Overview of Cloud Computing

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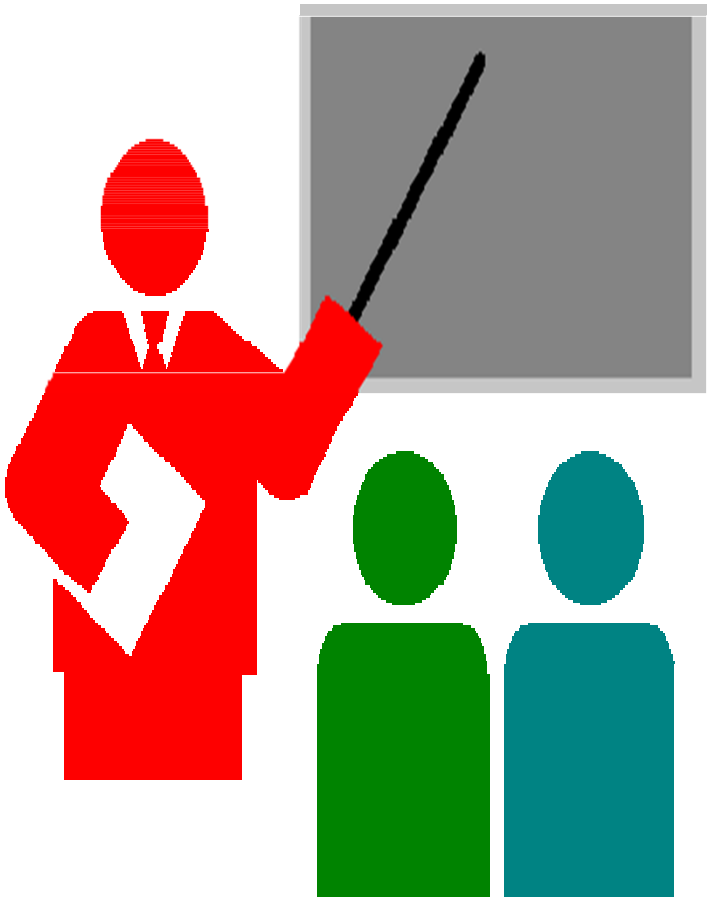
Overview of Cloud Computing



- Definition
- Enabling technologies
- Cloud Layers and types
- Beyond the functional challenges
- Concrete examples
  - Cloud Based Content Delivery
  - Cloud Based IoT

Definition

A definition

" Clouds are a large pool of easily usable and accessible virtualized resources (such as hardware, development platforms and/or services). These resources can be dynamically reconfigured to adjust to a variable load, allowing also for an optimum resource utilization. This pool of resources is typically exploited by a pay-per-use model in which guarantees are offered by the infrastructure provider by means of customized SLAs""

Reference [1]

1.L.M. Vaquero et al., A Break in the Clouds: Towards a Cloud Definition, ACM SIGCOM Computer Review, January 2009

Better than a Definition

Identify the combination of characteristics that make cloud computing a distinct paradigm. Some examples:

- Multiple tenancy
- Scalability
- Elasticity
- Pay per use
- Appearance of infinite computing resource available on demand
- Elimination of an upfront commitment by users
- Rapid service provisioning

Cloud Computing vs. other paradigms

- Cloud computing vs. peer to peer computing
- Cloud computing vs. grid computing

Enabling Technologies

Virtualization

Provides virtual resource from real resource (e.g. hardware, storage, network) to ensure an efficient usage of the real resource

- Key to several cloud distinctive characteristics, e.g.
  - Efficiency in resource usage
  - Multiple tenancy

Virtualization

- **Several approaches**
  - Machine virtualization
  - Containerization
  - Uni-kernel

Web Services

Web services

- Integration of hardware/software systems over communication networks including Internet

Key enabler for:

- Rapid applications and services provisioning

Web Services

"The term Web Services refers to an architecture that allows applications (on the Web) to talk to each other. Period. End of statement"

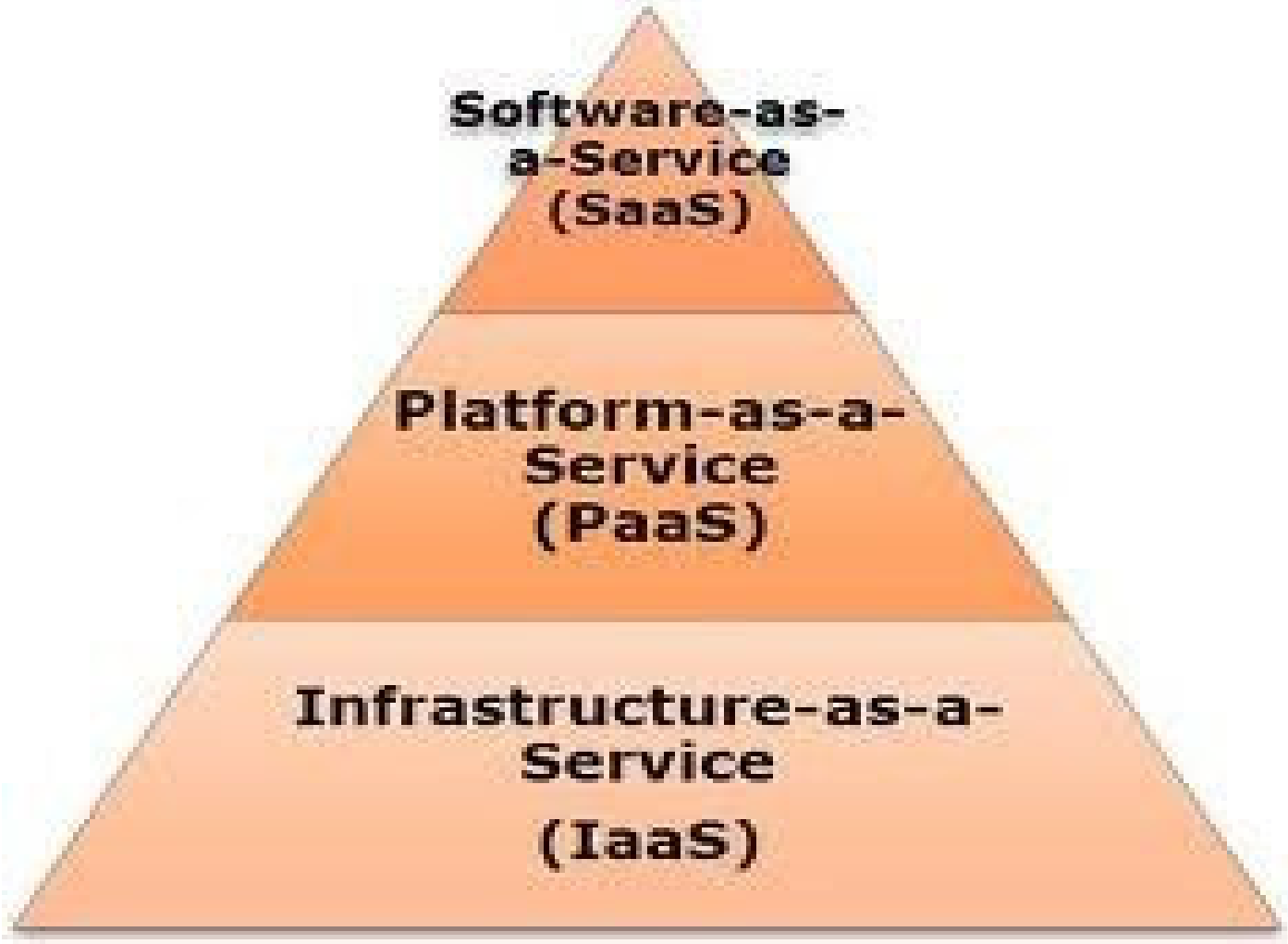
Adam Bobsworth in ACM Queue, Vol1, No1

RESTful Web Services

- REST is a way to reunite the programmable web with the human web.
- Relies on HTTP and inherits its advantages, mainly
  - Addressability
  - Unified interface

Cloud Layers

Cloud Layers



Software as a Service

Software as Services (SaaS): the tip of the iceberg (End-user perspective)

Software as a Service

Software as Services (SaaS): the tip of the iceberg (End- user perspective)

Applications offered by service providers and residing in the cloud

- Pay per use basis
- Accessible by end-users (and eventually other applications)
- An example:
  - Zoom video conferencing –
    - Runs in:
      - Oracle cloud infrastructure
      - Amazon WS cloud infrastrcture

Platform as a Service

Platforms as a Service (PaaS): immersed part I (End-user perspective)

Platform as a Service

Platforms as a Service (PaaS): immersed part I (End-user perspective)

- Platforms used for the development and management of the applications offered as SaaS to end-users (and other applications)
  - Examples:
  - Google Cloud Engine
  - Cloud Foundry

Infrastructure as a Service

Infrastructure as a Service (IaaS): immersed part II: End-user perspective)

Infrastructure as a Service

Infrastructure as a Service (IaaS): immersed part II: End-user perspective)

- Virtualized resources (e.g. CPU, memory, storage) used (on a pay per use basis) by applications
  - Generally accessible via Web service
  - Amazon EC2
  - Google cloud
  - Oracle cloud

Layers

Infrastructure as a Service (IaaS): immersed part II: end-user perspective)

Virtualized resources (e.g. CPU, memory, storage) used (on a pay per use basis) by applications

- Generally accessible via Web service
- Amazon EC2
- Google cloud
- Oracle cloud

Infrastructure as a Service

Data centers:

- Virtual machines (VMs), containers and uni-kernels running on servers
- Switches
- Data center gateways

Infrastructure as a Service

https://aws.amazon.com/about-aws/global-infrastructure/ (March 13, 2021)

Infrastructure as a Service

https://www.ibm.com/cloud/data-centers/

March 13, 2021

Cloud Types

Types of Clouds

Public cloud:

- Resources offered to the general public
  - No initial capital investment required from the service providers that wish to offer services using a public cloud
    - Ex: Content Delivery Networks (CDNs) built on top of public storage clouds

Types of Clouds

Public cloud:

- On the other hand:
  - Less control over data, network and security
    - In CDNs for instance there might be possibility of surrogate servers in some countries due to the lack of coverage by storage cloud

Types of Clouds

Private cloud:

- Exclusive use by a given organization
  - Might be built and managed by the organization or external providers
    - High control over security, performance reliability and others
  - However:
    - Require high initial investment cost

Types of Clouds

Hybrid cloud:

- Combination of public and private cloud
  - The “best” of the 2 worlds
    - Tries to address the limitations of public and private clouds
    - Key issue:
      - Best split between public and private components

Types of Clouds

Virtual private clouds:

- Alternative for getting the “best” of the 2 worlds
  - Runs on top of public clouds
  - Leverages virtual private network technics to get more control over:
    - Topology
    - Security
    - And others …

Beyond functional challenges / characteristics

Beyond the Functional Challenges

Key functional challenges

- Multiple tenancy
- Scalability
- Elasticity
- Rapid provisioning of services and applications
- Pay per use

…

Beyond the Functional Challenges

Examples:

- Availability
  - Which level of outage is acceptable ?
    - Depend on users and / or applications
    - An example of cloud with very stringent availability requirement:
      - Telco cloud
    - For examples of outage of known cloud products (e.g. Amazon S3, Google Apps Engine)

Beyond the Functional Challenges

Examples:

- Data lock in
  - Most cloud products still rely on proprietary APIs / protocols
    - Interoperability and portability issues
    - Numerous cloud standardization bodies are now tackling the issues, eg.
      - IEEE, ITU-T, NIST, DMTF (de jure)
      - Open Stack, Cloud Foundry (de facto)

...

Beyond the Functional Challenges

Examples:

- Security
  - Most cited objection against cloud adoption
    - Security threats from inside the cloud and outside the cloud
    - Primary mechanism used today:
      - virtualization
        - Prevent to some extent against users attacking each other and users attacking the cloud infrastructure thanks to isolation

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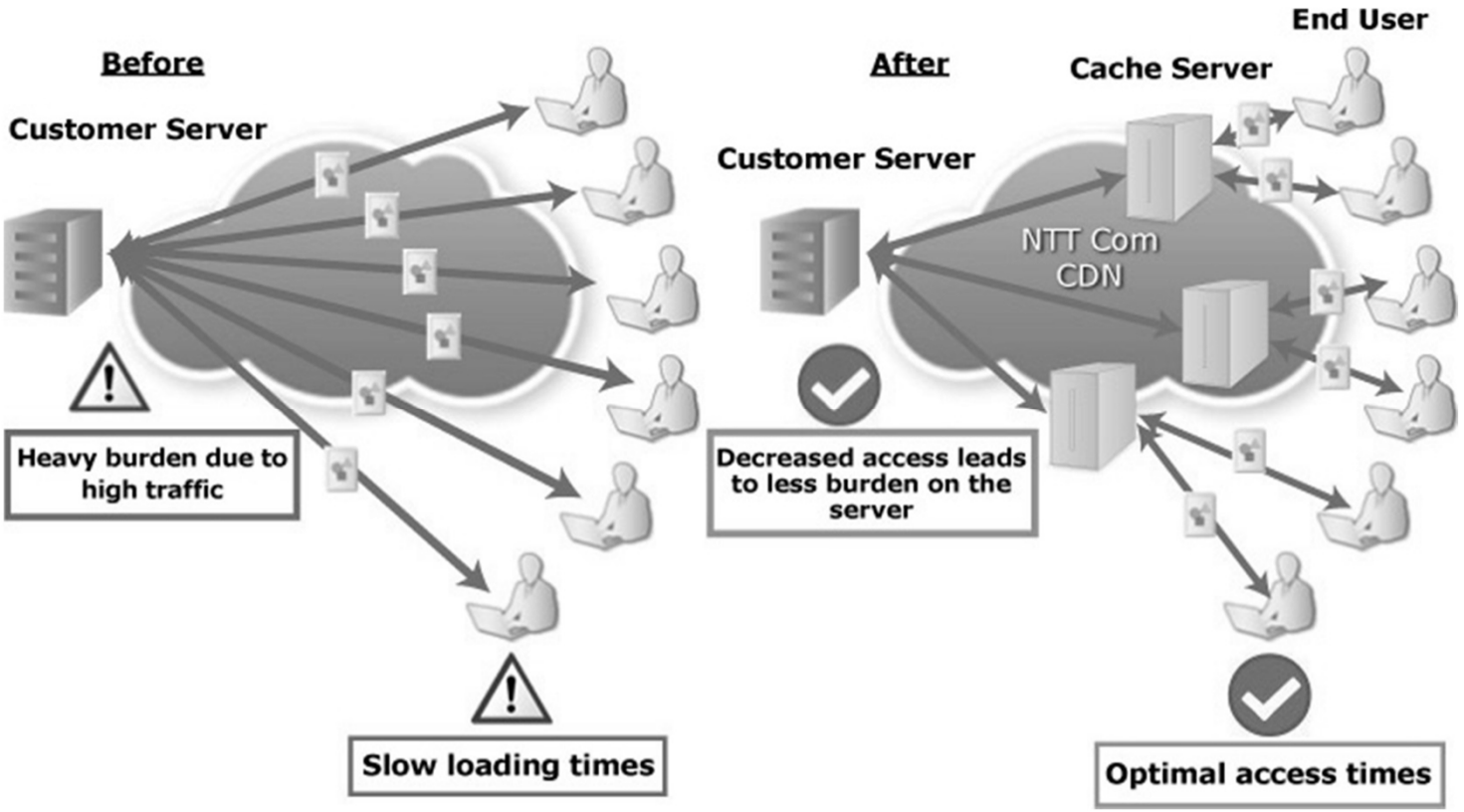
Cloud Based – Content Delivery Networks

Cloud Based – Content Delivery

Content Delivery Networks: Fundamentals

What are Content Delivery Networks?



What are Content Delivery Networks?

Architectures (nodes, interfaces) + Algorithms for content life cycle management

Content distribution

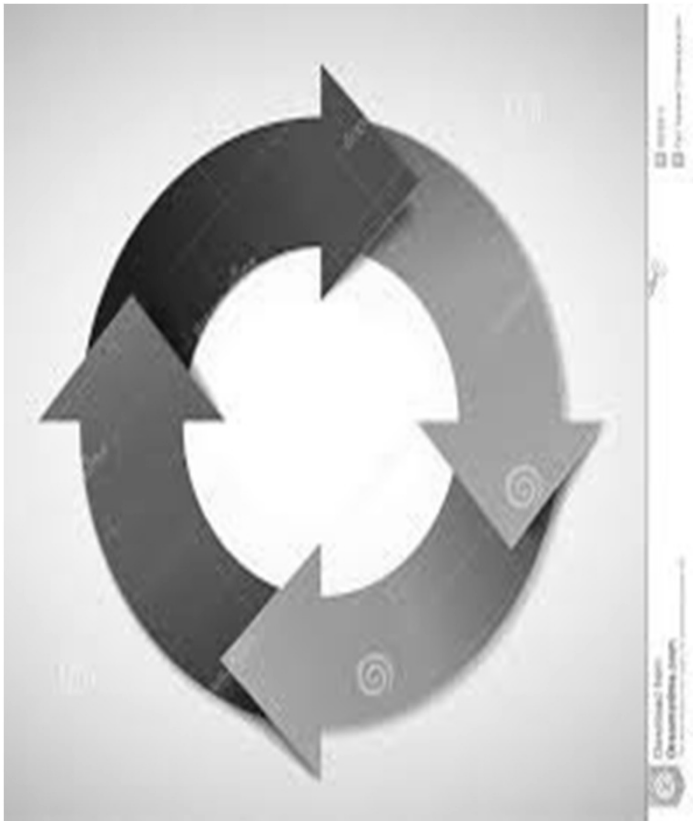
-Send content from their original sources to the caches

Request routing

-Route end-user request for content to content locations

Content acquisition/consumption

- Send content to end-user devices



What are Content Delivery Networks?

Architectures (nodes, interfaces) + Algorithms

Ultimate goal: Make trade offs between

End – User QoS / QoE, e.g

- Latency
- Video resolution

Cost, e.g.

- Cost for storing content in caches
- Network cost for content distribution / acquisition

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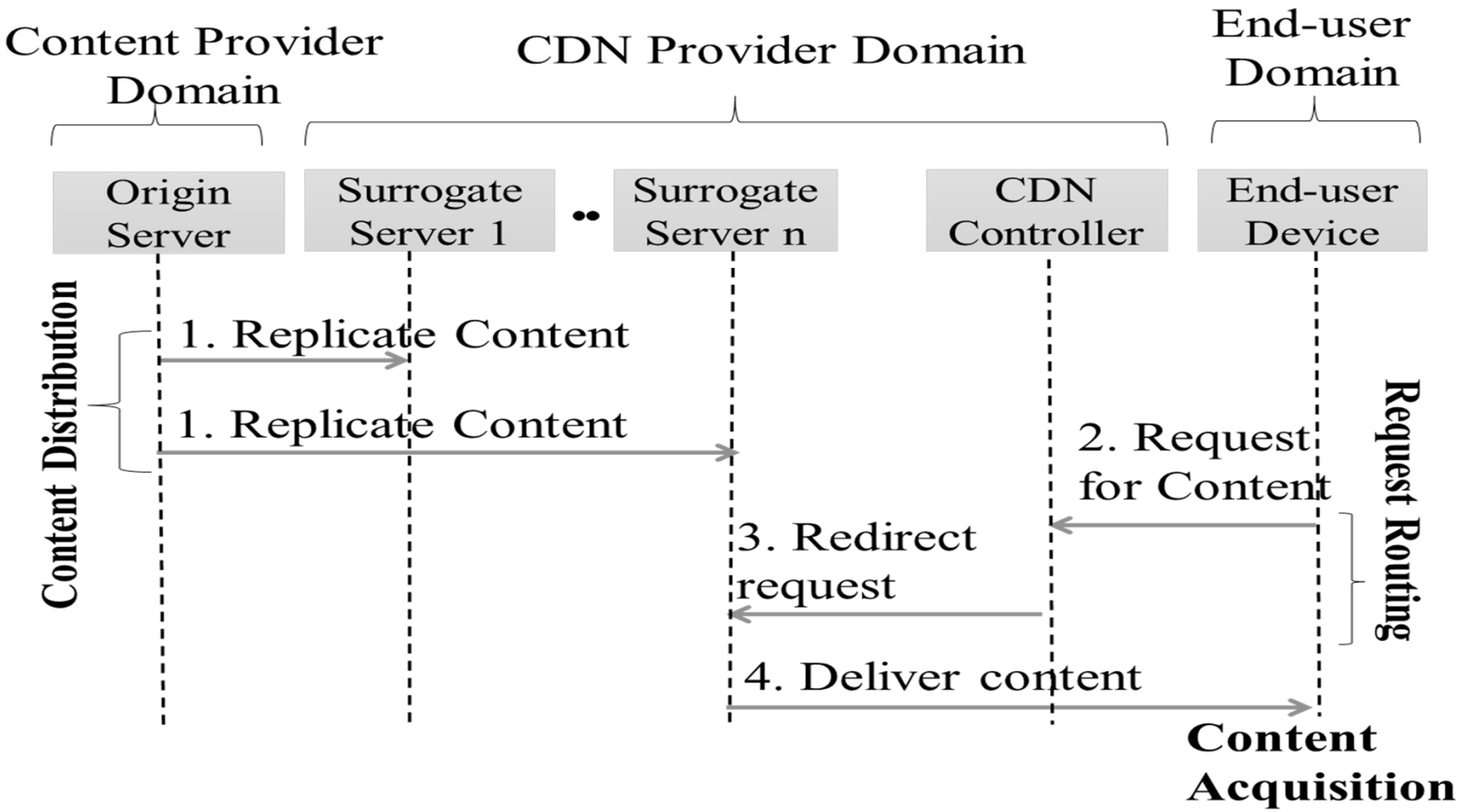
Traditional Content Delivery



Traditional Content Delivery Networks (Distinctive characteristics)

Traditional Web Technologies, e.g.

- Static resource allocation

Traditional Internet Technologies, e.g.

- Host centric routing, vs. content centric routing

Cloud Based - CDNs

What could Cloud CDN bring?

CDN goal: Trade offs between end-user QoS/QoE and cost

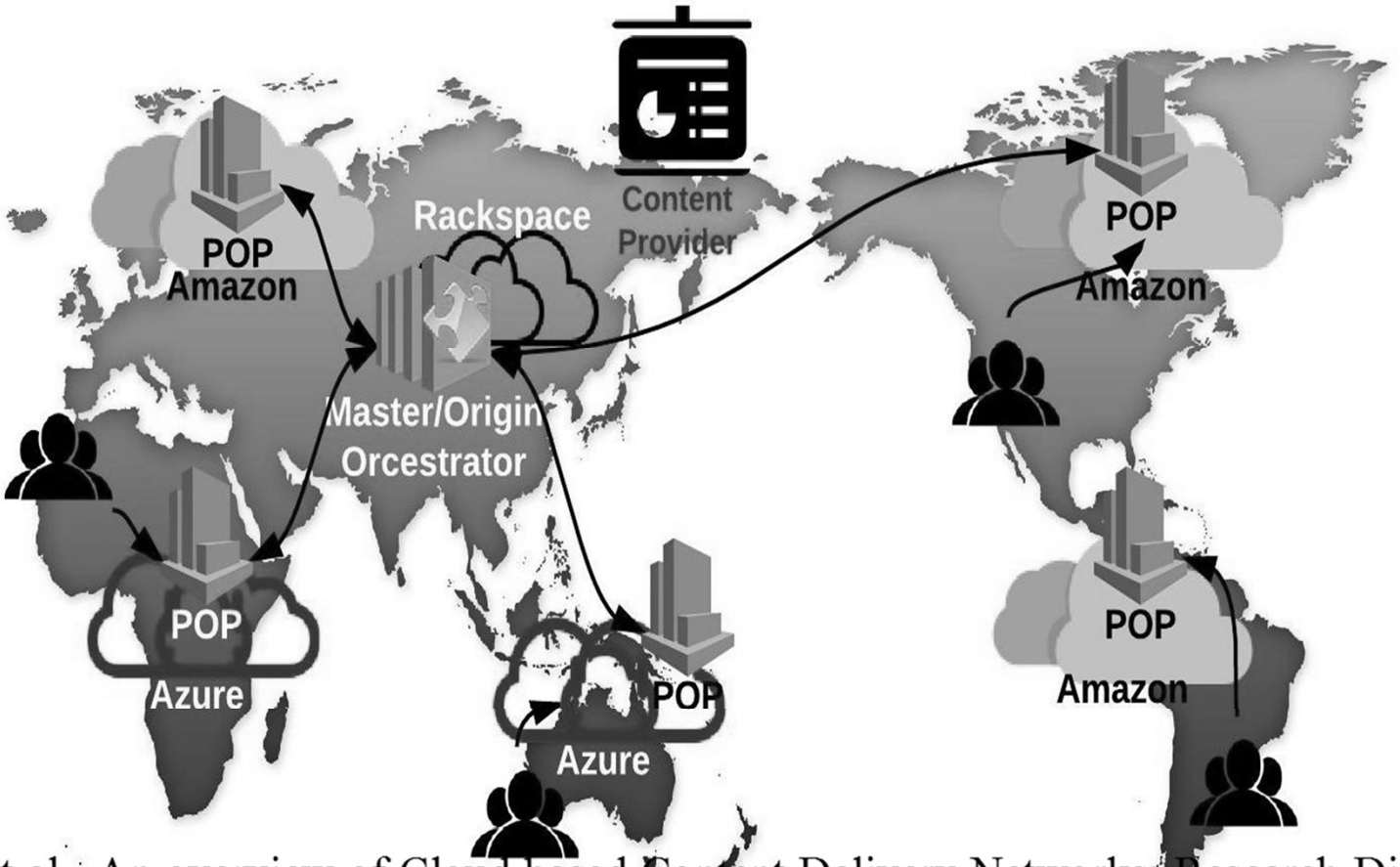
End-user QoS / QoE

- More flexibility in responding to end-user fluctuating demands
- Rapid provisioning of new value added services

Cost:

- Dynamic resource provisioning
- Pay per use

What could Cloud CDN bring?



[1] M. Wang et al., An overview of Cloud based Content Delivery Networks: Research Dimensions and state-of-the-art," Transactions on Large-Scale Data-and Knowledge-Centered Systems, pp. 131-158, 2015.

Cloud CDN
(A few emerging commercial products)

Cloud Based – IoT

Internet of Things: Fundamentals

Definition:

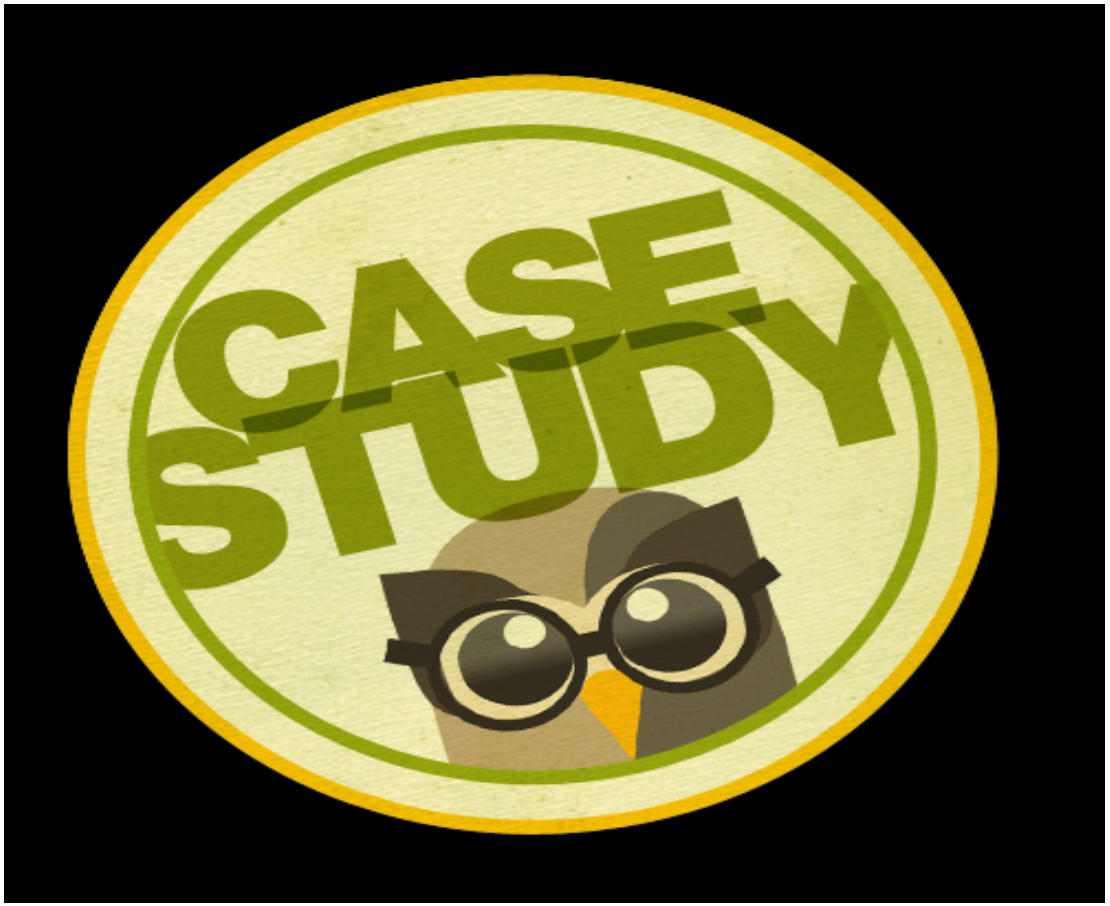
Things that cooperate in order to reach common objectives, e.g.
RFID tags
sensors
Actuators
Robots
Mobile phones

Characteristics

- Battery powered devices
  - Might have to work many years without maintenance
  - Might cover large geographical areas

Applications: General view (Reference 1)

A Case Study on the Integration of IoT and Cloud

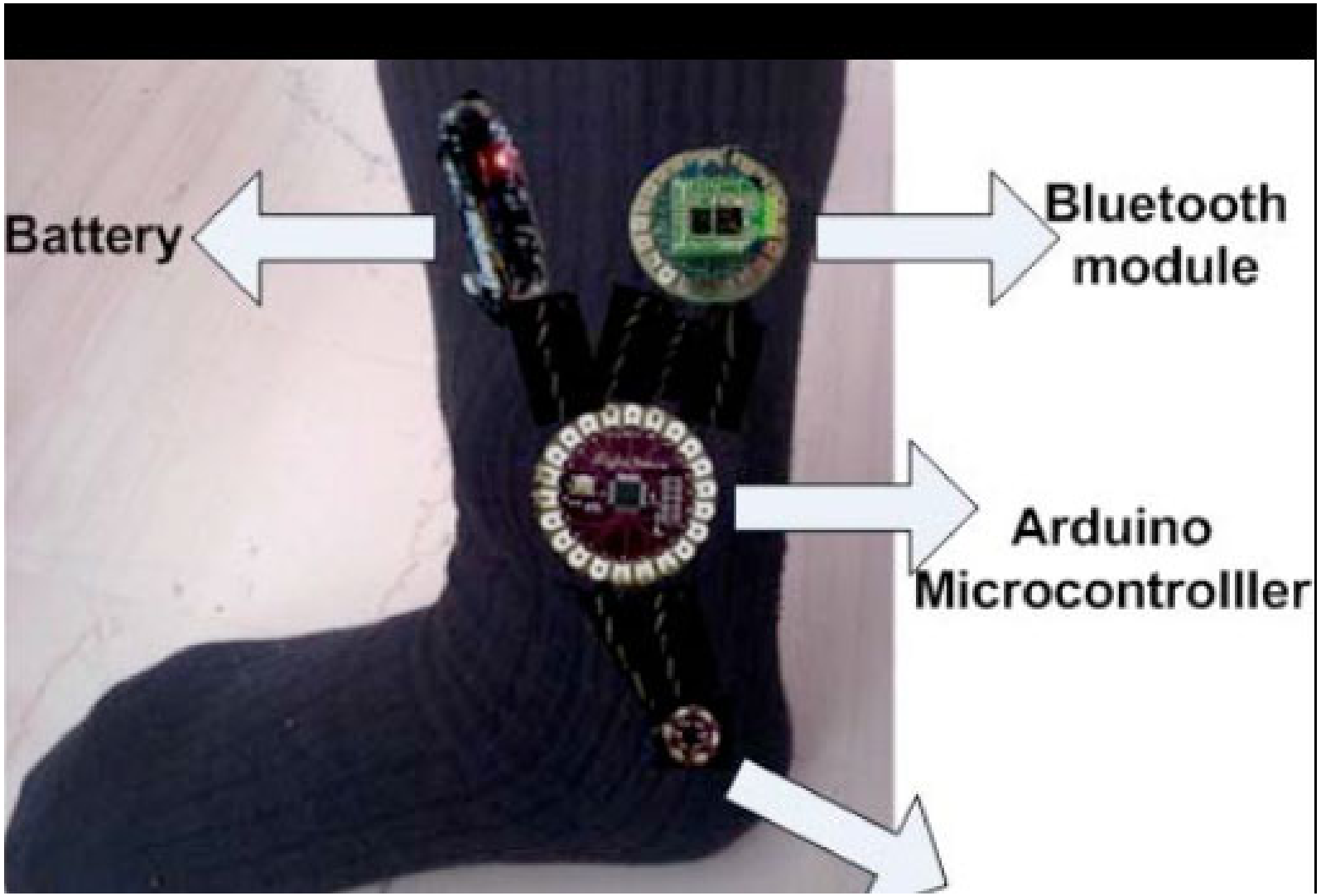


Use of Cloud Processing and Storage Power

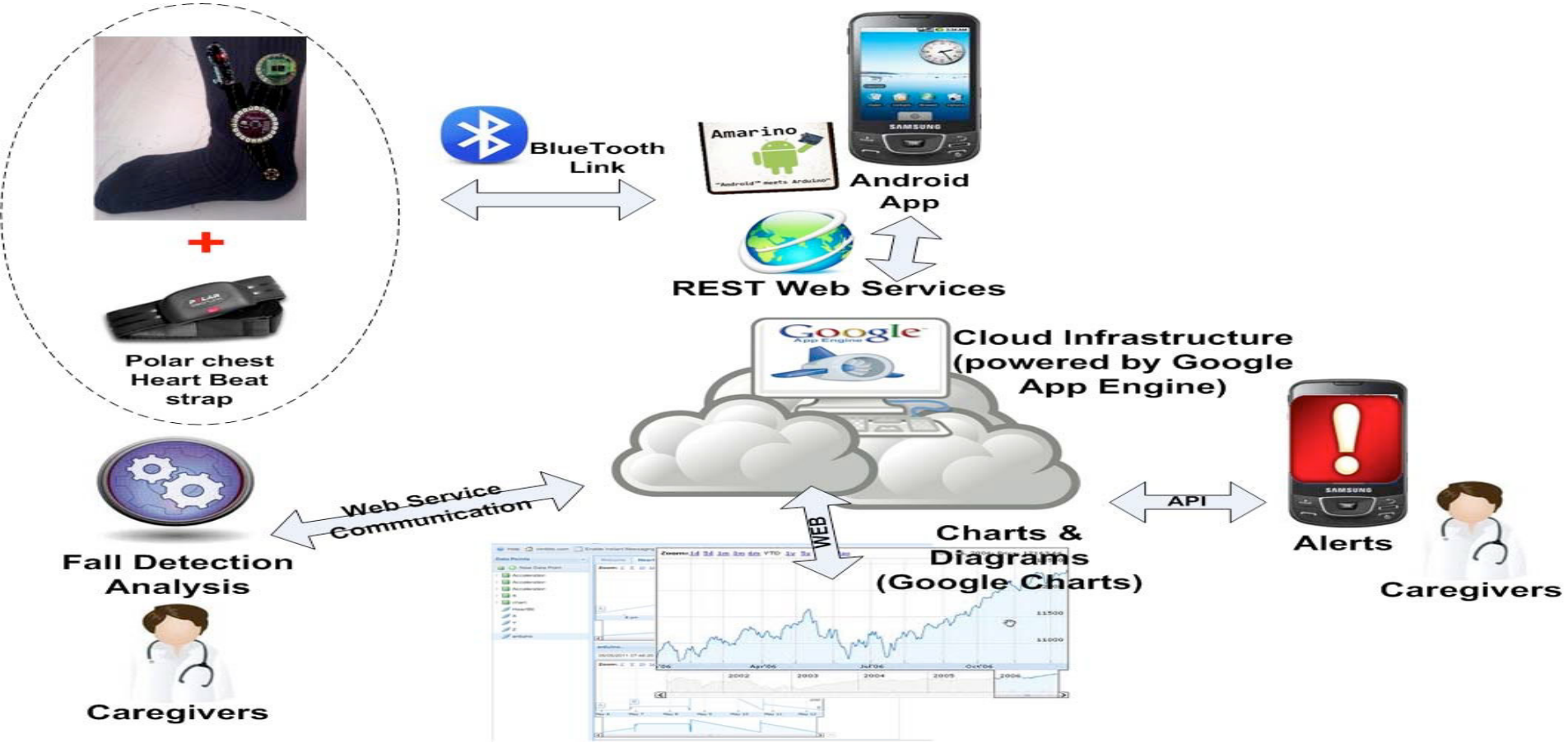
Managing Wearable Data Through Cloud

C. Doukas and I. Maglogiannis, Managing Wearable Sensor Data through Cloud Computing, 2011 Third International Conference on Cloud Computing Technology and Science

Managing Wearable Data Through Cloud



Managing Wearable Data Through Cloud



Managing Wearable Data Through Cloud

The End