Cloud Computing for Energy Applications

Smart Energy Conference, 27th October 2016

Dr. Kai Daniel
Leading Question for Smart Grids

Has Cloud Computing an Impact on Energy Applications?

(Transmission) / Distribution Grid

Customers & Smart Home

CLOUD Computing

Generation

Loads

Dr. Kai Daniel

Smart Energy – Cloud Computing for Energy Applications

27th October 2017
Outline

- Introduction
  - Motivation to Discuss „Cloud Computing“
  - Definition: “What is Cloud Computing”
  - Evolution to Cloud Computing
  - Fundamental Cloud Service Building Blocks

- Significance for Cloud Computing
  - It as a Cost Drivers
  - Application Areas for Cloud Computing
  - Market Overview

- Role of Cloud Computing for Energy Applications
  - Use Cases: Smart Grid, Smart Metering, Water Management
  - Discussion of Technical Requirements
  - Hybrid Cloud Computing: Bridge to OT

- Summary
  - Chances and Risks
  - Conclusion
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Introduction
Gartner Hype Cycle

Expectations

Technology Trigger
Introduction
Gartner Hype Cycle 2012

Expectations

- Augmented Reality
- Mobile Apps
- NFC Payments
- QR Codes
- E-Books
- Gamification
- Google Glasses

Technology Trigger
Peak of Inflated Expectations
Trough of Disillusionment
Slope of Enlightenment
Plateau of Productivity

Time

- Multi-Variate Testing
- SMS
- Video Content
- Mobile Web
- Social Networking
- Virtual Worlds
- Tailored Online Journeys

- E-Books
- Gamification
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Introduction

Gartner Hype Cycle 2014 Predicts Plateau for Cloud Computing in 2-4 years
Definition
The NIST Definition of Cloud Computing

DEFINITION

„Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction“


BUILDING BLOCKS OF CLOUD COMPUTING

Virtual Computers/Servers
Data Storage Capacity
Networks
Services

NOTE
…it is still a buzz word…
Definition – Simple Explanation
“Cloud Computing is like Crude Oil”
Significance of Cloud-Technologies
Known Digitalization Trends built on Interacting Technologies

INTERNET OF THINGS

CLOUD COMPUTING

BIG DATA ANALYTICS
Significance of Cloud-Technologies
Known Digitalization Trends built on Interacting Technologies

THINGS WITH NETWORKED SENSORS & ACTORS

DATA STORES

ANALYTIC ENGINES

Report States
(internal states / external states)

Feedback & Control
commands and requests

Iterate
Models/analyses

Human/machine learning

Servers/Cloud

Data
Models/analyses
Text
Videos
Images

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Significance of Cloud-Technologies
Known Digitalization Trends built on Interacting Technologies

**THINGS WITH NETWORKED SENSORS & ACTORS**
- **At rest**
- **Active**

**DATA STORES**
- Data
- Models/analyses
- Text
- Videos
- Images

**ANALYTIC ENGINES**
- Human/machine learning
- Servers/Cloud

**Report States**
(internal states / external states)

**Feedback & Control**
commands and requests

**CONNECTED DEVICES**
- 12B IoT devices connected in 2020 (5B Today)

**DATA AS A COST DRIVER**
"The total amount of data being captured and stored by industry doubles every 1.2 years"

Source: Cisco

Source: http://www.waterfordtechnologies.com

"The total amount of data being captured and stored by industry doubles every 1.2 years"
Cloud Computing is a Next Step in the Computing Evolution

Grid Computing
- Solving large problems with Parallel computing
- Made mainstream by Global Alliance

Utility Computing
- Offering computing resources as a metered service
- Introduced in late 1990s

SaaS Computing
- Network-based subscriptions to applications
- Gained momentum in 2001

Cloud Computing
- Next-Generation Internet computing
- Next-Generation Data Centers

Rented Computing resources on demand without virtualization
Example: Cisco WebEx, GoogleApps

Centrally controlled and based on virtual resources
Example: GoogleWebMail

Decently controlled
Example: Seti@home

source: http://www.dsp-ip.com
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Cloud Computing Reached the Plateau of Productivity, where Several Services are Available Today
Fundamental Building Blocks: Cloud Computing is the Headline for Different Services, which are Part of a Cloud
Fundamental Building Blocks: Cloud Computing is the Headline for Different Services, which are Part of a Cloud

**Software as a Service (SaaS)**
- Google Apps
- Gmail
- Facebook

**Platform as a Service (PaaS)**
- Google App Engine
- Windows Azure
- force.com

**Infrastructure as a Service (IaaS)**
- AT&T
- Amazon Web Services
On Average, Business loose between 130K€ to 500k€ every hour of unplanned IT system downtime (1/2)

[Source: Gartner – Network Downtime, 2014]
On Average, Business lose between 130K€ to 500k€ every hour of unplanned IT system downtime (2/2)

THE COST OF DOWNTIME

With managers more and more keen to get the most out of their employees, more resources are being spent on attempts to eradicate time-wasting. Here are some of the prime culprits.

SOURCE PayScale.com
Cloud Computing is Furthermore Motivated by Green Internet: Impact of Cloud Computing on Energy Consumption

„Using a cloud saves up to 87% of the energy demand for IT infrastructures“

By moving 86 million U.S. office workers to the cloud, we would use up to 87% less energy. That's enough to power Los Angeles for 1 year.
Size of the Cloud Computing and Hosting Market Worldwide from 2011 to 2019 (in billion USD)


* Predictions

http://www.dolcera.com/

Advertising is a key cloud business
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Use Case 1: Smart Metering
System-of-Systems Architecture Focussing Metering Functions

https://www.rewi.uni-jena.de/rewi2media/Bilder/Fakult%C3%A4t/Institute/Energirechtsinstitut/Veranstaltung+Smart+Metering/20160121_MME_IMSYS_ZAYER_F.pdf
Use Case 2: Smart Grid
System-of-Systems Architecture Focussing Control Functions

Grid Control & Management Functions

Common Interface
(Enterprise Application Bus)

VPP-System

CLS-Management-System

Energy Customers

Gateway & Control Box

Secondary process control
Remote Control

Direct Process Connection

Direct Connection

Digitale / El. Interface

„EEG-System/ EnWG §14a System

Use Case 3: Preventive Performance
Product Development as a Service

**I**  
Sensor-/Actor System

**II**  
Wide Area Network (WAN)

**III**  
Data Analytics

**IV**  
Testing

**V**  
Product Development

**VI**  
Maintenance/Service

- Best Practice
- Integration & Vorauswertung
- Sensor data-transmission
- Correlation & Predikcion
- Verifikation/Validierung
- Optimalized Development

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Requirements Towards Cloud Computing from Utility Perspective (1/2)

- Public
  - Access
  - User Authentication
  - Unified API
  - Service Registration

- Private
  - Services
    - Data Analytics
    - Performance Management
    - Stability Analysis
    - Simulation/Modelling

- Public
  - Management
    - Security Infrastructure
    - Resource Monitor
    - Load Balancing
    - SLA Management

- Public
  - Infrastructure
    - Storage
    - Computing
    - Network

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http://energy.gov/sites/prod/files/Friday_Trinity_Ballroom_3_0855_Primetica_final.pdf
Hybrid Cloud Computing Allows to Exploit the Advantages of Cloud Technologies (1/2)
Hybrid Cloud Computing Allows to to Exploit the Advantages of Cloud Technologies (2/2)

**Private**
- Single tenant implementation
- Owned and operated by IT organization
- Define your own data management policies
- Self-service and automation capabilities provide new agility

**Public**
- Multi-tenant implementation
- Owned and operated by Service Provider
- Bound by multi-tenant data management policies
- Similar self-service and automation capabilities as Private Cloud

**Hybrid**
- Combination for Private & one or more public clouds
- Allows IT organizations to become brokers of services

**GRID CONTROL & MANAGEMENT**

**SMART METERING & PRODUCT DEVELOPMENT**

**SMART HOME & OFFICE IT**

https://media.licdn.com
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Selected Benefits and Risks of Cloud Computing

**BENEFITS**

- No Invest in Hardware and Cost Reduction by Outsourcing
- Scalability and Flexibility of Services (“on demand”)
- High Availability and Reduction of Downtime Risks
- Utilization of Infrastructures & “Green IT”

**RISKS**

- **Vulnerability**
  - Violations of Data Security, e.g. Confidentiality and Integrity
- **Limited Control**
  - Delete Data permanently “Right to be forgotten”
- **Compliance Risks**
  - (Multi-Country ⇔ Multi-Law)
- **Hardware**
  - Insolvency and Confiscation of sub-contractors in foreign countries
Conclusion
Cloud Computing is an Established Technology for Energy Applications

**CLOUD COMPUTING IS A MEGATREND...**

...which

a) provides already mature technologies

b) facilitates the development of new and promising technologies

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**CLOUDs WILL COME TO ENERGY SECTOR**

Clouds are already used in the energy domain. In particular for smart home or smart metering applications cloud technologies are already in use. However, interface to smart grid applications are still in development.

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**STANDARDIZATION IS A CHALLENGE**

Deployment of hybrid cloud environments and using a variety of platform, development and connectivity technologies complicates **interoperability** for different application needs.
Thank you very much for your attention

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Introduction
Gartner Hype Cycle 2015 Motivates to Investigate Emerging Technologies

http://blogs.gartner.com
Dr. Kai Daniel is the Director of Systems & Engineering in the Corporate Research and Technology Division of Carl ZEISS.

Prior to this position he gained experience in the development of information and communication systems at Nokia Mobile Phones, RWE Deutschland AG (which is Innogy SE today) and WILO SE.

Kai studied Electrical Engineering and Information Technologies at the Ruhr-Universität Bochum and received his doctoral degree in the area of communication networks from TU Dortmund university.
Requirements Towards Cloud Computing from Utility Perspective (2/2)

https://www.sevone.com/
The following elements are critical to achieving this vision:

1. **Sensing and measurement technologies**: To support faster and more accurate response such as remote monitoring, time-of-use pricing and demand-side management.

2. **Advanced components**: To apply the latest research in superconductivity, storage, power electronics and diagnostics.

3. **Advanced control methods**: To monitor essential components, enabling rapid diagnosis and precise solutions appropriate to any event.

4. **Improved interfaces and decision support**: To amplify human decision-making, transforming grid operators and managers quite literally into visionaries when it comes to seeing into their systems.