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Advanced Distributed Systems

Lecture 01-Introduction to distributed systems from Cloud to Edge

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Agenda

- Distributed systems
- Cloud computing
- Computing continuum

Distributed systems

Introduction to distributed systems

- Distributed systems:
  - Collection of independent computers
  - Capable of collaborating on a task
  - Exchanging messages
  - Appears to its users as a single coherent system
  - Interconnected via a network
  - Distributed logically and physically

Distributed systems features

- No common physical clock
- Enhanced fault tolerance
- Increased performance
- Reducing the cost
- Resource sharing
- Access to geographically remote data and resources
- Scalability
- Transparency
- Heterogeneity

Cloud computing

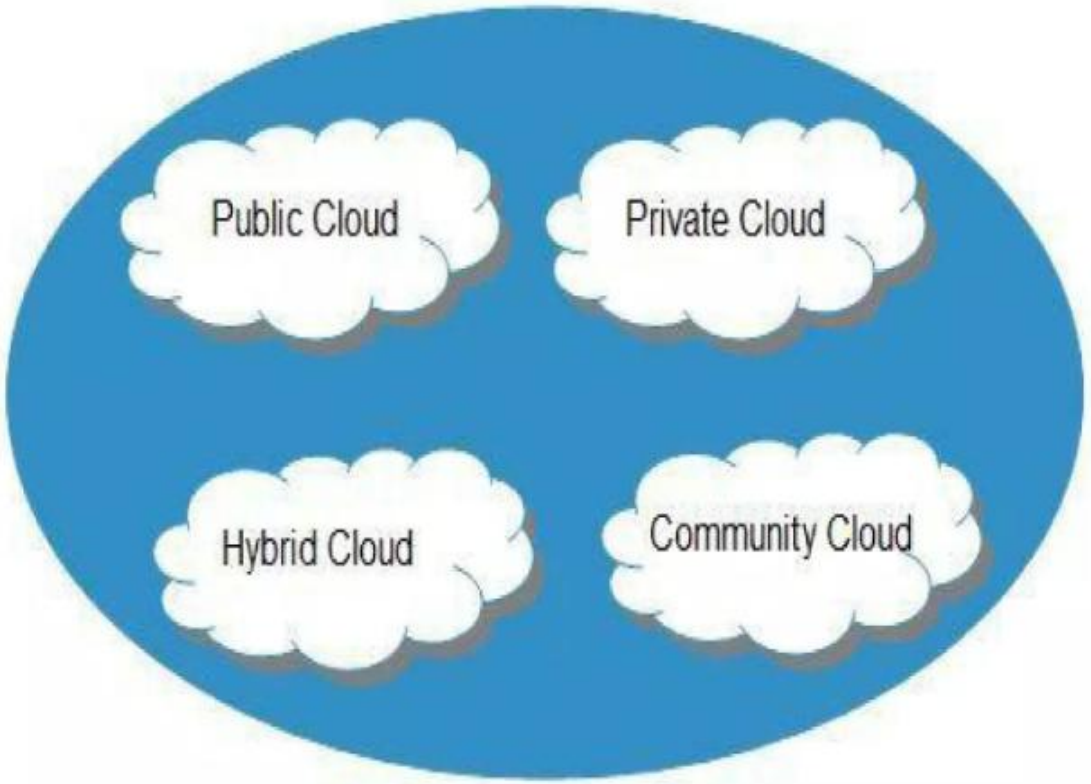
Cloud computing

- Cloud computing provides on-demand access to shared pool of computing resources over the internet.
- Cloud computing refers to manipulating, configuring, and accessing the services online.
- Cloud computing offers online data storage, infrastructure and application.
- Cloud computing is a combination of software and hardware based computing services delivered as a network service.

Cloud computing

- Cloud computing is feasible and accessible through two working model:
  - Deployment models
  - Service models

Deployment model



Deployment models

- **Public Cloud:** allows systems and services to be easily accessible to the general public. Public cloud may be less secure because of its openness.
- **Private Cloud:** allows systems and services to be accessible within an organization.
- **Hybrid Cloud:** is mixture of public and private cloud. The criterial activities are performed using private cloud while the non-critical activities are performed using public cloud.
- **Community cloud:** allows systems and services to be accessible by group of organizations.

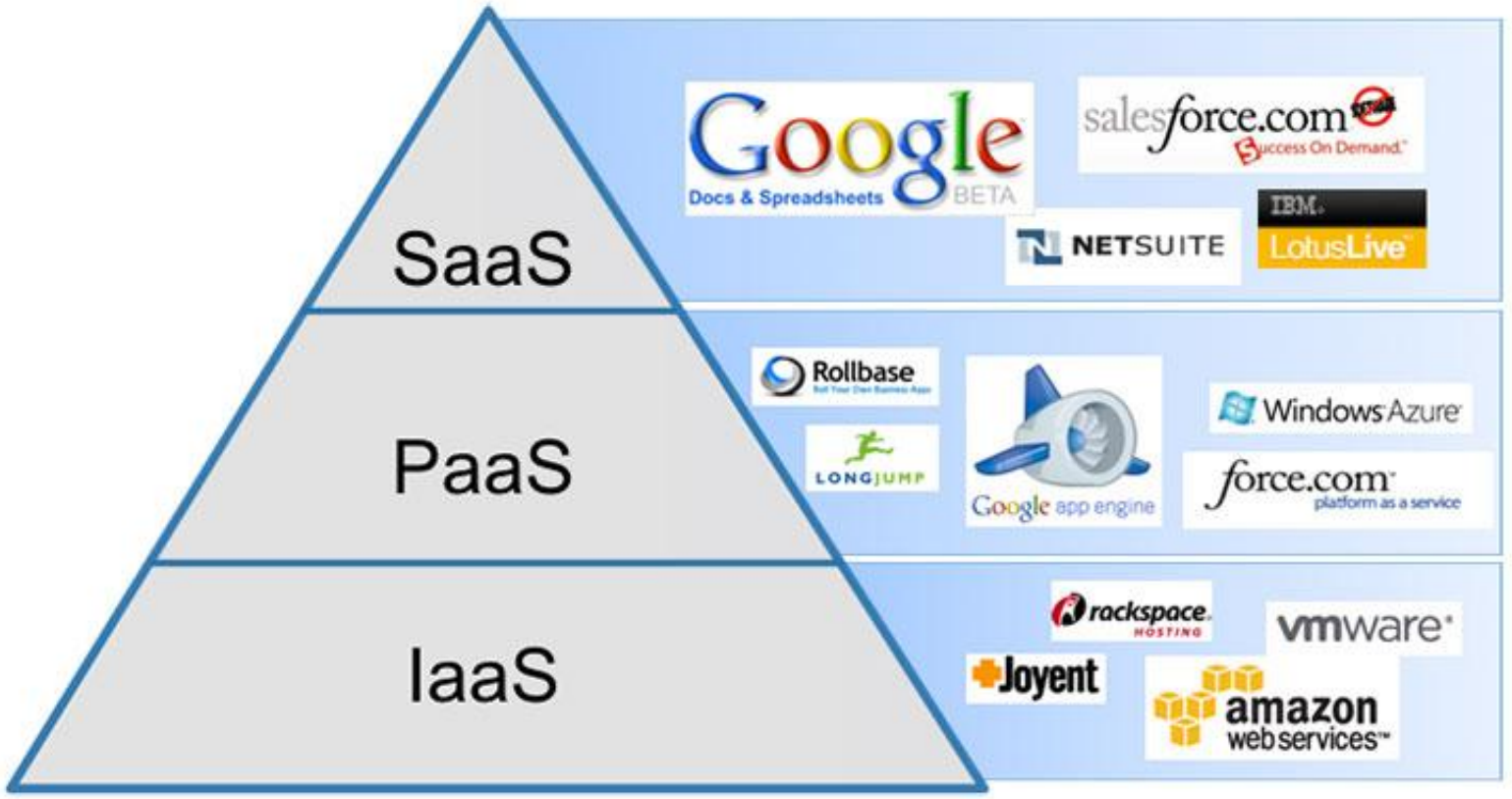
Service models

- Service models are categorized into three basic service models:
- Infrastructure as a service (IaaS): provides access to fundamental resources such as physical machines, virtual machines, virtual storage, etc.

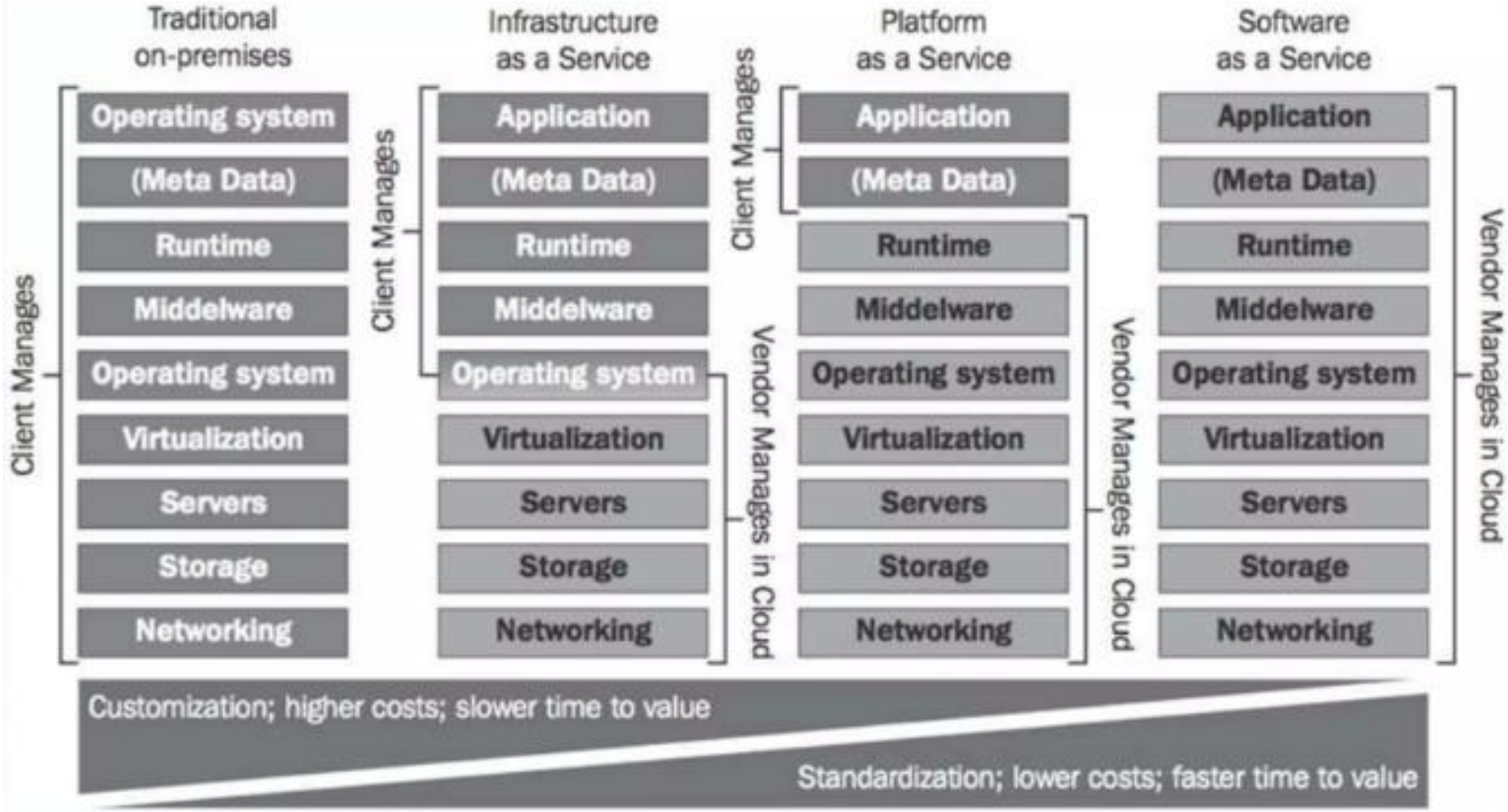
- Platform as a service (PaaS): provides all facilities required to build and deliver web applications and services entirely from internet.

- Software as a service (SaaS): provides licensed multi-tenant to software and its functions remotely as a web-based service.

Service models



Service models



Cloud computing advantages

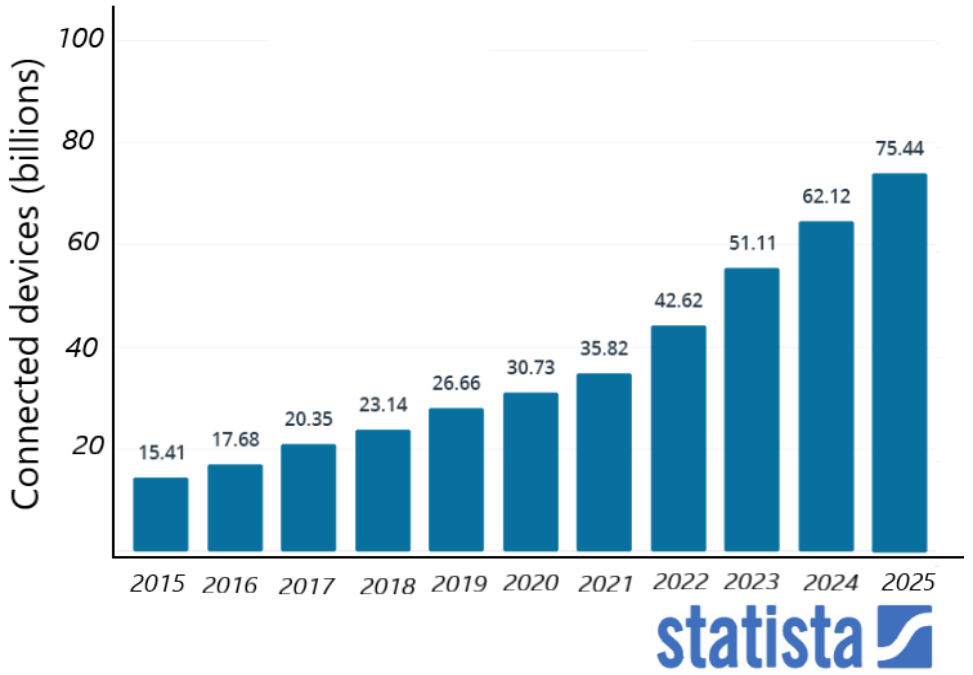
- Lower computer cost
- Improved performance
- Instant software updates
- Improved document format compatibility
- Unlimited storage capacity
- Increased data reliability
- Universal document access
- Latest version availability
- Devices independence

Cloud computing disadvantages

- Requires a constant internet connection
- Does not work well with low-speed connection
- Features might be limited
- Stored data can be lost
- Stored data might not be secure

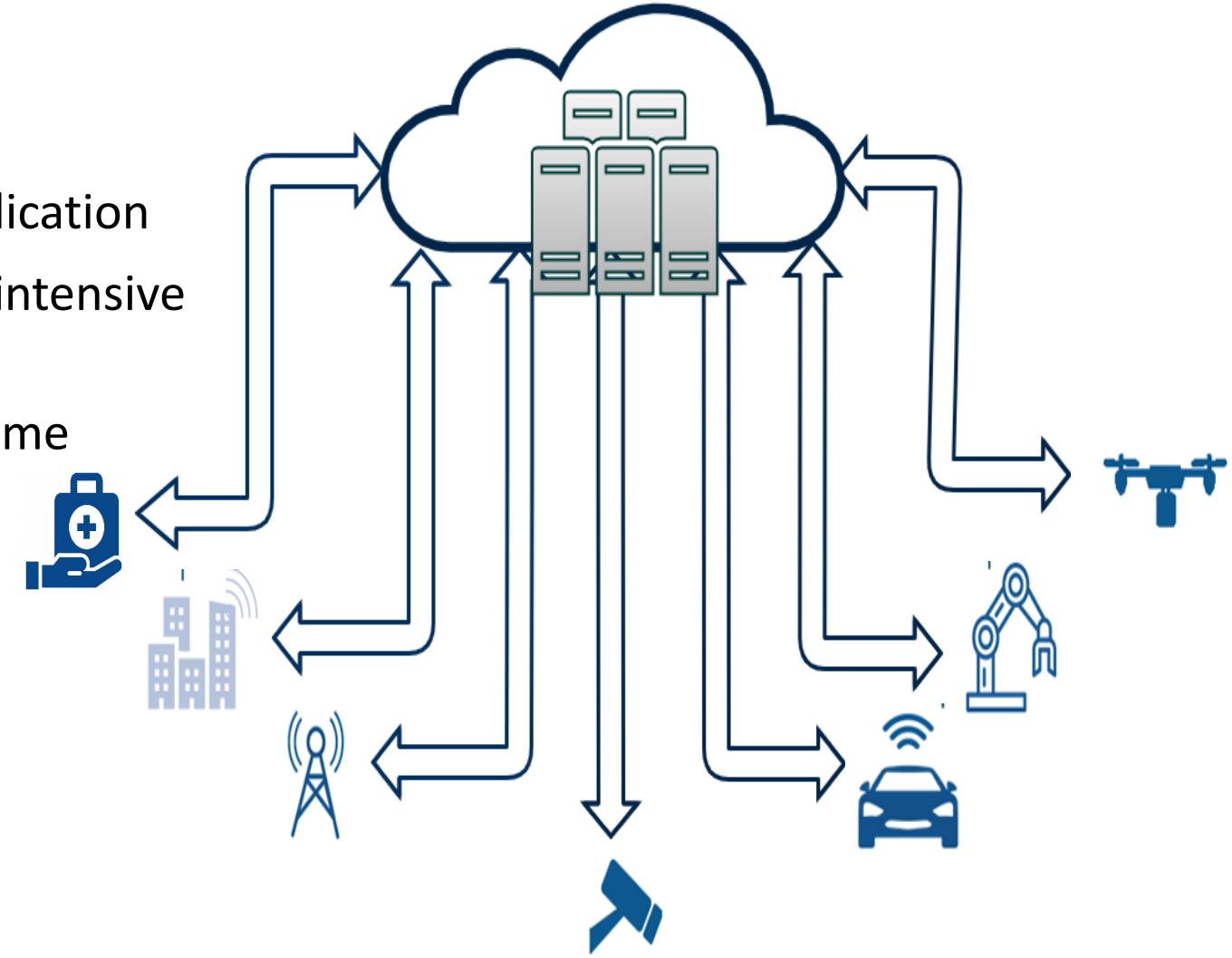
Cloud computing challenges

- Increasing number of IoT devices
- Increasing demand for time-critical application
- Dominating latency and bandwidth intensive services
- Processing data streams in nearly real time



Cloud computing challenges

- Increasing number of IoT devices
- Increasing demand for time-critical application
- Dominating latency and bandwidth intensive services
- Processing data streams in nearly real time
- Cloud computing limitations
  - Located further from end user
  - High communication latency
  - Centralized
  - High operating expenses
  - Low security

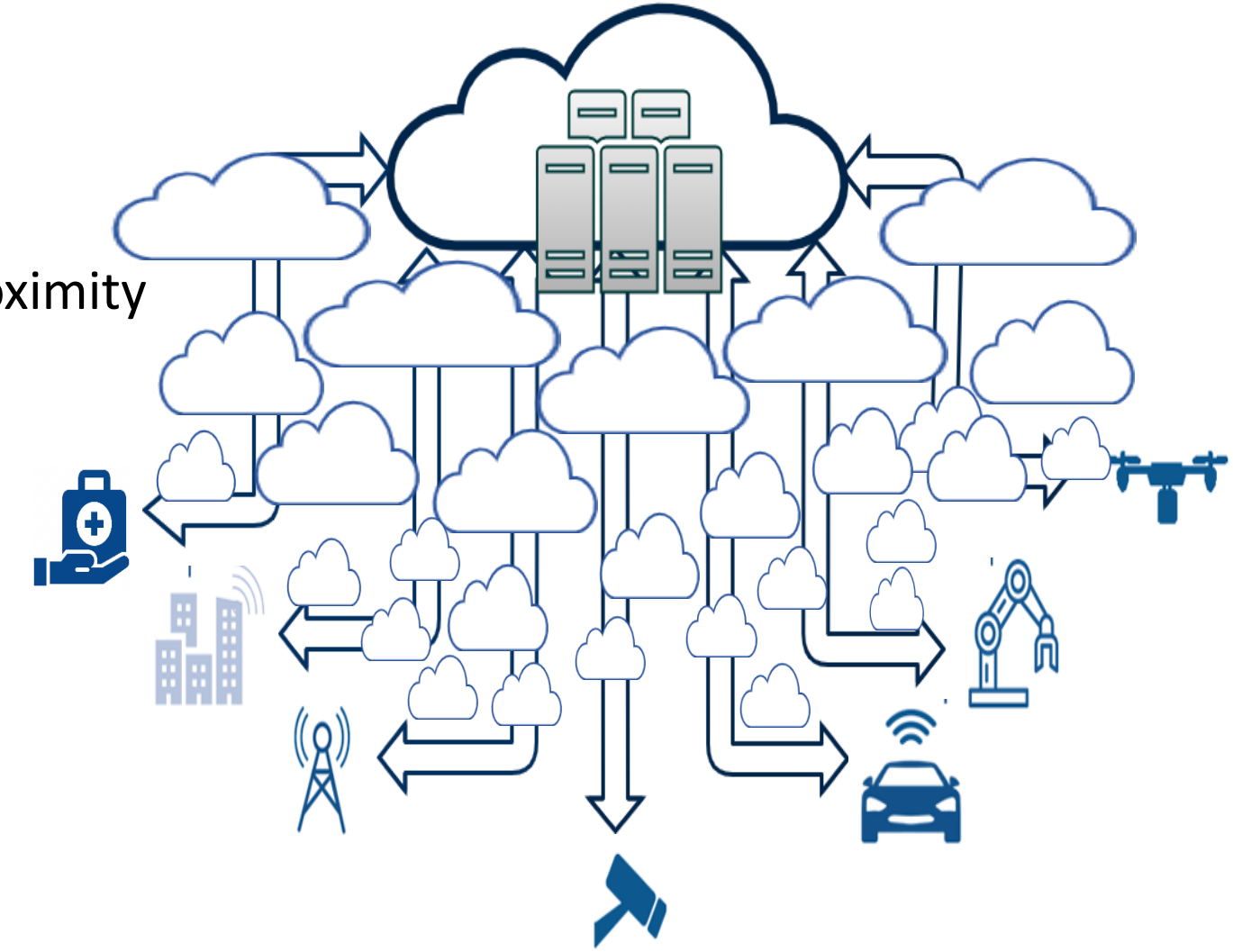


Computing continuum

Computing continuum

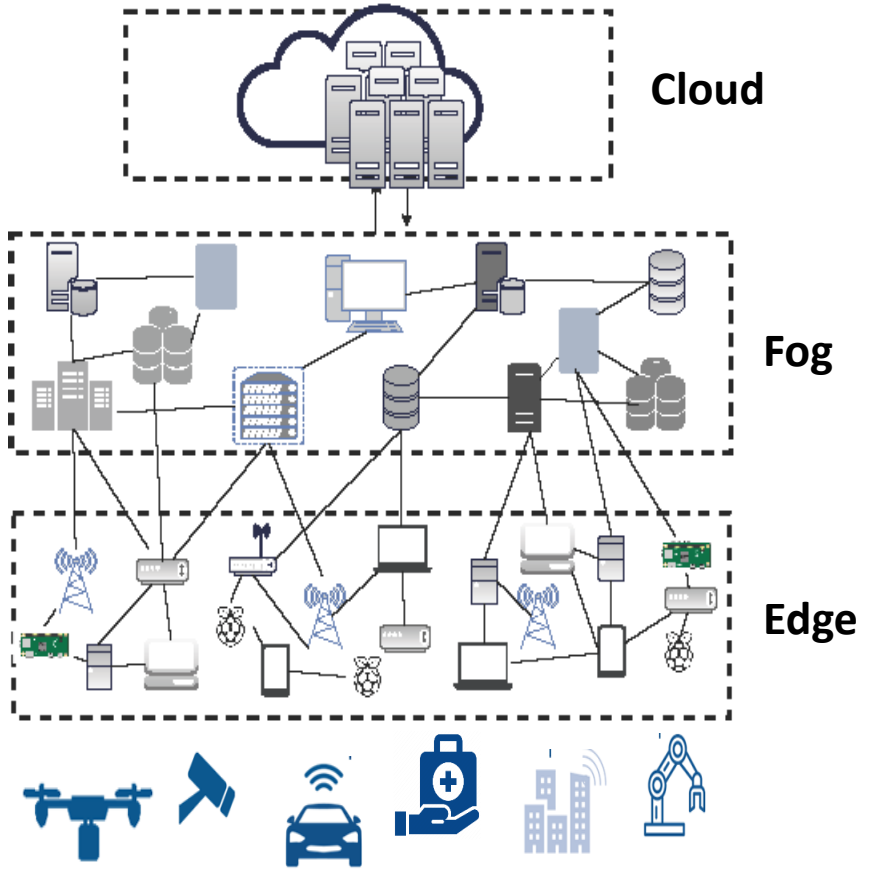
- Extension of the cloud:
  - Providing compute, storage and application services in users' proximity

- Computing continuum:
  - Wide distribution
  - Low communication latency
  - Support for users' mobility
  - Real time interaction



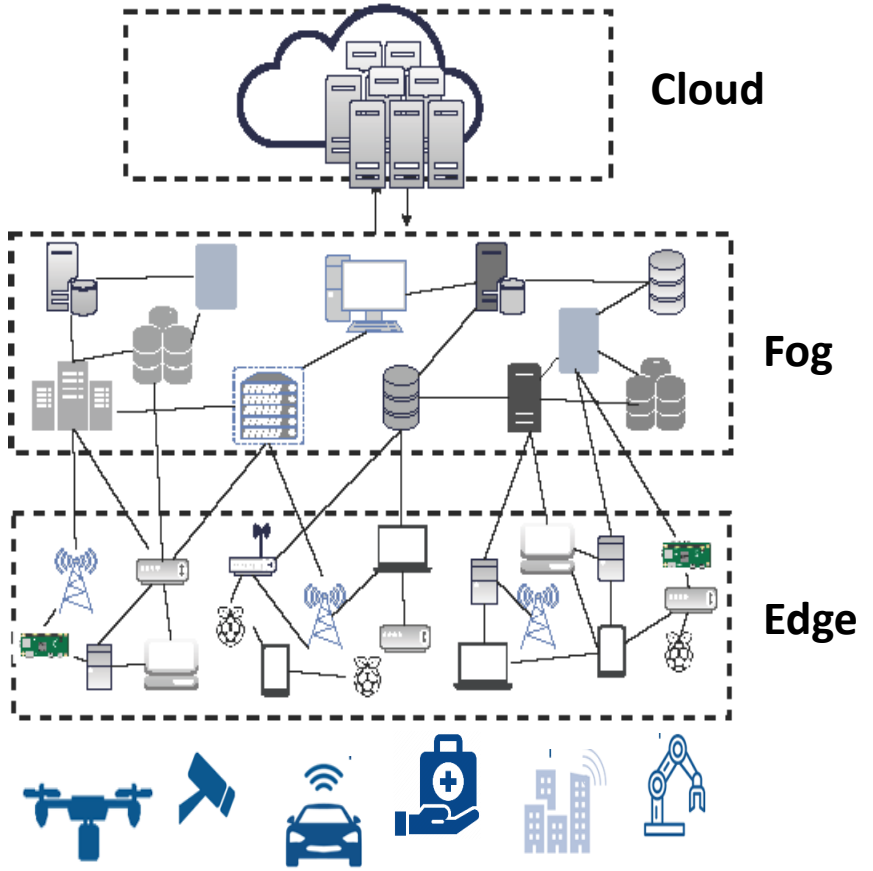
Computing continuum

- **Cloud computing:** the highest level of the computing continuum, containing many high-performance resources with high latency and low bandwidth, which presents a significant disadvantage for time-critical applications.
- **Fog computing:** the computational and storage resources consolidated in small data centers between the cloud and Edge. Fog resources are located farther from end-users with higher latency compared to the Edge but closer with lower latency than Cloud data centers.
- **Edge computing:** nearby devices locating between the Fog and the end-users. The Edge resources are directly connected to the end-users and provide low latency suitable for time-critical applications.



Computing continuum

Characteristic	*Cloud*	*Fog*	*Edge*
Latency	high	low	very low
Bandwidth	low	high	very high
User location	multiple hops	few hops	one hop
Computation capability	very high	high	low
Architecture	centralized	distributed	decentralized
Devices	thousands	millions	billions
Mobility	low	high	very high



Computing continuum challenges

- Heterogeneous environment
- Limited computing capacities
- Owned by different providers
- Diverse application requirements
- Intense time-critical application requests
- Connection over the complex network
- Dynamic changes in the network

References

- Van Steen, M., & **Tanenbaum**, A. (2002). Distributed Systems Principles and Paradigms. Network, 2, 28. A digital personalized copy is available here: https://www.distributed-systems.net/index.php/books/ds3/

- Hwang, Kai, Jack Dongarra, and Geoffrey C. Fox (2013). *Distributed and cloud computing: from parallel processing to the internet of things*. Morgan kaufmann.

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Thank you for your attention☺

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