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Compute Continuum Tutorial

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Intended Learning Outcomes

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1. Describe the compute continuum concept and selected application areas
2. Analyse challenges of a compute continuum architectures and its components
3. Implement a simple workflow using containers deployed on cloud and edge nodes

Agenda

13:30 - 13:55	Compute continuum and 1-2 use cases
13:55 - 14:15	Introduction to key technologies I: Containers and container orchestration systems
14:15 - 15:00	Hands-on I: Container building and deployment in homogeneous environments
15:00 - 15:30	*Break*
15:30 - 15:35	Introduction to key technologies II: KubeEdge
15:35 - 16:00	Hands-on II: Container building and deployment in heterogeneous environments
16:00 - 16:10	Introduction to key technologies III: Prometheus
16:10 - 16:45	Hands-on III: Workflow implementation based on prepared components
16:45 - 17:00	Wrap-up

Compute Continuum: Definitions and Terminology

- Definition of **Compute Continuum** used here: [S. Moreschini et al., 2022]

  A continuum of resources available from the Edge until Cloud/HPC data centres

  - Resources = compute, storage, network
- **Cloud computing** [NIST SP 800-145, 2011]
  - NIST: “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.”
  - Essential characteristics
    - On-demand self-service
    - Broad network access
    - Resource pooling = centralised data centres
    - Rapid elasticity

Compute Continuum: Definitions and Terminology (cont.)

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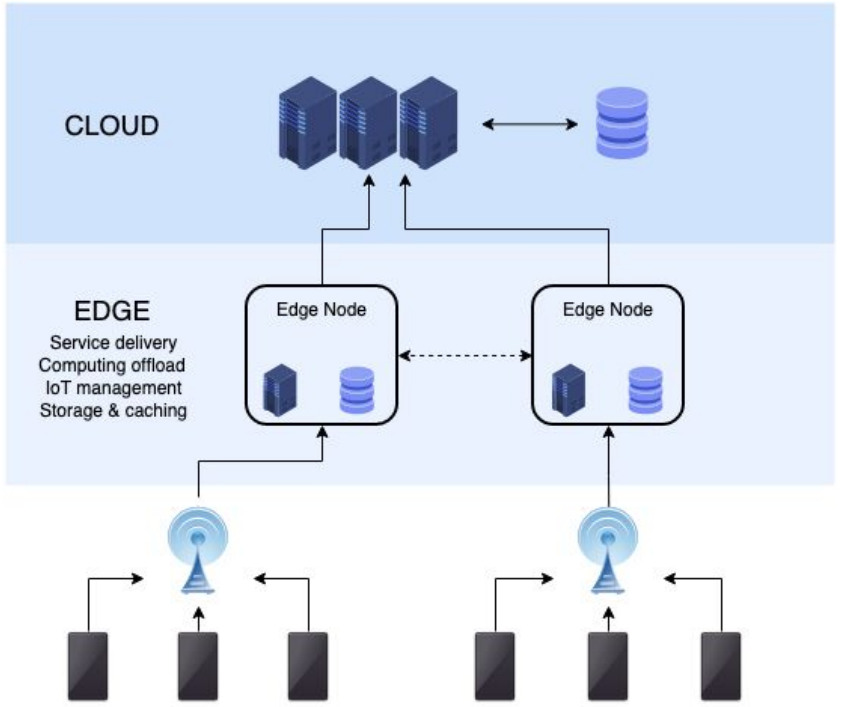
- **Edge computing**

  [Weisong Shi et al., 2016]

  A set of resources at the edge of the network with downstream connection to IoT resources and upstream connection to Cloud computing resources

  - Key role: Gateways to connect (a potentially large number of very simple) IoT devices to Cloud services

[Wikimedia Commons, 2019]



- **Fog computing**: Here considered as a synonym for Edge computing

Compute Continuum Overview

Here: A more telecommunications industry-centric view

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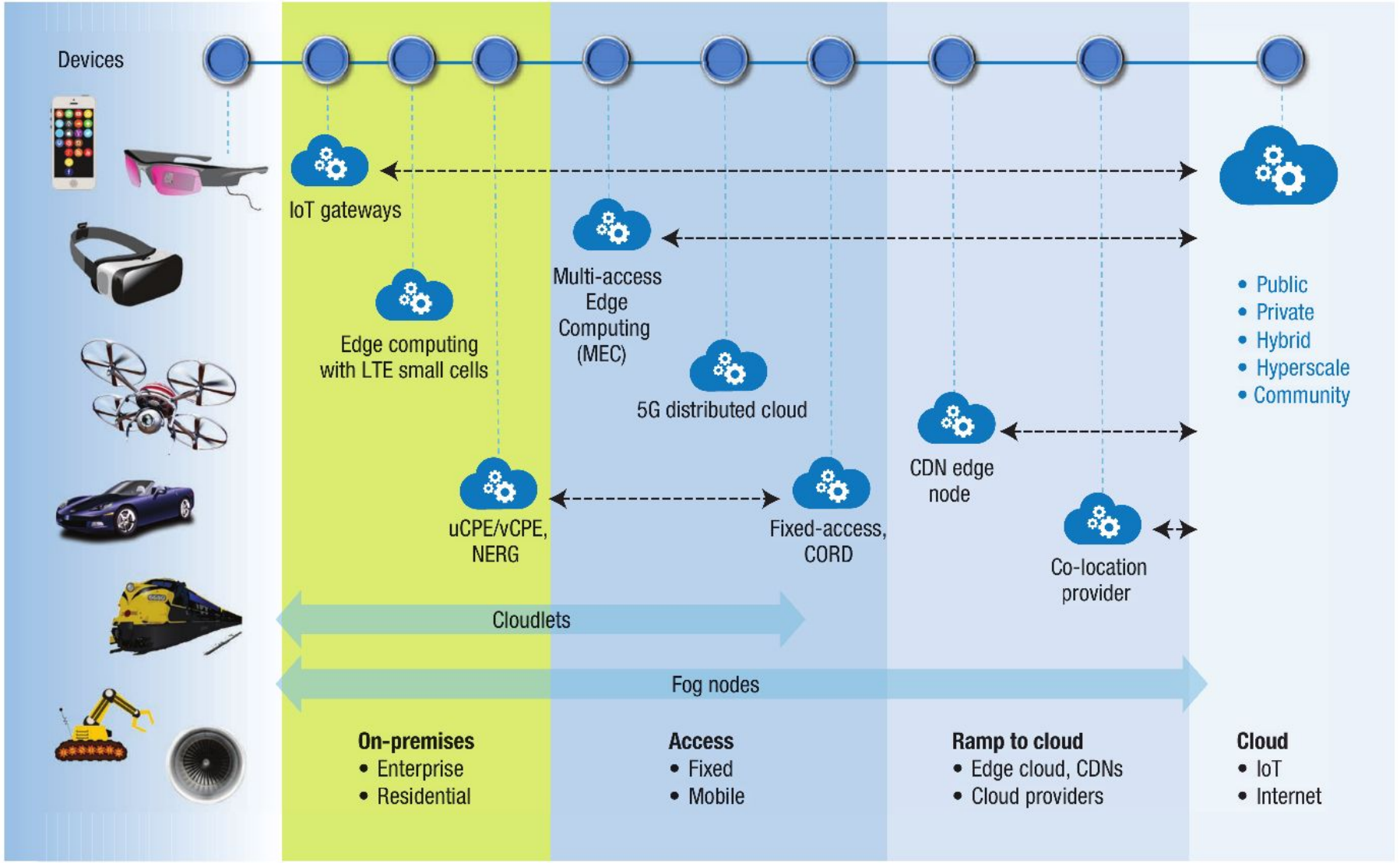
[G. Klas, 2017]



Potential Benefits from Extensions towards the Edge

[G. Klas, 2017]

- Low latencies and faster response from applications running at the edge
  - Virtual reality applications require round-trip-times O(10 ms)
- Reduction of data transport requirements
  - Data filtering and aggregation by edge services
- Improved data protection by keeping data locally, i.e. at the edge
  - Forward only aggregated and/or anonymised data, federated learning
- More predictable quality of service
  - Elastic Cloud services versus dedicated edge devices
- Facilitate integration of IoT devices

Selected Challenges

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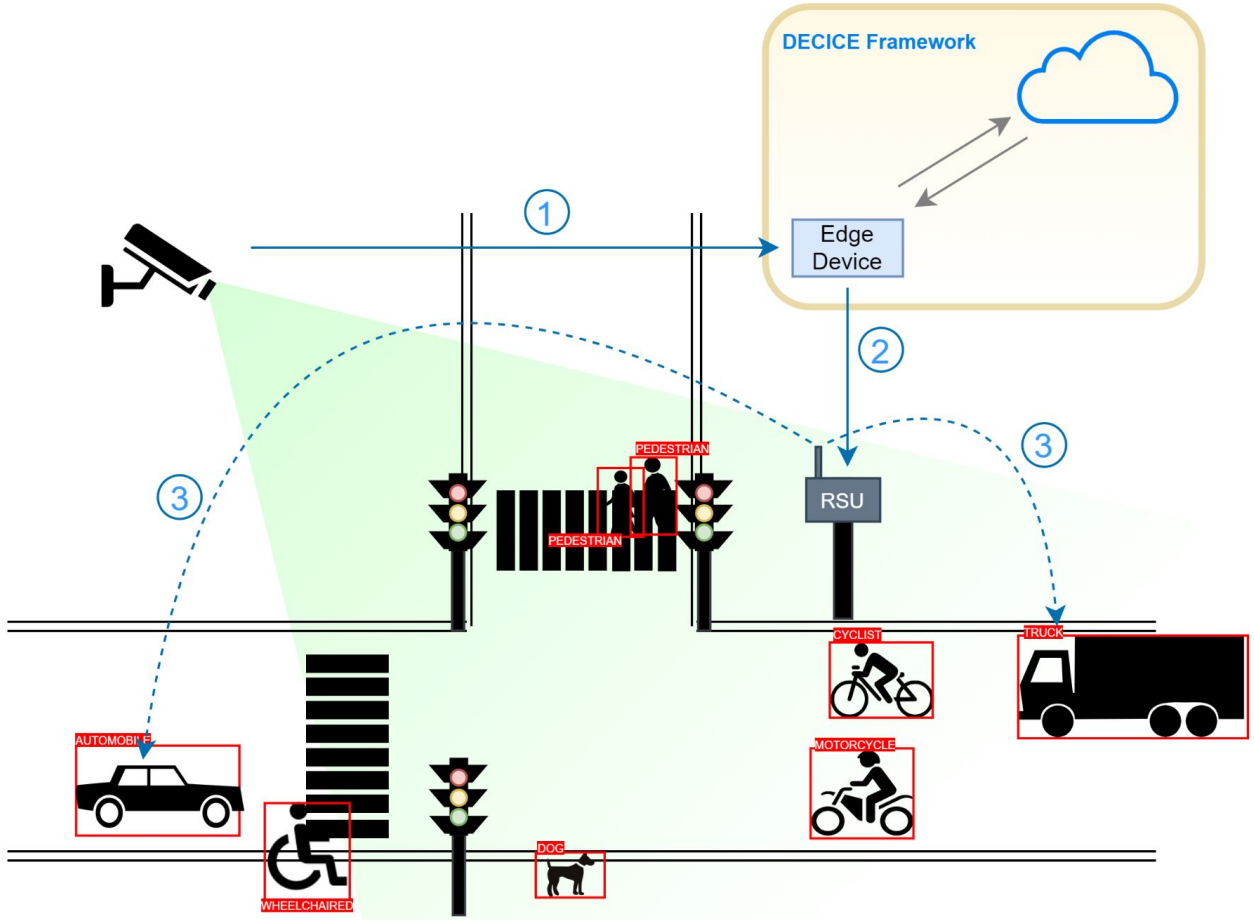
- Edge devices are typically resource constrained
  - Power envelope of O(10 W)
- Heterogeneity of edge devices
  - CPUs with different ISA (Arm, RISC-V, …), various compute accelerators
- Potentially unstable or shielded network connectivity
  - Edge devices are often connected to a private network without public IP address
- Decentralised infrastructure monitoring
  - Service degradation
  - Upcoming needs for suitable billing mechanisms
- Resource allocation and service scheduling
- Trust and security

Example Use Case I: Intelligent Transportation Systems

[M. Soyturk, 2023]

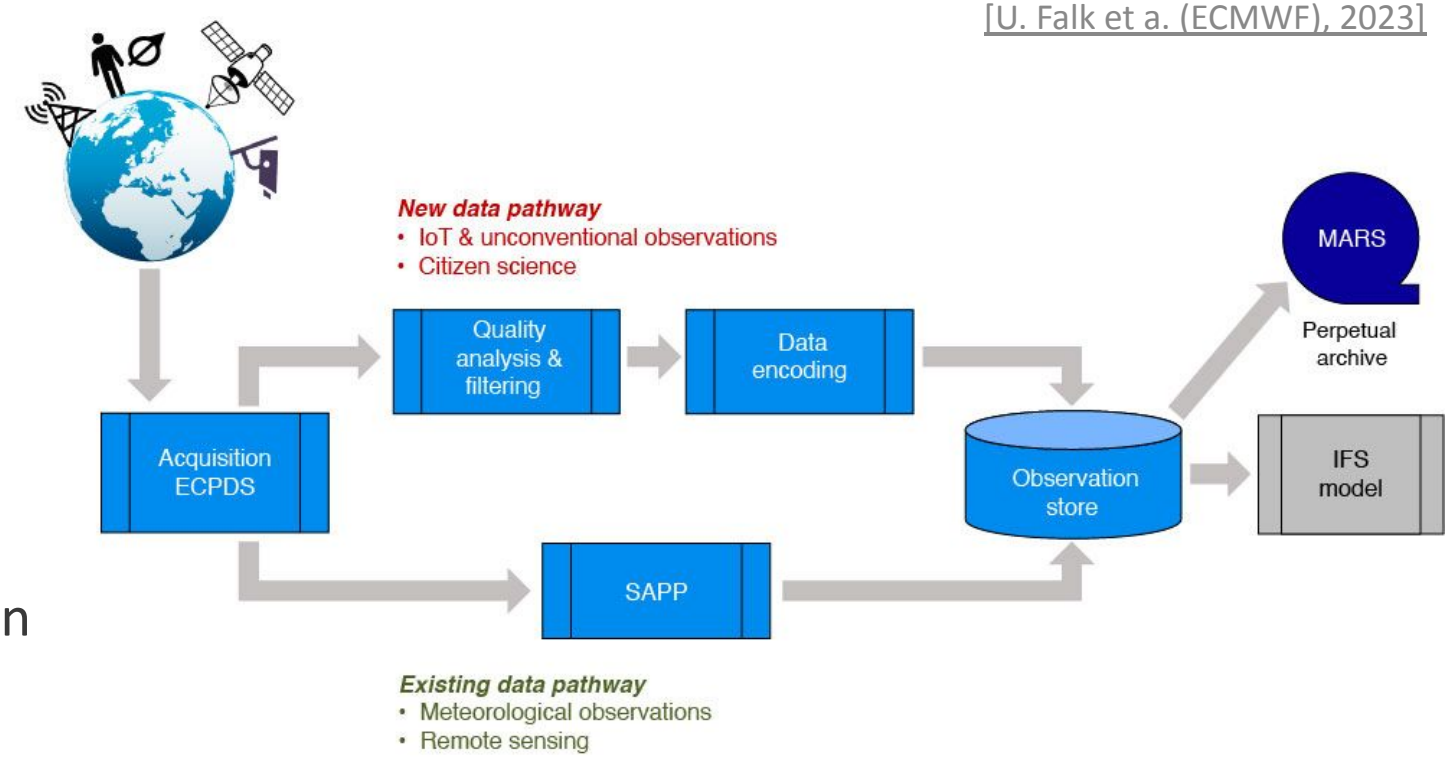
- Goal: Realise intelligent intersections to protect Vulnerable Road Users (VRU)
  - Cameras and edge devices detect VRU
  - Road-Site Units (RSU) connect to vehicles to collect vehicle sensor data and provide safety information
- Need for compute continuum
  - Local edge devices ensure low-latency responses
  - Cloud resources are used to continuously train models



Example Use Case II: Weather Prediction

- Goal: Integrate novel observations into weather prediction workflows
- Need for compute continuum:
  - Novel observations = input from IoT devices
  - Workflows comprise model simulations on HPC
- Challenges
  - Low reliability of data streams and need for filtering of noisy data at the edge
  - Heterogeneous data integration

[U. Falk et a. (ECMWF), 2023]



Questions?