

Example: Smart Farm

Smart Health

Public Safety

Gas & Water Leak Detection

Smart Energy

Water Quality

Smart Buildings

Electric Vehicle Charging

6.1

Smart Home

mart Environment

Waste Management



How do we structure an IoT system?



- ▶ 18,000 sensing points.
- Outdoor deployments, Mobile nodes, Human interaction.
- Real City Services Continuous operation.
- Large variety of sensors Large data.
- Business models and sustainable exploitation combining research & service support.



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Example: Smart City

What Makes a Smart City? Multiple Applications Create Big Data



It's all in the Cloud



IoT Application Example & Main Components





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Green Awareness in Action

- Educational buildings constitute 17% of the non-residential building stock in the EU
- Wide variety of buildings of different ages (some built around 1950s)
- Expensive to renovate existing buildings
- Affect the behavioral characteristics of the buildings users.
- Educational community:
 - 1. students,
 - 2. educators,
 - 3. parents,
 - 4. researchers.





IoT infrastructure inside buildings

- IoT nodes installed to monitor the power consumption of the building as a whole, or specific floors/sectors.
- IoT nodes installed in classrooms and other supporting rooms to monitor a set of environmental parameters such as temperature, humidity, activity and noise levels.
- IoT gateway nodes installed in central points of the building to bridge the IoT nodes that communicate using IEEE 802.15.4 with the Internet, while gateways communicate directly with GAIA cloud services

Green Awareness in Action



IoT infrastructure inside buildings



- Arduino-based devices measuring indoor environment.
- Rasberry-based devices measuring indoor environment.
- Positioning of IoT devices within school rooms.
- Positioning of IoT devices at electric box.



IoT infrastructure inside buildings



Sample Application: Students

- Classic board game logic
- Students move through the board by answering questions from "challenges"
- Gradually the game board becomes more "alive"
- Students can see the progress of other schools



Sample Application: Students



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Sample Application: Building Managers

- Continuous monitoring
- Building comparison
- Real-time suggestion









Cloud-based System Architecture



Internal Mechanisms









Edge Cloud Computing in a nutshell



Motivation

Some mobile network functions cannot be fully centralised for a country or region.

Some 3rd party applications don't work well when centrally deployed purely in a hyper-scale Cloud or on a device (e.g. poor responsiveness, not sufficiently real-time, poor battery lifetime of devices).

Solution

- Introduction of distributed cloud computing.
- Software deployment closer to devices, at the "Edge" of telecoms networks or in the "Fog".

Role of operator

- Provides edge cloud computing infrastructure Hosts own software $+ 3^{rd}$ party applications there
- Provides value-added services to hosted applications at the Edge through APIs
- Enables completely new applications and improves QoE for existing applications

The Move to the Edge – What is the Edge?

The edge differs for Tier 1 Cloud providers and network operators like Vodafone

Network Operator's Edge

Edge Locations: Potentially: Gi-LAN, BBU-hotel, access network hub, base station, fixed access network component, cable network component



Amazon's Edge

AWS Edge Locations: Amsterdam, The Netherlands (2), Dublin, Ireland, Frankfurt, Germany (3), London, England (3), Madrid, Spain, Marseille, France, Milan, Italy, Paris, France (2), Stockholm, Sweden, and Warsaw,



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Edge Computing Move to the Edge – What's the Motivation? QoE, latency, bandwidth Connected Network operator's view Amazon's view 1 Connected Oil Platform REAL-TIME ANALYTICS GE GATEWAY ... to help our customers achieve "... to help our customers achieve TRANSACTIONAL ANALYTICS better QoE, lower latency and Connected Appliances BUSINESS Connecte Vind Turbin 口山 lower latency, higher throughput, and ٠ Smart Factories 8 • higher throughput for delayto ensure that their data Smart Tra sensitive, CPU-hungry, realresides only in the Region time services, they specify" ¹⁾ • longer battery lifetime, DATA CENTER, CLOUD more privacy, LATENCY NOT AN ISSUE new 4G/5G services (for Smart Grid • Connected Rail Systems Smart Buildings 1) Src: http://aws.amazon.com/about-aws/global-infrastructure/ MEDIUM LATENCY enterprises and consumers) REQUIREMENTS LOW LATENCY REOUIREMENTS Connected ▲□▶▲□▶▲□▶▲□▶ ■ のQ@ Main Architectural Levels IoT, Cloud and 5G converging **Common Functionalities Shared Technologies** Levels * **س** ا **Collaboration & Processes** 7 (Involving People & Business Proce Data at Center Rest Application A 6 1 Reporting, Analytics, Control) Cloud Cloud IoT IoT -Data Abstraction e computing closer to use Aggregation & Access) Data in Architecture for moving computing Motion Data Accumulation (Storage) functions around Edge (Fog) Computing Service automation technology (Data Element Analysis & Transfo Ways to use distributed resources Connectivity 2 (Communication & Processing Units) Ways to support multi-tenancy · Lifecycle management of devices, Edge **Physical Devices & Controllers** 1 sors, Devices, Machi lanage distributed resources (The "Things" in IoT) apps, resources, and systems Intelligent Edge Nodes of all type: are distributed resources None of these is unique to Cloud, 5G 5G IoT, or 5G

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Main Architectural Levels

Main Components and Processing Stages



