Aalto University
School of Science

Architecting Big Data Platforms

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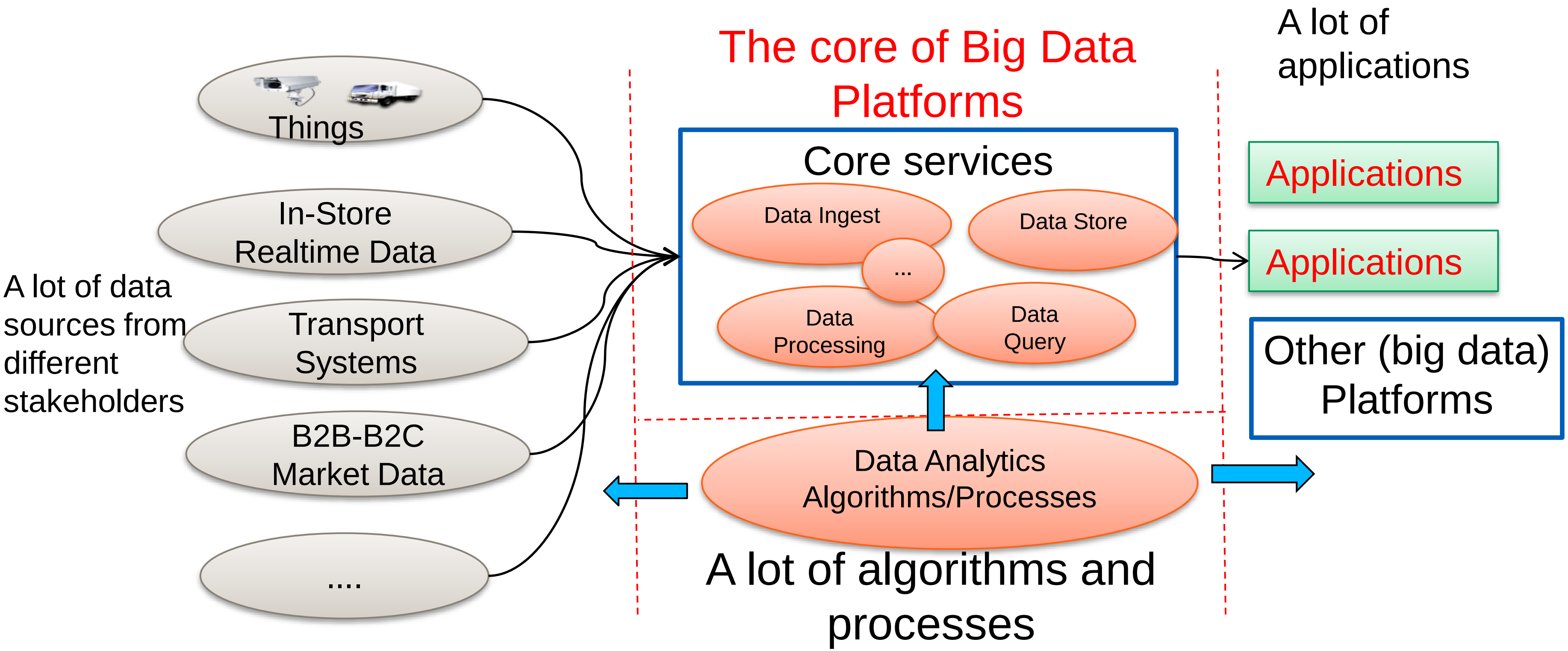
Learning objectives

- **Understand key issues in designing a big data platform**
- **Study different big data architectures**
- **Learn key architecture design issues**
  - interaction, partitioning, elasticity, API
- **Understand big data platform technologies**

Your big data platform story - an evolving scenario

"Your team has to build a big data platform for X types of data. Data will be generated/collected from N sources. We expect to have 10+ GBs/day of data to be ingested into our platform. We will have to serve K thousands of requests for different types of analytics – to be determined. Our response time should be in t milliseconds. Our services should not be …"

Big data platforms: system of systems view



A lot of data sources from different stakeholders

Things

In-Store Realtime Data

Transport Systems

B2B-B2C Market Data

....

The core of Big Data Platforms

Core services

Data Ingest

Data Store

...

Data Processing

Data Query

Data Analytics Algorithms/Processes

A lot of algorithms and processes

A lot of applications

Applications

Applications

Other (big data) Platforms

You may have several questions?

- Do we have to support multiple types of data?
- How do data pipelines and data load look like?
- How to enable different data processing models?
- Which runtime parameters must be monitored? Which service level metrics must be guaranteed?
- To where we should distribute/deploy our components?
- Which part of the platform we must do self-manage and which part will be fully managed by other providers?
- How to design elastic big data infrastructures?
- Etc.

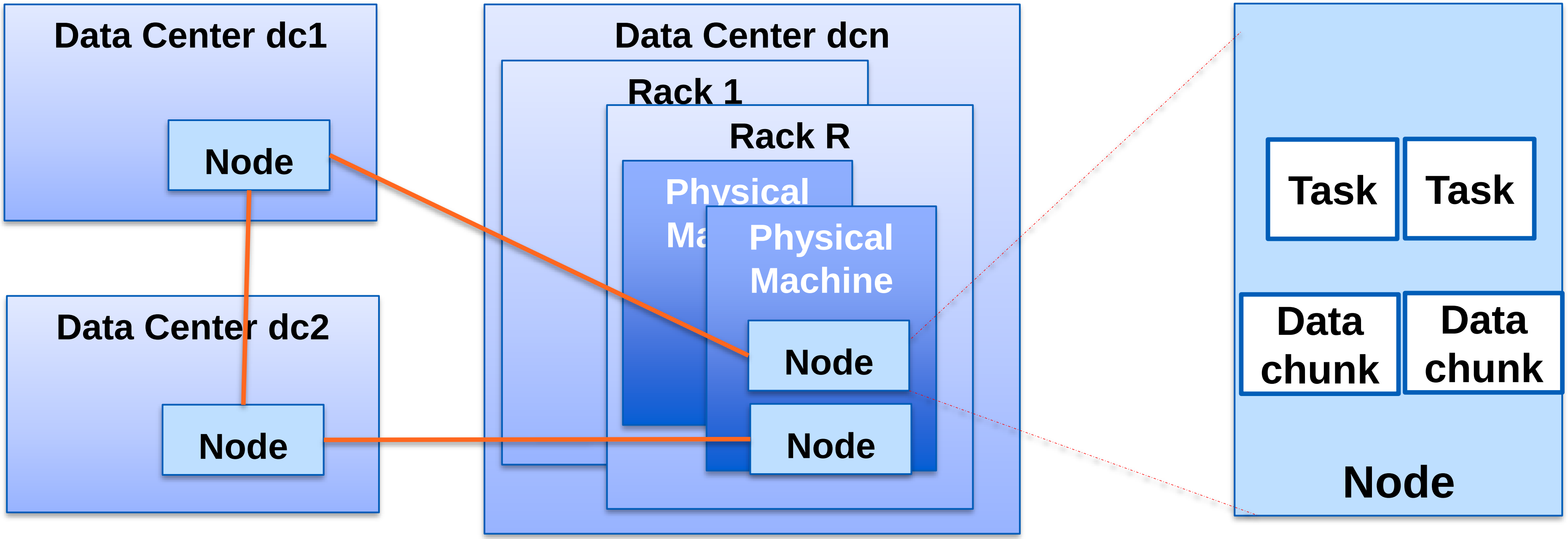
Your Big Data Platform story starts with Big Data Platform architectures!

To architect the platform centered around data!

Understanding the underlying computing infrastructures

- **Computing resources and services**
  - Many machines, virtual infrastructures, different types of services
- **Distributed infrastructures from different administrative domains**
  - in multiple data centers, locations and countries
  - with different security and network policies
- **Diverse service level objectives (SLO) and service level agreements (SLAs)**
  - performance, service failure, cost, privacy/security …

Understanding the underlying computing infrastructures



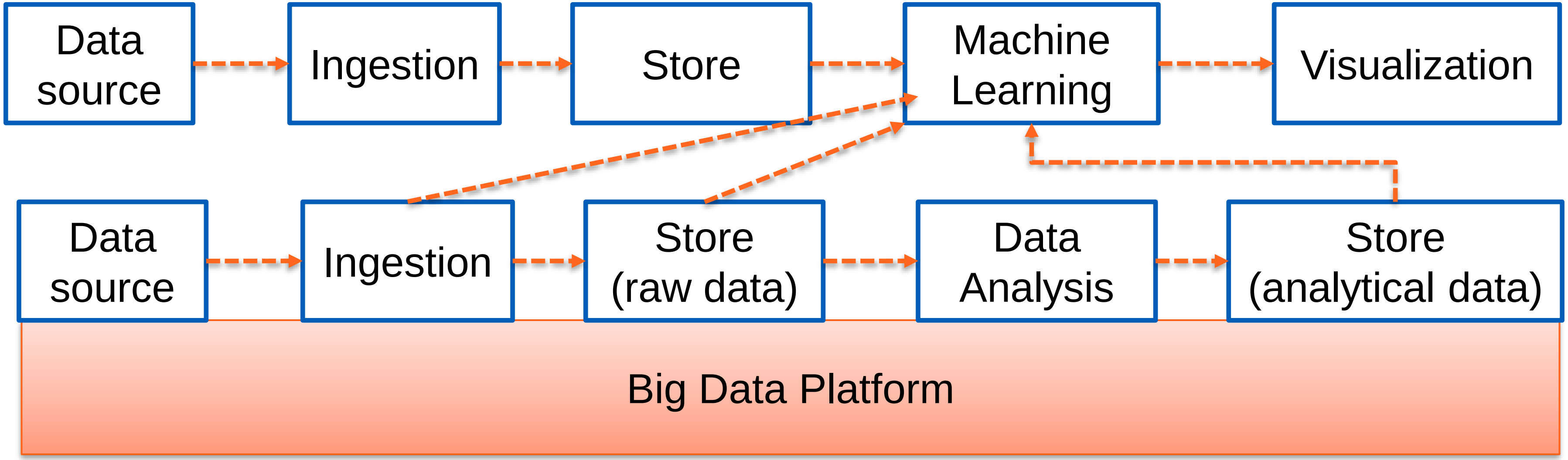
Remember: large-scale distributed infrastructures!

Data-centric development & operations

- **Data ingestion and data movement**
  - from various data sources we move data into the platform
- **Data storing and management**
  - ingested data will be stored and managed using different types of storages and databases
- **Data analyzing and (Machine) learning**
  - data within platforms will be processed, analyzed and learned to improve data, find insights and to create models
- **Reporting and visualization**
  - patterns/insights in data will be interpreted and presented for decision-making, reporting and creating stories

Big Data Pipelines

Multiple big data pipelines can be constructed atop a big data platform (and across distributed infrastructures)



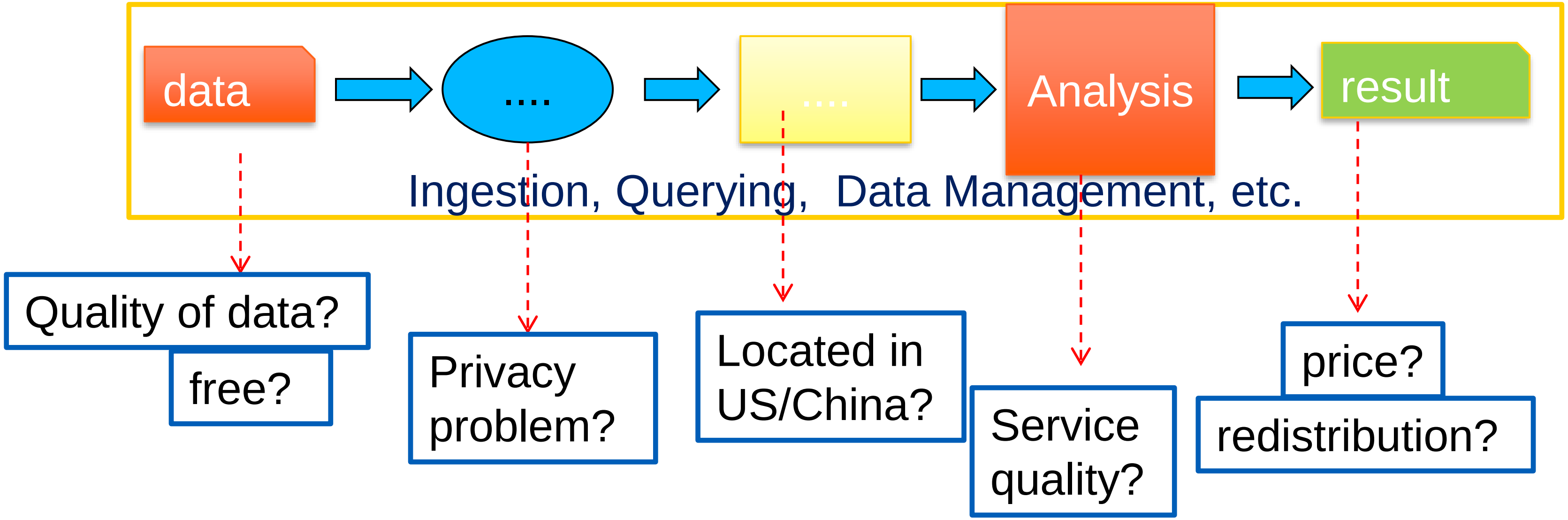
Handling multiple types of data?

- **First important aspect: you don’t have to support multiple types of data**
  - but are you sure that you will not have this in the future?
- **Multiple types of data**
  - Any linked models among them?
- **Any elastic solution that ensures minimum changes to support generalization and extensibility**
  - E.g., multi-model databases, microservices of multiple of databases or data lake

Data concerns and SLAs

- **Ingesting data**
  - Mapping and transforming data
  - Ingestion of data under V*
  - Data validation/quality control during ingestion
- **Storing data**
  - Data sharding and consistency, data backup, retention, etc.
- **SLA multitenancy versus single tenancy**
  - Security, privacy, performance, reliability and maintenance?

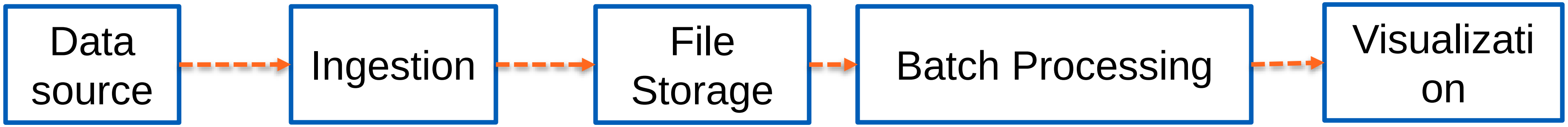
Data concerns: data validation and quality of analytics



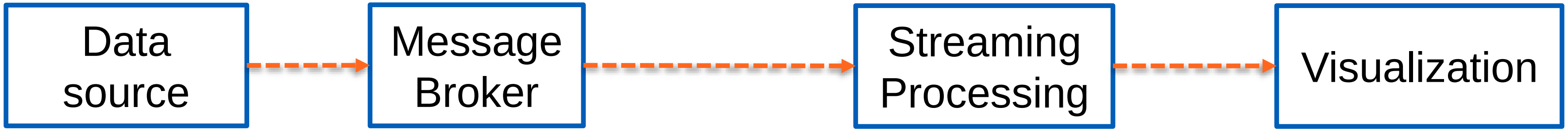
- Ethical consequences?
- Regulation-compliant platforms: e.g., GDPR

Fast versus slow processing

big data but not near real-time, e.g., take customer transaction files from companies and move to data centers for analytics



fast, small IoT data in near real-time flows, e.g. position of cars



But

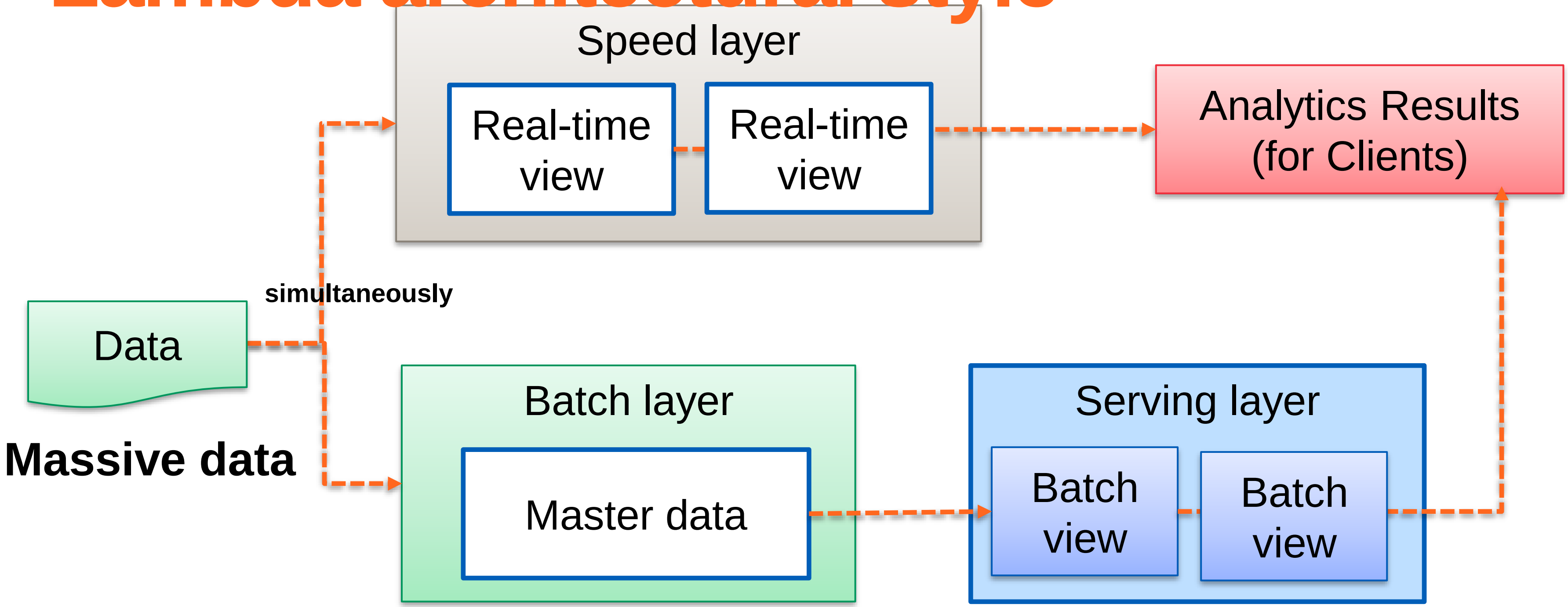
if you have mixed types of data

Or

if you have big data you want to do analytics with different quality of analytics (cost, performance, quality of data)?

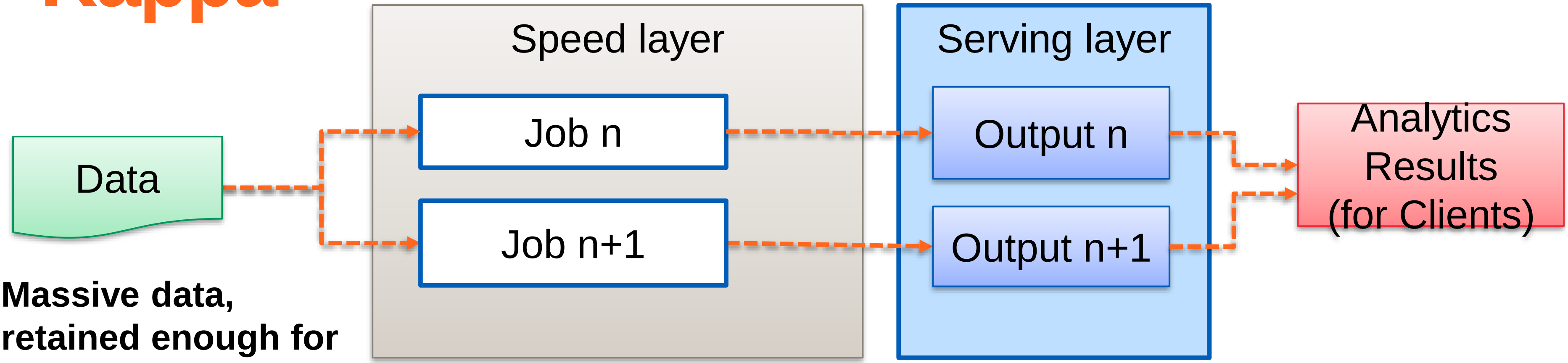
Then ?

Lambda architectural style



Check: http://lambda-architecture.net/

Kappa



Massive data, retained enough for preprocessing

Switch from version n to version n+1

Check: https://milinda.pathirage.org/kappa-architecture.com/

The set of big data tools/frameworks (and configurations) used is dependent on the big data architecture

be aware of your personal techradar!

Quick check

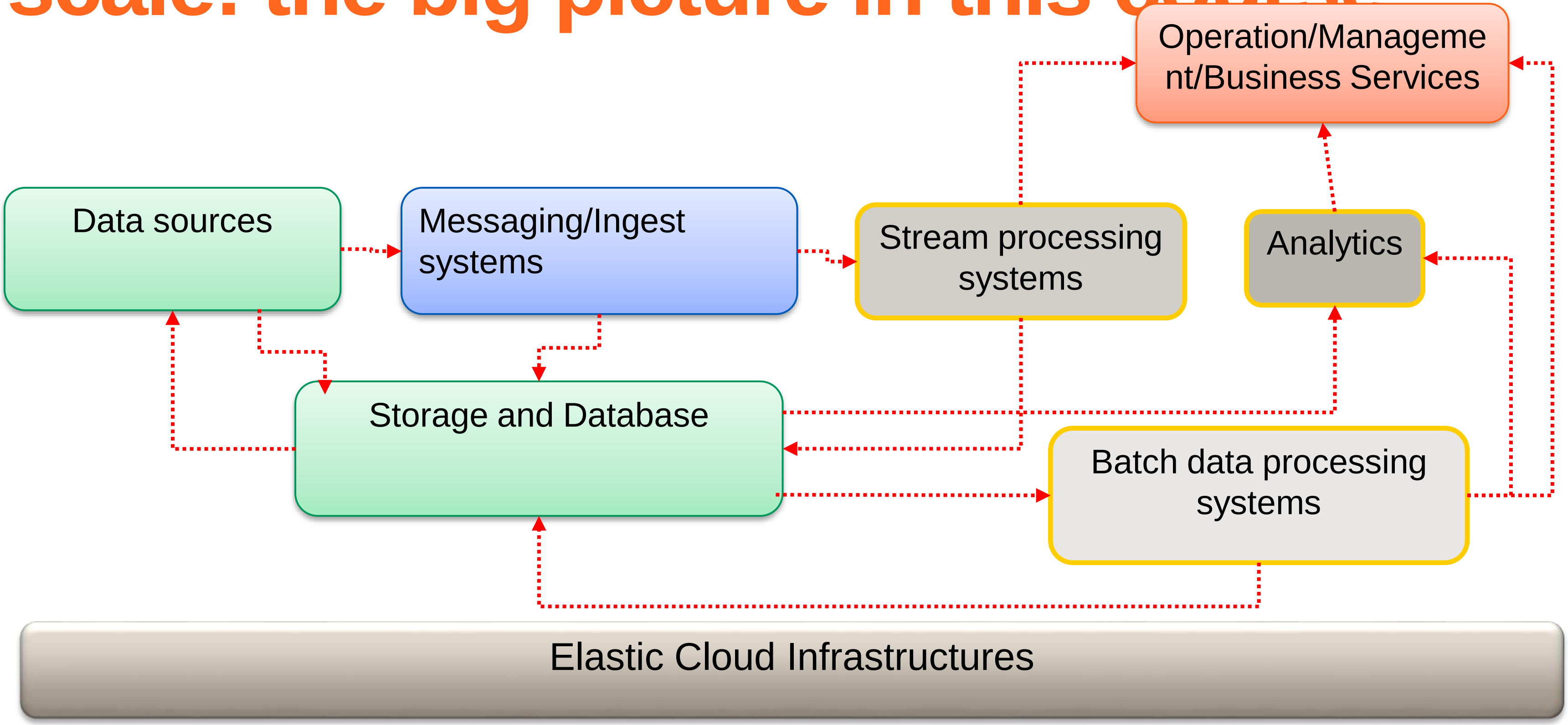
“A big data platform monitors network usage of devices from million+ customers. We have different levels: Sensor/Customer, Node (concentrator of multiple customers), Agent (concentrator of multiple Nodes) and the whole network. In a region, the real operator can generate 1.4 billion records per day ~ 72GB per day”

Quickcheck

First: breakout room discussion and then vote your choice

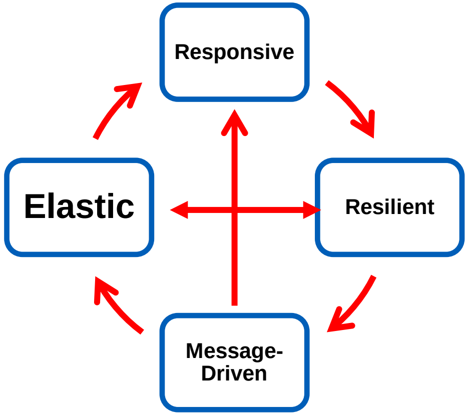
https://presemo.aalto.fi/bdp

Basic building blocks big data at large-scale: the big picture in this course


Operation/Management/Business Services
Data sources
Messaging/Ingest systems
Stream processing systems
Analytics
Storage and Database
Batch data processing systems
Elastic Cloud Infrastructures

How to architect big data platforms and pipelines as reactive systems?

Reactive systems



Source: https://www.reactivemanifesto.org/

Why? For dealing with V*

- Responsive: quality of services
- Resilient: deal within failures
- Elastic: deal with different workload and quality of analytics
- Message-driven: allow loosely coupling, isolation, asynchronous among many components

Designs must address various aspects

- **Responsive:**
  - distributed computing, multi layer optimization
- **Resilient:**
  - replication, containment, isolation
- **Elastic:**
  - sharding, replication, load balancing, scale up/out
- **Message-driven:**
  - loosely coupling of services with messages, non-blocking protocols, location-independent

Partitioning: splitting functionality & data

- breakdown the complexity
- easy to implement, replace and compose
- deal with performance, scalability, security, etc.
- support teams in DevOps
- cope with technology changes

Example of functional and data partitioning

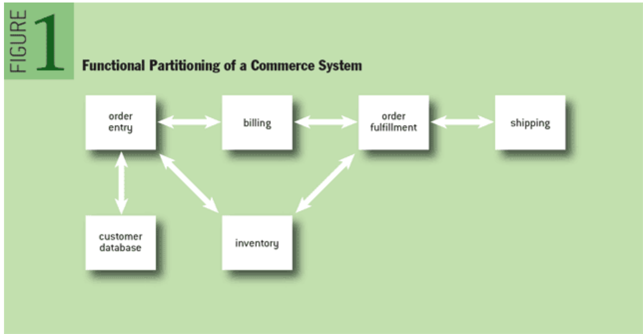


FIGURE 1 Functional Partitioning of a Commerce System

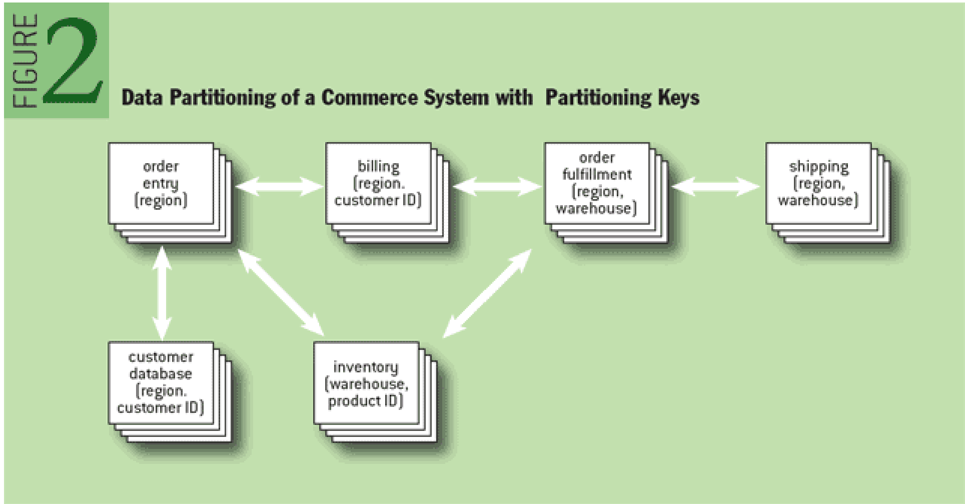


FIGURE 2 Data Partitioning of a Commerce System with Partitioning Keys

order entry (region)
billing (region. customer ID)
order fulfillment (region, warehouse)
shipping (region, warehouse)
customer database (region. customer ID)
inventory (warehouse, product ID)

Figures source: http://queue.acm.org/detail.cfm?id=1971597

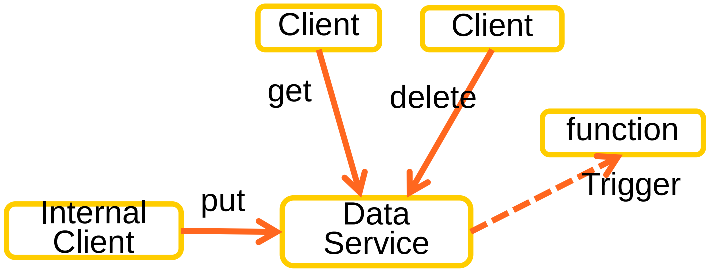
Distributed systems of components are used to manage, ingest data and process data

Interaction: protocols & interfaces

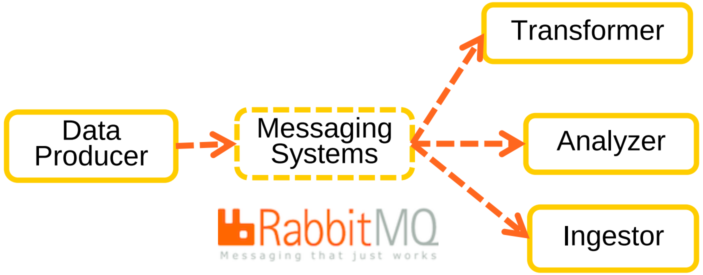
- **Large number of communication protocols and interfaces**
- **Interaction styles, protocols and interfaces**
  - REST, gRPC, Message Passing, Stream-oriented Communication
  - Your own protocols
- **Other criteria**
  - Architectural styles: microservices/serverless
  - Scalability, Elasticity, Performance, Monitoring, Logging, etc.

Interaction: Complex interactions

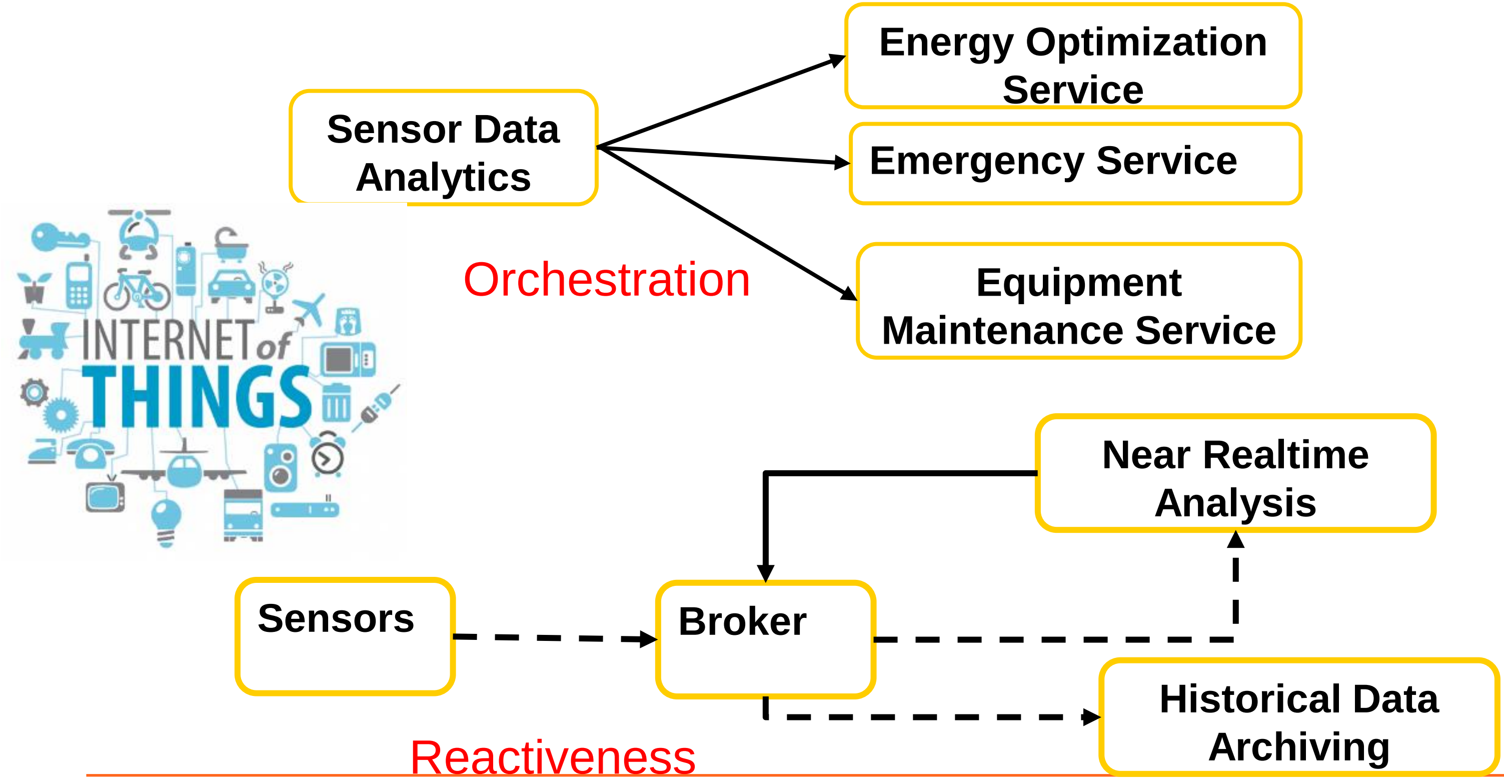
- One-to-many, many-to-one, many-to-many
- Synchronous/asynchronous calls
- Public/Subscribe, Message-oriented Middleware
- Internal data exchange versus open/external exchange



Amazon S3/MongoDB



Coordination: Orchestration and Reactiveness



Sensor Data Analytics

Energy Optimization Service

Emergency Service

Equipment Maintenance Service

Orchestration

Near Realtime Analysis

Sensors

Broker

Historical Data Archiving

Reactiveness

Distribution: Edge or Data Centers?

Big data & components components can be distributed in different places!

Global deployment or not?

Move analytics/work or move data?

Use Case 3: Video Analytics

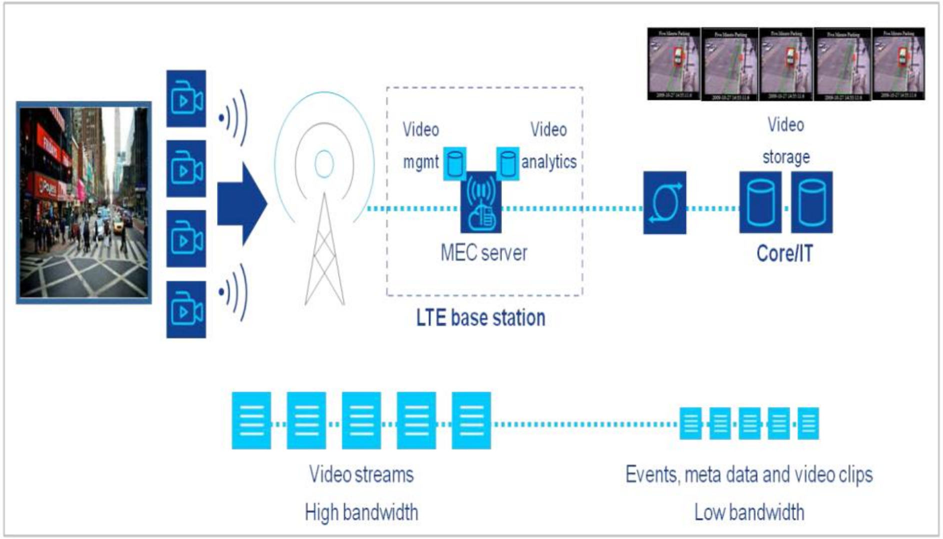


Figure 4: Example of video analytics

Figure source: https://portal.etsi.org/portals/0/tbpages/mec/docs/mobile-edge_computing_-_introductory_technical_white_paper_v1%2018-09-14.pdf

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https://presemo.aalto.fi/bdp

Scalability and elasticity: scale out

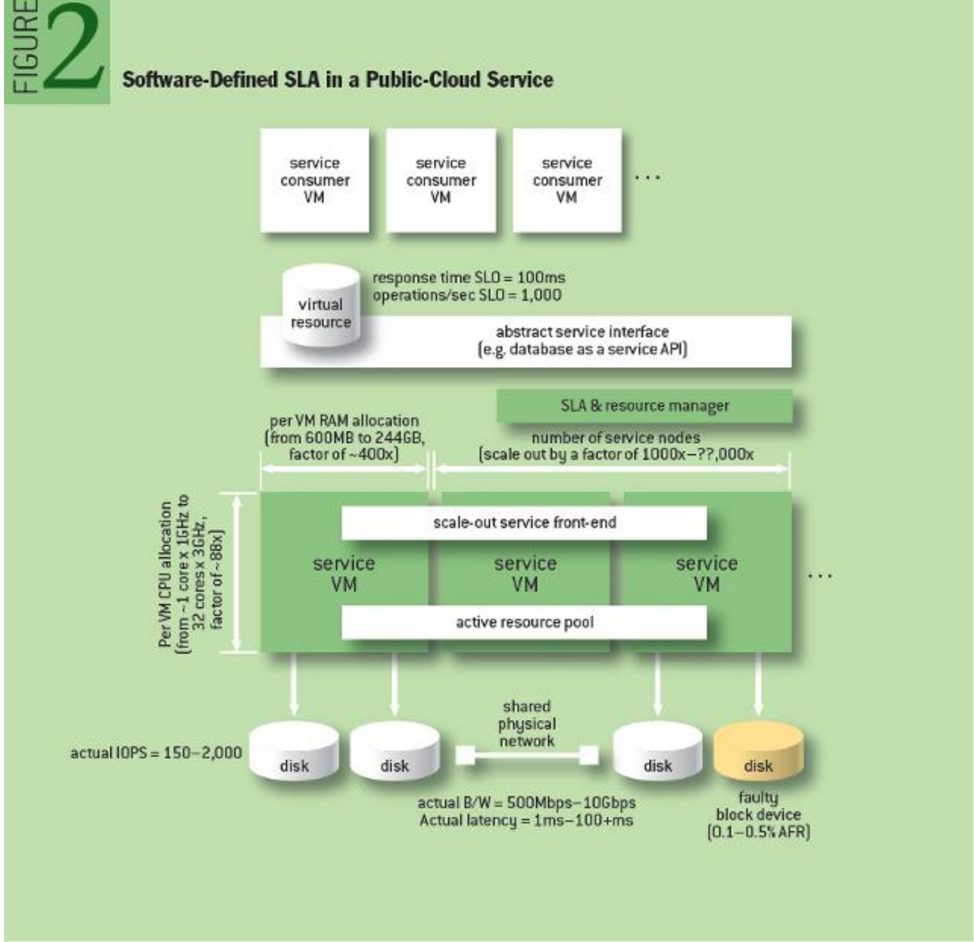


FIGURE 2 Software-Defined SLA in a Public-Cloud Service

Figure source: http://queue.acm.org/detail.cfm?id=2560948

Scalability and elasticity: load balancing

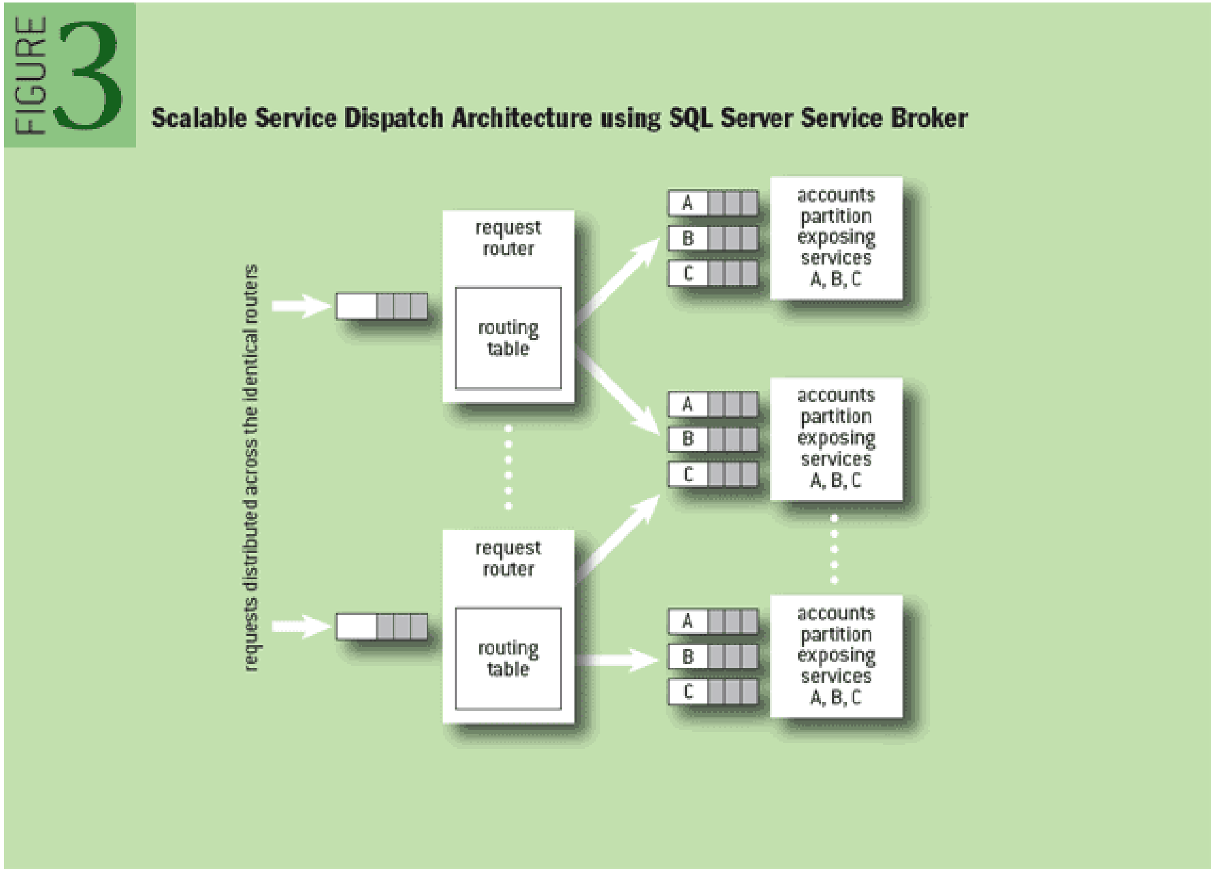
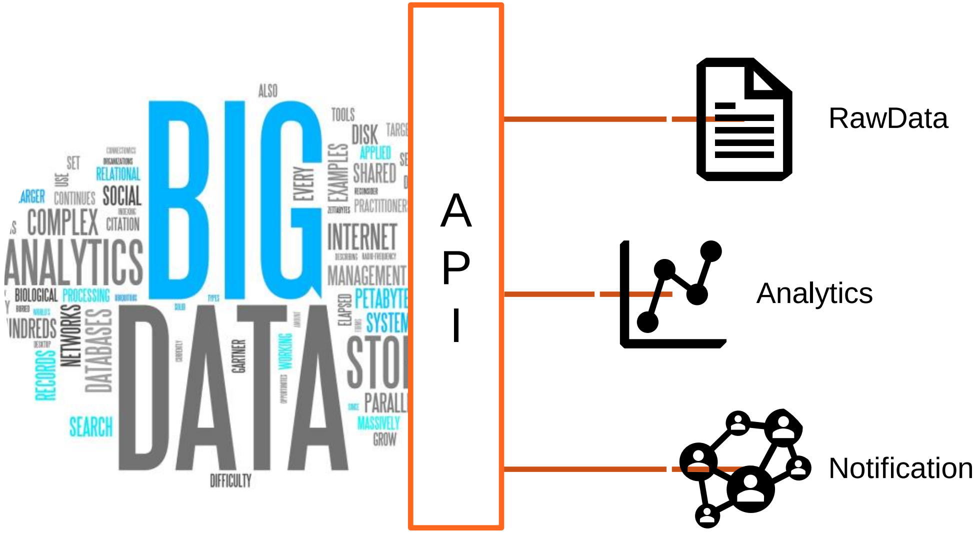


FIGURE 3
Scalable Service Dispatch Architecture using SQL Server Service Broker
requests distributed across the identical routers
request router
routing table
request router
routing table
A
B
C
accounts partition exposing services A, B, C
A
B
C
accounts partition exposing services A, B, C
A
B
C
accounts partition exposing services A, B, C

Figure source: http://queue.acm.org/detail.cfm?id=1971597

API for Platform as a Service

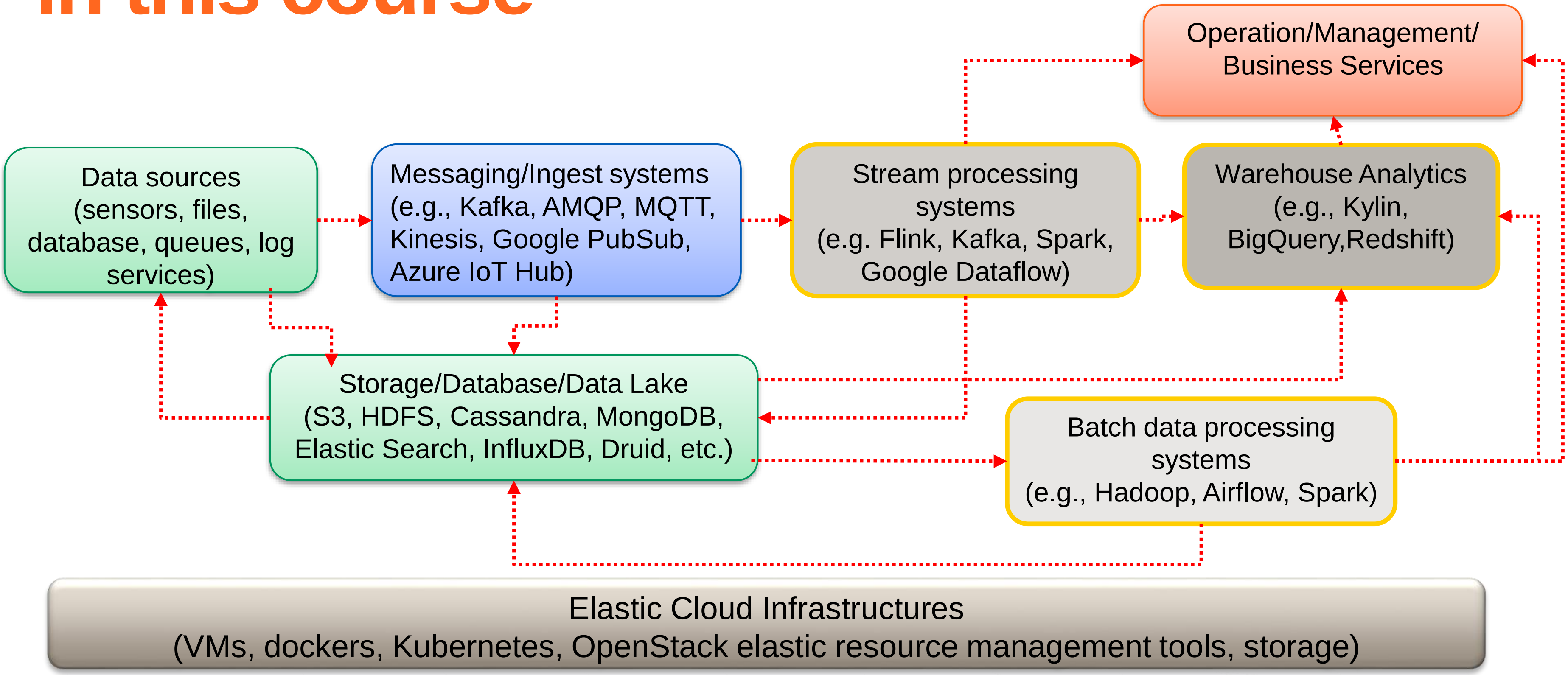
- **APIs are key! Why?**
  - Enable customers access to data and analysis functions from your big data platforms without worrying about changes within your platforms
  - Virtualization and management (hide internal, control access, throttling)



Which API would you publish? And how other concepts are related, e.g. API Gateways for Load balancing and Fault-Tolerance?

Common, high-level architecture view with popular state-of-the art tool for our study

Big data at large-scale: the big picture in this course



Operation/Management/ Business Services

Data sources (sensors, files, database, queues, log services)

Messaging/Ingest systems (e.g., Kafka, AMQP, MQTT, Kinesis, Google PubSub, Azure IoT Hub)

Stream processing systems (e.g. Flink, Kafka, Spark, Google Dataflow)

Warehouse Analytics (e.g., Kylin, BigQuery,Redshift)

Storage/Database/Data Lake (S3, HDFS, Cassandra, MongoDB, Elastic Search, InfluxDB, Druid, etc.)

Batch data processing systems (e.g., Hadoop, Airflow, Spark)

Elastic Cloud Infrastructures (VMs, dockers, Kubernetes, OpenStack elastic resource management tools, storage)

Thanks!

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rdsea.github.io