Cloud Computing Architecture

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- *Cloud Computing Introduction*
- *Cloud Computing Architecture*
- *Software Architecture for Cloud*
- *Outlook*

Corporate Research and Technologies ,
Munich, Germany

Gerald Kaefer

* 4th Generation Datacenter
IEEE Spectrum, Feb. 2009

20th May 2010

SATURN 2010

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Motivation and Goals

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- Cope with Cloud Computing paradigm in complex enterprise and industrial environments in the roles as customer, provider, and ISV

- Design guidelines for native cloud applications for industrial domains
    - Embedded systems integrated with cloud services
    - ISVs prepare their software for cloud operation

- Support for re-engineering existing on-premise applications for the Cloud Computing paradigm

- Coping with required break to existing IT and software architecture (data (storage, distribution), processing, transactions, caching, workflows, access control, etc.).

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Reminder: Cloud Computing
….focus on automation, resource sharing and business

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Novelty comes from the composition of existing technologies combined with new business models for software and service selling.

Cloud computing is a model for enabling 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
(Source: NIST Cloud Computing Project*)

* http://csrc.nist.gov/groups/SNS/cloud-computing/cloud-def-v14.doc

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Cloud Computing Business Challenge
Which applications profit from Cloud Computing?

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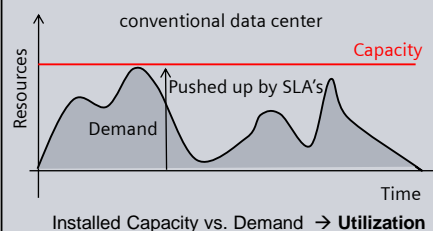
Applications with these requirements are candidates:
- massive scale (computation, storage, …)
- high reliability and availability
- heavy load variations
- world-wide distribution
- non- deterministic life-time (start-up's)
- collaboration across company boundaries
- application do not fit to company core business

Benefiting from:
- reduced administration effort
- contract flexibility (pay as you go)
- availability and elasticity

Business Driver - TCO
- Utilization Rate
- CAPEX → OPEX

conventional data center

Resources

Capacity

Pushed up by SLA's

Demand

Time

Installed Capacity vs. Demand → **Utilization**

Business Driver - Flexibility
- pay as you go instead of long-term contracts

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Cloud Computing Architecture
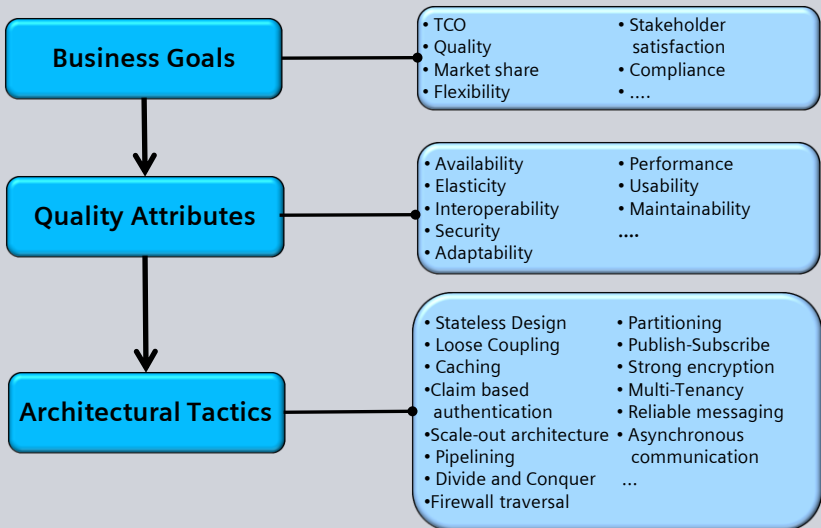Our first definition

Service Orient Architect...

Middleware Architecture)

Cloud Computing Architecture

Enterprise I Architecture

Software Architecture

The **Cloud Computing Architecture** of a cloud solution is the structure of the system, which comprise on-premise and cloud resources, services, middleware, and software components, geo-location, the externally visible properties of those, and the relationships between them.

The term also refers to documentation of a system's cloud computing architecture. Documenting facilitates communication between stakeholders, documents early decisions about high-level design, and allows reuse of design components and patterns between projects.

Context: High-level Architectural Approach
… aligned with common architectural approaches

Business Goals

- TCO
- Quality
- Market share
- Flexibility
- Stakeholder satisfaction
- Compliance
- ....

Quality Attributes

- Availability
- Elasticity
- Interoperability
- Security
- Adaptability
- Performance
- Usability
- Maintainability
- ....

Architectural Tactics

- Stateless Design
- Loose Coupling
- Caching
- Claim based authentication
- Scale-out architecture
- Pipelining
- Divide and Conquer
- Firewall traversal
- Partitioning
- Publish-Subscribe
- Strong encryption
- Multi-Tenancy
- Reliable messaging
- Asynchronous communication
- ...

Cloud Computing Architecture
Major building blocks

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Reference Architecture
- Basis for documentation, project communication
- Stakeholder and team communication
- Payment, contract, and cost models

Technical Architecture
- Structuring according to XaaS Stack
- Adopting Cloud Platform paradigms
- Structuring cloud services and cloud components
- Showing relationships and external endpoints
- Middleware and communication
- Management and security

Deployment Operation Architecture
- Geo-location check (Legal issues, export control)
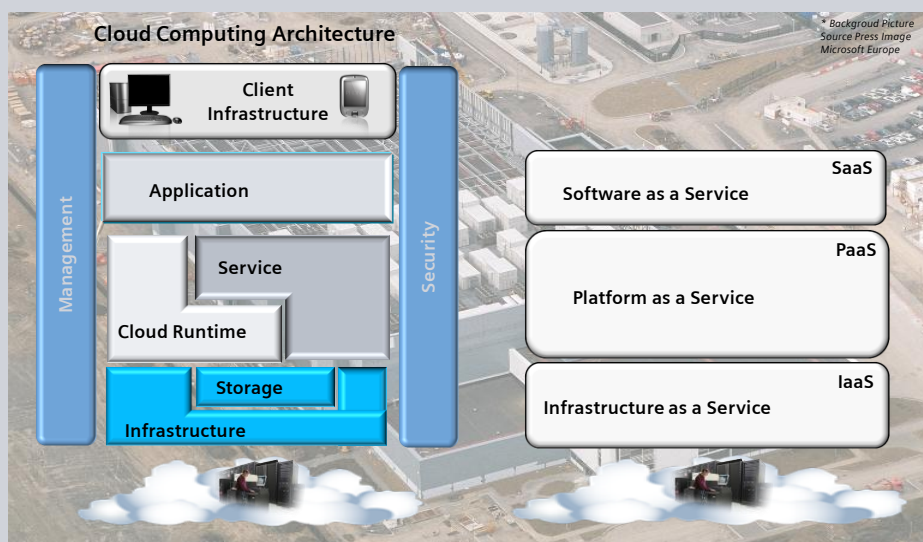- Operation and monitoring

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Cloud Computing Architecture vs. "XaaS"
… allows comparisons, maps to common dictionary

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Cloud Computing Architecture

* Background Picture
Source Press Image
Microsoft Europe

Client Infrastructure

Application

Service

Cloud Runtime

Storage

Infrastructure

Management

Security

SaaS — Software as a Service

PaaS — Platform as a Service

IaaS — Infrastructure as a Service

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"XaaS" Stack Views
Customer View vs. Provider View

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Customer View

User, Application Administrator

Software Architect, Developer

IT Architect, IT Operator

SaaS

PaaS

IaaS

e.g. CRM

e.g. Access Control

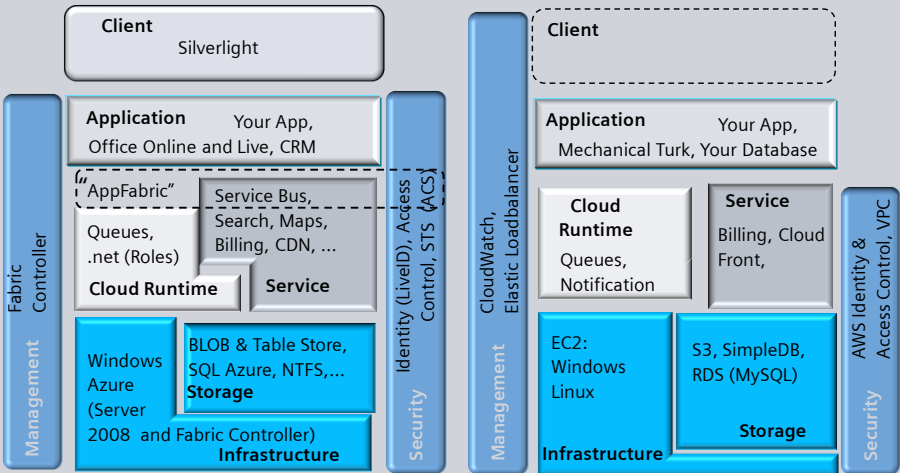VMs and Networks

Provider View
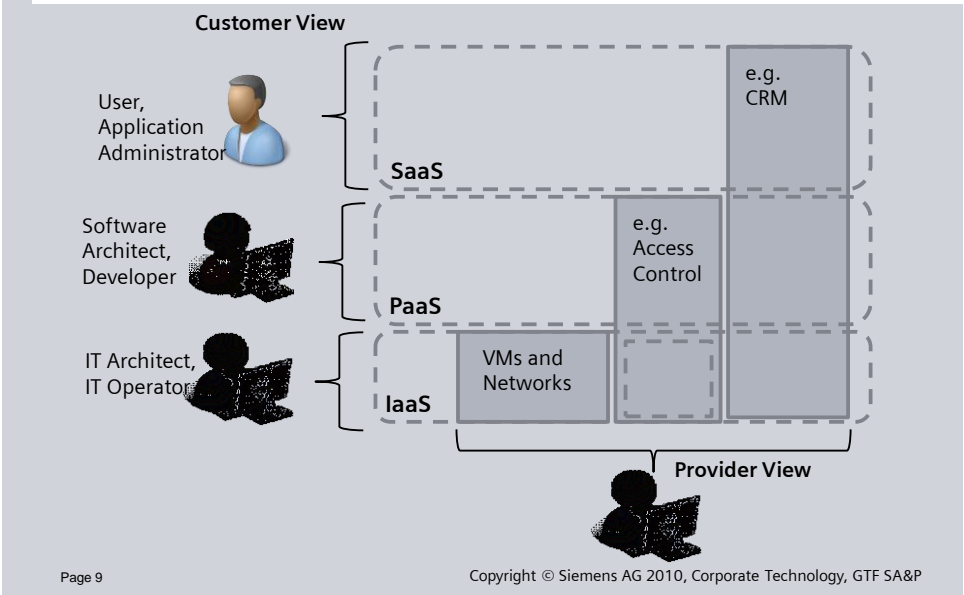
Cloud Reference Architectures
Allow comparison of vendors and technologies
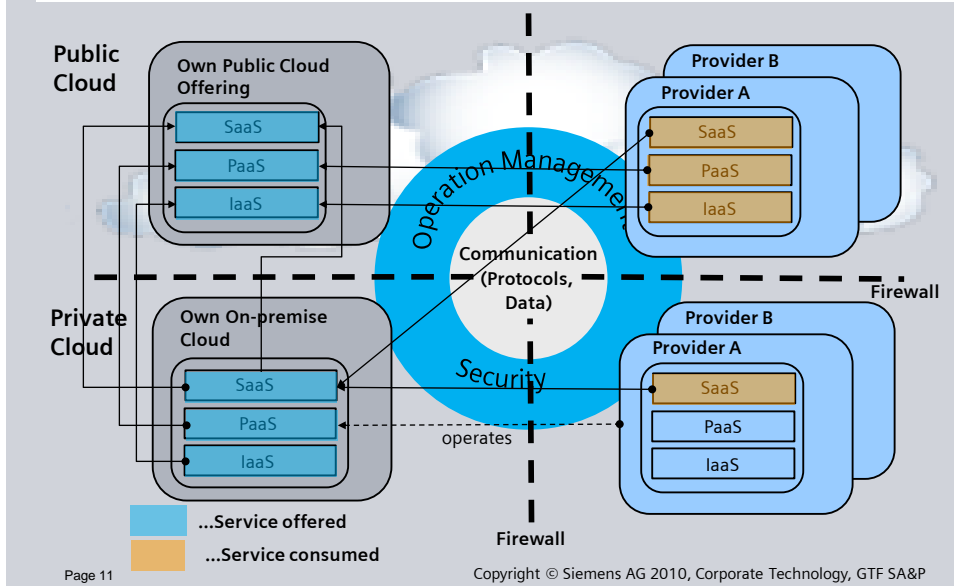
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e.g. Microsoft Windows Azure Platform

e.g. Amazon Cloud Platform

Client Silverlight

Application Your App, Office Online and Live, CRM

"AppFabric"

Service Bus, Search, Maps, Billing, CDN, ...

Queues, .net (Roles)

Cloud Runtime

Service

Windows Azure (Server 2008 and Fabric Controller)

BLOB & Table Store, SQL Azure, NTFS,...
Storage

Infrastructure

Fabric Controller

Management

Identity (LiveID), Access Control, STS (ACS)

Security

Client

Application Your App, Mechanical Turk, Your Database

Cloud Runtime Queues, Notification

Service Billing, Cloud Front,

EC2: Windows Linux

S3, SimpleDB, RDS (MySQL)

Storage

Infrastructure

CloudWatch, Elastic Loadbalancer

Management

AWS Identity & Access Control, VPC

Security

Hybrid Cloud Architecture Model
… XaaS Stack extended by the location, provider dimensions

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Public Cloud

Own Public Cloud Offering
- SaaS
- PaaS
- IaaS

Provider B
Provider A
- SaaS
- PaaS
- IaaS

Operation Management

Communication (Protocols, Data)

Security

Firewall

Private Cloud

Own On-premise Cloud
- SaaS
- PaaS
- IaaS

Provider B
Provider A
- SaaS
- PaaS
- IaaS

operates

…Service offered
…Service consumed

Firewall

Cloud Migration Strategy
…which layer fits the demand?

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Cloud Application

? — **Replacement of Application**
Abandon of legacy software +
Data and process migration cost -

? — **Redesign for Platform***
High scalability and flexibility +
Pay per use applications possible +
(Architecture-) change required -
Migration cost could become high -

? — **Redeployment**
Migrate software "as is" +
Low migration cost +
Application scalability not improved -
No pay-per-use for applications per tenant -

STOP — **Run on-premise**

Client Infrastructure

Application — **Virtualized Application** — SaaS

Service / **Platform** — PaaS

Storage / **Infrastructure** — IaaS

*… "Requires change of applications (own or partner application) or development of adapter layer"

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Cloud Platforms - Simpler NFR Engineering
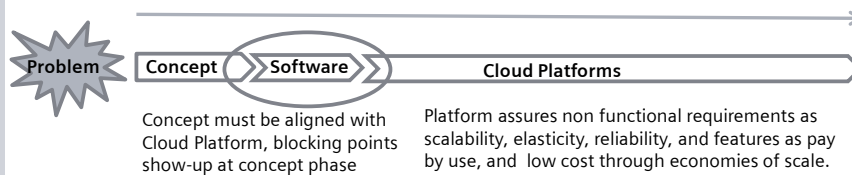Software architecture becomes deployment architecture

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Challenge: Traditional achievement of NFR (Non Functional Requirements) assurance

Problem

| Concept | Software Solution | IT Operation Solution | Infrastructure |

Abstract problem focus and constraints

Concept requirements have to be implemented, software focuses on efficient implementation

Software constraints have to be encountered to fulfill SLA requirements

Infrastructure is selected according to operation requirements
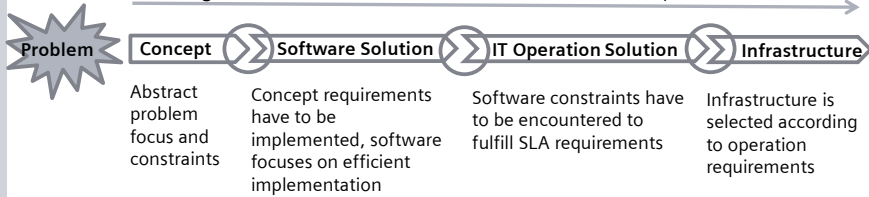
Advantage: Match of NFRs are verified at higher level (platforms plus SAL), miss-match adaptation is possible through **change of concept or change of cloud platform**.

Problem

| Concept | Software | Cloud Platforms |

Concept must be aligned with Cloud Platform, blocking points show-up at concept phase

Platform assures non functional requirements as scalability, elasticity, reliability, and features as pay by use, and low cost through economies of scale.

Architecture for Elasticity
…elasticity and cost requirements impact architecture

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Vertical Scale Up

- Add more resources to a single computation unit i.e. Buy a bigger box

- Move a workload to a computation unit with more resources
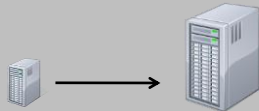
For small scenarios scale up is probably cheaper - code "just works"

Horizontal Scale Out

- Adding additional computation units and having them act in concert

- Splitting workload across multiple computation units

- Database partitioning

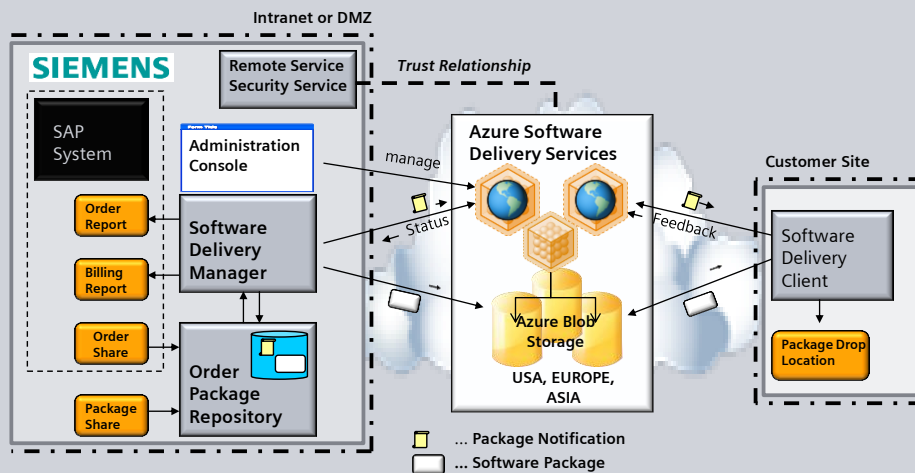For larger scenarios scale out is the only solution 1x64 Way Server much more expensive that 64x1 Way Servers

Siemens Cloud-based Software Distribution
Some experiences …

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Siemens Cloud Software Delivery Service provides saleable software distribution based on Windows Azure across enterprise boundaries (firewall friendly).

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Outlook

- Cloud Computing approaches will spread because of lower TCO and higher flexibility (business, technical)
- Cloud Computing will massively change the future IT business in a way that many standard IT services will offered by big IT providers
- Cloud Computing platforms commoditize native Internet scale application development and operation
- Cloud Computing Architecture aspects will be integrated in Cloud platforms as framework, process, templates, guidance to lower the business, legal, and technical burden for application developers

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Thank You for your Attention!

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Dr. Gerald Kaefer

gerald.kaefer@siemens.com

Siemens AG, CT T DE IT1
Corporate Technology,
Global Technology Field
System Architecture and
Platforms
Otto-Hahn-Ring 6
81739 Munich, Germany

www.ct.siemens.com

*Within Corporate Technology the Global Technology Field System
Architecture and Platforms focuses on software architectures for a wide
range of software-types. This includes embedded systems, distributed
applications, and enterprise software.*
*In the recent field of cloud computing the focus is cloud computing
architecture for cloud platform stacks and applications. Cloud computing
architecture is key for scalability, cost efficiency, and meeting of legal and
business requirements. These activities are completed by the industry
focused evaluation of strategic cloud computing platforms in order to
support customers on their way to cloud computing.*