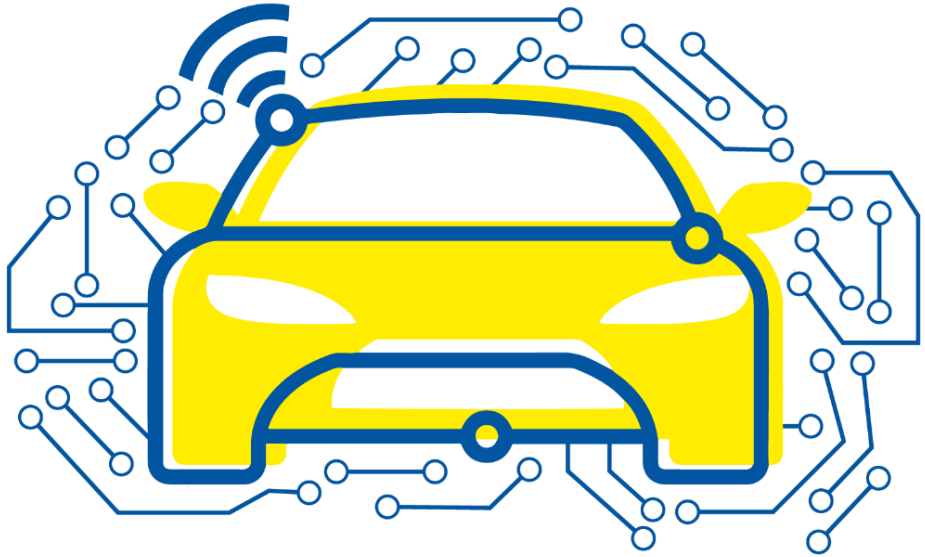
Automated and Connected Driving Challenges

Section 5 – Connected Driving

Collective Cloud Functions

Introduction



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Collective Cloud Functions – Introduction

Definition Recap – Collective Cloud Functions

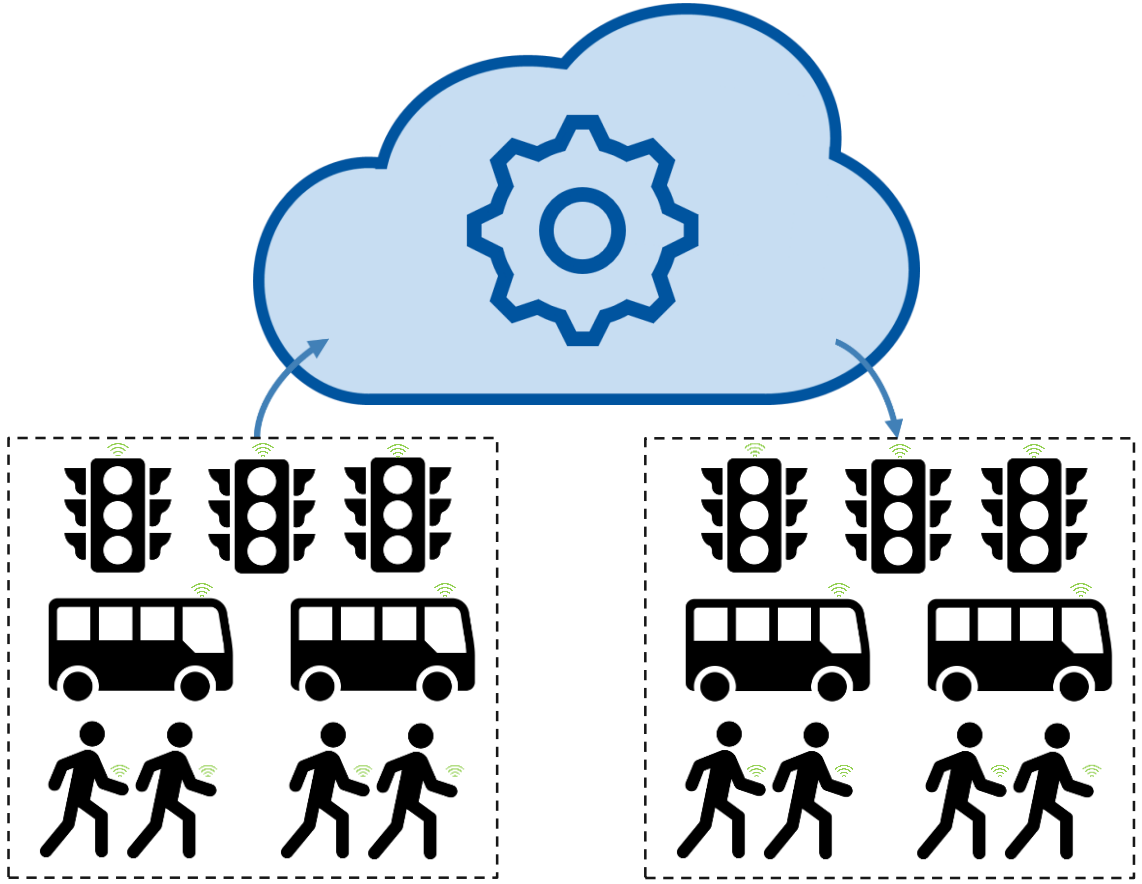
Collection of
data

from individual connected **entities**

for **central** data processing

in (edge) clouds

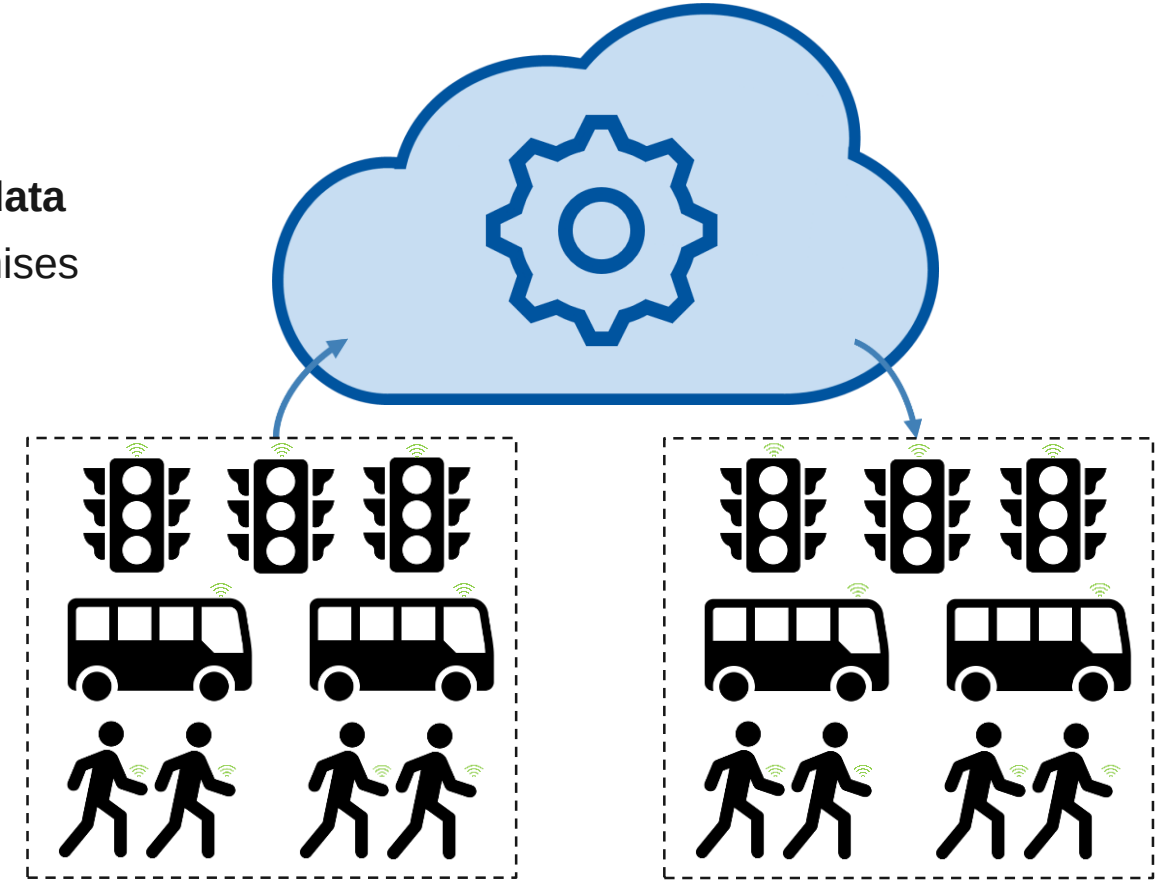
to **distribute** processed **collective** data



Collective Cloud Functions – Introduction

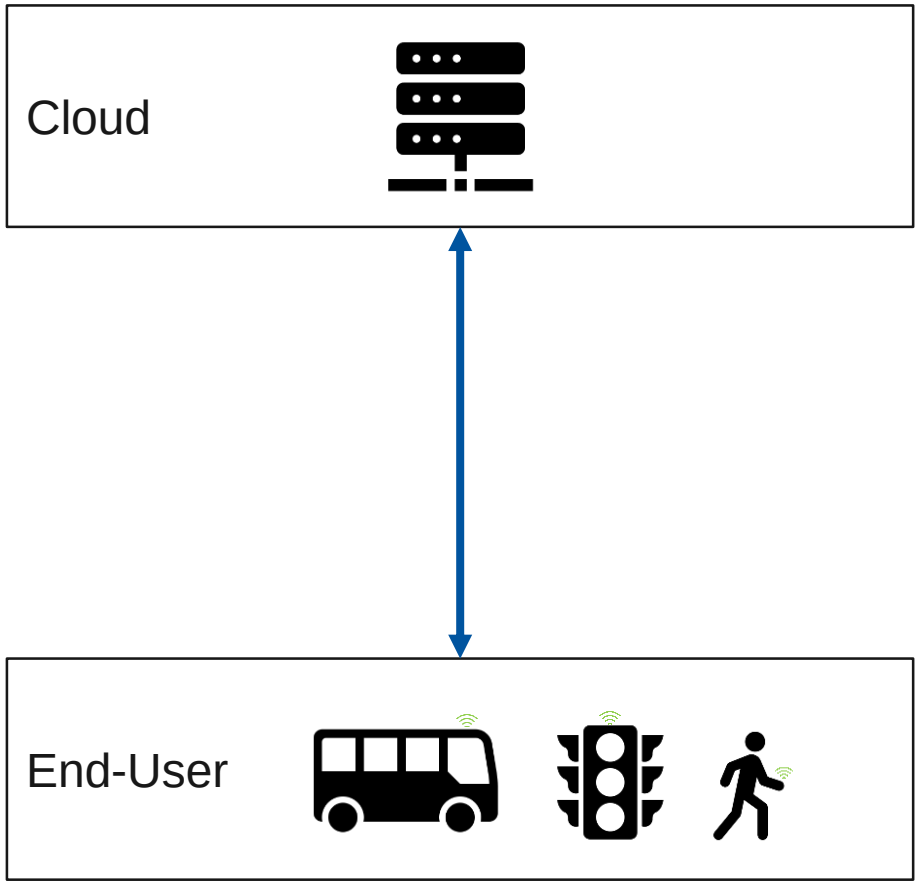
Advantages of (Collective) Cloud-based Data Processing

- **Multiple** connected entities may **provide data**
  → Combination of data possible
- **Multiple** connected entities may **receive the same data**
  → Agents base their actions on the same premises
- **More powerful hardware** possible in cloud servers
  → Bigger and better models may be used
- **Energy-intensive processing** less problematic
  → Energy saving in the vehicle possible
- **Large storage capacity** available
  → Saving large amounts of data possible
- **Hardware updates and upgrades** easier
  → More frequent hardware updates and upgrades possible

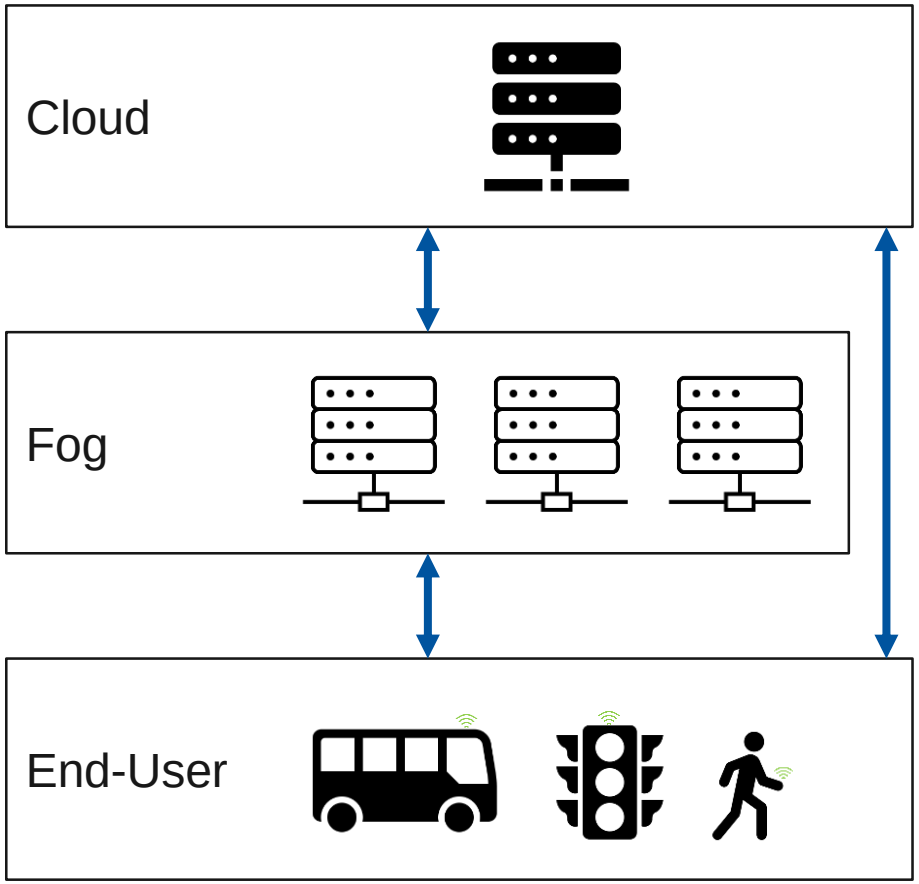


Collective Cloud Functions – Introduction

Architectures: Cloud Computing vs Fog Computing



Cloud Computing Architecture



Fog Computing Architecture

Collective Cloud Functions – Introduction

Online and Offline Data Processing

Online functions	Offline functions

Collective Cloud Functions – Introduction

Online and Offline Data Processing

Online functions

- Receive **continuous data streams** from connected entities
- Immediately **process** received data
- Provide **processed data**
- **No inherent need** to **store data** long-term
- **Strict requirements** regarding latency, throughput, connection reliability

Offline functions

Collective Cloud Functions – Introduction

Online and Offline Data Processing

Online functions

- Receive **continuous data streams** from connected entities
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Offline functions

- Receive **continuous data streams** or **intermittent data packages** from connected entities
- **Filter and store** received data
- Provide **processed data** or **functions**

Collective Cloud Functions – Introduction

Online and Offline Data Processing

Online functions

- Receive **continuous data streams** from connected entities
- Immediately **process** received data
- Provide **processed data**
- **No inherent need** to **store data** long-term
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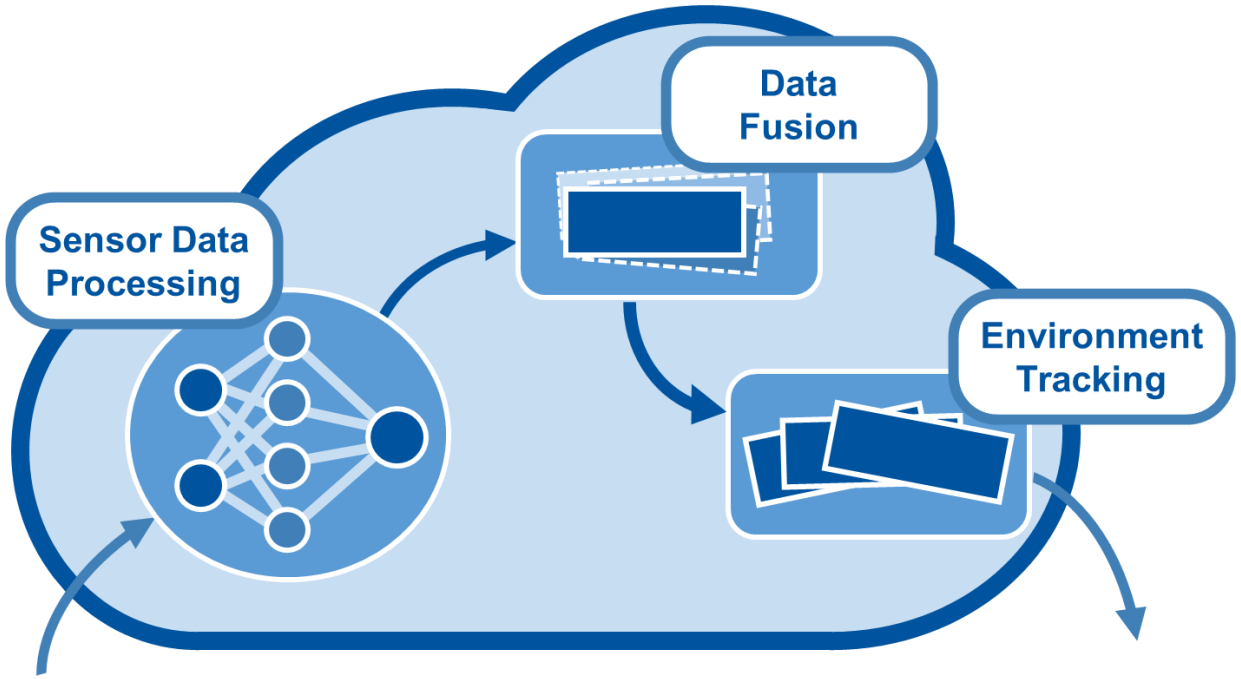
Offline functions

- Receive **continuous data streams** or **intermittent data packages** from connected entities
- **Filter and store** received data
- Provide **processed data** or **functions**
- **Need** to store data long-term
- **Less strict requirements** regarding latency, throughput, connection reliability

Collective Cloud Functions – Introduction

Online Use-Case: Collective Environment Model



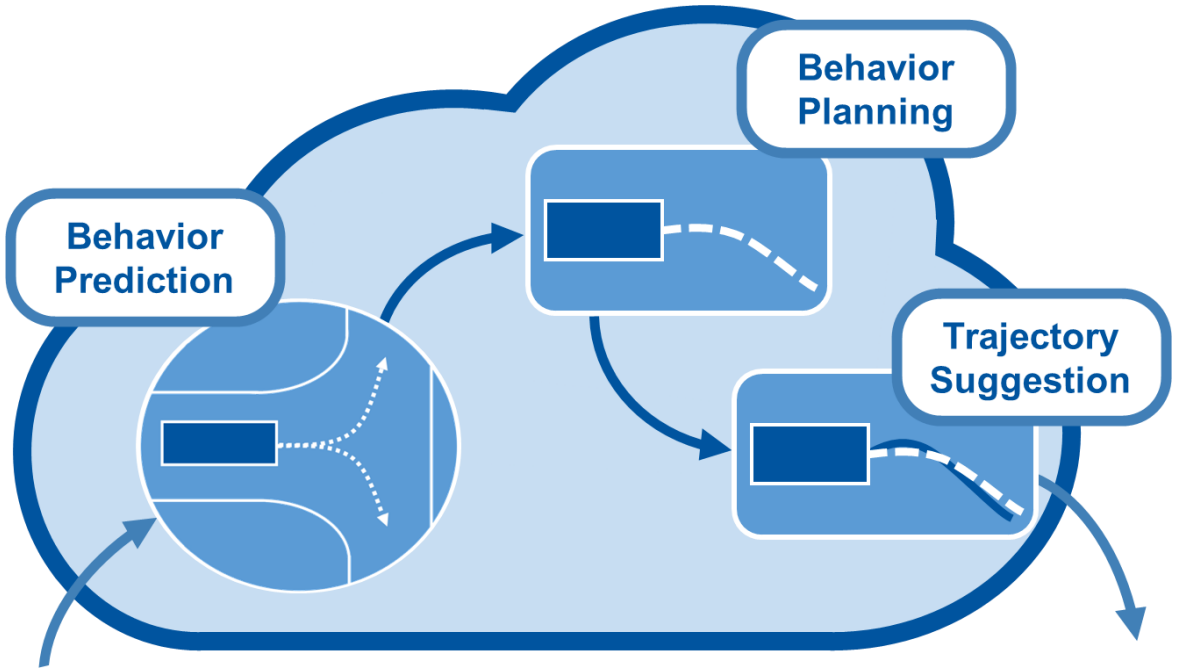
- **Sensor data** is processed in **real time** by artificial neural networks for the **perception** of **connected vehicles** and **intelligent infrastructure**
  → **Sensor Data Processing**

- Data from **multiple** connected entities is **fused** to **increase accuracy and range**
  → **Data Fusion**

- Elements in the environment are **associated** and **tracked** to form the **collective environment model**
  → **Environment Tracking**

Collective Cloud Functions – Introduction

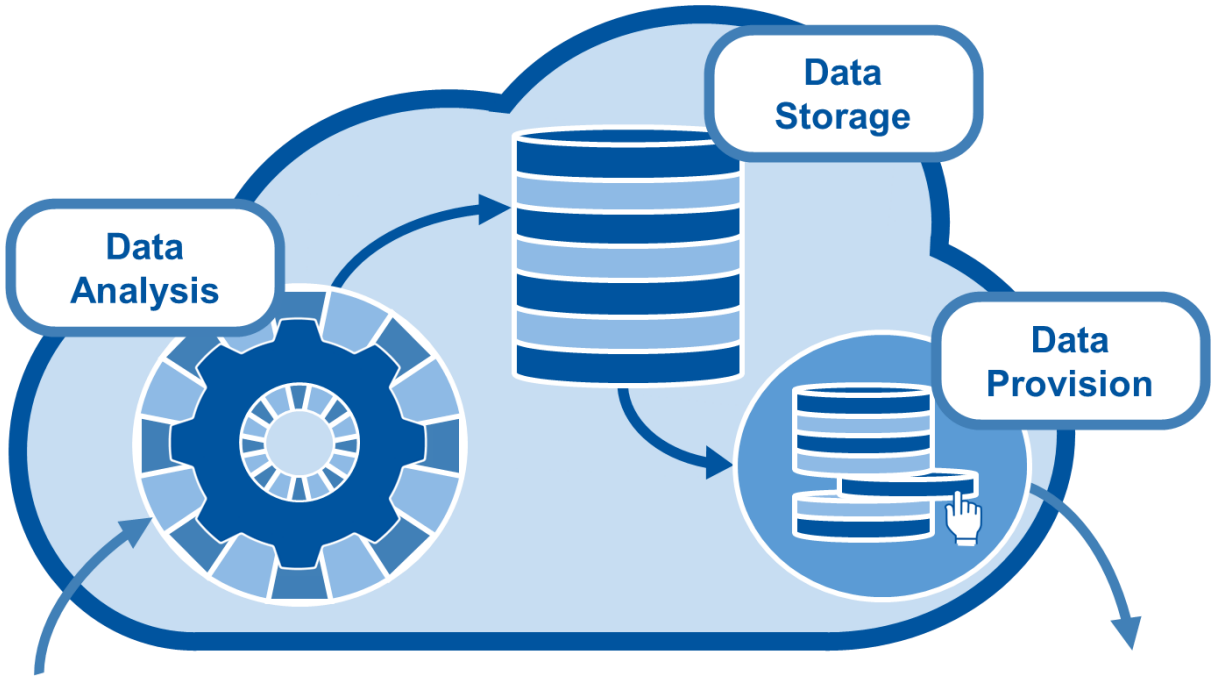
Online Use-Case: Collective Behavior



- The actions of **other road users** are **continually predicted** based on the collective environment model and **shared plans** by individual agents
  → **Behavior Prediction**
- Based on the latest predictions, optimized **trajectories** are computed
  → **Behavior Planning**
- Behavior **recommendations** are provided to **connected agents**, which may choose to incorporate them into their behavior
  → **Trajectory Suggestion**

Collective Cloud Functions – Introduction

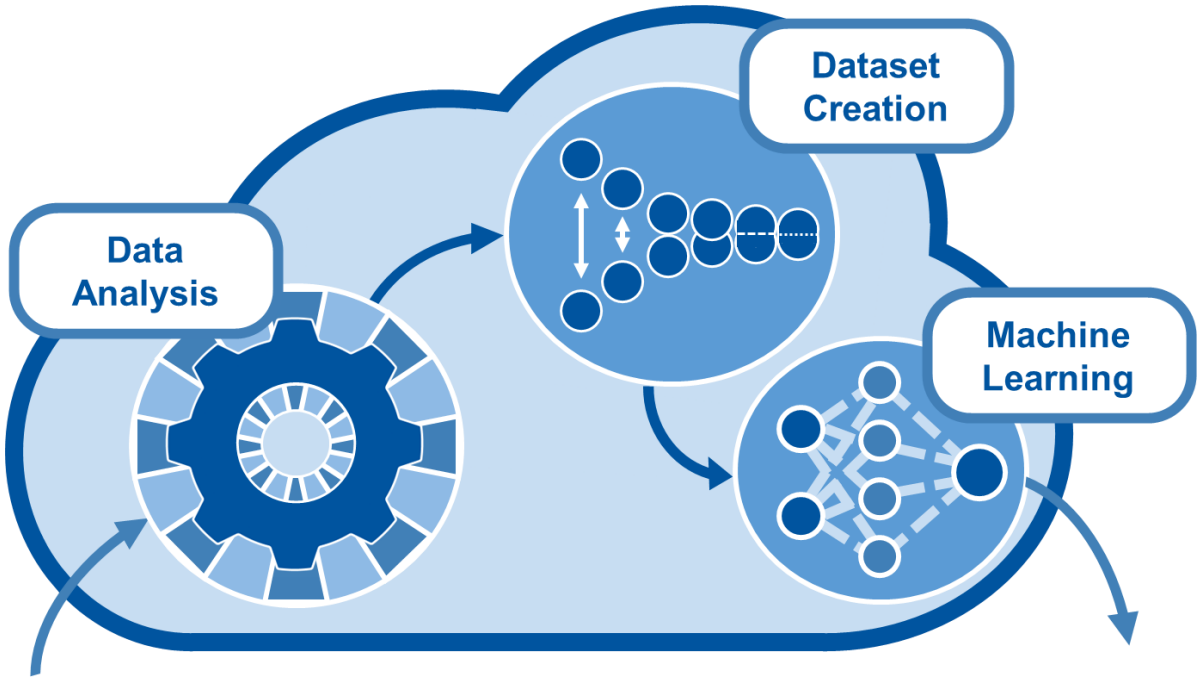
Offline Use-Case: Collective Memory



- **Large** amounts of **heterogeneous data** from connected entities are gathered in a **short-term memory** and **analyzed** for a preliminary identification of **relevant data**
  → **Preliminary Data Analysis**
- Selected data are **efficiently stored** in an accessible **long-term memory**
  → **Data Storage**
- **Interfaces** for **manual data analysis** and **automatic retrieval** of requested data for detailed analysis are made available
  → **Data Provision**

Collective Cloud Functions – Introduction

Offline Use-Case: Collective Learning



- An **in-depth analysis** can identify **compositions** of Collective Memory **data** suitable for **automatic training data set creation** and collective learning
  → **Detailed Data Analysis**
- Data of **multiple perspectives, time frames** and **connected entities** is **combined**
  → **Dataset Creation**
- **Continually improved models** for perception, prediction and planning are **automatically learned** and **validated**
  → **Machine Learning**