Result: Change speed to the specified speed value

Incline

Field	Type
value	Double
unit	String
timestamp	Long

/incline-id
if: core.a
rt: iot.demo.incline.device
obs

POST

Body: Empty
Result: Increase incline of 0.5 degree

PUT

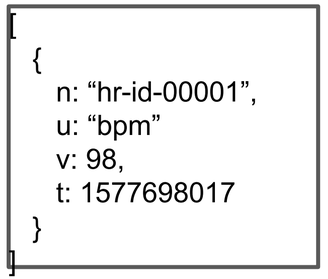
Body: New incline value (degree)
Result: Change incline to the specified degree value

Scenario 2 - MQTT Topics & Data

Hearth-rate

Field	Type
value	Double
unit	String
timestamp	Long

/device/<treadmill_id>/telemetry/hr



SENML
+
JSON

Scenario 2 - Cloud HTTP API - Resources

HTTP RESTful API - Example

/sporthealth/api/patient

- GET: retrieve the list of all patients
- POST: add a new patient

…/<patient_id>

- GET: get detailed data on the target patient
- PUT: update existing patient data
- DELETE: remote the existing patient

…/results

- GET: retrieve all the completed results
- POST: create a new test result

…/<result_id>

- GET: load test result data
- PUT: update of the target data
- DELETE: remote target data

Patient's Test Result - Resource Representation Example

Patient Data

```
{
  patient_id: “0001”,
  name: “Marco”,
  surname: “Rossi”,
  age: 35,
  …..
}
```

Result Data

```
{
 patient_id: “0001”,
 timestamp: 1578210921,
 doctor_id: “d0001”,
 device_id: “treadmill-id-00001”,
 is_success: true,
 avg_hr: 160,
 hr_graph_data: [
  {
    timestamp: 1572121902,
    hr_value_bpm: 140
  },
  {
    timestamp: 1572121912,
    hr_value_bpm: 141
  },
  {
    timestamp: 1572121922,
    hr_value_bpm: 142
  }
 ],
 conf_data: [
   {
     timestamp: 1572121902,
     speed_value: 8,
     incline_value: 0
   },
   {
     timestamp: 1572141902,
     speed_value: 14,
     incline_value: 3
   }
 ]
}
```

IoT Architectures End to End Design

- Scenario 3 (a): Industrial Remote Telemetry
- Scenario 3 (b): Industrial Remote & Local Telemetry

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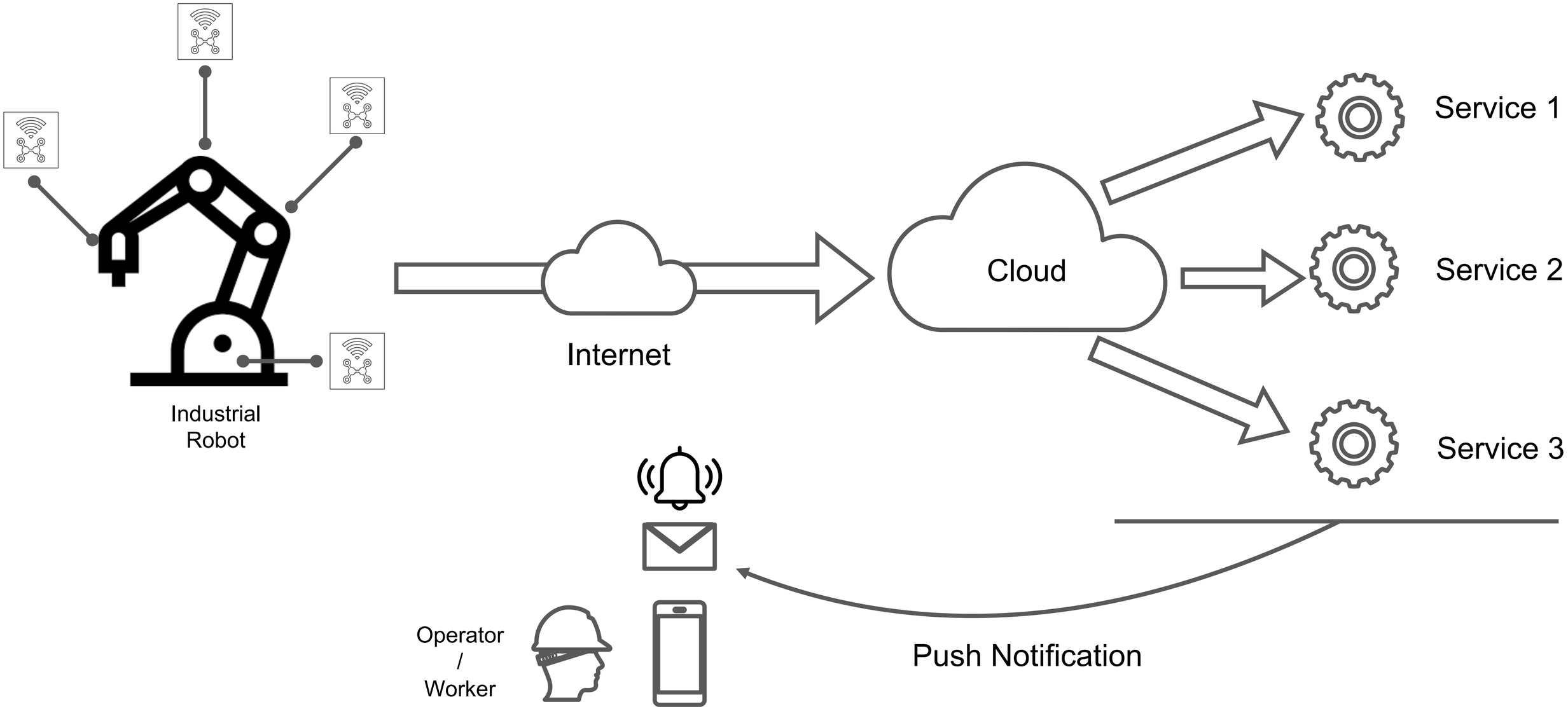
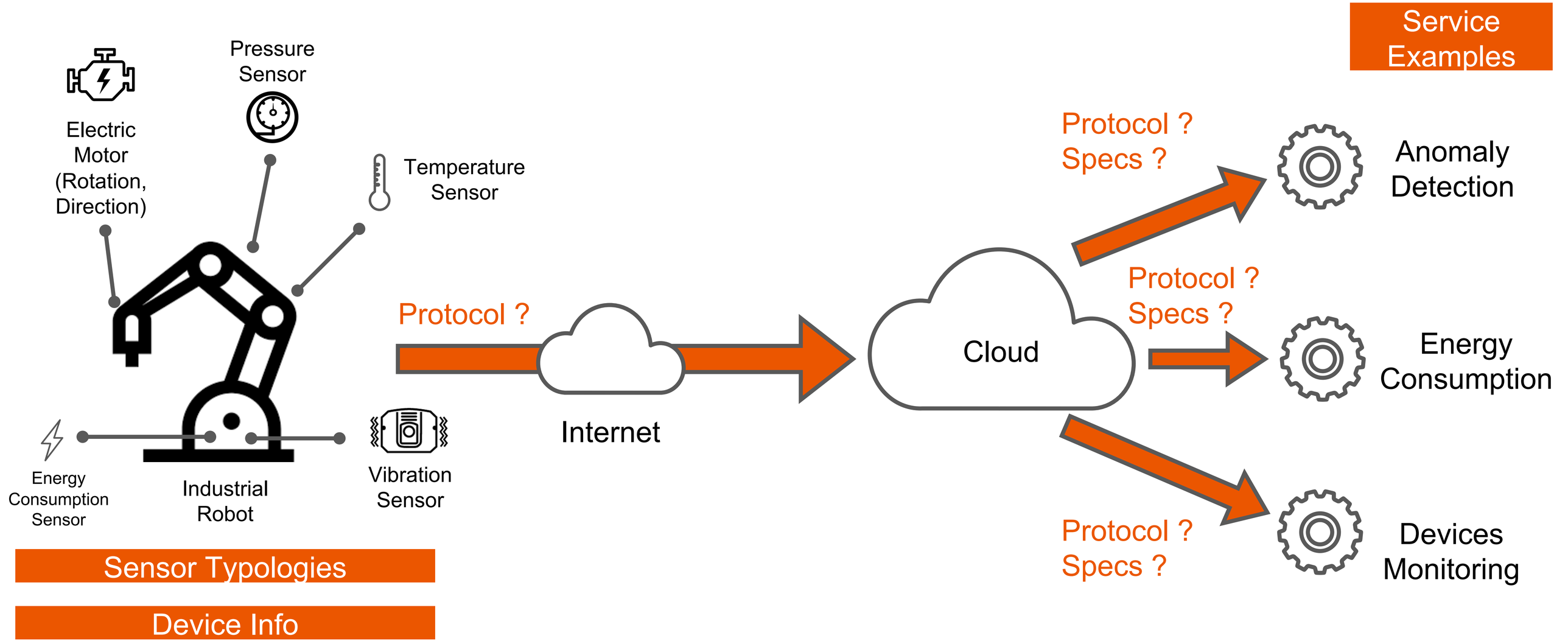
Scenario 3 - Industrial Remote Telemetry



Scenario 3 - Industrial Remote Telemetry



Scenario 1 - Data Modeling

Electric Motor Sensor

Field	Type
speed	Double
speed_unit	String
rotation	Double
rotation_unit	String
timestamp	Long

Pressure Sensor

Field	Type
value	Double
unit	String
timestamp	Long

Temperature Sensor

Field	Type
value	Double
unit	String
timestamp	Long

Vibration Sensor

Field	Type
value	Double
unit	String
timestamp	Long

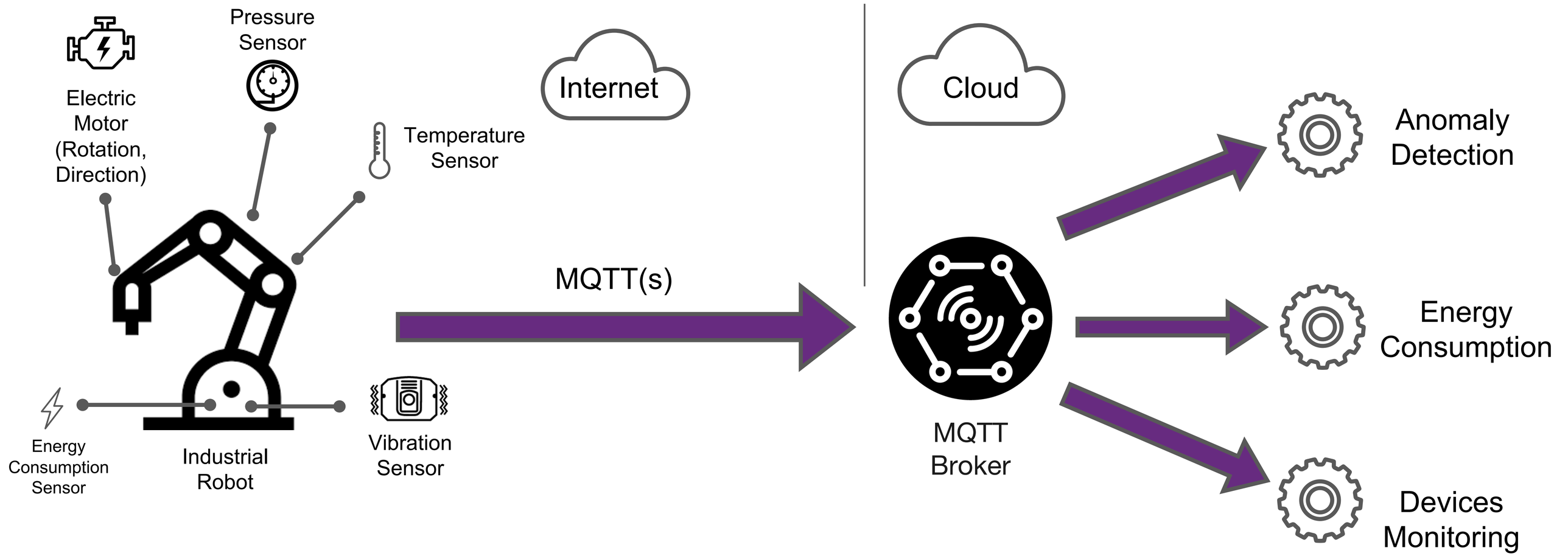
Energy Consumption Sensor

Field	Type
value	Double
unit	String
timestamp	Long

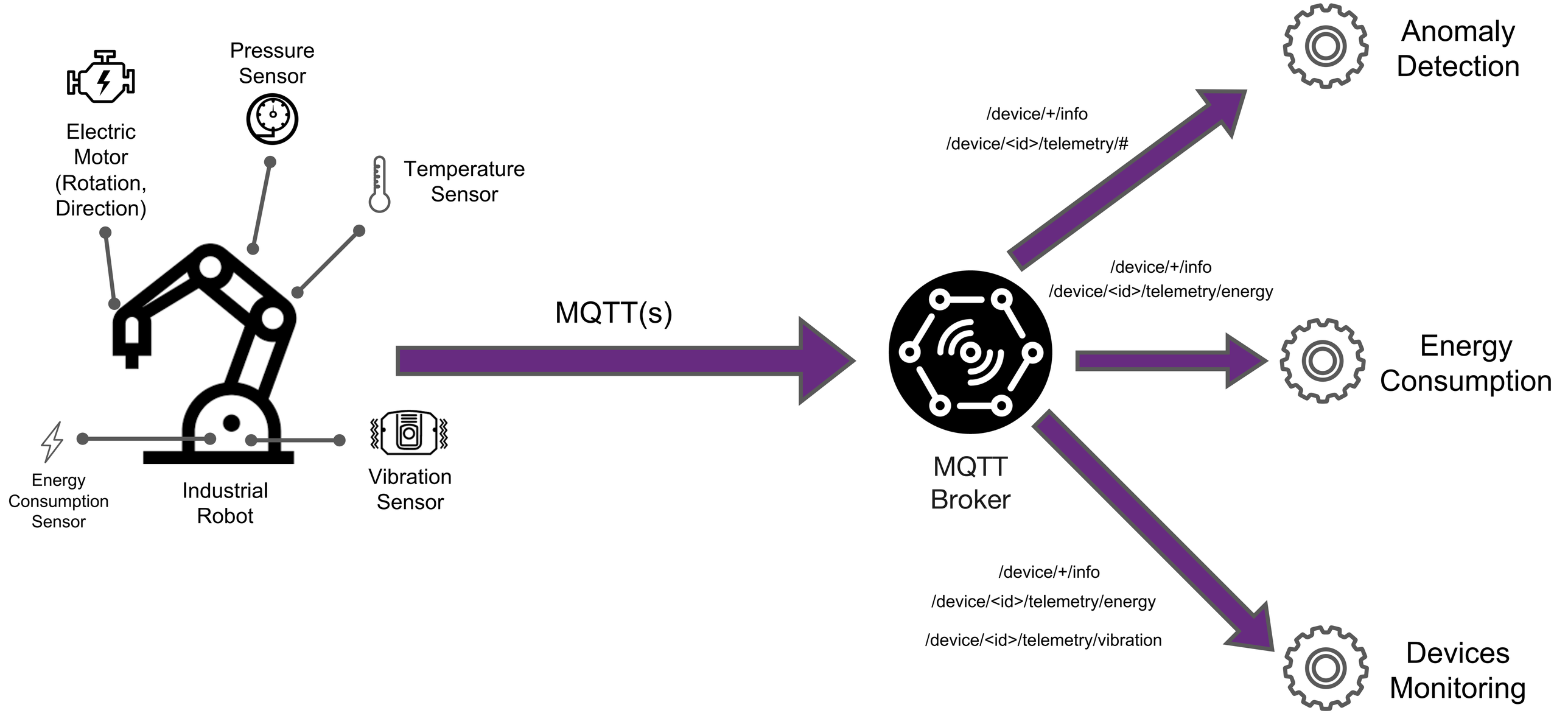
Device Info

Field	Type
id	String
software_version	String
manufacturer	String
manufacturer_device_type	String

Scenario 3 - Industrial Remote Telemetry



Scenario 3 - Industrial Remote Telemetry



Scenario 3 - MQTT Topics & Data

Device Info

Field	Type
id	String
software_version	String
manufacturer	String
manufacturer_device_type	String

→ /device/<id>/info

/device/**deviceTest0001**/info

*retained message

→

```
{
  id: “deviceTest0001”,
software_version: “0.0.1-beta”,
manufacturer: “ACME”,
manufacturer_dt: “acme:robot-a”
}
```

Electric Motor Sensor

Field	Type
speed	Double
speed_unit	String
rotation	Double
rotation_unit	String
timestamp	Long

→ /device/<id>/telemetry/emotor

Pressure Sensor

Field	Type
value	Double
unit	String
timestamp	Long

→ /device/<id>/telemetry/pressure

Vibration Sensor

Field	Type
value	Double
unit	String
timestamp	Long

→ /device/<id>/telemetry/vibration

Temperature Sensor

Field	Type
value	Double
unit	String
timestamp	Long

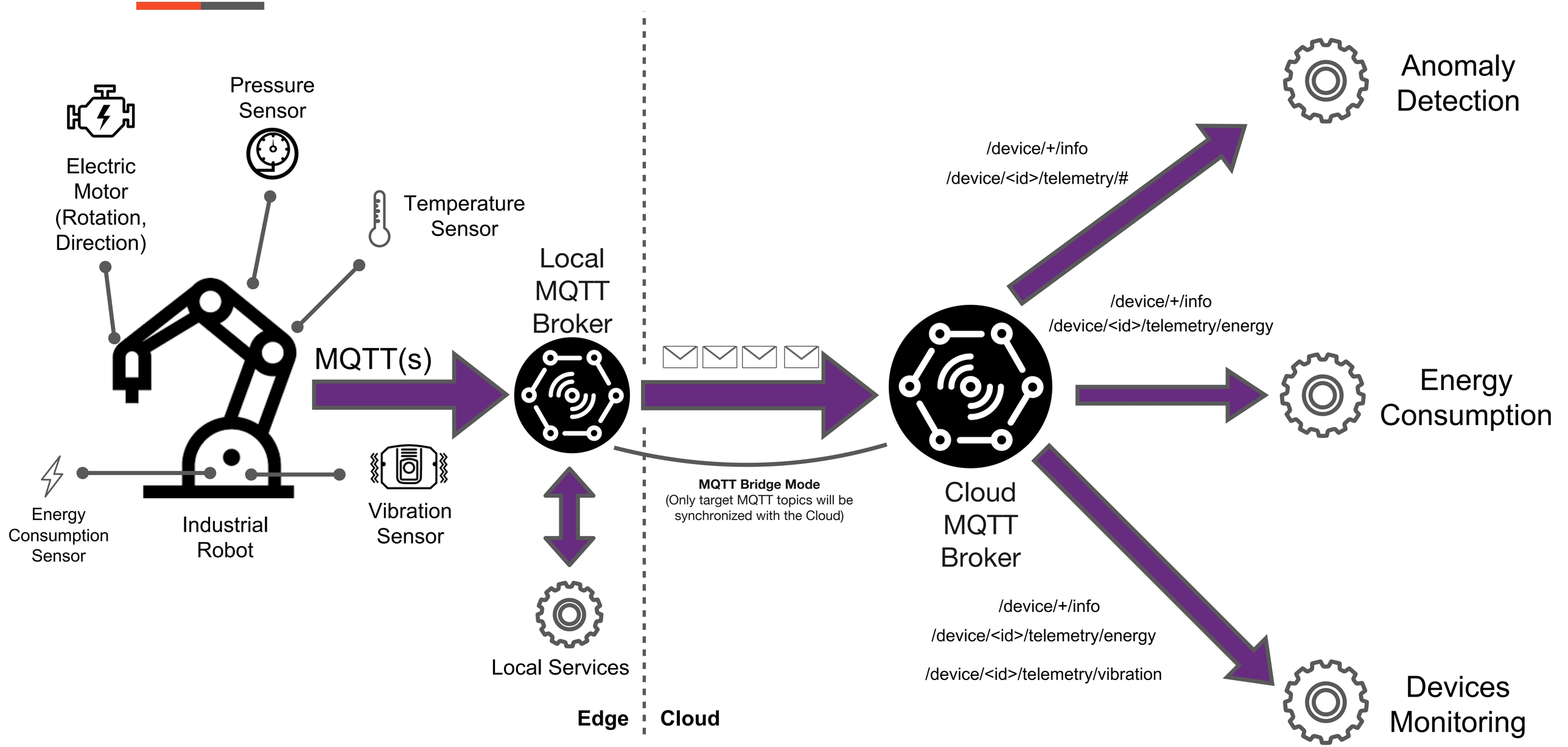
→ /device/<id>/telemetry/temperature

Energy Consumption Sensor

Field	Type
value	Double
unit	String
timestamp	Long

→ /device/<id>/telemetry/energy

Scenario 3 (b) - Industrial Remote & Local Telemetry



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- Scenario 4: Industrial Edge Deployment

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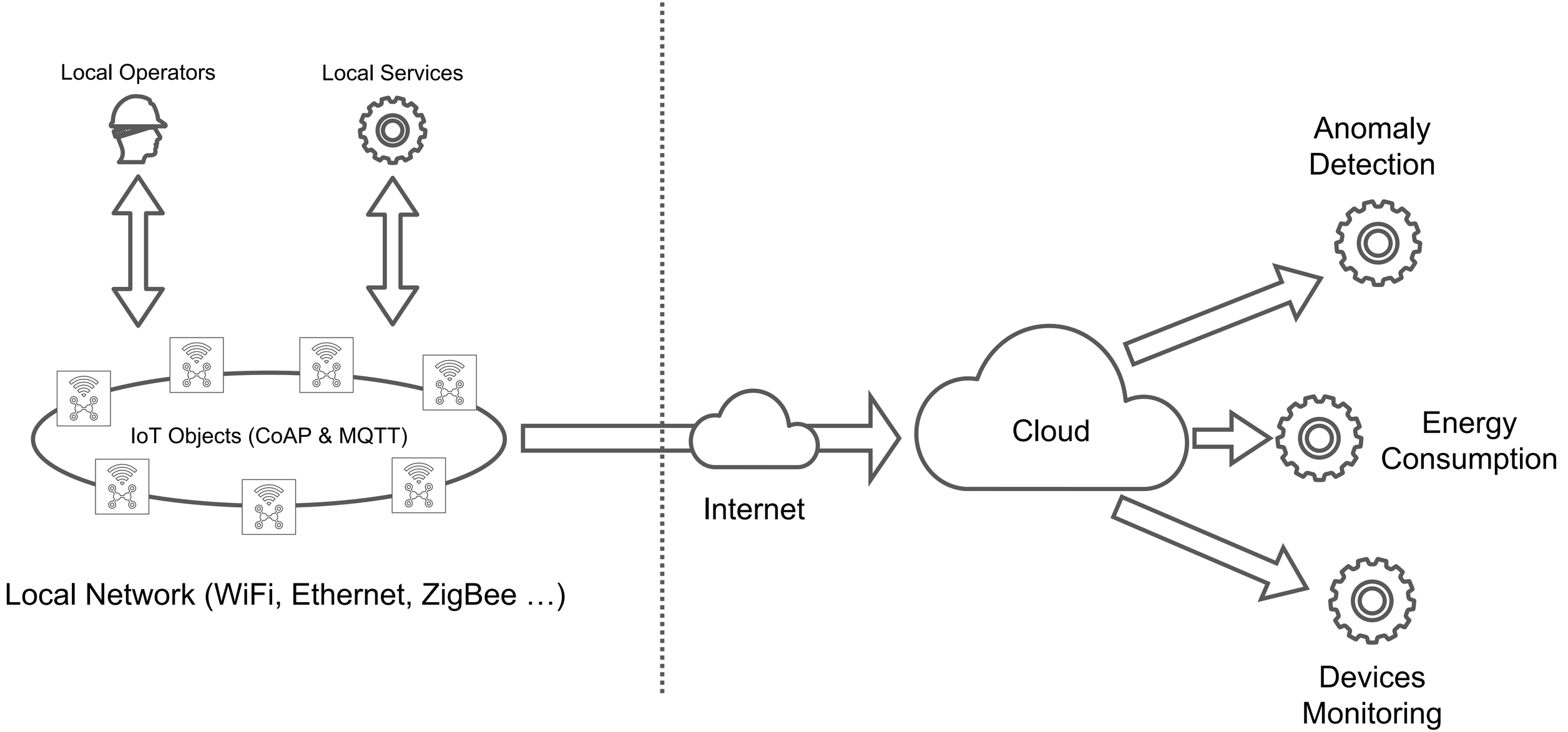
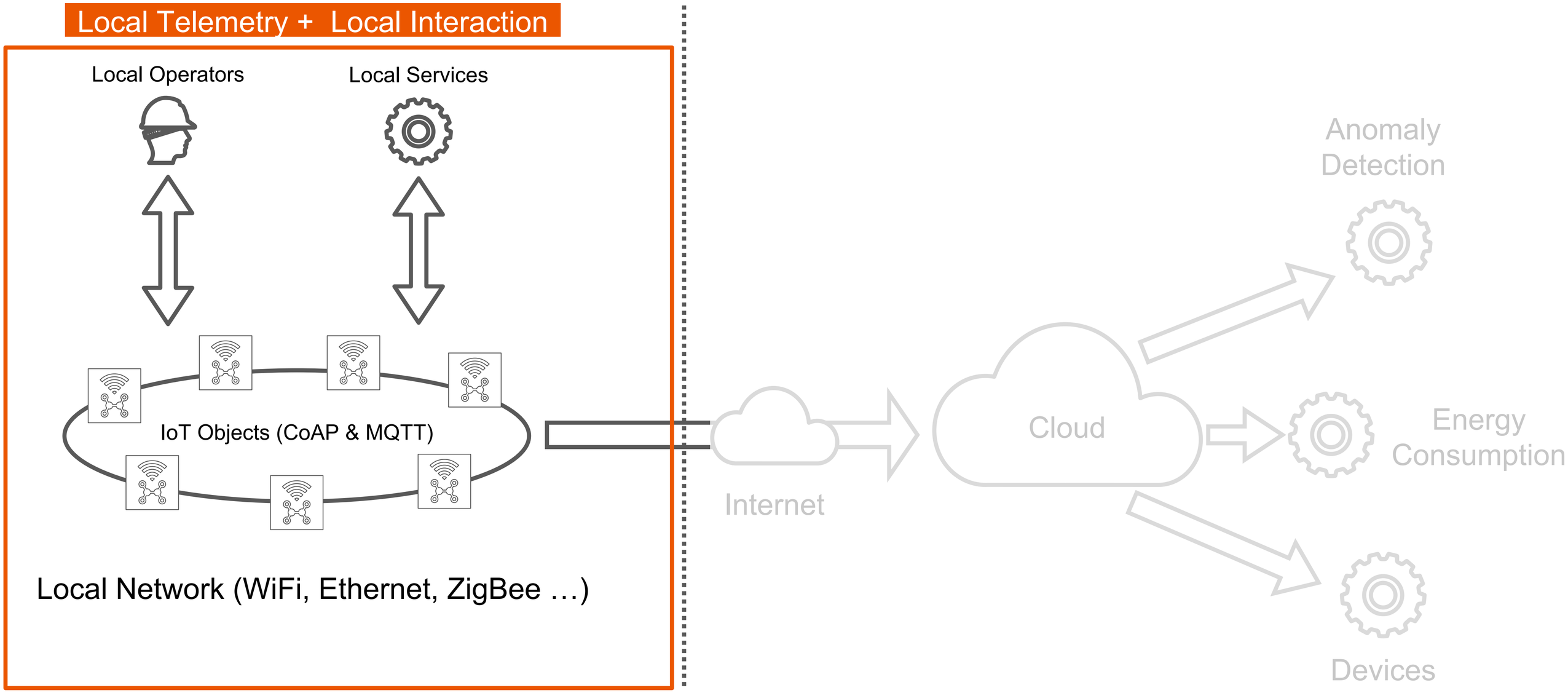
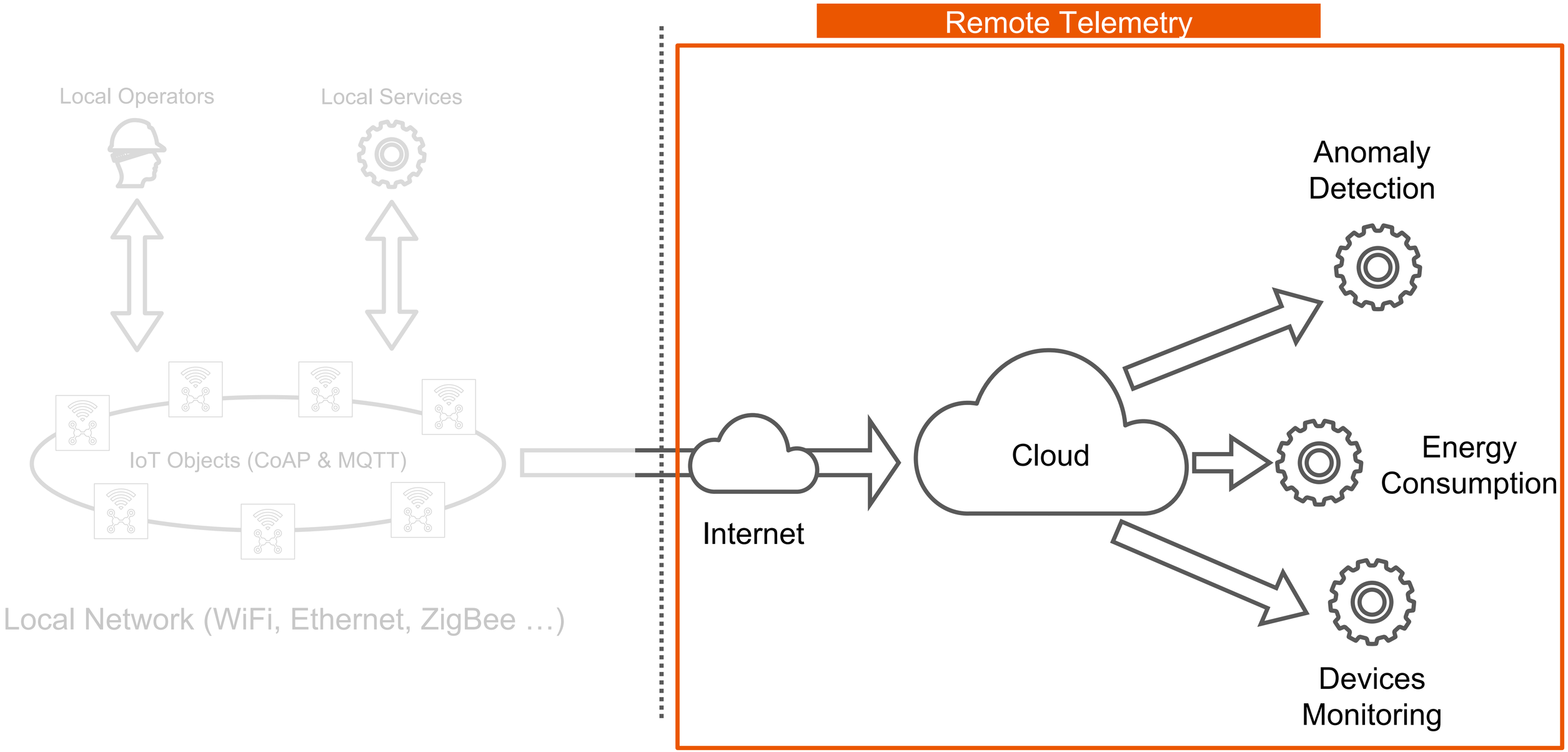
Scenario 4 - Industrial Edge Deployment



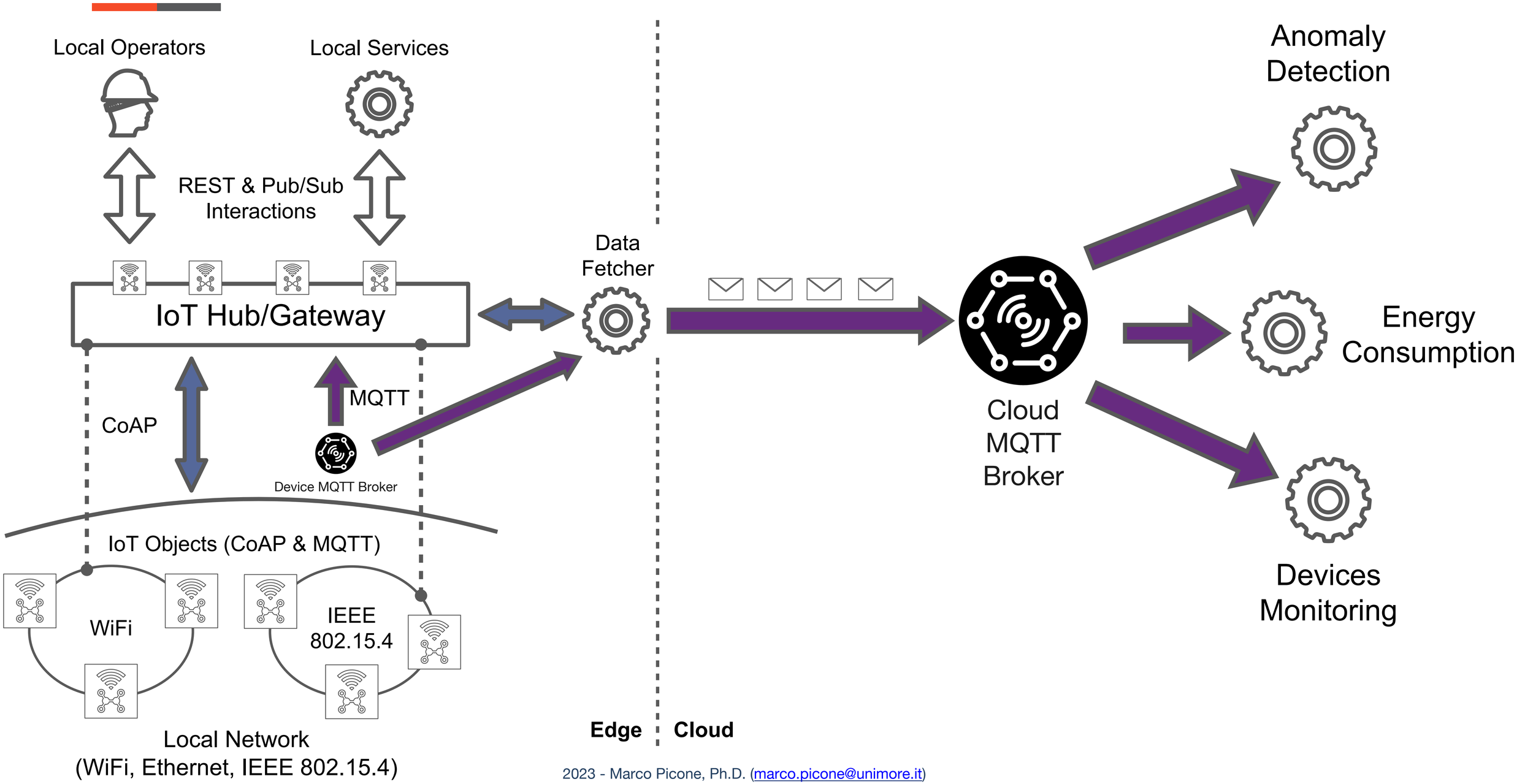
Scenario 4 - Industrial Edge Deployment



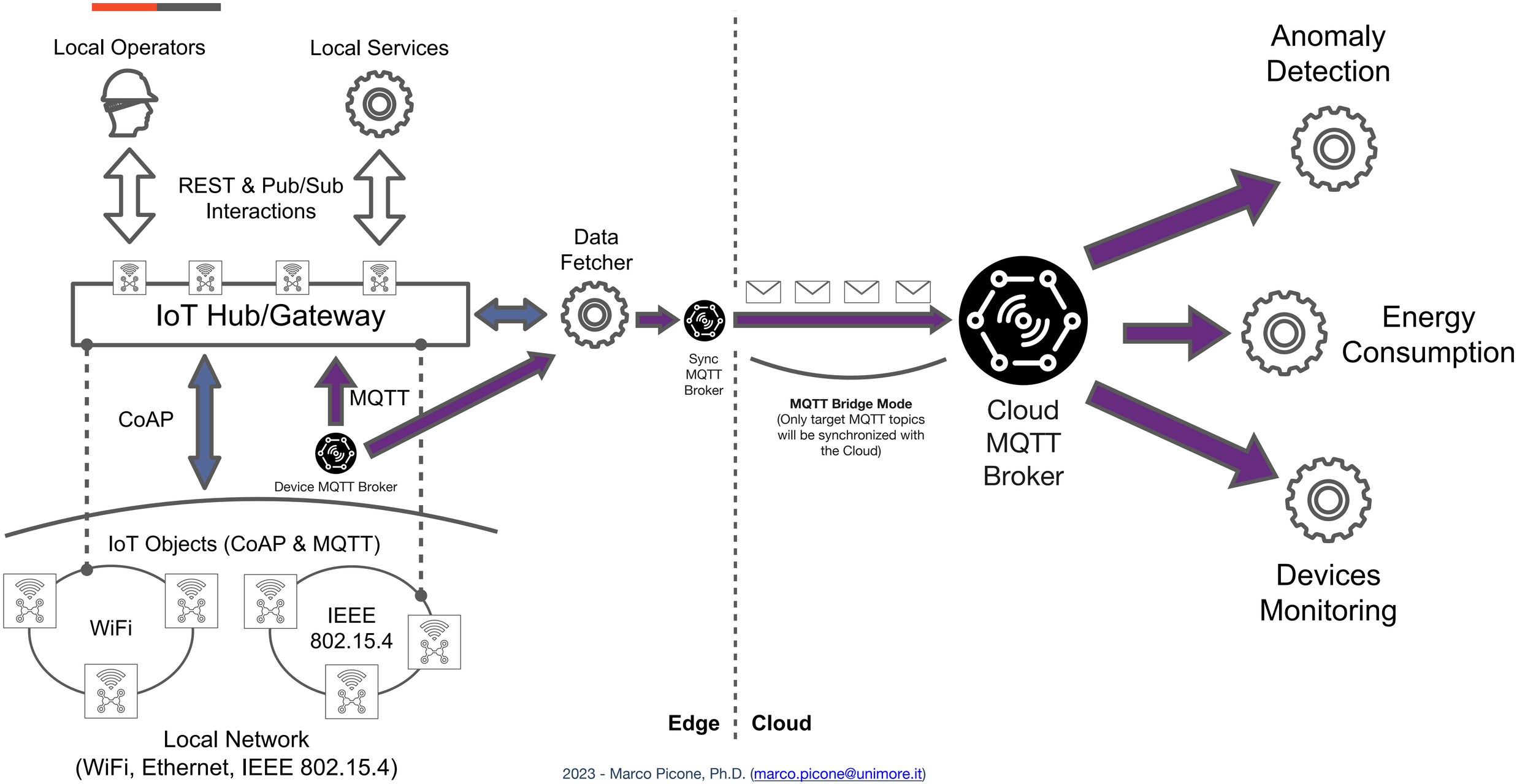
Scenario 4 - Industrial Edge Deployment



Scenario 4 - Industrial Edge Deployment - Case 1



Scenario 4 - Industrial Edge Deployment - Case 1



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IoT Architectures
End to End Design

- Scenario 5: Smart Building

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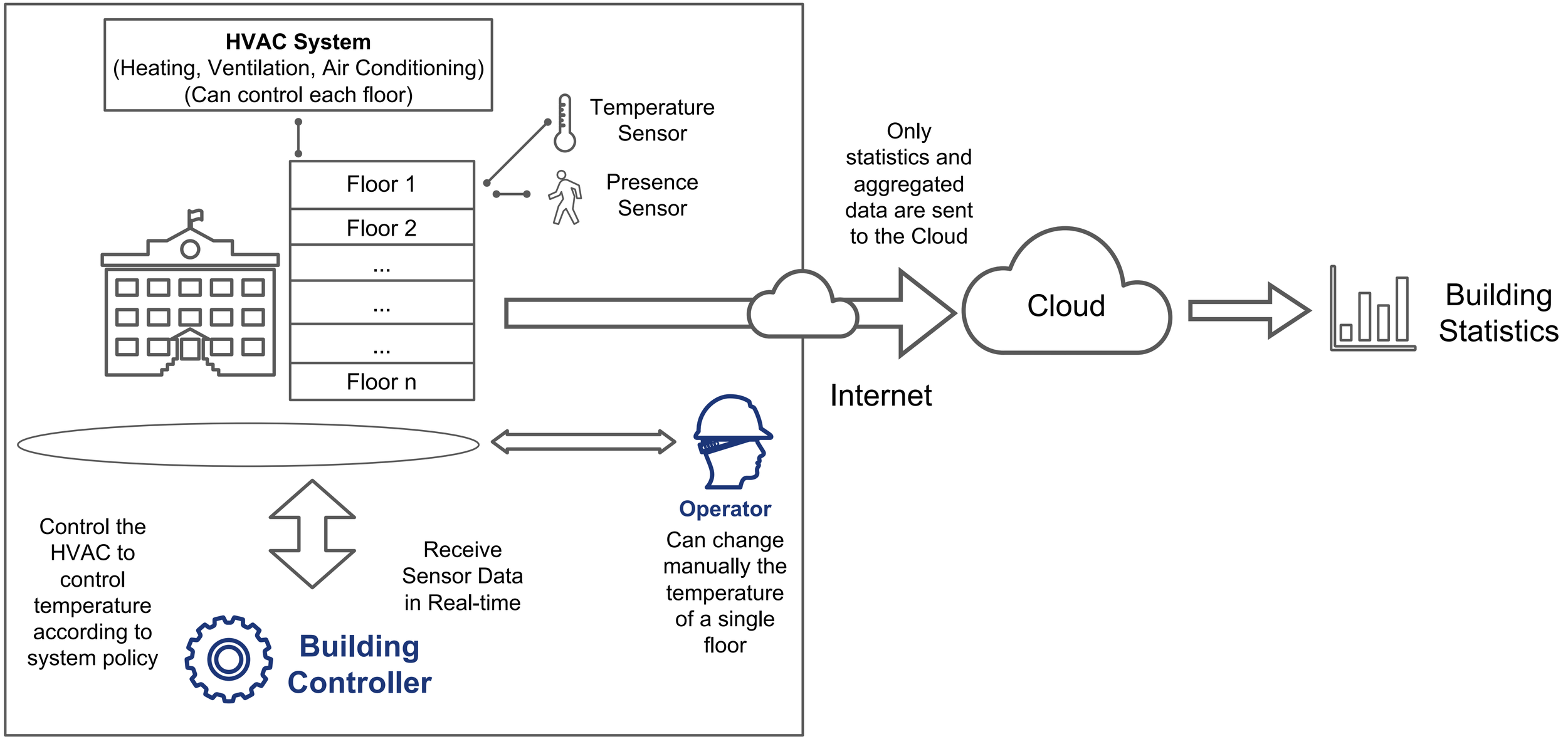
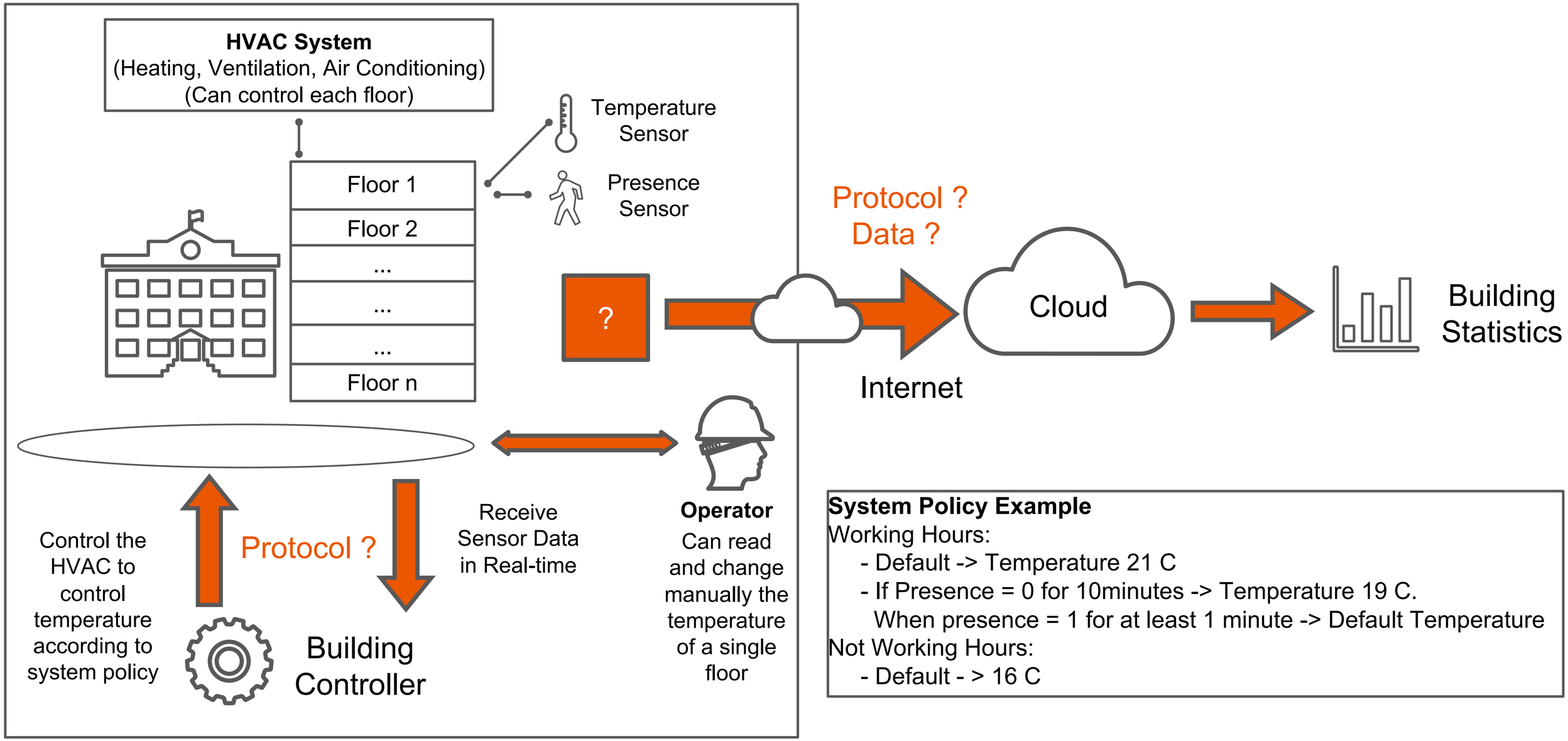
Scenario 5 - Smart Building



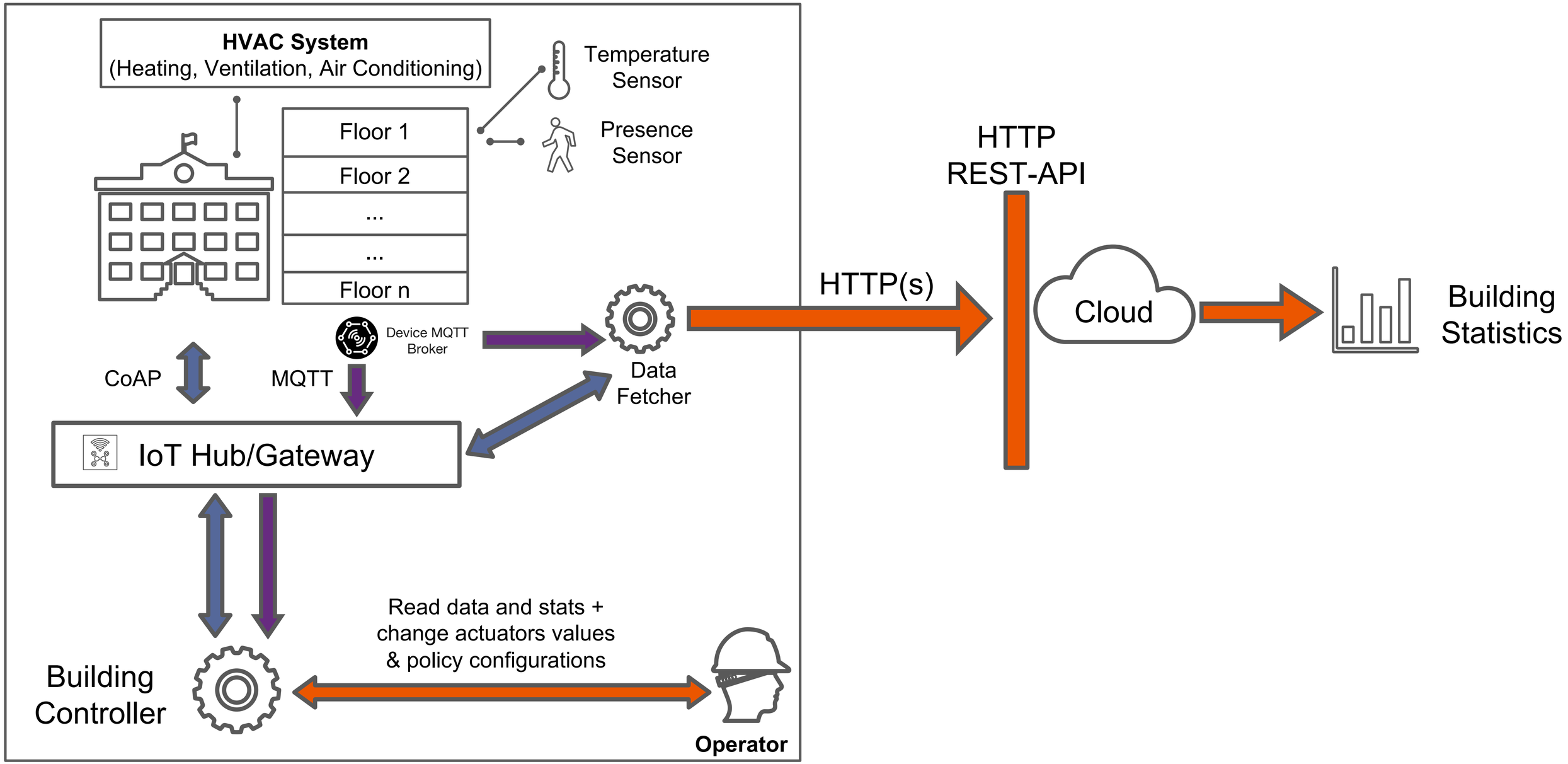
Scenario 5 - Smart Building



System Policy Example
Working Hours:
- Default -> Temperature 21 C
- If Presence = 0 for 10minutes -> Temperature 19 C.
  When presence = 1 for at least 1 minute -> Default Temperature

Not Working Hours:
- Default - > 16 C

Scenario 5 - Smart Building



Scenario 5 - Data Modeling

Indoor Location Info

Field	Type
internal_loc_id	String
location_id	String
floor_id	String
room_id	String

Temperature Sensor

Field	Type
internal_loc_id	String
value	Double
unit	String
timestamp	Long

Presence Sensor

Field	Type
internal_loc_id	String
value	Double
unit	String
timestamp	Long

HVAC System - Indoor Location

Field	Type
device_id	String
internal_loc_id	String
temperature	Double
temperature_unit	String
ventilation_level	Double
working_type	String

Building Policy(s)

Field	Type
policy_id	String
is_enabled	Boolean
active_working_temperature	Double
inactive_working_temperature	Double
working_period_hvac_type	String
inactive_period	Double
inactive_period_unit	String
active_period	Double
active_period_unit	String
notworking_temperature	Double
notworking_period_hvac_type	String

Building Stats

Field	Type
building_id	String
start_timestamp	Long
stop_timestamp	Long
avg_floor_presence	Double
avg_temperature_temperature	Double
tempearture_history_graph	Array[…]
presence_history_graph	Array[…]
policy_history_data	Array[…]

Scenario 5 - Edge HTTP API (Building Controller)

Building Structure

/building/floor
- GET: provide the list of available floors
- POST: create a new building floor

../<id_floor>
- GET: provide the info of the single floor
- PUT: change data of the target floor
- DELETE: delete the floor

../room
- GET: retrieve the list of the floor's rooms
- POST: create a new room

../<room_id>
- GET: load the target room' info
- PUT: change room data
- DELETE: delete room data

/device
- GET: load device (sensor/actuator) data
- POST: create a new device in the room

../<device_id>
- GET: load device data
- PUT: update device data
- DELETE: delete device

Policy & HVAC

/building/policy
- GET: load the list of all available policies
- POST: create a new policy

../<policy_id>
- GET: load the target policy
- PUT: update the policy
- DELETE: delete the policy

/building/hvac
- GET: load info about the HVAC System

../device
- GET: retrieve the list of all HVAC devices

../device_id
- GET: provide the info about target hvac device
- PUT: update device info (this call trigger an interaction with the IoT Hub in order to properly work with the physical device and update the value)

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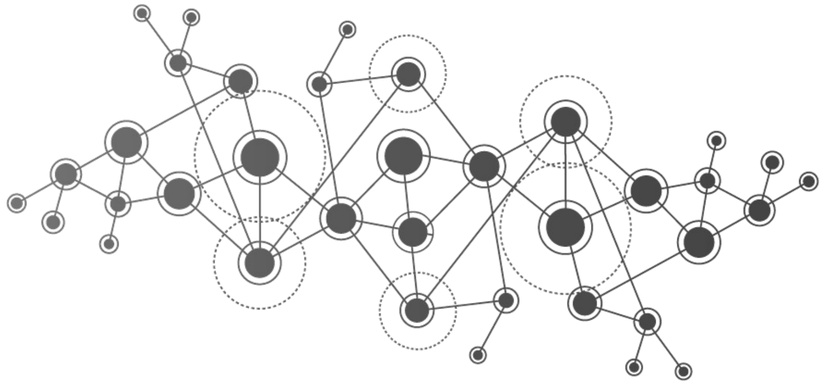

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