Institut Mines-Télécom

GREEN 2016

July 24 – 28, 2016 – Nice France

Tutorial 2

Architectures for IoT Applications in the Energy Domain

Dr. Guillaume HABAULT

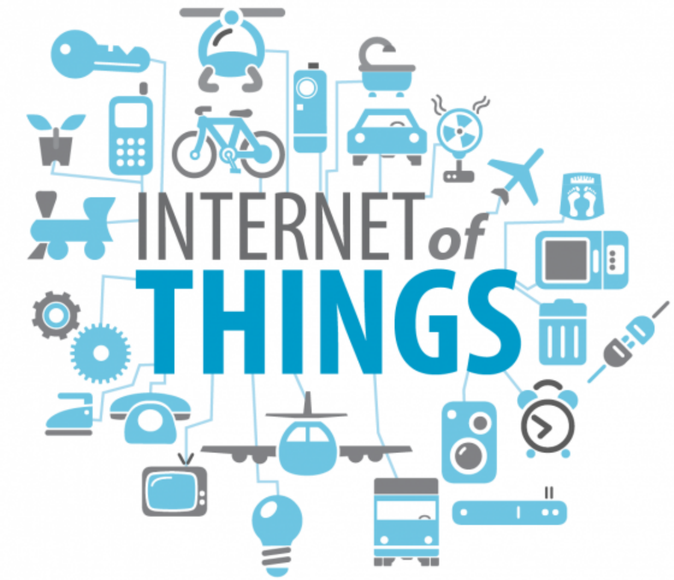
guillaume.habault@telecom-bretagne.eu

24/07/2016

Outline

- **Context**
  - Internet of Things
  - Challenges
  - Energy
  - Issues and challenges
- **Architectures for IoT**
  - oneM2M
  - IoT-A
  - IIC
  - AIOTI
- **Smart Energy Aware Systems (SEAS)**
  - Objectives
  - SEAS Reference Architecture Model (S-RAM)

Context



- Internet of Things
- Energy
- Trends, issues and challenges

Internet of Things – Context (1/4)

- **Smart "objects"**
  - Connecting to Internet
  - Feeding others with collected information

- **Anything can be a "thing"**
  - Uniquely identified
  - Provide empirical data
- **Limitless concept**
  - Domains (health, environment, energy, etc.)
  - Services
  - Lots of potential

Internet of Things – Context (2/4)

- **Monitor different environments**
  - Analyze collected data
  - Manage/control environment

- **Constrained devices**
  - Limited capabilities
  - Required adapted protocols

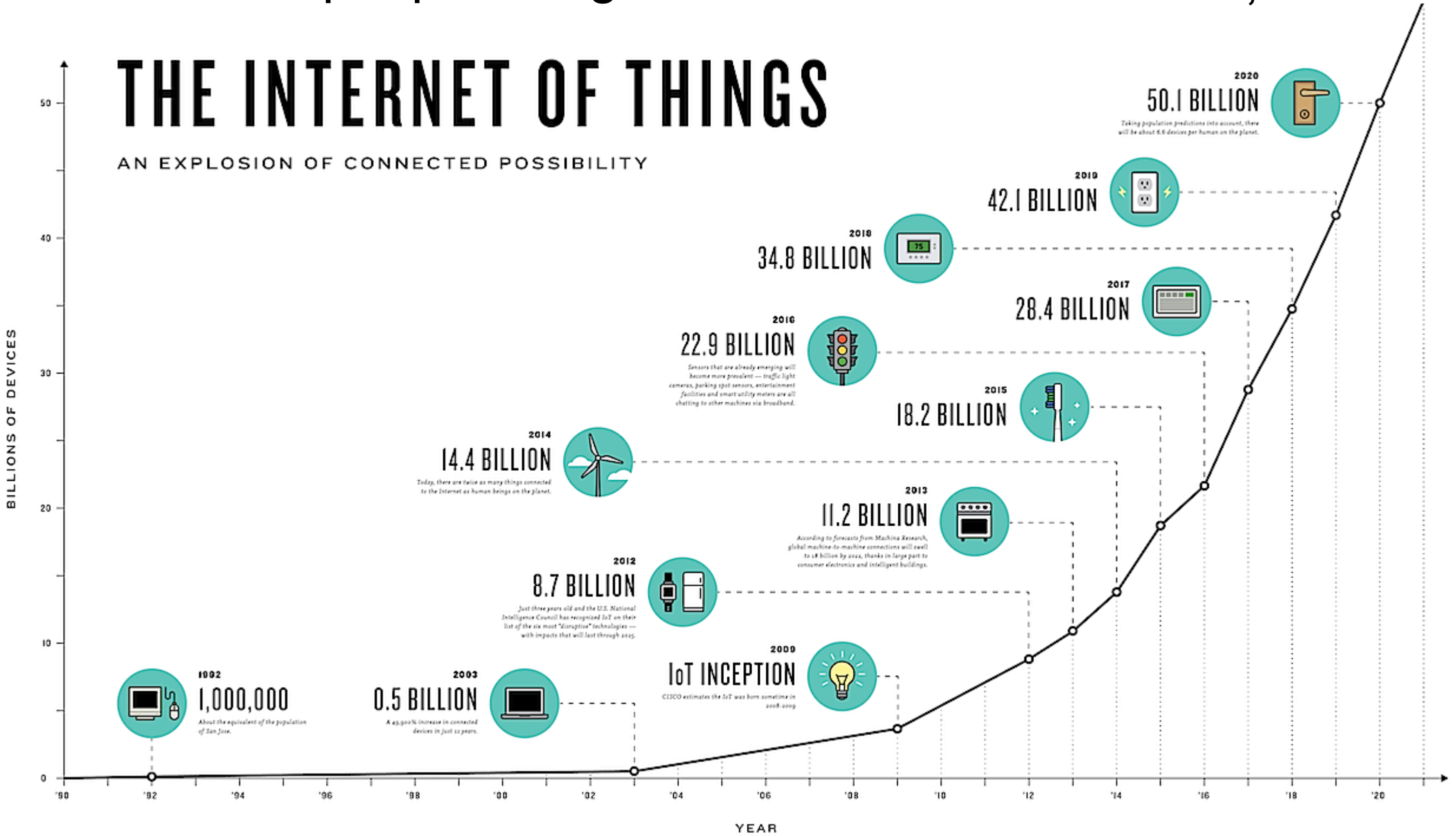
- **Nature of the traffic**
  - Low volume per endpoint
  - Event-driven or Scheduled at regular interval
  - Energy-, resource- and cost-efficient

- **Different from Human communications**
  - High-volume per endpoint
  - Burst-like

⇒ **Internet has not been designed for such traffic**

Internet of Things – Trends (3/4)

- **Cisco's prevision, number of things:**
  - In 2008, > people living on earth
  - In 2020, ~ 50 billion



⟹ **Exponential grows of devices and traffic**

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Internet of Things – Challenges (4/4)

- **Manage such amount of devices**
  - With different capabilities (Access, hardware, etc.)
  - Specific traffic
  - Required specific protocols (IPv6, CoAP, etc.)

- **Architecture**
  - Scalable, adaptable and dynamic
  - Automated
  - Develop new business and services

- **Protect device and information**
  - Access control and storage of data
  - Privacy of data
  - Secure communication

⇒ **Dedicated architecture is required**

Energy – Context (1/3)

- **Different type of energy sources**
  - Each with advantages and drawbacks
    - (un)limited
    - (ir)regular
    - Hazardous for the planet

- **Increasing needs**

- **Difficulty to manage/monitor**
  - Needs vs Production vs Actual consumption
  - Over-production penalty
  - Understand consuming behavior

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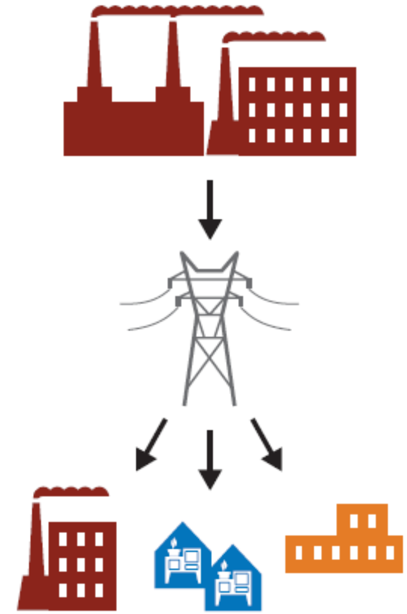
Energy – Context (2/3)

- **Energy network**
  - Centered on big production sites
  - With widespread distribution network
  - And consumer at endpoints



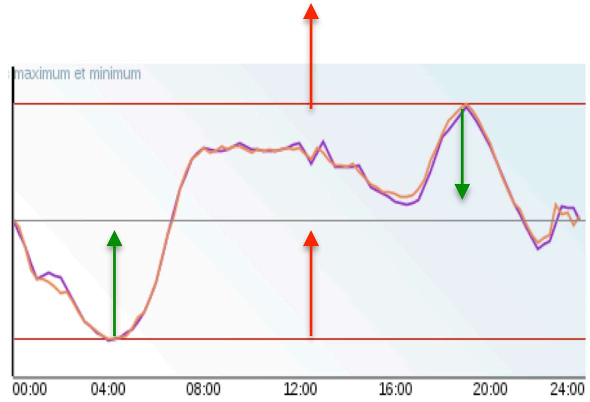
- **Desire to**
  - Protect the planet with
    - Better sources
    - Better consumption
  - Decrease pollution
  - Lower waste and losses

⇒ **IoT might help achieve these objectives**

Energy – Electricity (3/3)

- **Growing usage of local renewable production**
  - ⇒ Producer and consumer : “Prosumer”
  - Less reliable
  - Higher demand
  - From rigid to distributed network

- **Timely issue**
  - Growing number of devices
  - Increasing number of Electric Vehicles
  - ⇒ Effect on peak time consumption
  - Need for better management systems



- **Optimize consumption**
  - Influence “prosumer”
    - Via demands (shift or use of alternatives)
    - With tools to better use renewable energies
  - At different scale

IoT and Energy – Challenges (1/4)

- **IoT can help monitor, manage, optimize and coordinate both production and consumption**

- **With proper management,**
  - Local production and consumption can be balanced
  - Both local and global production can be optimized and coordinated
  - Local behavior can support the main grid when required (e.g. peak time)
  - Etc.

- **Create new businesses**
  - Flexibity (e.g. negawatts)

IoT and Energy – Challenges (2/4)

- **Need for an architecture to interconnect energy actors and better manage energy use**

- **Properly balancing energy network**
  - Real-time and predictive measurement
  - Control capabilities on large distributed volume
  - Involve end-user

- **Control load possible for decades but is not widely enough adopted to cope with current challenges**

- **Required to**
  - Find each party
  - Access a resource
  - Learn details from different endpoints
  - Implement technical compatibility to each endpoints
  - Compensate for access and compliance to commitments

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IoT and Energy – Requirements (4/4)

- **Need for an architecture**
  - Scalable
  - Dynamic
  - Automated
  - Secure

- **Include prosumer in the architecture and management**

- **Enable different levels of management**
  - Local
  - Global (when possible)
  - Etc.

- **Different architectures/platforms/systems exist to**
  - Interconnect different nodes and systems
  - Manage energy Demand and Response
  - Collect and analyze data

Architecture for Internet of Things

- State-of-the-Art
  - oneM2M - FA
  - IoT-A - ARM
  - IIC - IIRA
  - AIOTI - HLA
- Which one for the Energy domain?

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Functional Architecture (1/4)

- **oneM2M**
  - 8 ICT standards bodies
  - 6 Standard Development Organizations
- **Observation:**
  Several M2M standardization effort
  - ETSI M2M
  - OMA DM
  - Lightweight M2M
- **Consequences**
  - Scattered effort
  - No common solution

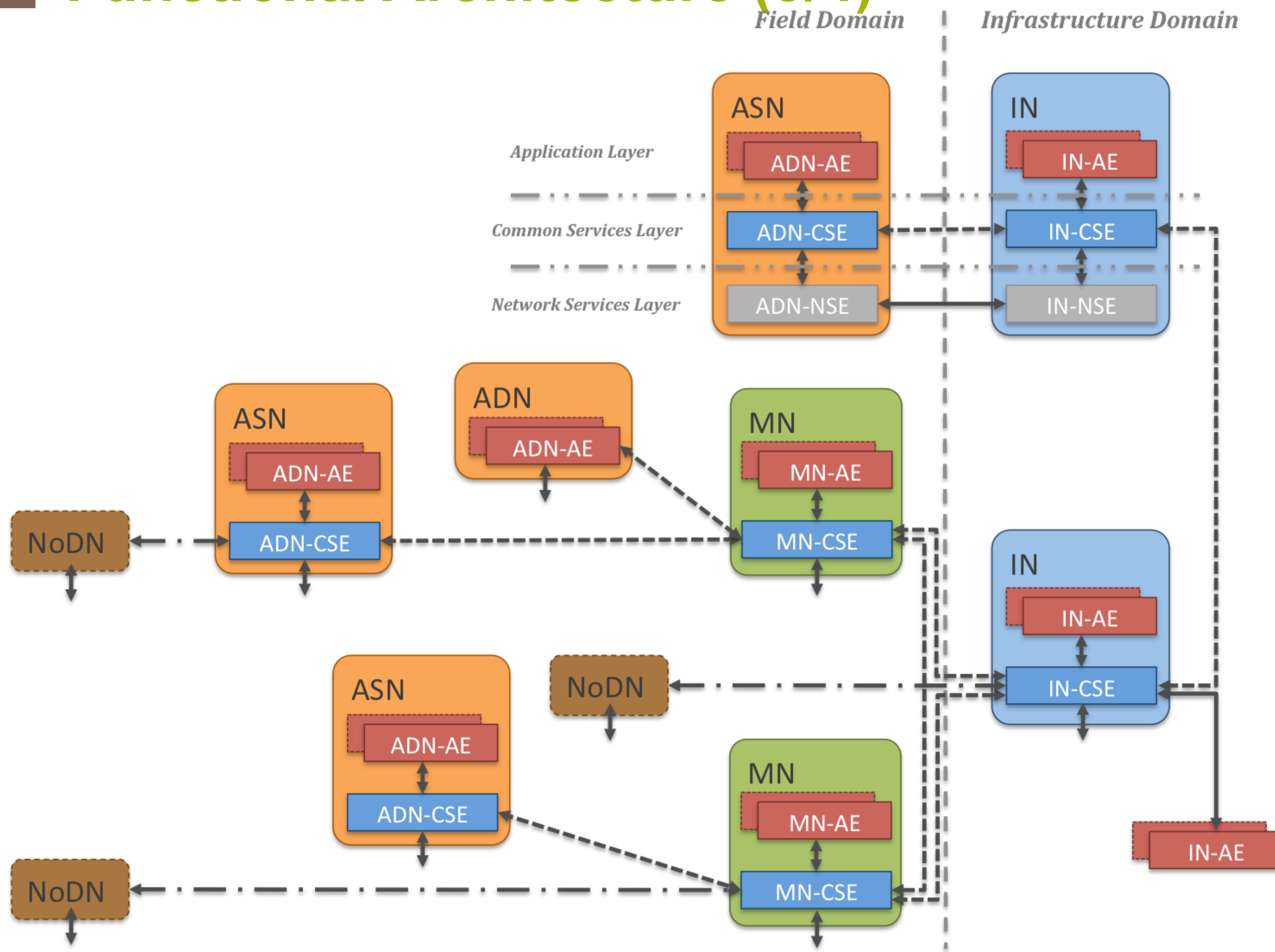
Functional Architecture (2/4)

- **Proposition: oneM2M Functional Architecture**

- **Motivations**
  - Prevent duplication of standardization effort
  - Need for a common M2M Service Layer
  - Connect the myriad of field devices with all M2M applications

- **Objectives**
  - Ensure most efficient deployment of M2M communications systems
  - Develop technical specifications

Functional Architecture (3/4)



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Functional Architecture (4/4)

- **Results**
  - Full technical M2M architecture
  - Interconnection with bank systems

- **No information regarding**
  - Automation using semantics and ontology (yet)
  - Different management levels

- **Drawbacks**
  - Focus on M2M
  - Few involvement of end user

Architecture Reference Model (1/4)

- **Internet of Things – Architecture (IoT-A)**
  - European FP7 Research Project
- **Observation: Current “smart” solutions**
  - Used specific application and architecture
  - Left little place for interoperation
- **Consequences**
  - IoT landscape fragmented
  - Not fully using IoT potential
    - i.e. crossing information from different domains

Architecture Reference Model (2/4)

- **Proposition: Architecture Reference Model**

- **Motivations**
  - Develop guidelines to build compliant IoT solutions
    - Common understanding of IoT
    - Common foundation (interoperable system)
    - Standardized interfaces
    - Providing best practices

- **Objectives**
  - Provide a common Reference model for IoT Domain
  - Help develop all IoT-related solutions

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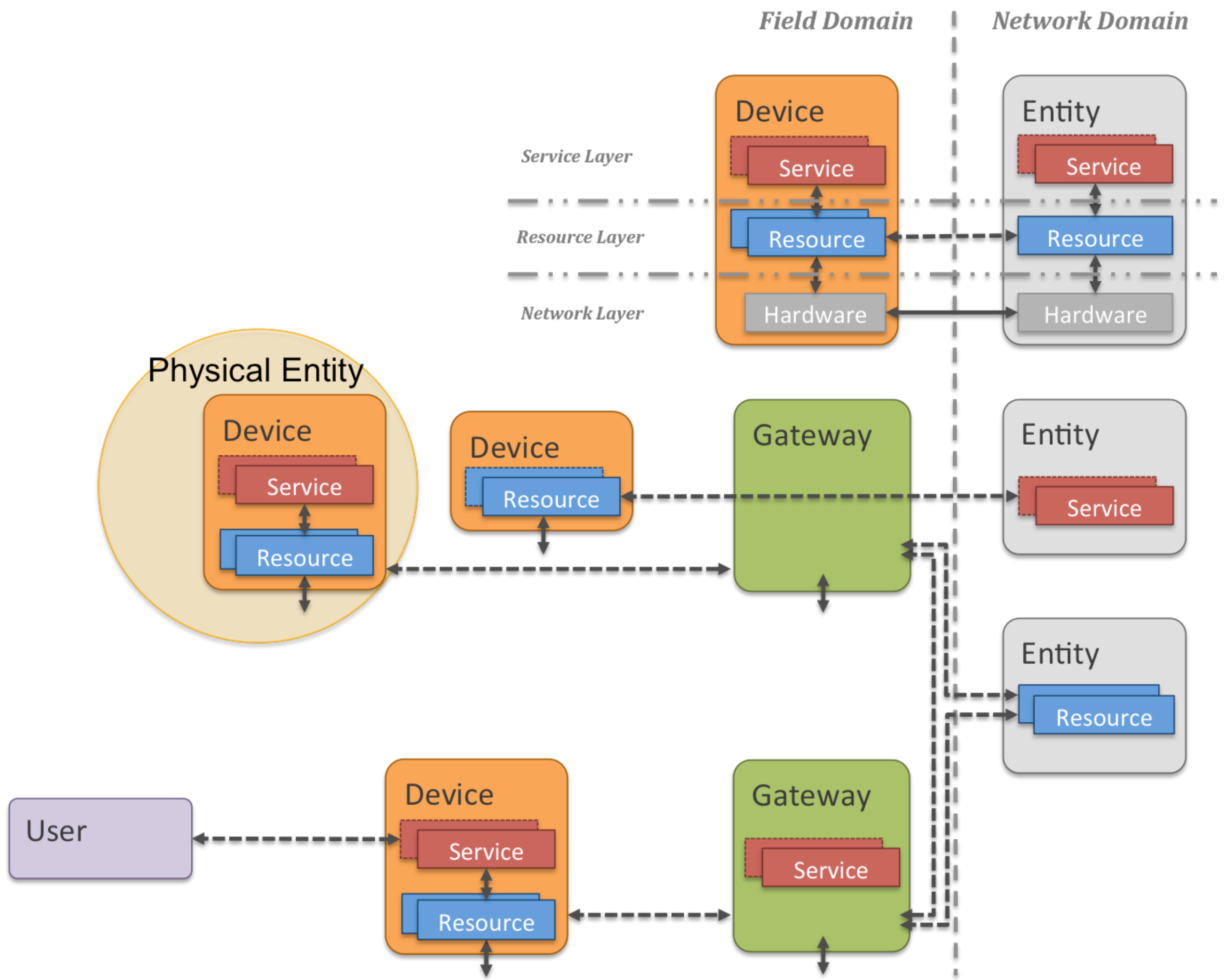
Architecture Reference Model (3/4)



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Architecture Reference Model (4/4)

Results

- Abstract model to fit to any domain
- Semantic description of each entity
- Several interoperable IoT solutions based on common grounds

No information regarding

- Automation using semantics and ontology
- Any implementation and performance result
- Interconnection with other systems (e.g. bank)

Industrial Internet Reference Architecture (1/4)

- **Industrial Internet Consortium**
  - Composed of several Industry players
  - Aims to promote and accelerate development of industrial internet technologies
- **Observation: Lots of industrial control systems**
- **Consequences**
  - Industrial IoT landscape fragmented
  - Not fully using power of IoT
    - i.e. crossing information from different domains, especially non industrial one

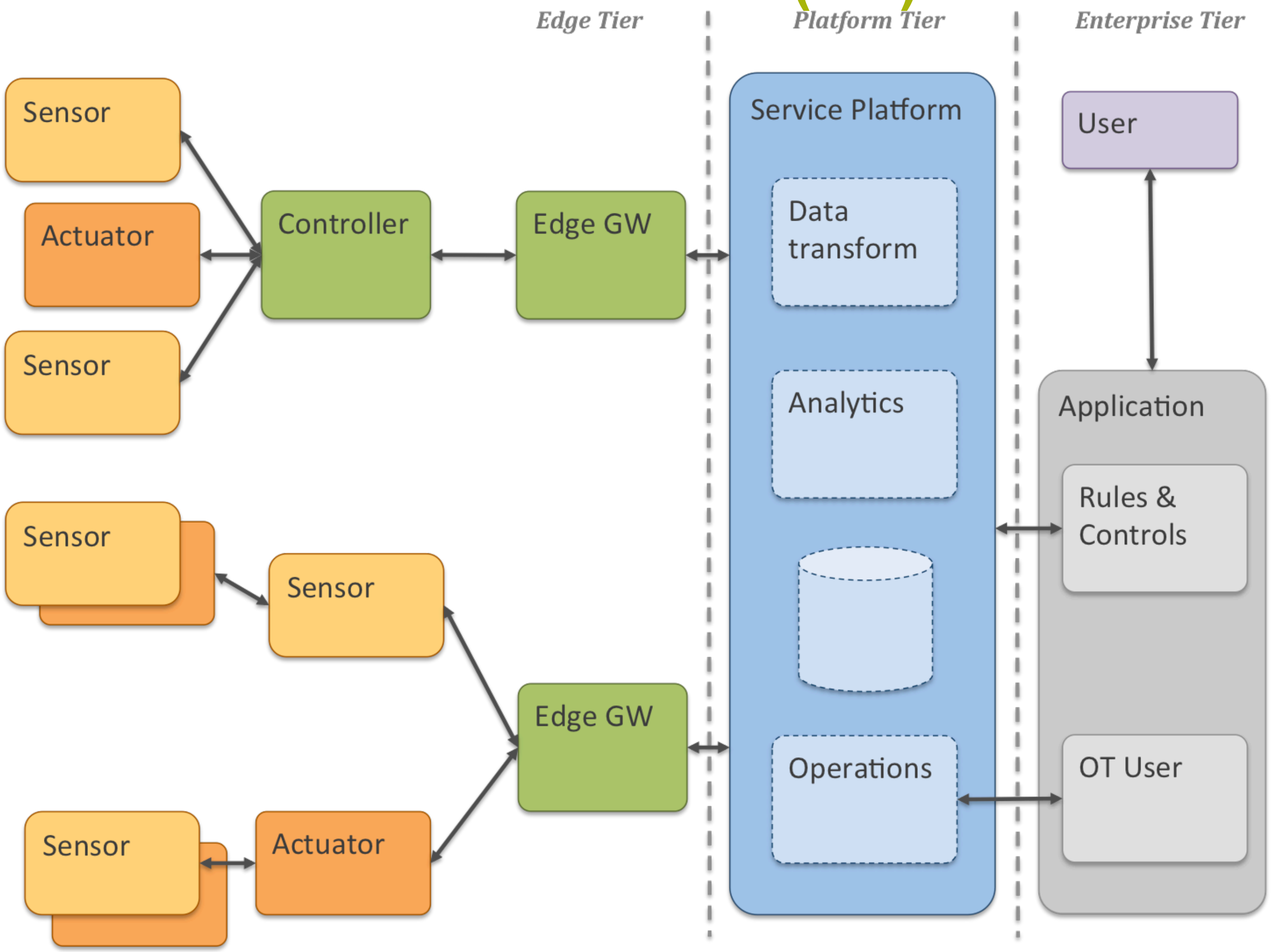
Industrial Internet Reference Architecture (2/4)

- **Proposition: Industrial Internet Reference Architecture**

- **Motivations**
  - Connect industrial systems with people
  - Fully integrate them with enterprise systems, business processes and analytics solutions
  - Increase optimization, operation and collaboration among different autonomous control systems

- **Objectives**
  - Bring these systems online
  - Combine them with organizational or public information
  - Form large end-to-end systems
  - Provide guidelines for
    - Standard-based, open and horizontal architecture frameworks
    - Implementing reference architectures with interoperable and interchangeable blocks

Industrial Internet Reference Architecture (3/4)



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Industrial Internet Reference Architecture (4/4)

Results

- High level of abstraction to support any industrial domain requirement
- Hierarchical node management
- On going testbeds

No information regarding

- Automation using semantics and ontology

Questioning

- Centralized solutions ?
- Application to non industrial scenario (e.g. energy) ?

High Level Architecture (1/3)

AIOTI

- **Alliance for Internet of Things Innovation**
  - Initiated by the European commission
  - Creation of a dynamic European IoT ecosystem to unleash the potential of the IoT
- **Observations:**
  - No common European IoT market
  - Current systems mainly focused on sensors
- **Consequences**
  - IoT landscape fragmented
  - Not fully using power of IoT, especially at large scale
    - i.e. crossing information from different domains

High Level Architecture (2/3)

AIOTI

- **Proposition: AIOTI High Level Architecture**

- **Motivations**
  - Need to foster interoperability
  - Link architecture with semantic interoperability
  - Use ISO/IEC/IEEE 42010 to provide minimal requirements

- **Objectives**
  - A single market for IoT
  - A thriving IoT ecosystem
  - A humand-centered IoT approach
  - Interconnection with non-IoT systems

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High Level Architecture (3/3)

- **Results**
  - Minimal model based on semantic
  - Three management levels (device, gateway and infrastructure)
  - Domain model derived from IoT-A
  - Functional model compatible with oneM2M and IIC architectures
- **No information regarding**
  - Interconnection with other systems
- **New alliance only few documents available**

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Which one to choose ?

- **Energy domain requires**
  - Involvement of prosumer
  - Interconnections with others systems (e.g. bank)
  - An architecture adaptable and scalable
  - Different levels of management, decision and optimization
  - Coordination between each level
  - Automation
  - Mobility management

- **None satisfy all these requirements**

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Smart Energy Aware Systems

- What ?
- Why ?
- Proposed solution

Smart Energy Aware Systems

SEAS
Smart Energy Aware Systems

- **European Project**

Itron, BAŞKENT, VTT, Fortum, EMPOWER, innova, CNR, EKE, ASEMA, engie

- **Goal**
  - Enable better energy resource management (both production and consumption)

- **Provides the means to do it**
  - Universal language enabling automatic communications
  - Innovative architecture enabling scalable, efficient, dynamic and real-time management

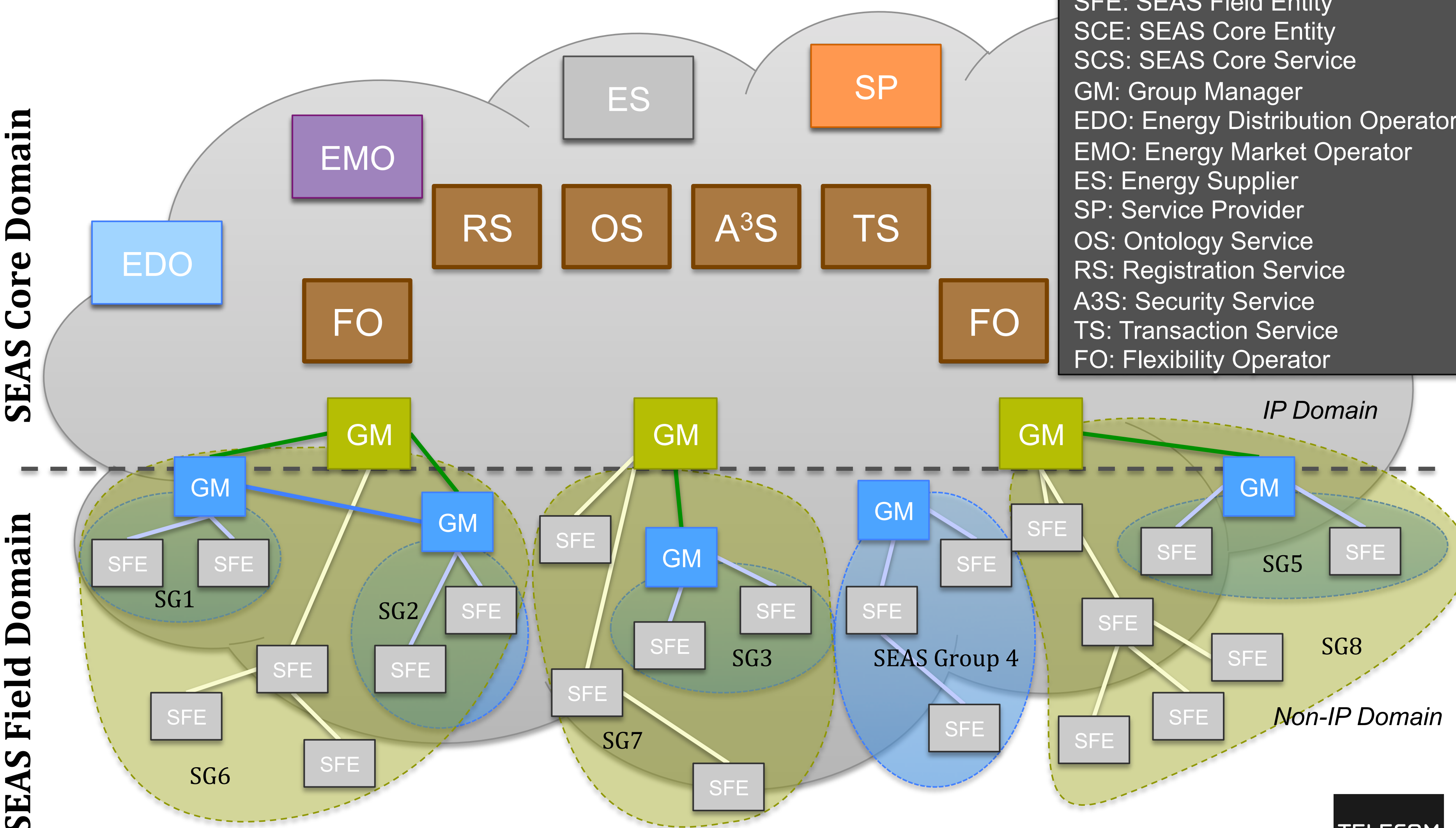
Enhanced architecture

- **Define an architecture**
  - Compatible with IoT architecture model
  - Suitable for energy domain and especially electrical network
  - Nodes may
    - Move without breaking the architecture
    - Evolve with hardware enhancement

- **Hybrid Architecture**
  - Interconnect all energy players
  - Structured peer-to-peer and client/server models
  - Efficiently search for a given resource/information
  - Optimizing entities interactions/requests
  - Facilitating data analysis

- **Requirements**
  - Common information model
  - Transaction capabilities
  - Data transmission
  - Field deployment
    - Self configuration
    - Supports discovery
    - Management capabilities
  - Security
    - Identity enable
    - Multiple trust levels
    - Multiple level of authorization

SEAS Reference Architecture Model (S-RAM)



- SFE: SEAS Field Entity
- SCE: SEAS Core Entity
- SCS: SEAS Core Service
- GM: Group Manager
- EDO: Energy Distribution Operator
- EMO: Energy Market Operator
- ES: Energy Supplier
- SP: Service Provider
- OS: Ontology Service
- RS: Registration Service
- A3S: Security Service
- TS: Transaction Service
- FO: Flexibility Operator

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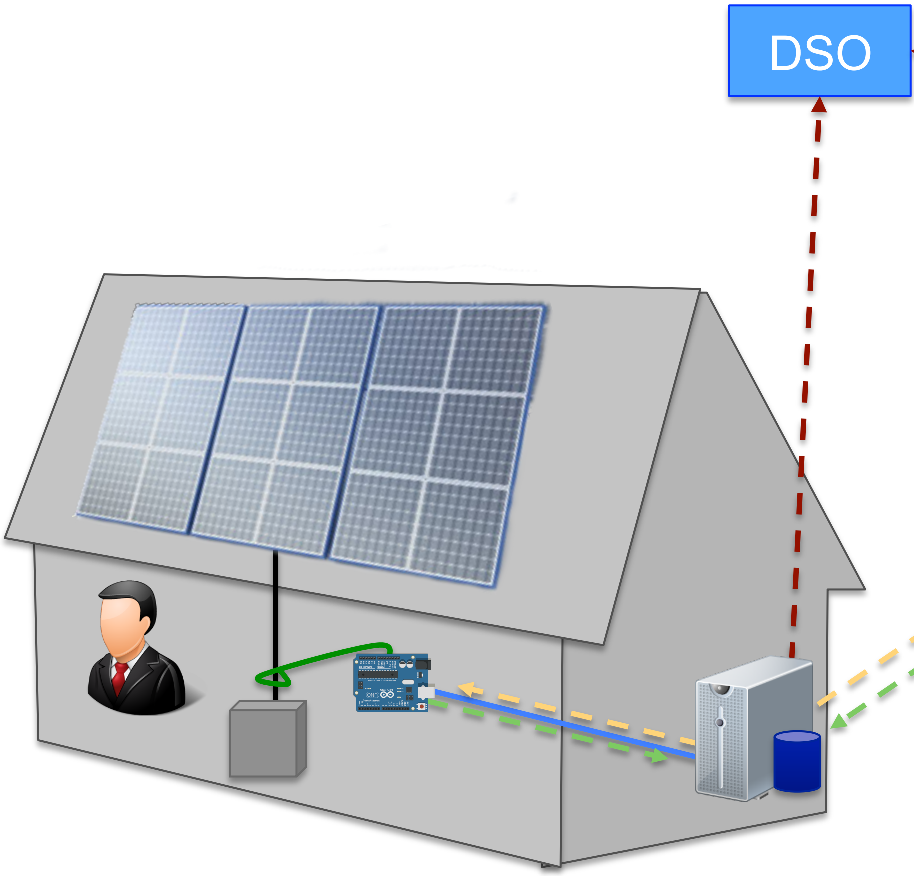
Estimation of Photovoltaic Panel Production



- **Simple scenario**
- **Measure production:**
  - Several possibilities
  - Fairly simple

  => EU visualizes its production

- **Estimate future production ?**
  - Inform the grid

  => Better knowledge of load shedding capabilities

  => Send demands accordingly

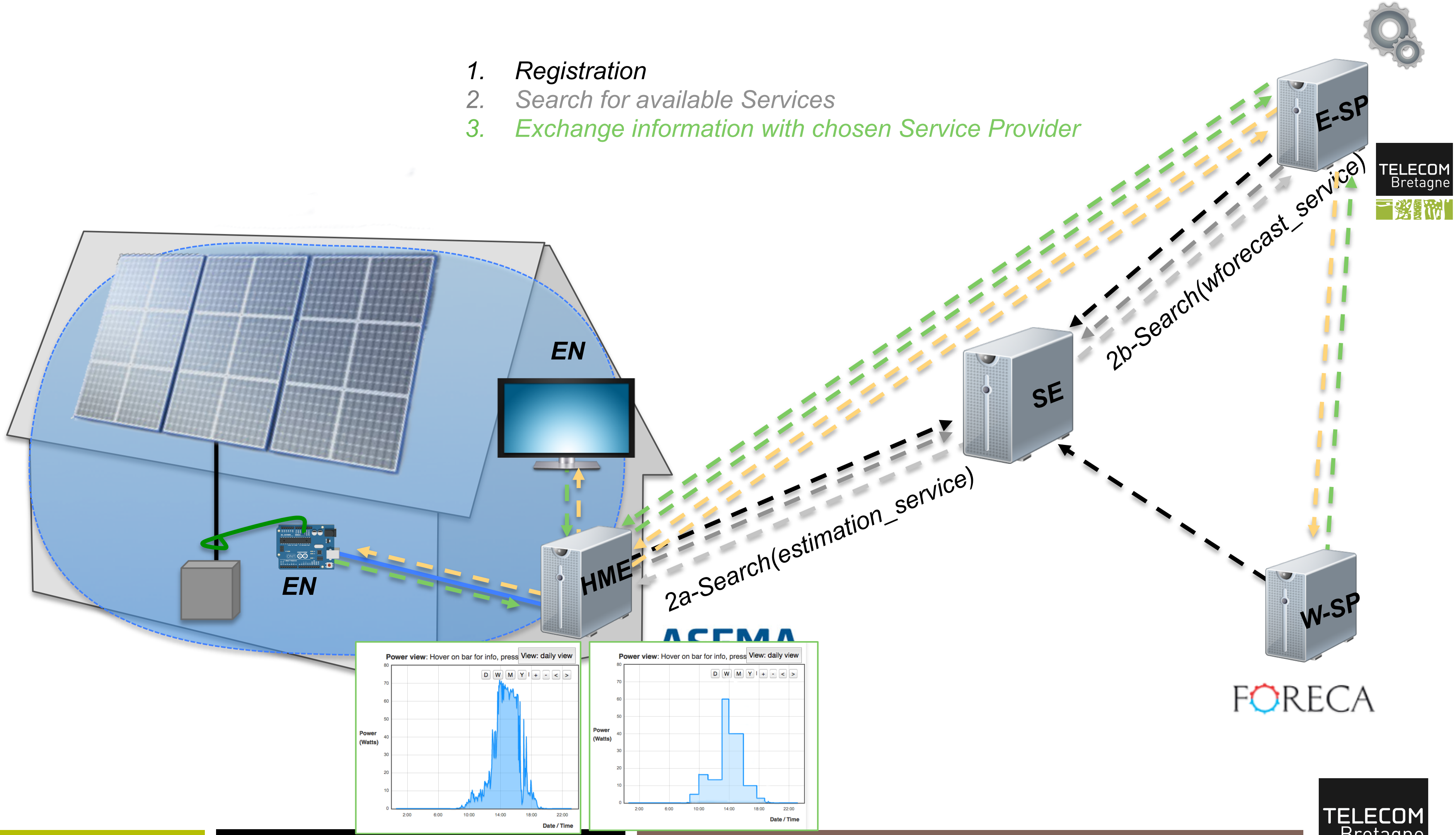
  - Inform the EU

  => Better consumption planning

- **How to realize it?**

S-RAM Proof-of-Concept

1. *Registration*
2. *Search for available Services*
3. *Exchange information with chosen Service Provider*



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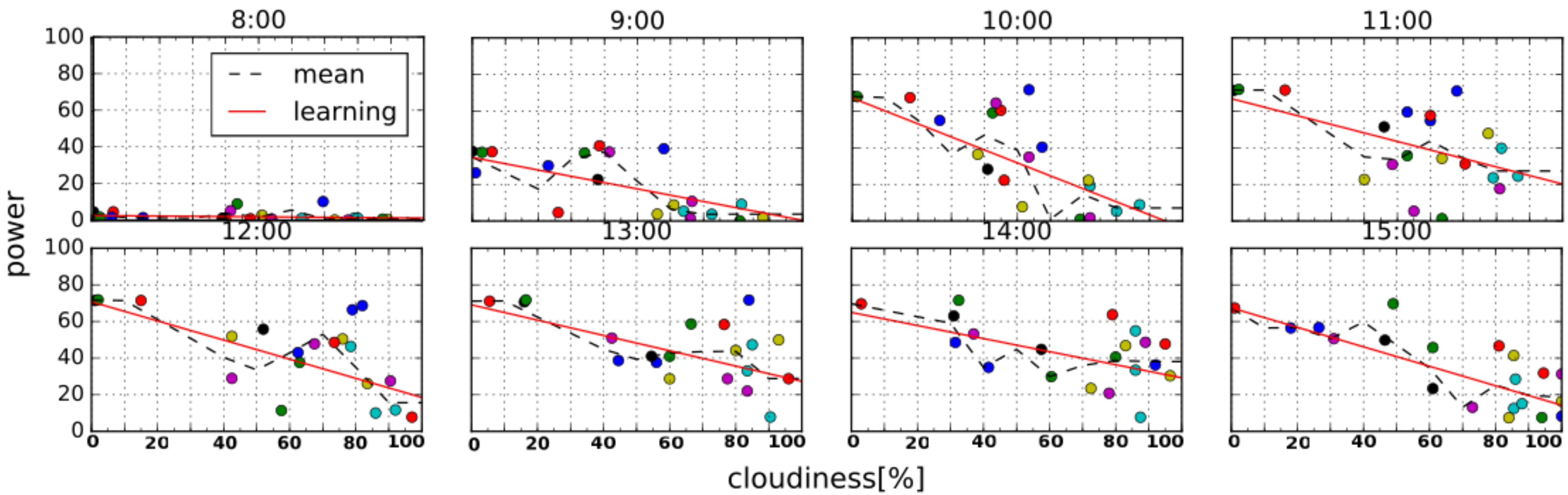
S-RAM PoC

- **Learning based on previous**
  - Production measurements
  - Cloudiness percentage forecasts



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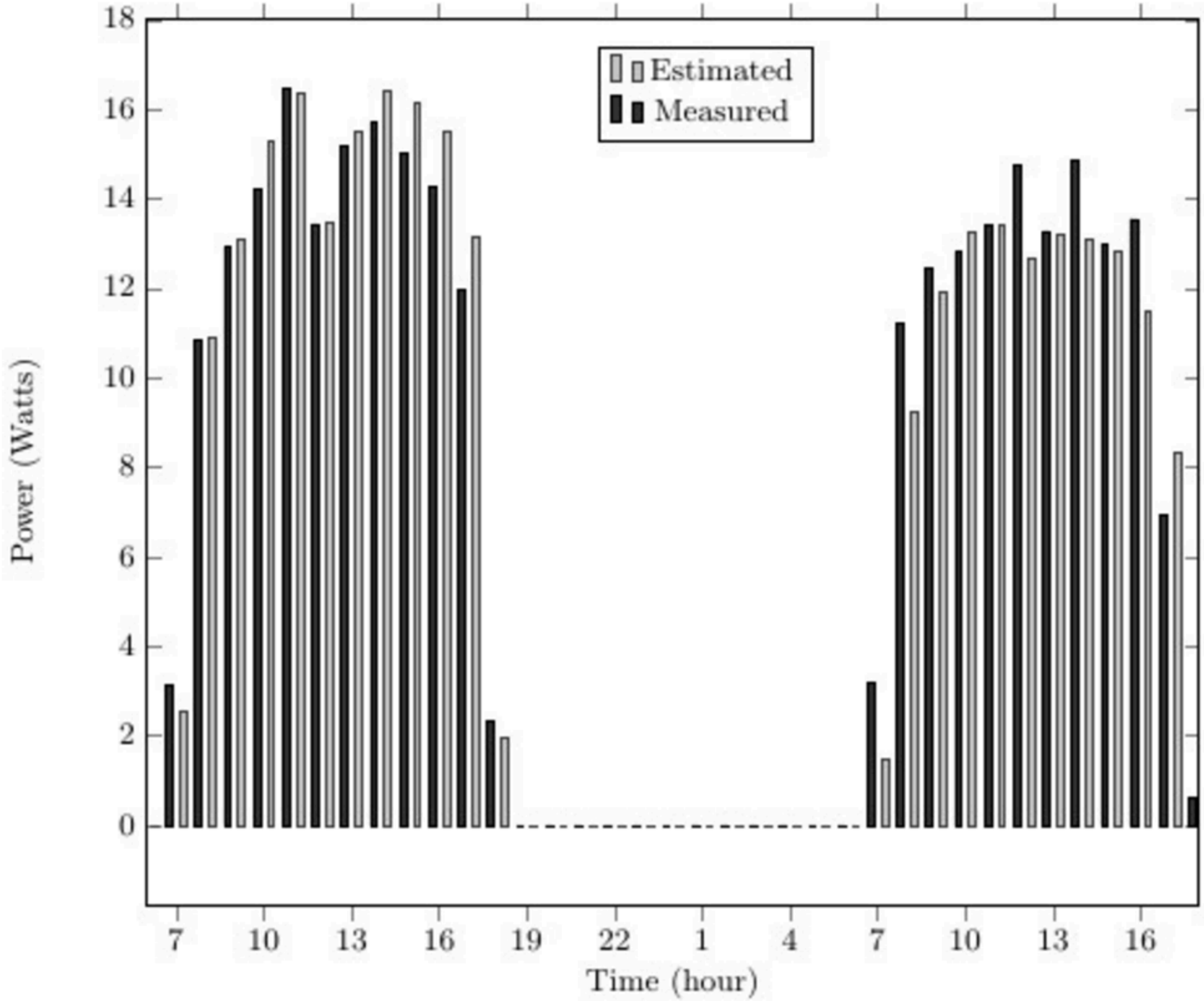
S-RAM PoC – Production estimation results



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What next ?

- **Finish implementation of Core Services**

- **Setup different testbeds**
  - Implement more services
  - Test automation for deployment and use

- **Test interoperability with other architectures**

Thank you for your attention