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A Generic Microservice Architecture for Environmental Data Management

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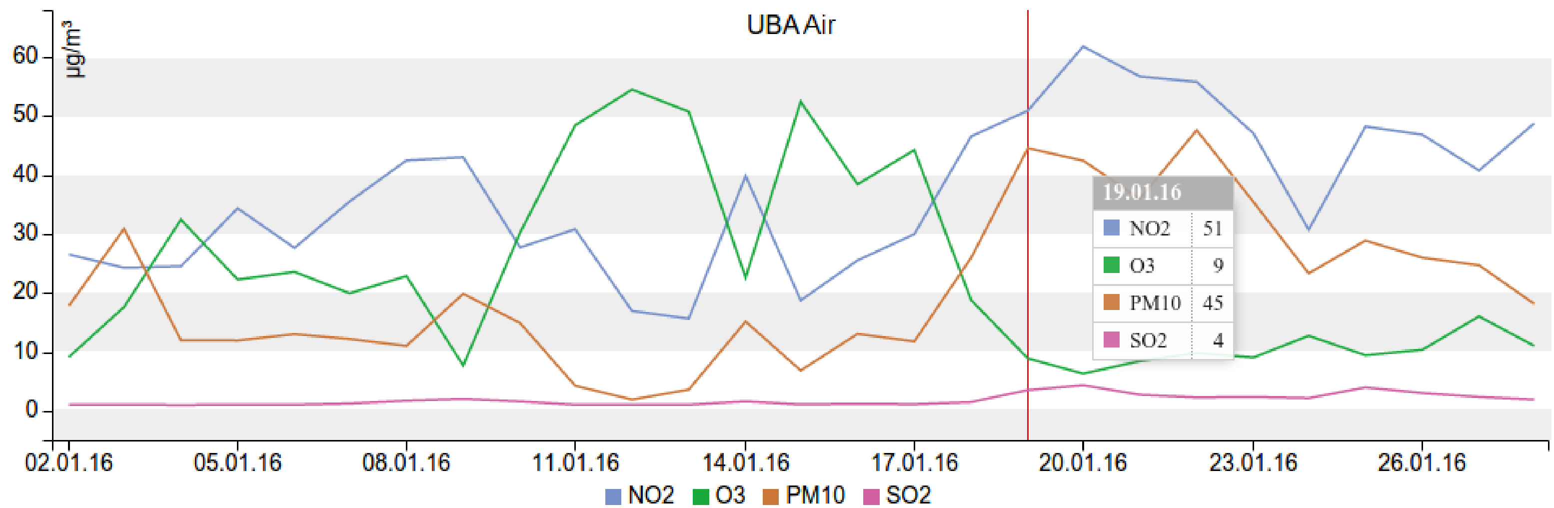

Motivation

- New IT trends influencing e.g. environmental information systems (and other applications), such as
  - Internet of Things (IoT) applications,
  - Sensor networks
  - Large scale crowdsourcing applications for gathering data with the help of the General Public
  - Mobile apps providing instant access to context-aware information
- Lead to new requirements on managing and serving data to applications
  - E.g. „Big Data" storage with high „velocity" and „volume"
  - Needs to add data analytics as part of the backend system of applications (e.g. using "Machine Learning Algorithms")
- Older (web-based) environmental information systems are not designed to cope with such requirements

Disadvantages of older Public Environmental Information Systems (PEIS)

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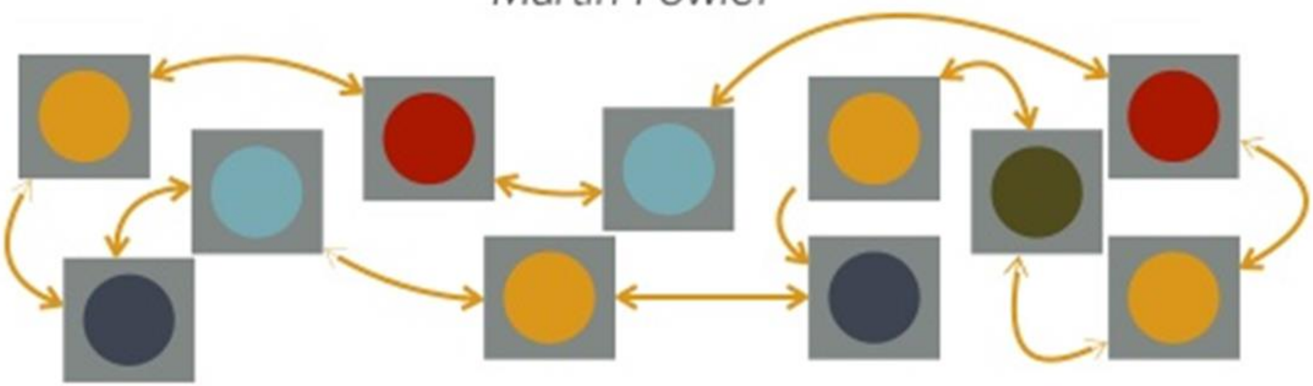
- Larger monolithic applications which have grown in functionality over years
  - Often multitier
  - And installed only on one bigger application server (e.g. JEE)
  - Dedicated proprietary solution with one large integrated data model
- Such large software applications are difficult to innovate because of their complexity
  - Updates take years
  - This hinders further development and innovation of the software slows down
- The software architecture is typically tied to one technology stack and often uses proprietary data semantics and interfaces
  - Changing the technology stack fosters a complete redesign of the whole application
  - Proprietary data semantics and interfaces complicate integration with third party software
  - Overall, this slows down technical innovation of the applications

Microservices

The **microservice architectural style** is an approach to developing a **single application** as a suite of **small services**, each running in its **own process** and **communicating** with **lightweight mechanisms**, often an HTTP resource API. These services are **built around business capabilities** and **independently deployable** by fully automated deployment machinery. There is a bare minimum of centralized management of these services, which may be written in different programming languages and use different data storage technologies.

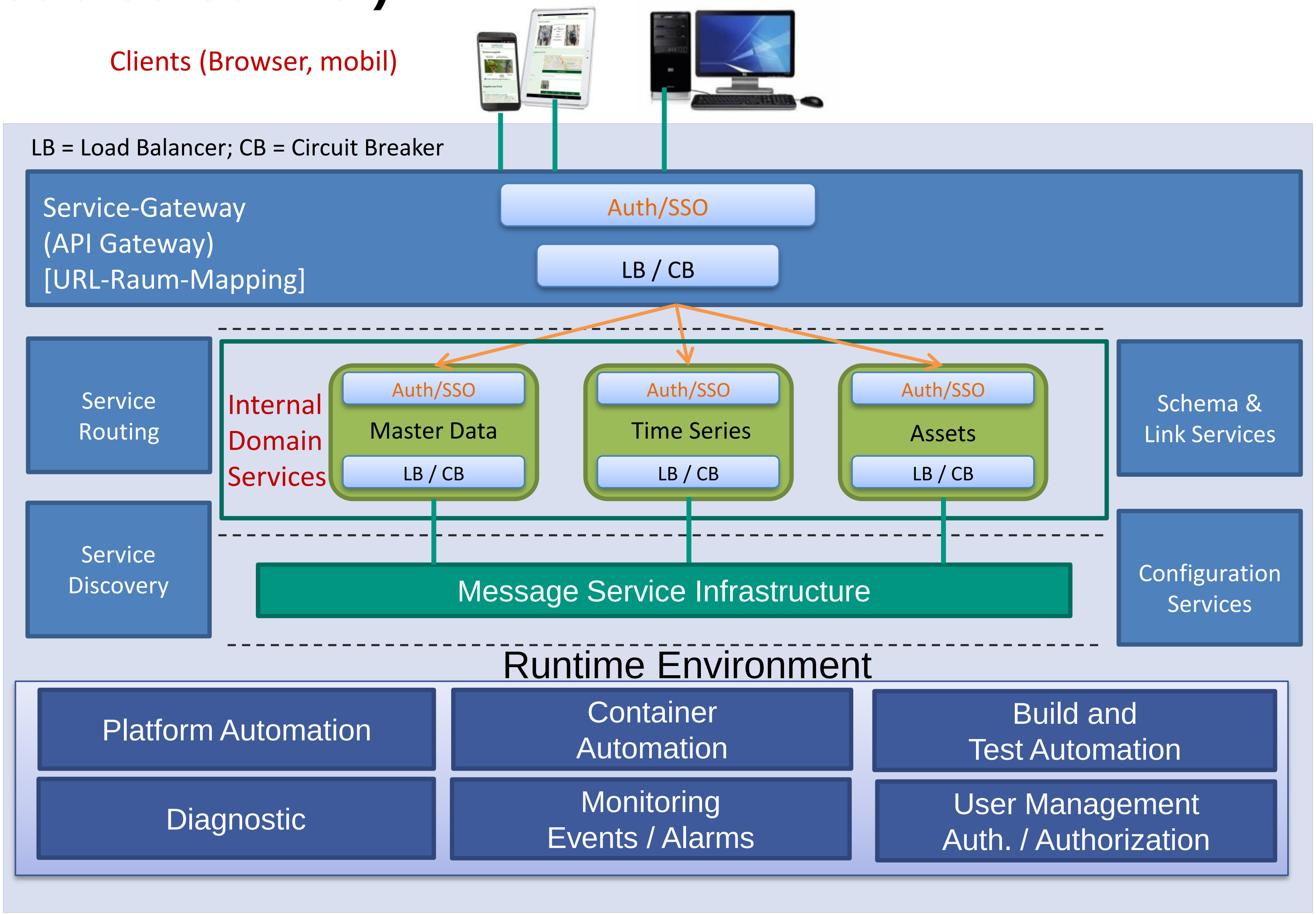
Martin Fowler



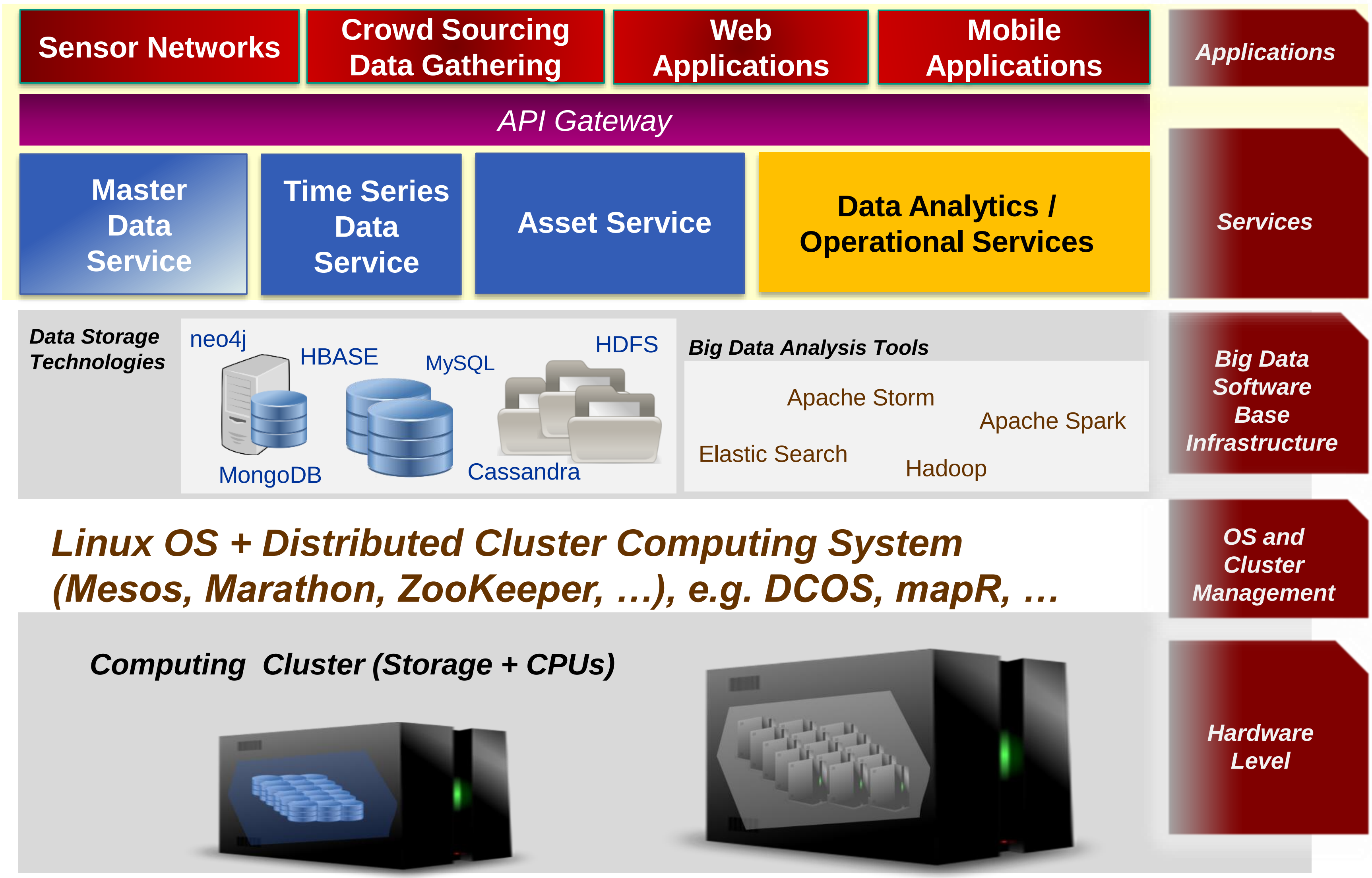
Advantages of Microservices

- Microservices focus on one functionality. This leads to a more modular design
- Smaller, separated codebases, easier to understand, „fun to develop and deploy"
  => Flexible and agile software development
- Each Microservice can use its own technology stack
  => This drives fast innovation
- Governance focus on (REST based) service interfaces by using standards
  => better interoperability possibilities
- Each Microservice provides its own runtime environment
  => faults are separated
- Each Microservice is designed to be horizontally scalable
  => flexible scalable system, where each service can be scaled independently from each other

Microservice Reference Architecture (see also Gartner)

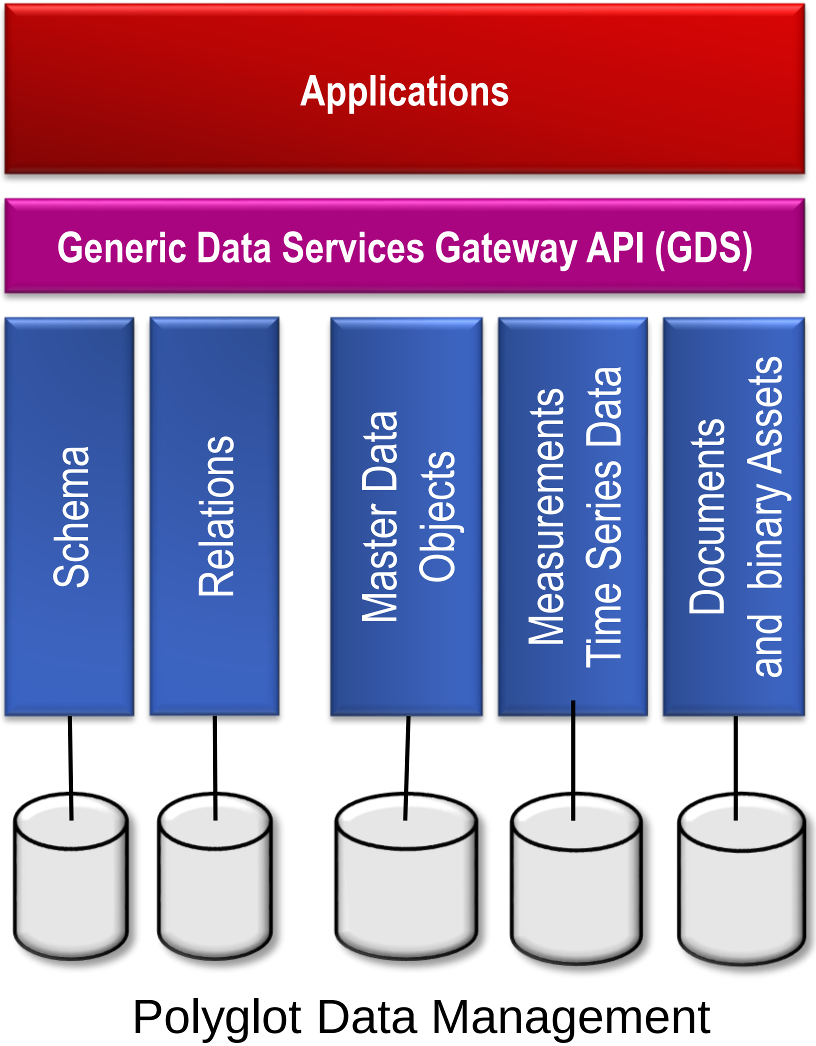


Generic Service Infrastructure for new PEIS



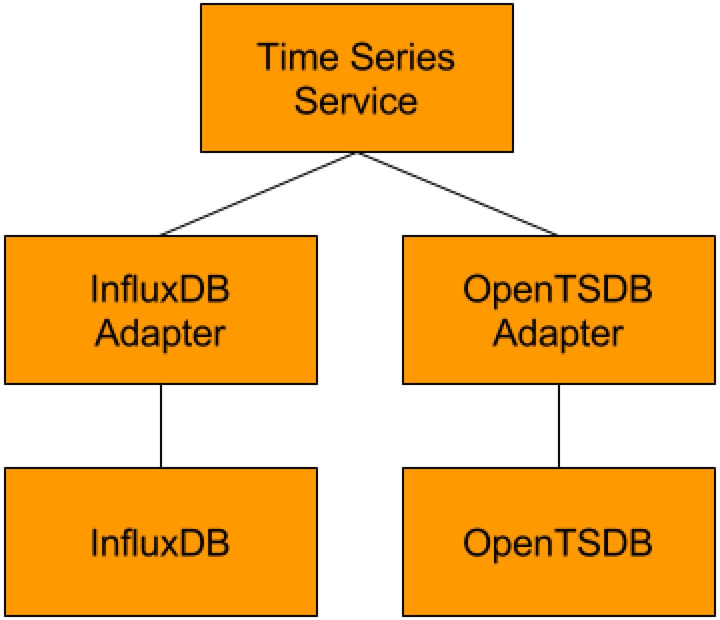
Generic Data Services (GDS)

- Polyglot data management instrumented by microservices
  - Time series service for storing and accessing measurement data based on e.g. column store databases
  - Document oriented database for storing master data
  - Use Asset Management System and / or Hadoop File System (HDFS) for storing large chunks of (binary) data
- Semantic Services
  - Use document-oriented database for storing Schema data (e.g. JSON schema)
  - Use graph databases to store network topologies and relations between data



Storage Abstraction

- Data services use a data storage abstraction layer (storage adapter)
- Allows to implement more than one storage option for a data service
- E.g. the „Time Series Service“ implements
  - An InfluxDB Adapter for storing time series data in an InfluxDB
  - An OpenTSDB adapter for storing data in an OpenTSDB
  - SQL Adapter for storing time series data in a relational database, etc.
- Application developer can decide on storage option depending on size, velocity (e.g. Big Data), complexity or needs for accessing the data



Time Series Service with two storage adapters

Example Schema: „Air Measurement Station“

JSON Schema Format

```
{
 "title": "Air Measurement Station",
 "type": "object",
 "properties": {
   "id": { "type": "string" },
   "name": { "type": "string" },
   "pm10Limit": { "type": "number" }
   "pm10Current": { "type": "number" }
   ...
   "timeSeries": { "type": "timeSeries"
}
 },
 "required": ["id", "name"]
}
```

- Simplified schema of an „Air Measurement Station“ in the Schema Service
- Objects of this type have properties like
  - Properties: „name“, „pm10Limit“, „pm10Current“
  - And a sub-object „timeSeries“ for pointing to associated measurement data

Example of Master Data Object Representations

JSON

Representation 1

```
{
 "id": "DEBW019",
 "name": "air station Ulm",
   "pm10Limit": 50,
   "pm10Current": 20,
 ...
 "timeSeries": [
   timeseries/DEBW019/no2,
   timeseries/DEBW019/pm10
 ]
}
```

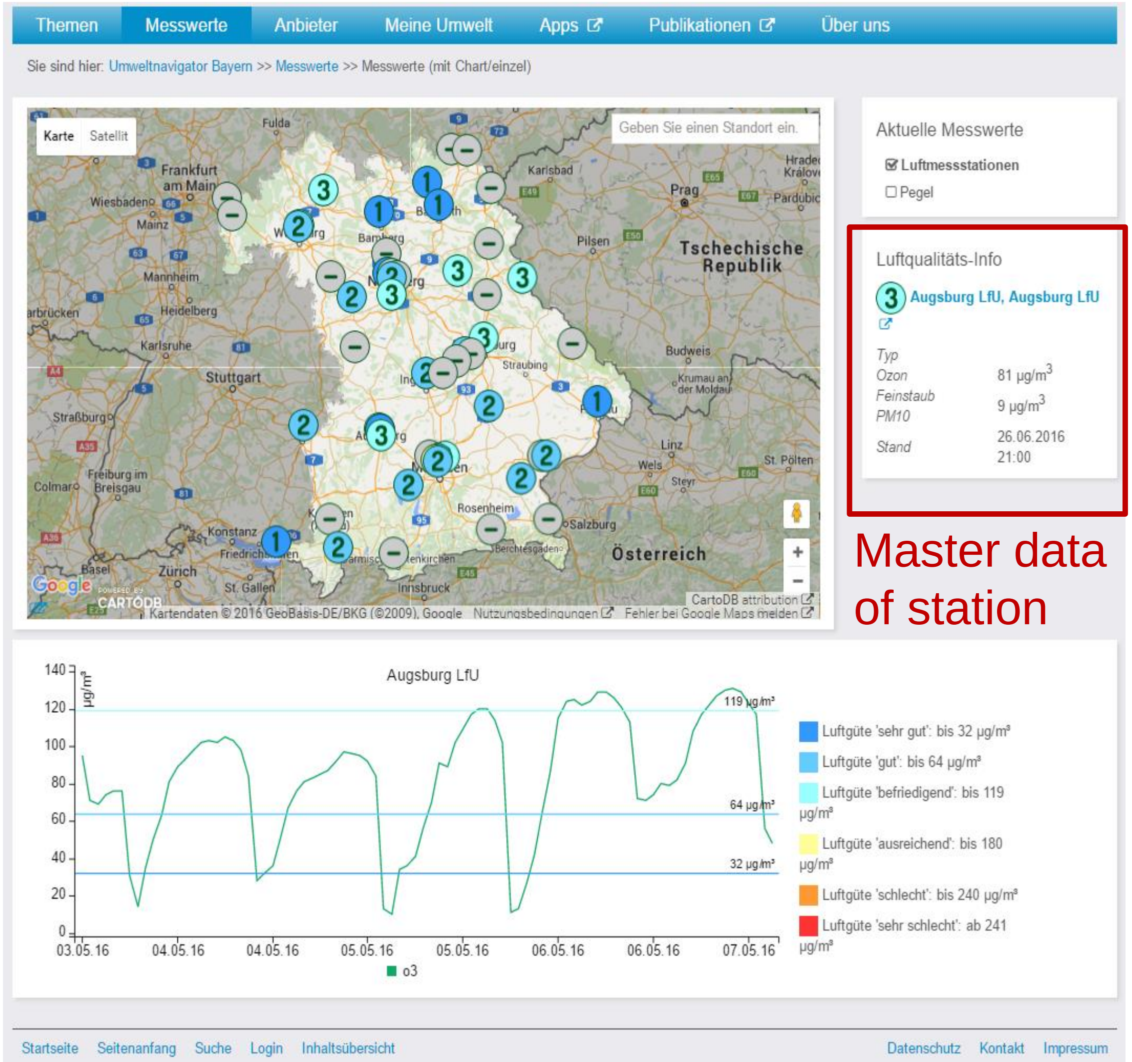
Representation 2

```
{
 "id": "DEBW019",
 "name": "air station Ulm",
   "pm10Limit": 50,
   "pm10Current": 20,
 ...
 "timeSeries": [
   [26, 22, 21, 23, 31, 58],
   [26, 14, 11, 15, 26, 20]
 ]
}
```

- Two representations of the „Air Measurement Station“ master data object with id „DEBW019“
  - Repr. 1: „timeSeries“ contains only URLs pointing to time series data in the Time Series Service
  - Repr. 2: Time series data is included in the master data object representation
- Clients can demand that links get resolved by the service

Example Application: „Umweltnavigator Bayern“

- Display of different measurement data on an interactive web page
  - Ozone, air quality (different substances)
  - Water levels of rivers
- Every symbol on the map represents a „measurement station“
- Clicking on the station symbol will result in
  - displaying the master data of the station on the right side of the web page
  - and displaying the measurement data as time series data below the map
- To achieve this, display components interact with each other by exchanging events and fetching data from background services



Example Application: Building Energy Dashboard

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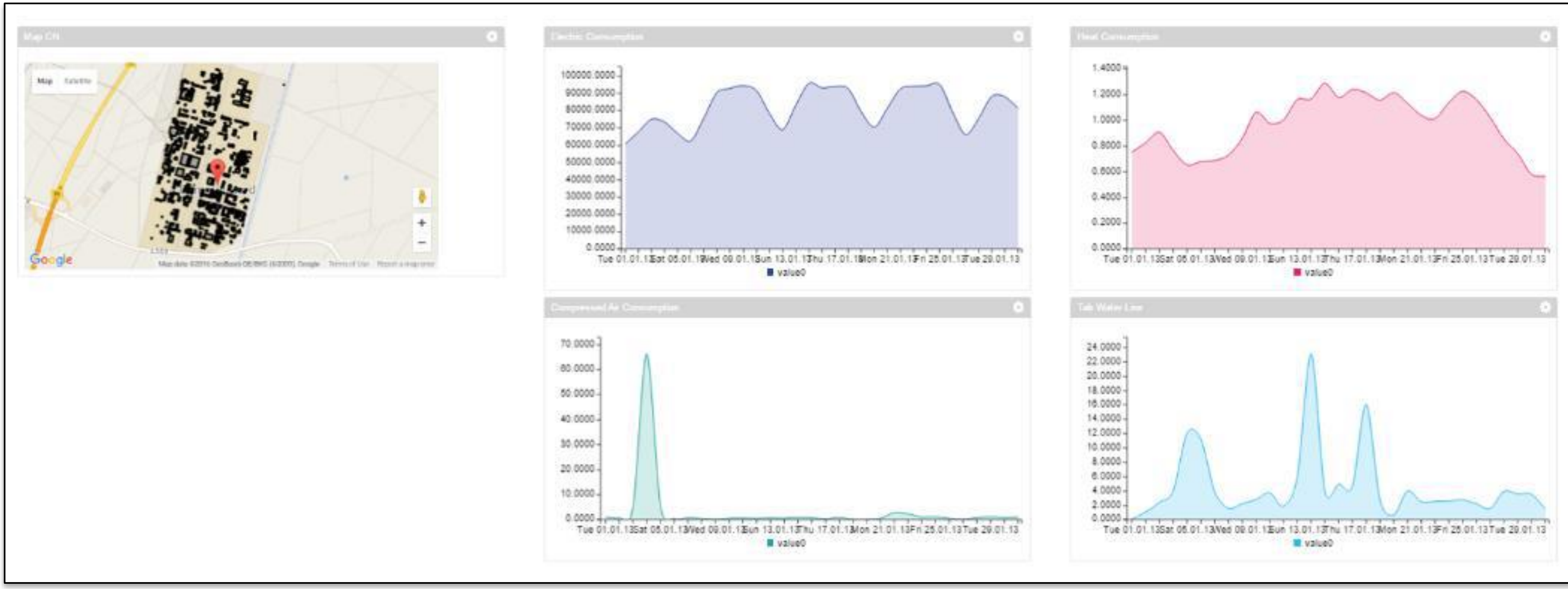

- Clicking in the map on a building symbol will result in:
  - Fetching the master data object for this building into the dashboard
  - Display components showing measurement data listen to changes of the master data object => therefore get a notification
  - Diagram components will be updated to show energy consumption of new selected building

Conclusion and Outlook

- Conclusion
  - Microservices allow the development of services which provide highly reusable generic functionalities for e.g. data management (or data analytics, etc.)
  - Usable for many kinds of applications
  - Very agile development and application environment
    - Allowing fast innovation
    - And functional extensions in a very short time
  - Corresponding modular display components (web components) for e.g. web applications and / or mobile apps allow to reuse services easily in different application contexts
- Further work
  - Building up a library of reusable web components for instrumenting services on the client side (based on Polymer and the Web Component Standards)
  - Adding generic data analytics and operational services to the service backend (e.g. for data analysis, data ingestion, …)