Internet of Things Introduction (CSC8112)

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Chair in Internet of Things

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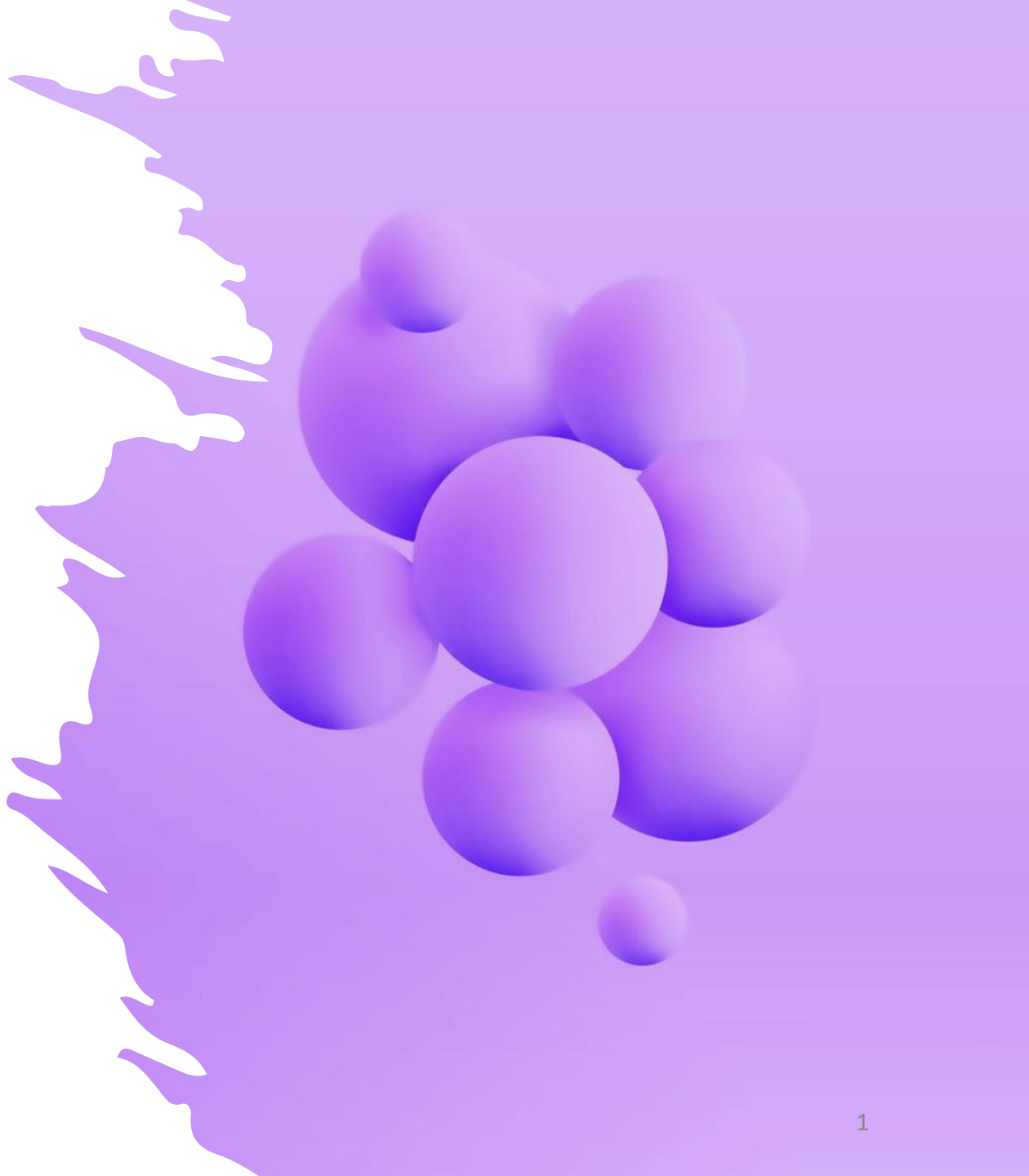


Why should we know about IoT?

Emerging technology

Growing IoT Services and Applications in various areas including **smart cities**, **healthcare**, **transport**, **logistics**, **retail**, and **safety** and **security.**

Business trends and new opportunities

What is IoT?

"The Internet of Things (IoT) refers to distributed systems that involve computation, sensing, communication, and actuation. IoT involves the connection between humans, non-human physical objects, and cyber objects, enabling monitoring, automation, and decision making."

– National Institute of Standards and Technology (as presented in Special Publication (SP[Ŧ]) 800-183)

"A network of items—each embedded with sensors—which are connected to the Internet."

– IEEE[ϕ]

Smart Refrigerator
www.samsung.com

The Internet of Things is composed of Smart Objects (SO) Or Internet Connected Objects (ICO)

Smart Objects: *abstract* vision

Objects that are able to **sense** the environment, **interpret** the environment, **self-configure**, **interact** with other objects and exchange information with people.

The Internet of Things is composed of Smart Objects (SO) Or Internet Connected Objects (ICO)

Smart Objects: *implementation* vision

- Objects have **communication** capabilities
- Objects have **storage** capabilities
- Objects have **unique** ID
- Objects can be **addressable** on Internet (URI/IP)

Example 1: Fitness tracker/smart watch

- Pure Pulse heart rate tracking.
- Tracks activities throughout the day such as
  - Footsteps, distance, floors climbed, active minutes, workouts, and calories burned
  - Tracks sedentary time.
- Also, helps in automatic monitoring of sleep and GPS tracking.

Watch image from: https://www.apple.com

Example 2: Smart footwear

- False-seated shoes can lead to
  - Pain, balance problems, unsteady state.
- Smart Shoes with embedded sensors collect data to
  - Analyse posture, Calories, fatigue, steps
  - Prevent injury.

Eat your heart out, Marty McFly! Futuristic $450 sneakers tighten automatically, warm your feet and are controlled by an app

- **Digitsole unveiled the futuristic 'Smartshoe' at CES in Las Vegas**
- **Design includes heater and sensors in the sole, controlled by an app**
- **Also comes with self-fastening mechanism like in Back to the Future**
- **Shoes will cost $450 (£307) but two less outlandish shoes were also shown**

By SARAH GRIFFITHS FOR MAILONLINE
PUBLISHED: 15:19, 5 January 2016 | **UPDATED:** 15:39, 5 January 2016

If you have always wanted a pair of Marty McFly's self-lacing sneakers, the wait is almost over.

Digitsole has unveiled a futuristic-looking pair of trainers that automatically tighten, as well as heat the feet.

Described as 'the world's first intelligent footwear,' the futuristic Smartshoe wouldn't look out of place in Back to the Future and it can also count calories and distance travelled too.

https://www.dailymail.co.uk/sciencetech/article-3385436/Eat-heart-Marty-McFly-Futuristic-sneakers-self-tying-laces-heat-controlled-phone.html

Smart Hospital

Fundamental concepts of IoT

Smart world of IoT **applications**

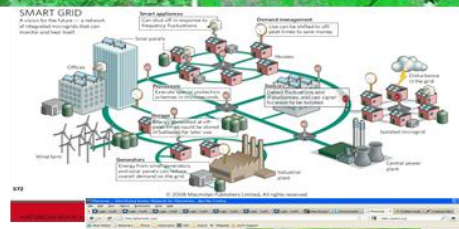
§Ranjan et al., 2018

IoT landscape

Environmental Sensors

Smart Meters

Water Management



Smart Grids

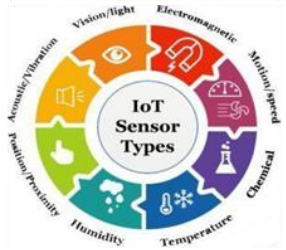
Smart Agriculture

Software as a Service

Cloud computing

Software Defined Networking

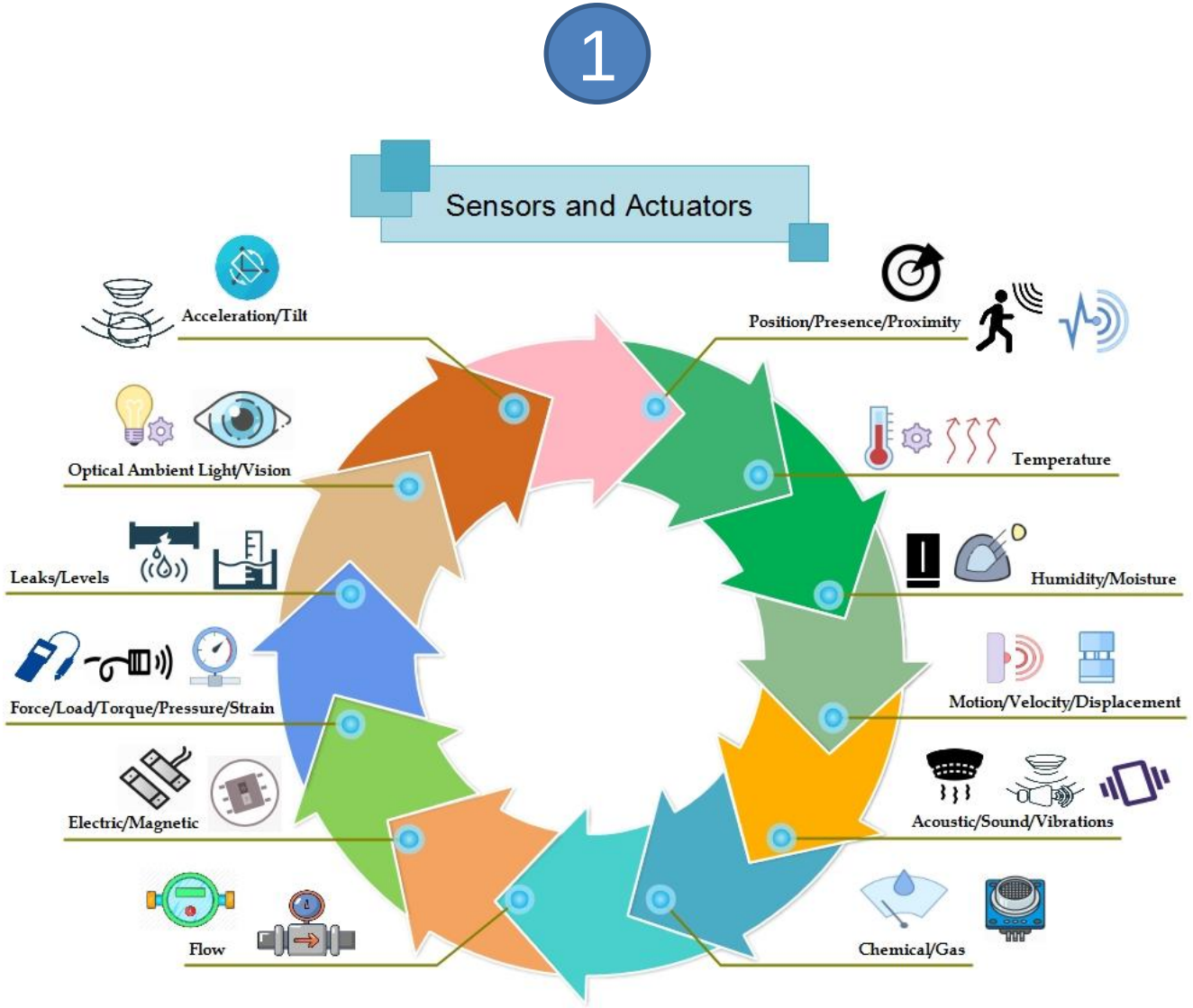
Edge Computing



Sensing and Actuating

Building blocks: IoT sensors and actuators

- Sensor
  - A device which measures or detects parameters related to a physical object and/or a human being
  - Records, stores, and in most cases, transfers to sensed data upstream cloud services for processing.
- Actuator
  - Takes corrective actions in response to external ‘stimuli’
  - Such ‘stimuli’ are often sent by sensors.



IoT Sensors: Microcontroller

- Small programmable device
- Support diverse connectivity protocols

Building blocks: Connectivity

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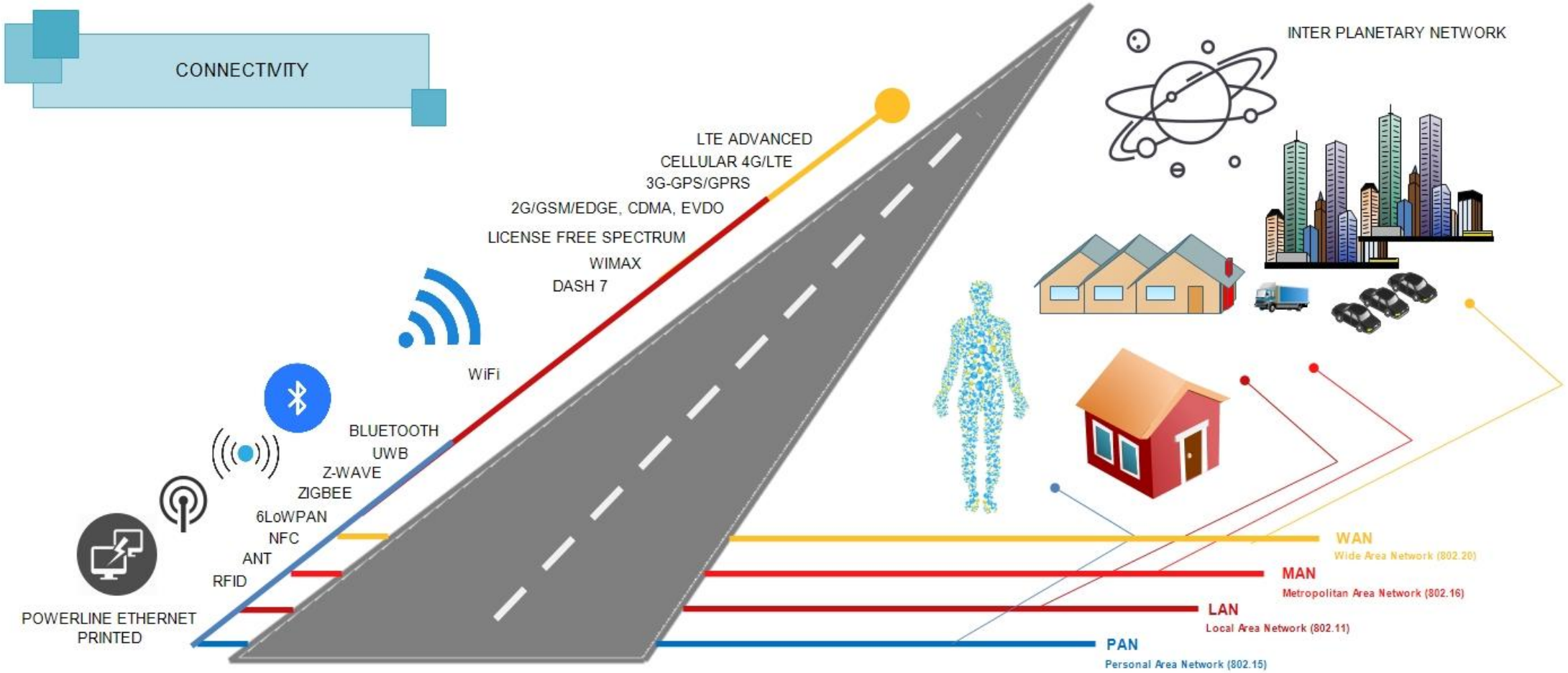


IoT Gateways

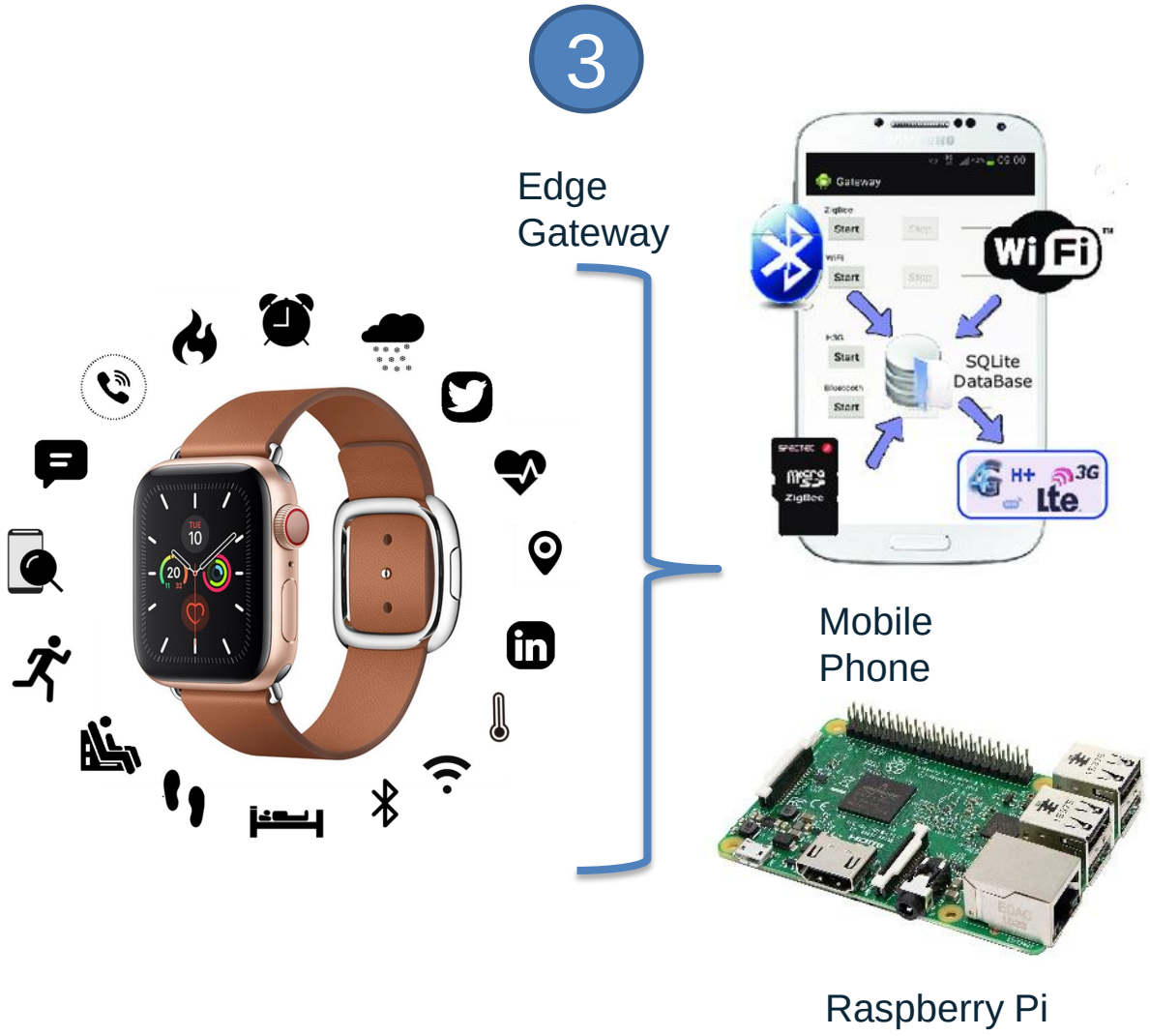
Network and Internet

IoT gateway

- Gather data from sensors
- Gateway protocols
  - 6LoPAN
  - LoRaWAN
  - BLE
- Internet protocol
  - CoAP
  - MQTT
  - HTTP
  - XMPP

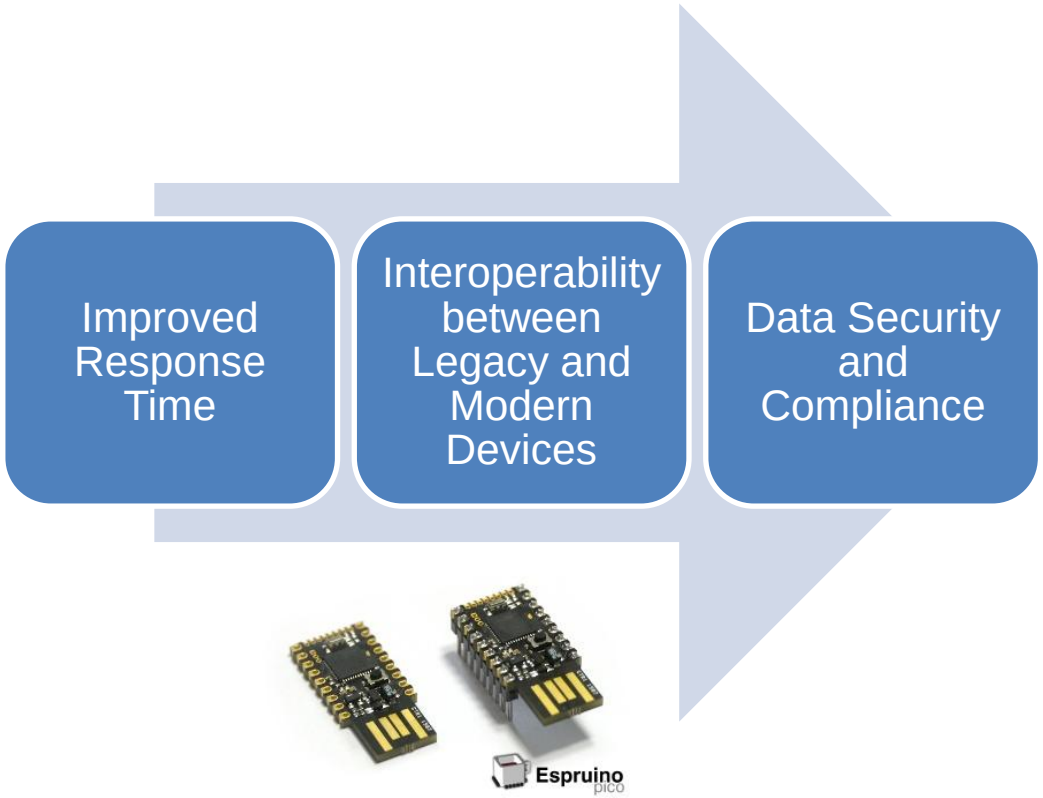
Is a physical device or virtual platform that connects sensors and smart devices to the cloud. Gateways serve as a wireless access portal to give IoT devices access to the Internet

Building blocks: Edge Computing



- Edge Computing (EC) offers computing and storage on a smaller scale than Cloud Computing (CC)
- Positioned closer to data sources or sinks, can provide more immediate analysis of streaming data, and can better support real-time decision making in latency-sensitive workflows,
- ECs could include edge devices such as smart gateways (e.g. Raspberry Pi 3, UDOO board, esp8266), software defined network solutions (e.g. Cisco IOx, Huawei CloudEngine 6800) or smart devices (e.g. smart phones with sensors).

Building blocks: Edge Computing benefits

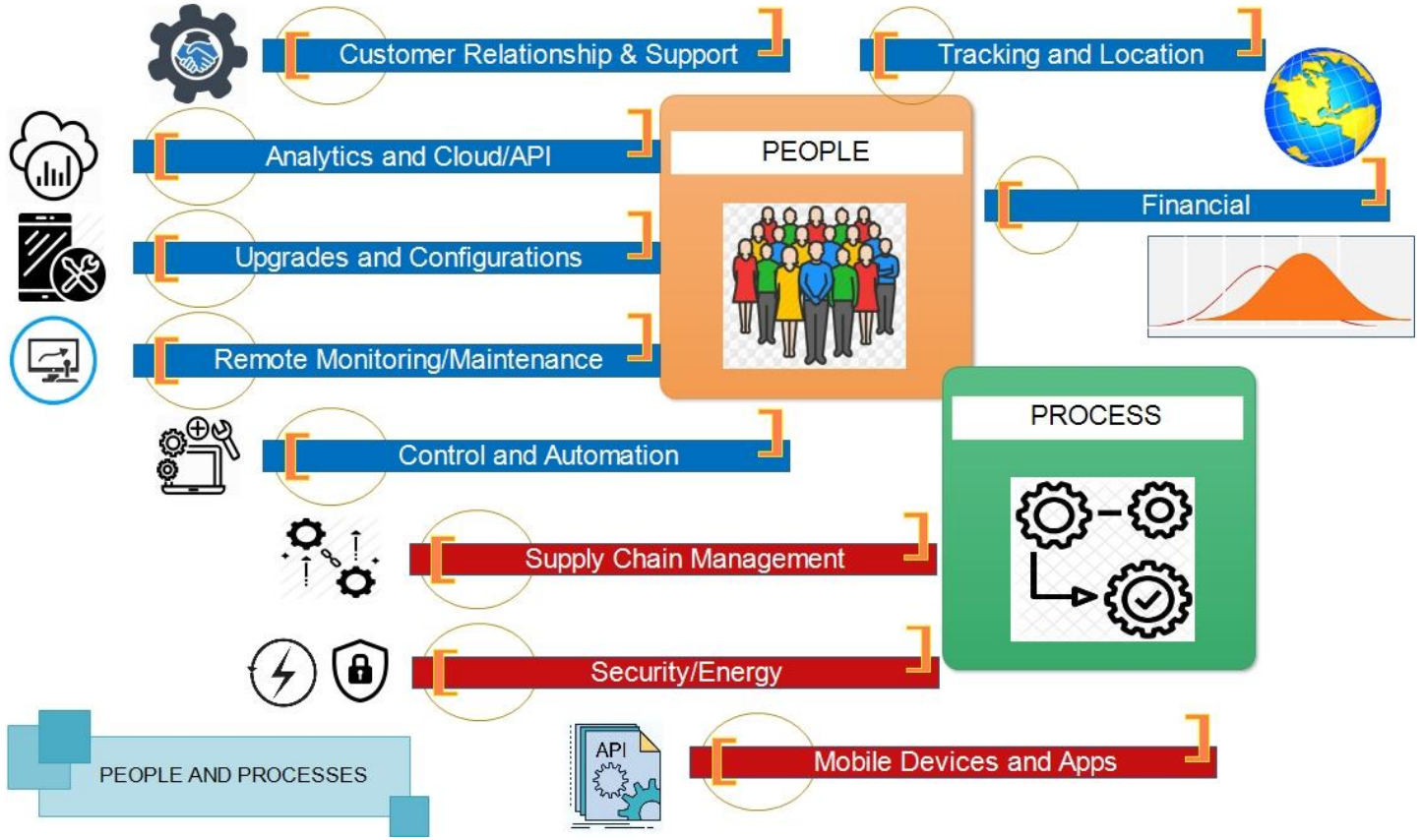


- **Energy saving** for the resource constrained edge devices which, currently, primarily upload data to the CC.
- **Reduced network congestion** achieved by filtering non-relevant events at the edge.
- **Reduction in event detection latency** (e.g. high blood sugar, fall) as sensors no longer need to send data to far off CCs.
- Aids data **security and compliance**.

Building blocks: Human in the loop

4

- User-centric design
  - Identify and define requirements before selecting appropriate technology stack.
  - Adopt a people-centred philosophy that identifies needs, drivers, and motivators, how the staff operates as a team, and what it is that produces success.
  - Focus should be on people who are going to interact with the IoT-based system rather than technology.



Building blocks: Cloud Computing

5

- Giant server warehouse filled with:
  - Racks of servers
  - Storage arrays
  - Cooling infrastructure
  - Power converters
  - Backup generators
  - Network infrastructure
  - Security devices

Cloud Datacenter

From: https://commons.wikimedia.org/wiki/File:123Net_Data_Center_(DC2).jpg

Building blocks: Cloud computing

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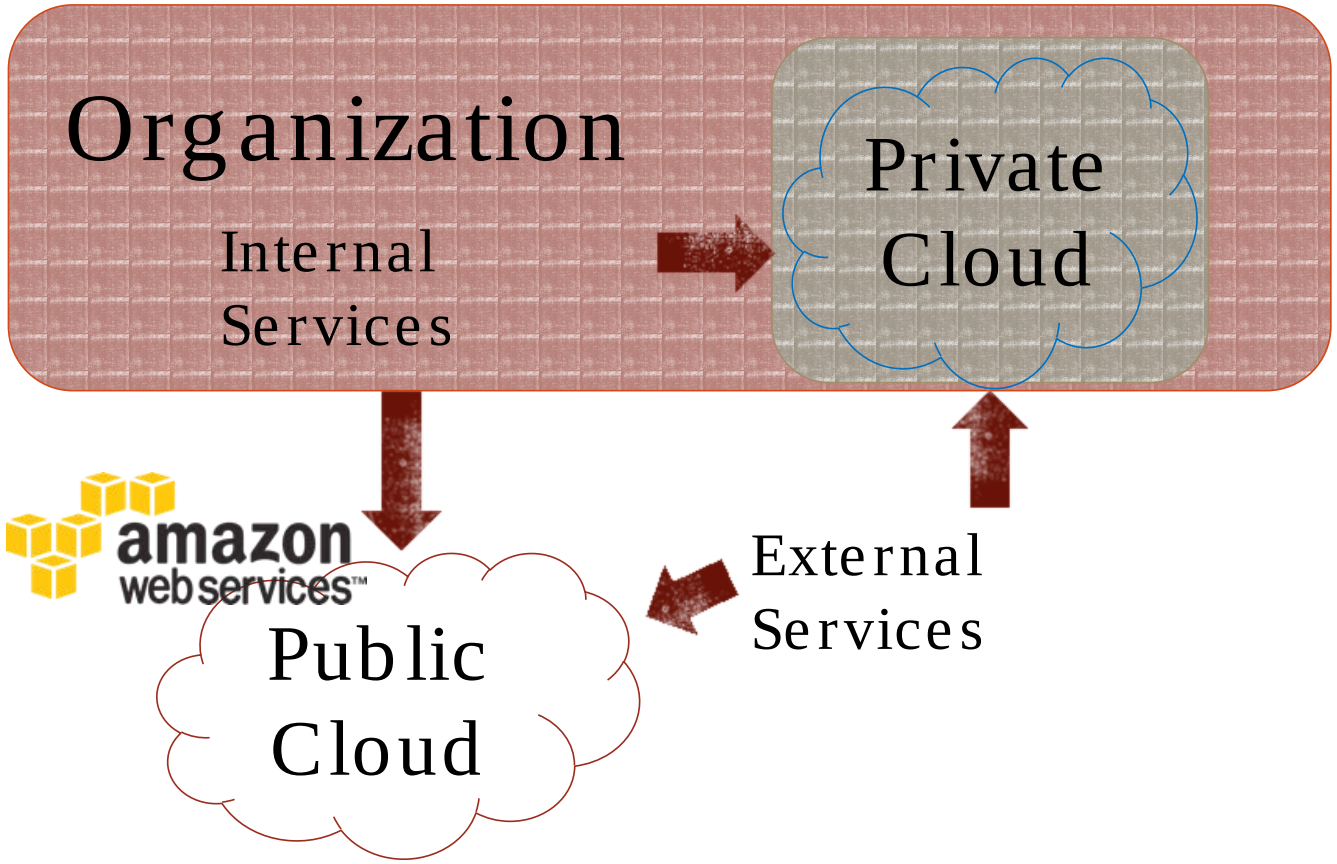
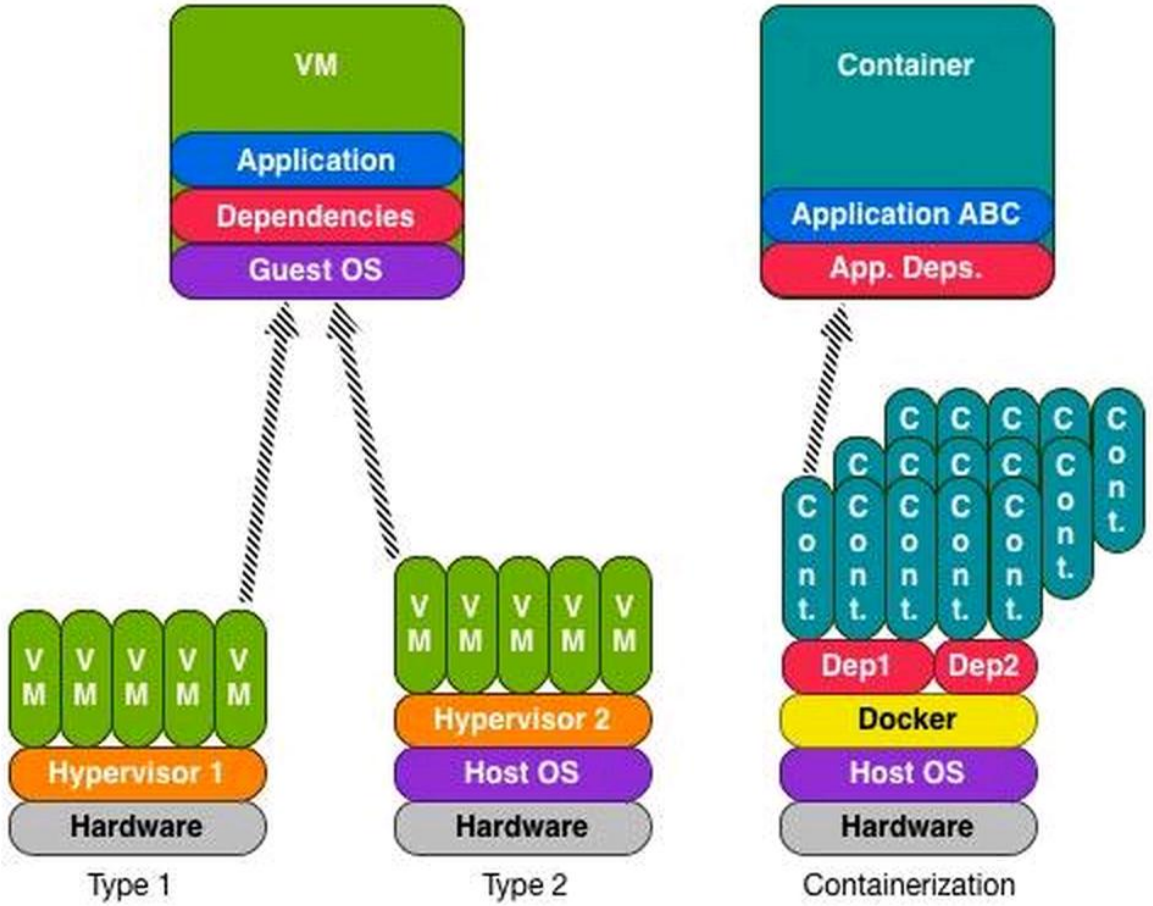


- Private cloud
  - one organization (but may be managed by a third party)
  - highly secure, on demand self-service
- Public cloud
  - available pretty much to all
  - in theory, less secure
  - pay as you go, on-demand self-service
- Hybrid cloud
  - a combination of the above
  - inherits the best of both worlds!!

Osmotic Building Blocks: Containerized Docker-based IoT Microservices

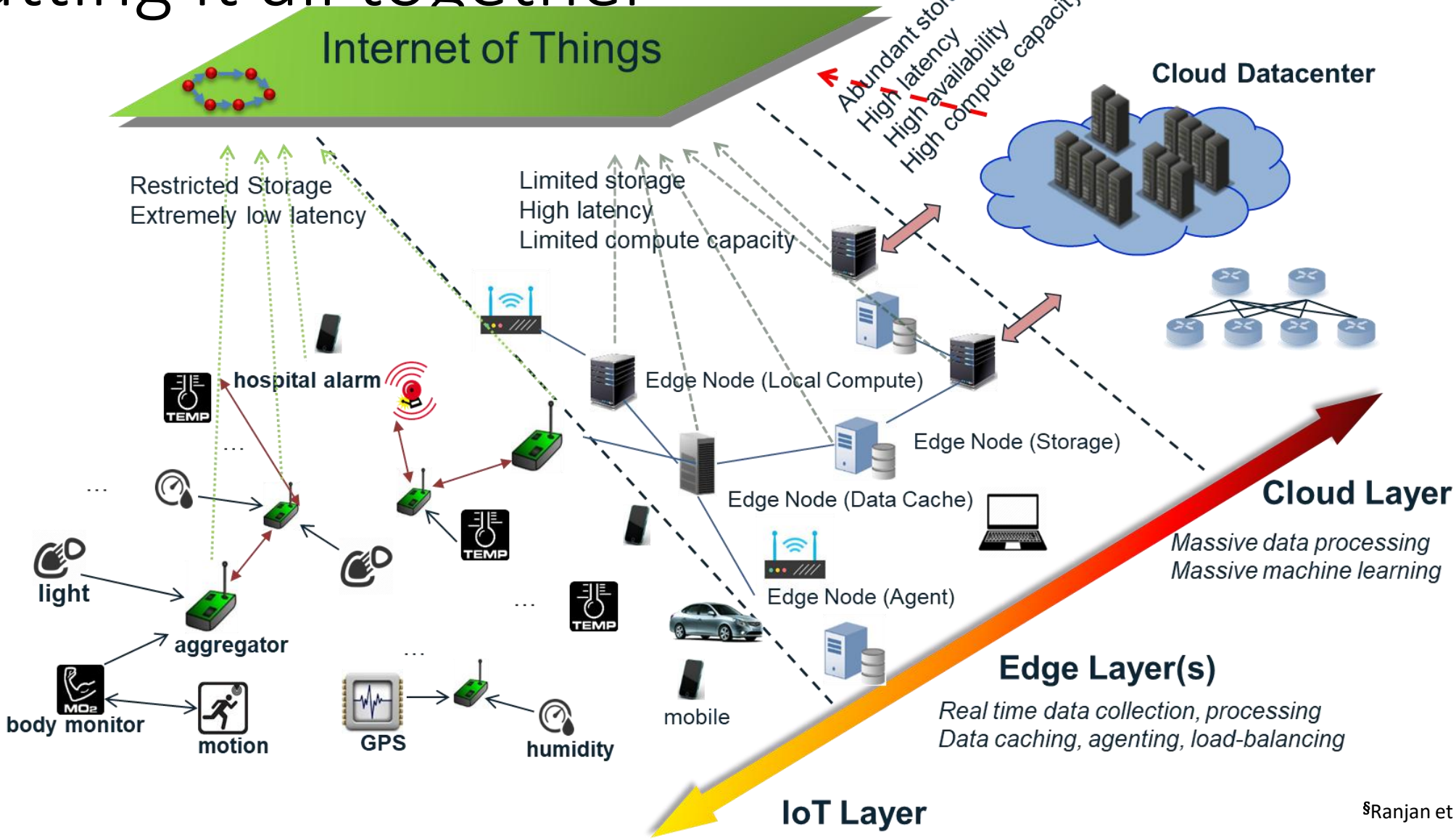
- **Division of functionality in to multiple components**
- **Easy to manage and upgrade**
- **Lightweight**
- **Improved performance**



Virtual Machines **Containers**

- **Export and import containers**
- **Container image migration**
- **Save and load images**
- **Migrate data volumes**
- **Move entire Docker containers**

Putting it all together



§Ranjan et al., 2018

Technical Barriers for Adopting IoT in Healthcare

- **IoT Devices and Data Security:**
  - Lack of security standard of smart devices and their vulnerabilities, Denial of Service (DoS) attacks, etc., loss/manipulation of IoT users data by actors (e.g., untrusted cloud providers) …
- **IoT Networking and Age of Information**
  - Measuring the freshness of data and updates. E.g., it is large if the IoT devices are deployed to sense temperature or humidity, whereas it may be very small for human safety applications.
- **Data Analytics (Big data)**
  - **Variety** of date: images, videos, plain text etc.; **Velocity**: historical (patient records) and real-time; **Volume** of data
- **Data Integration**
  - How to compose the services published by smart devices for realizing a user specification?
- **Data Governance and Compliance**
  - Checking the compliance of IoT actors (administrators, full nodes, and providers) with GDPR, etc.

References and further reading

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