Internet of Things and Services

Service-oriented architectures

IoT and Big Data Systems

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Big Data

"Big data exceeds the reach of commonly used hardware environments and software tools to capture, manage, and process it with in a tolerable elapsed time for its user population." - Teradata Magazine article, 2011

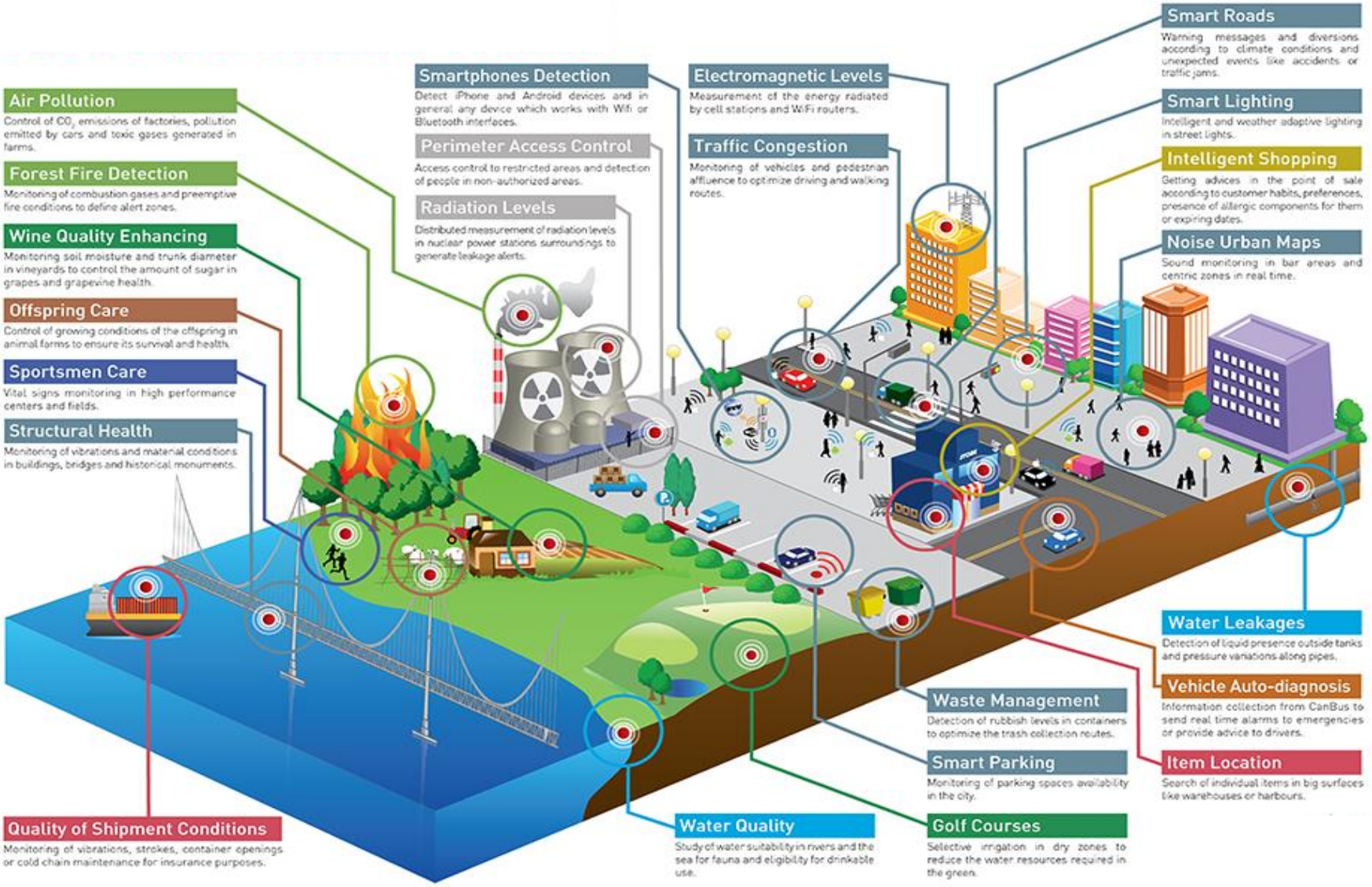
"Big data refers to data sets whose size is beyond the ability of typical database software tools to capture, store, manage and analyze." - The McKinsey Global Institute, 2012

"Big data is a field that treats of ways to analyze, systematically extract information from, or otherwise deal with data sets that are too large or complex to be dealt with by traditional data-processing application software." - Wikipedia, 2019

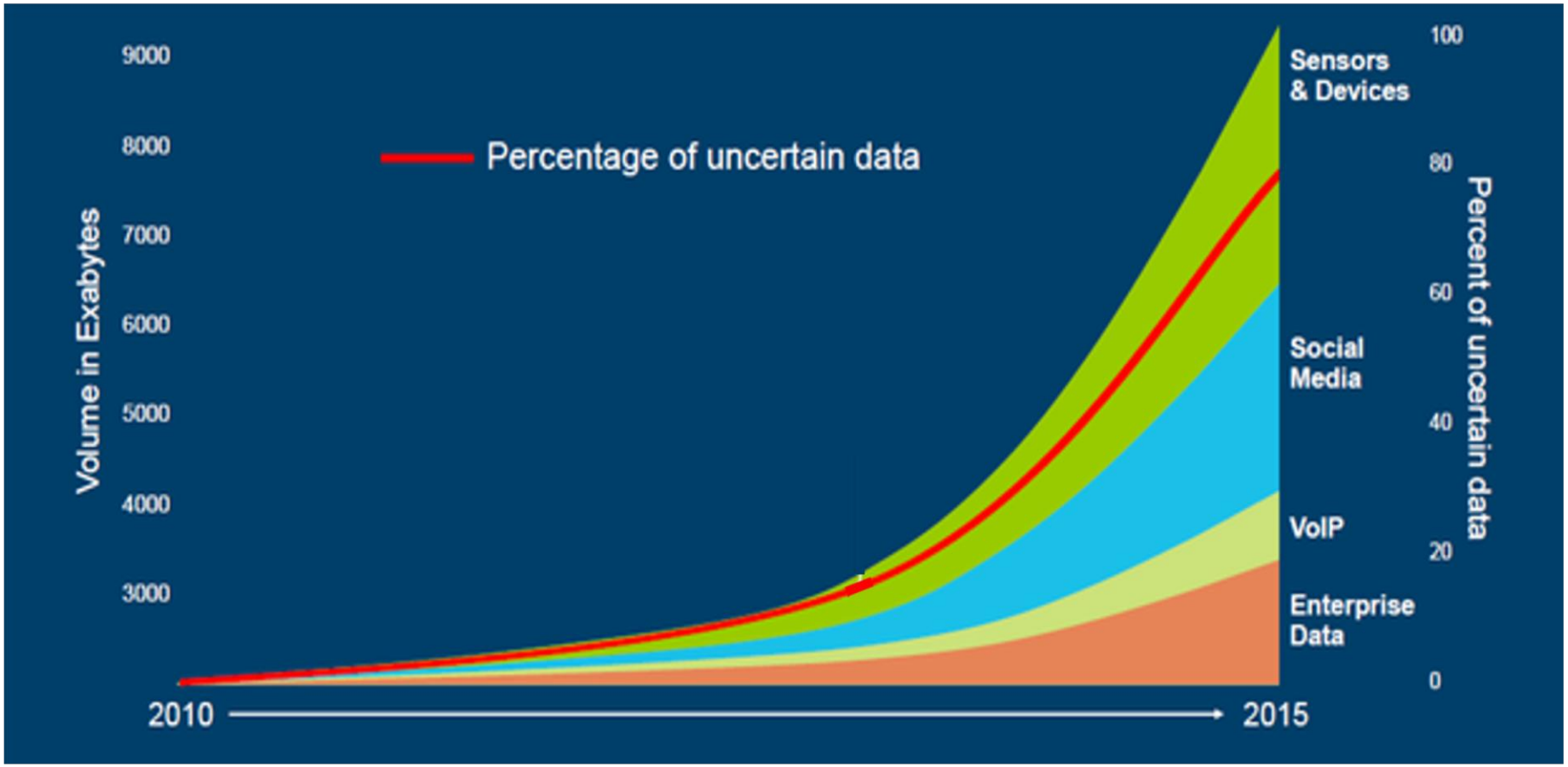
Big Data - Numbers

- How many data in the world?
  - 800 Terabytes, 2000
  - 160 Exabytes, 2006 (1EB = 10^{18}B)
  - 4.5 Zettabytes, 2013 (1ZB = 10^{21}B)
  - 44 Zettabytes by 2020
  - 163 Zettabytes by 2025
- How many data in a day?
  - 2.5 Exabytes
  - 8 TB, Twitter
  - 50 TB, Facebook
- 90% of world's data generated over last two years!

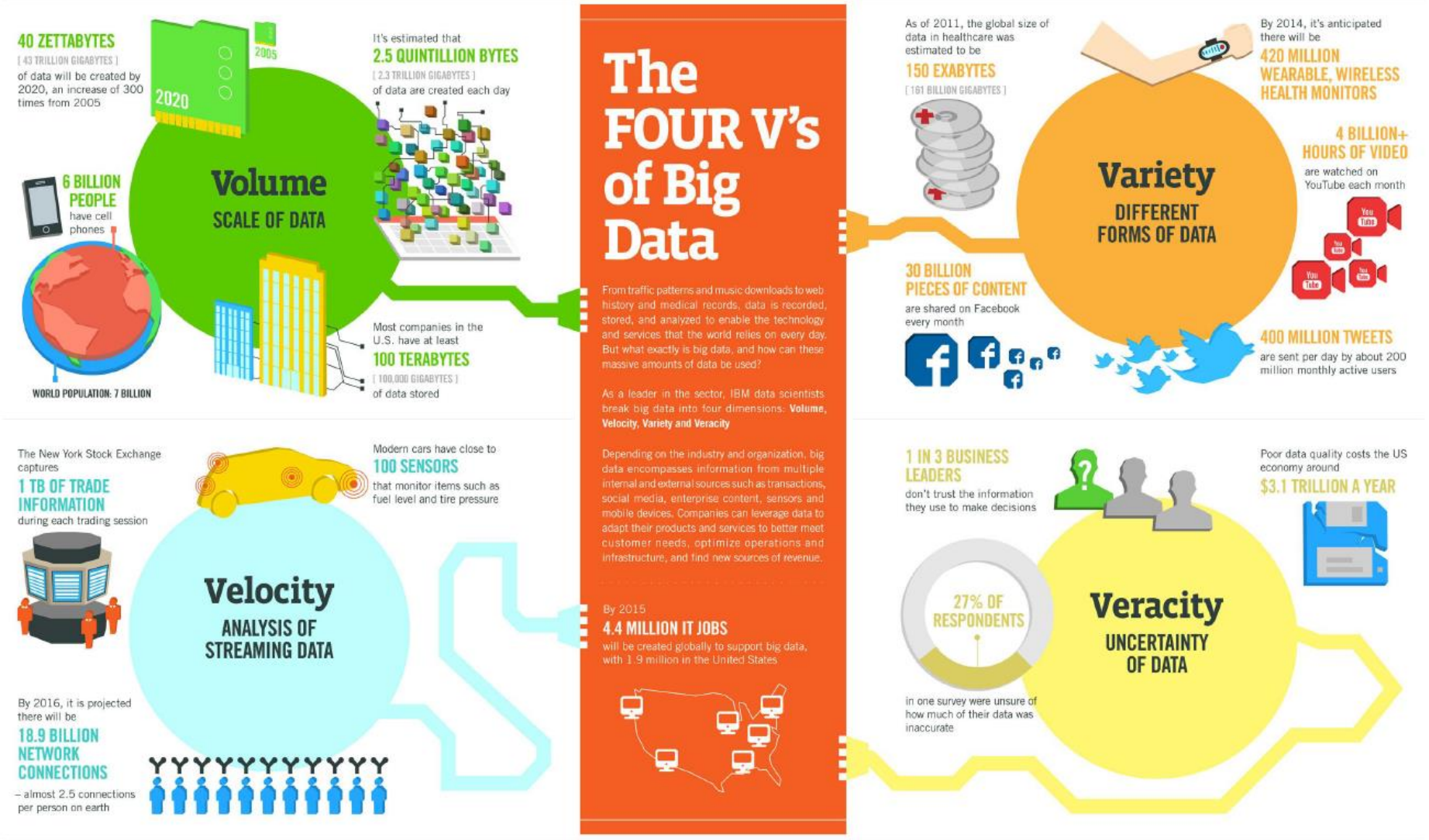
Big Data sources - Smart world



Big Data sources



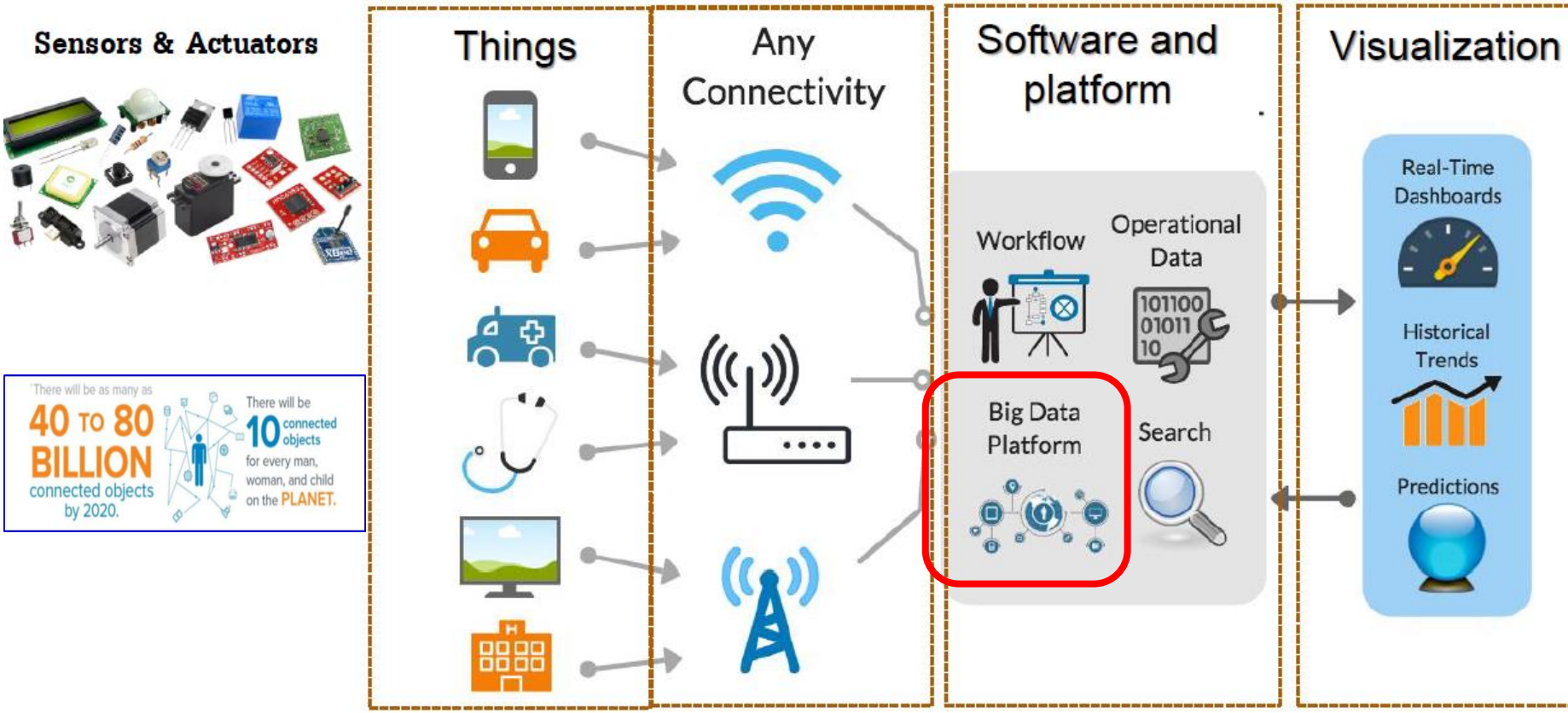
The four "V's" of Big Data



Big Data: 4V + VALUE

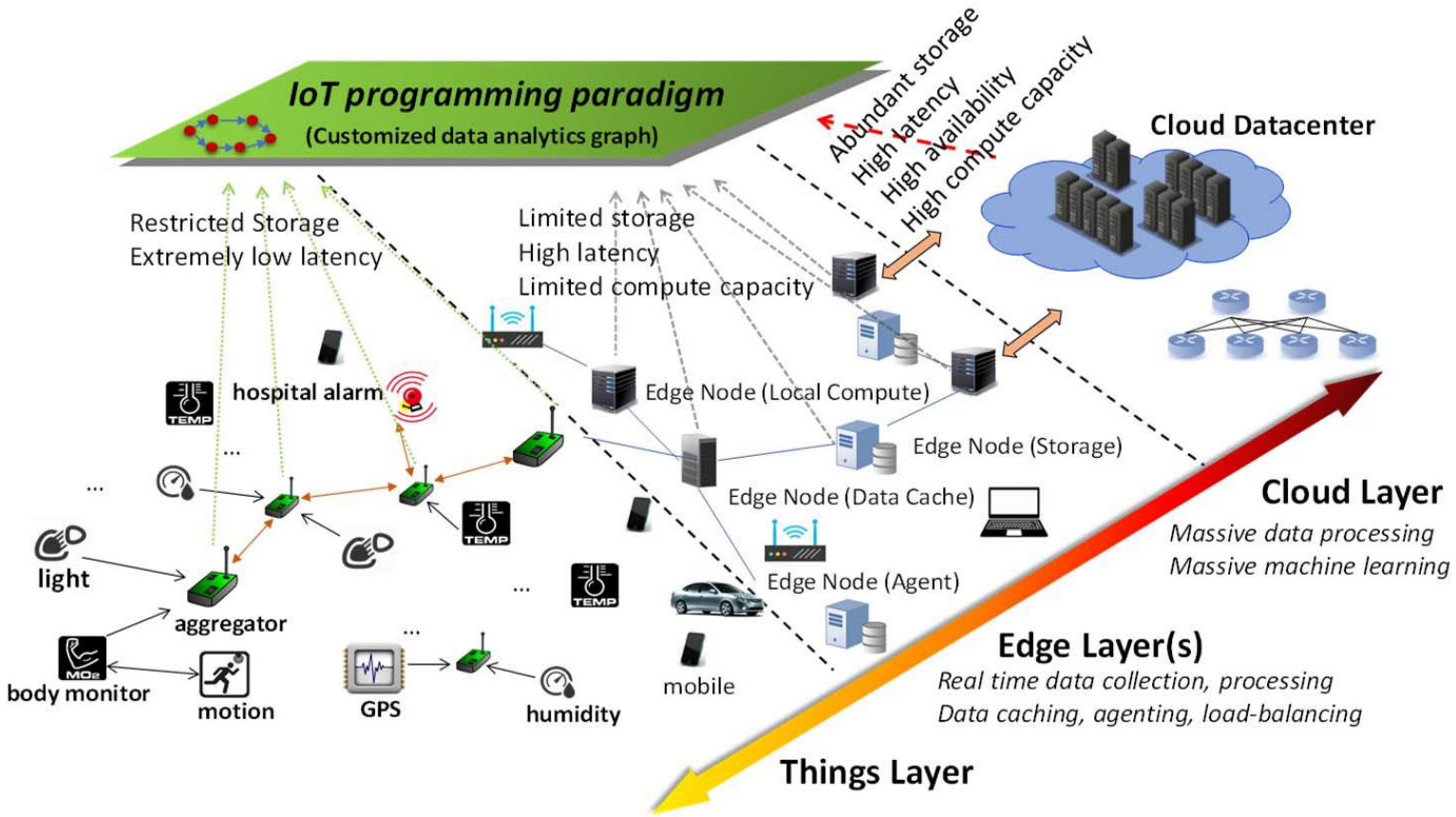
- Volume
  - Terabyte(10^{12}), Petabyte(10^{15}), Exabyte(10^{18}), Zettabyte (10^{21})
- Variety
  - Structured, semi-structured, unstructured;
  - Text, image, audio, video, record
- Velocity
  - Periodic, Near Real Time, Real Time
- Veracity
  - Quality of the data can vary greatly
- Value
  - Big Data can generate huge competitive advantages

IoT Big Data architecture



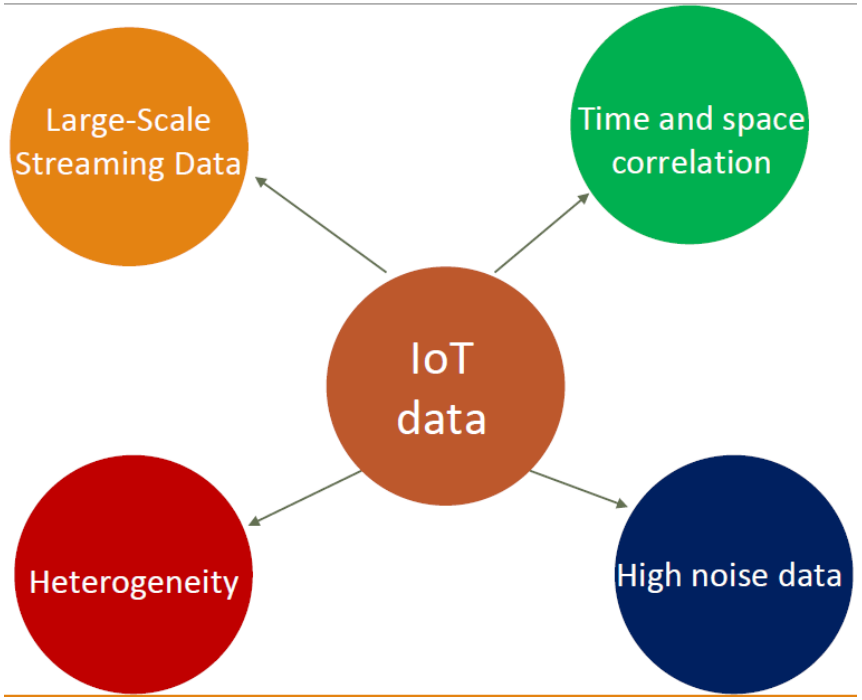
IoT & Smart health

- A typical IoT application infrastructure of a healthcare use case showing of Things, Edge, and Cloud layers.

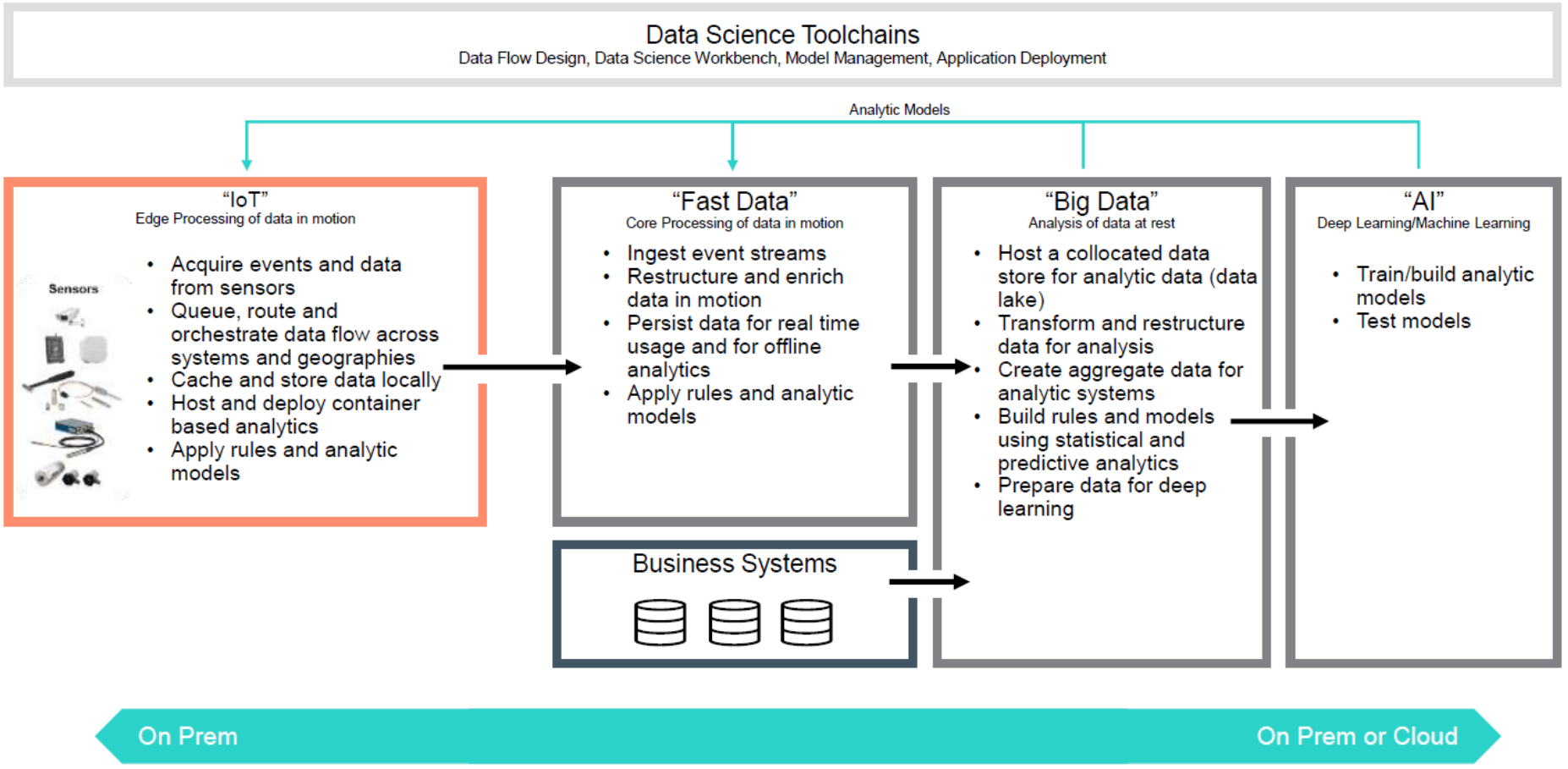


IoT Big Data characteristics

- Analytics requirement
  - Fast computing and advanced machine learning techniques require for IoT streaming data processing and IoT Big Data analytics
- IoT Applications support
  - High-speed data streams and requiring real-time or near real-time actions

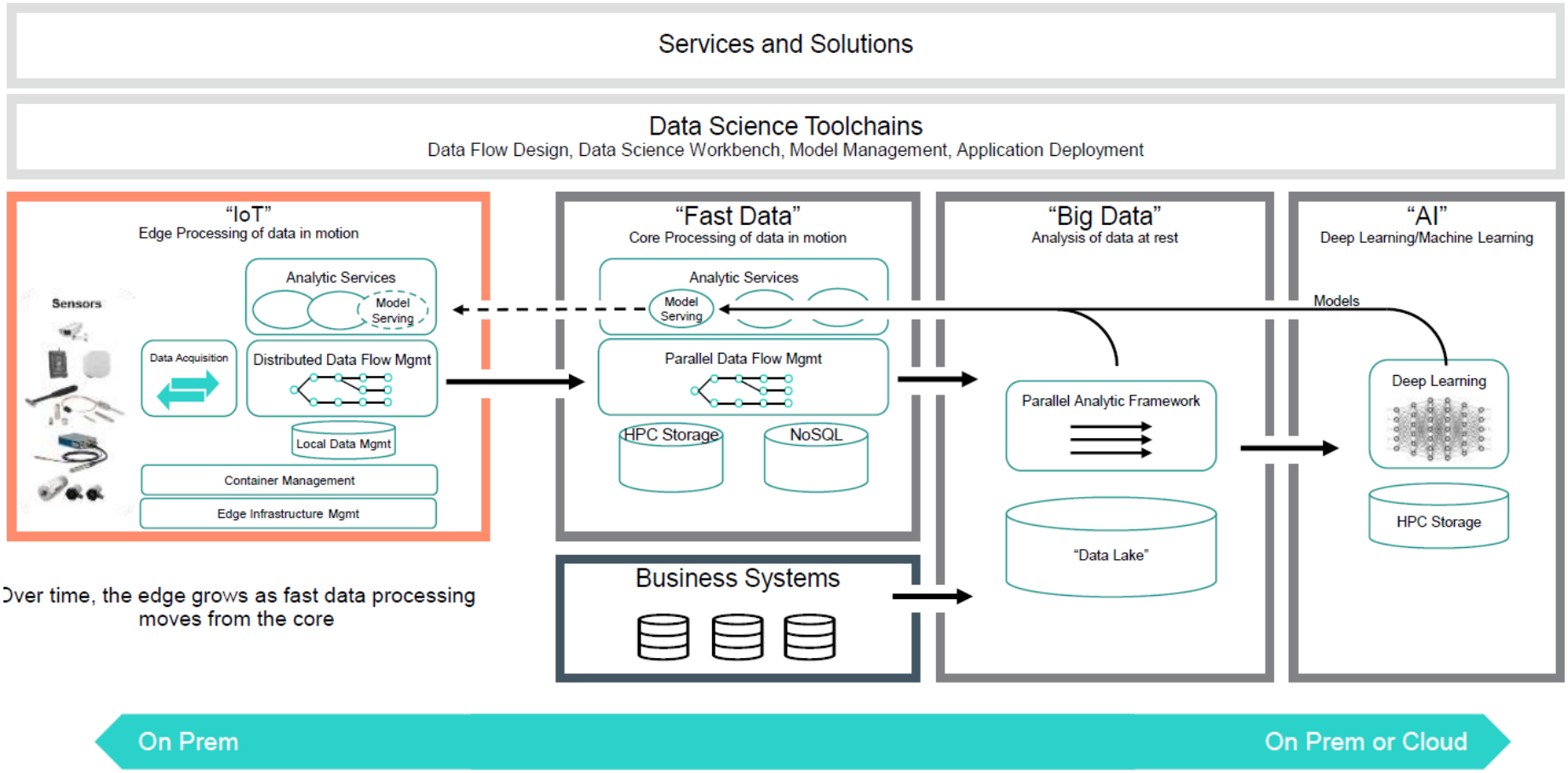


IoT Big Data flow (pipeline)

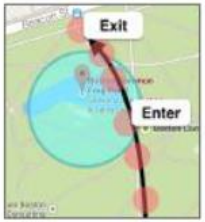


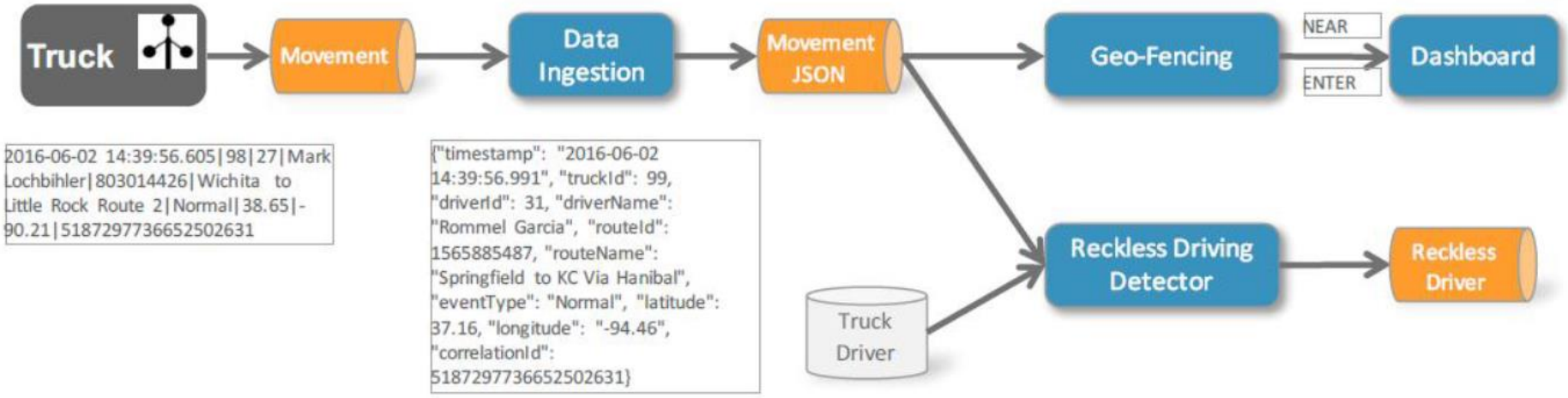
IoT Big Data flow (pipeline)

- Functional view



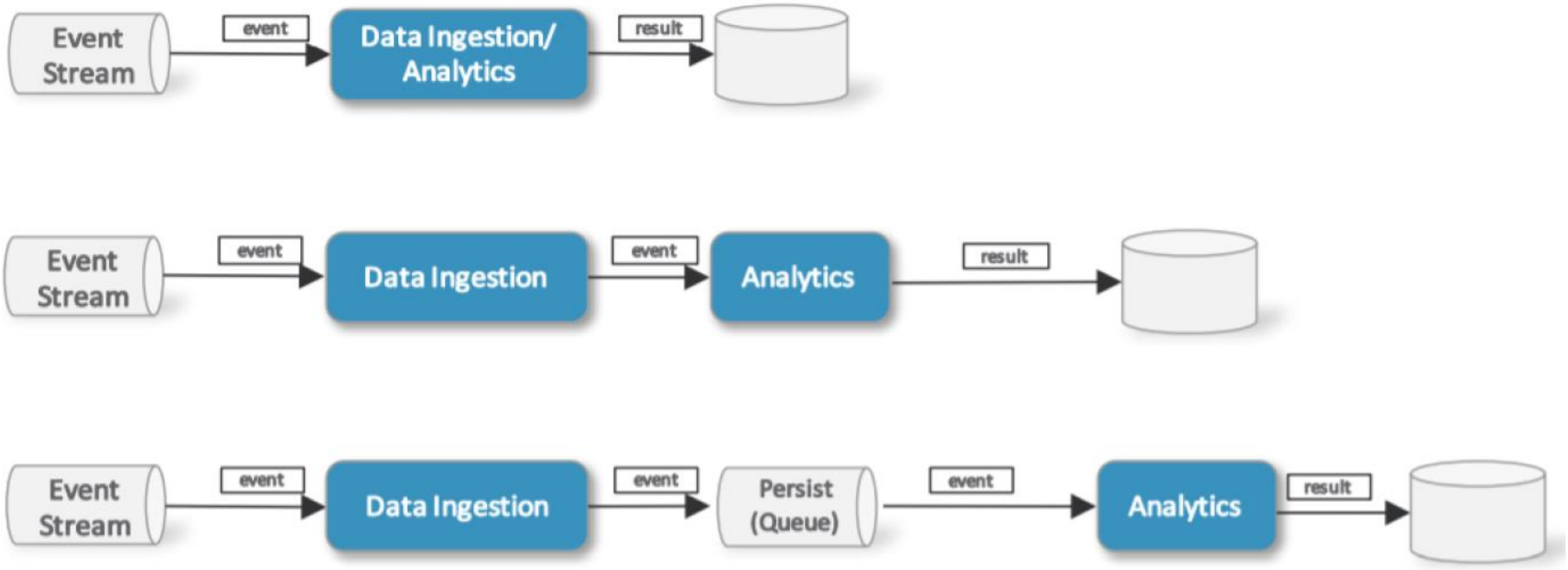
Truck monitoring - Use case





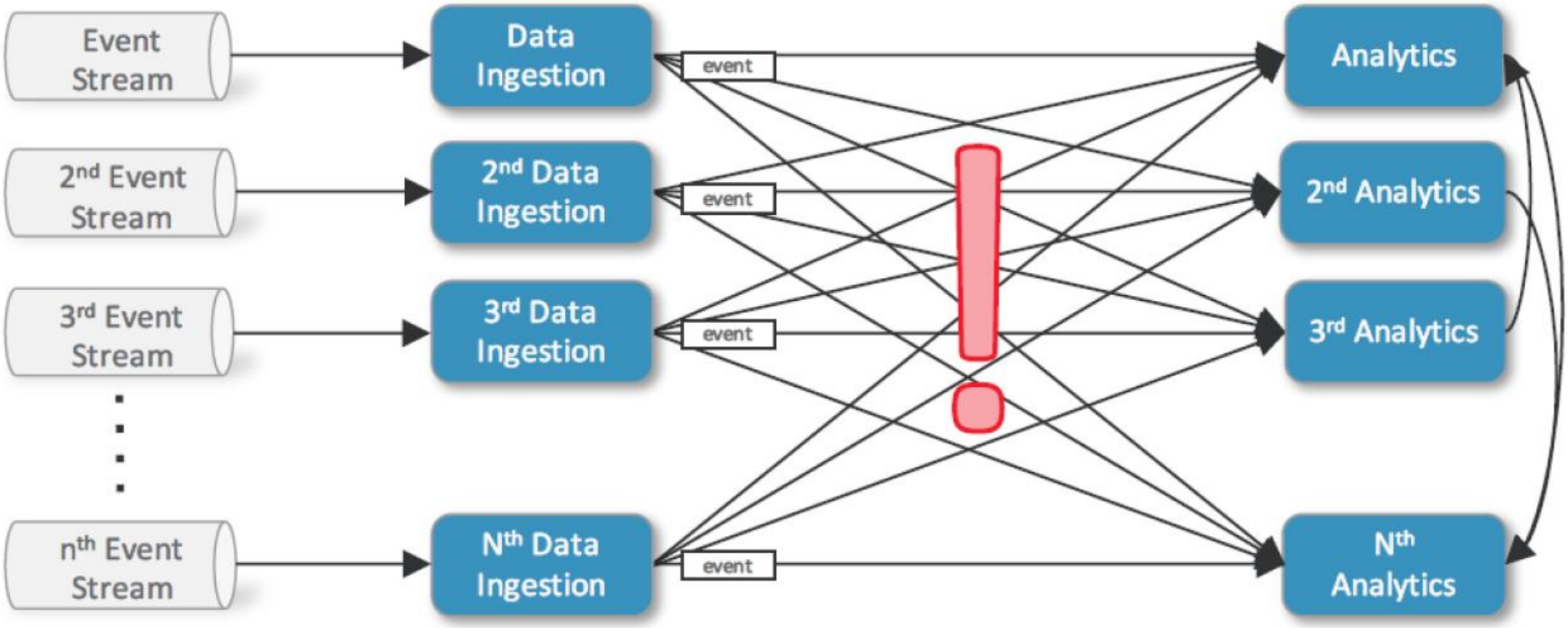
IoT streaming analytics

- How to design a Streaming Analytics Solution?



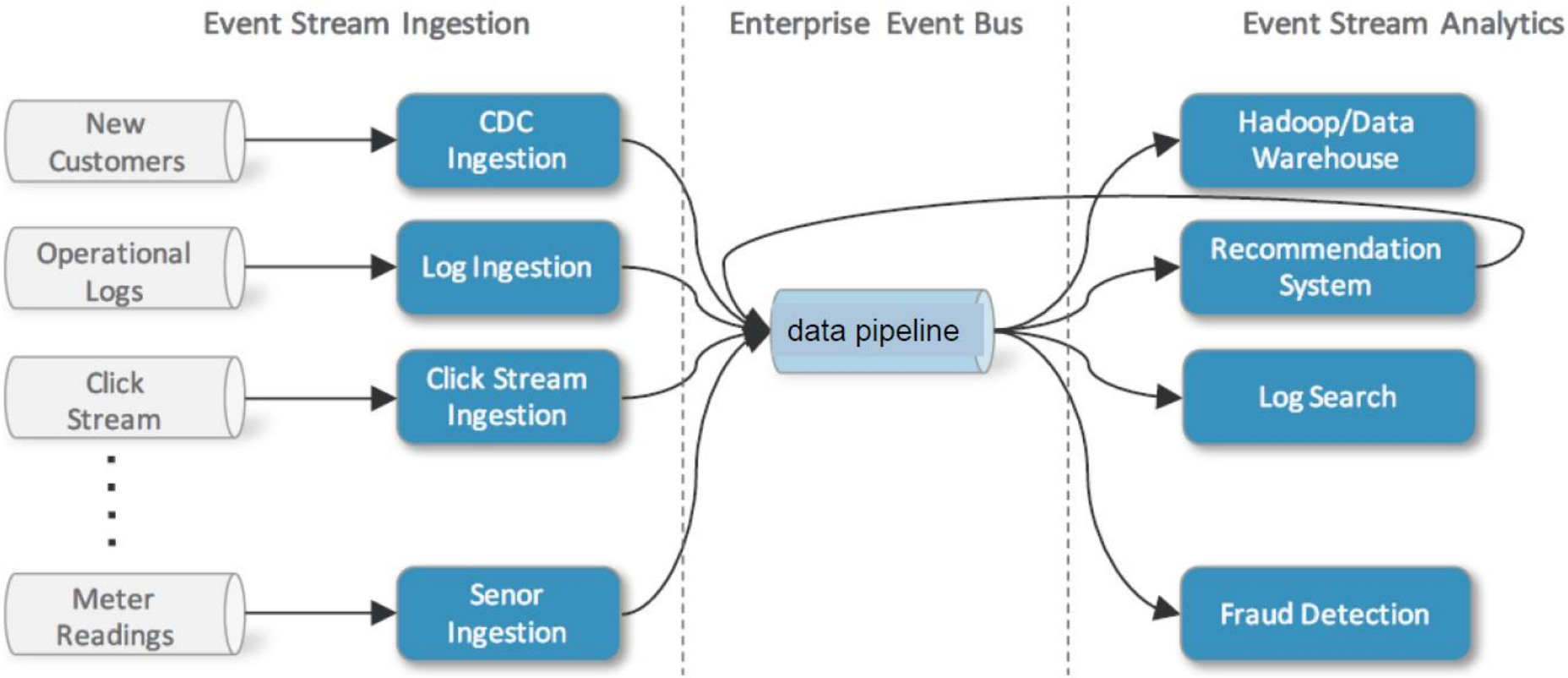
Stream sources and analytics

- New Event Stream sources are added and new Analytics are interested in the events



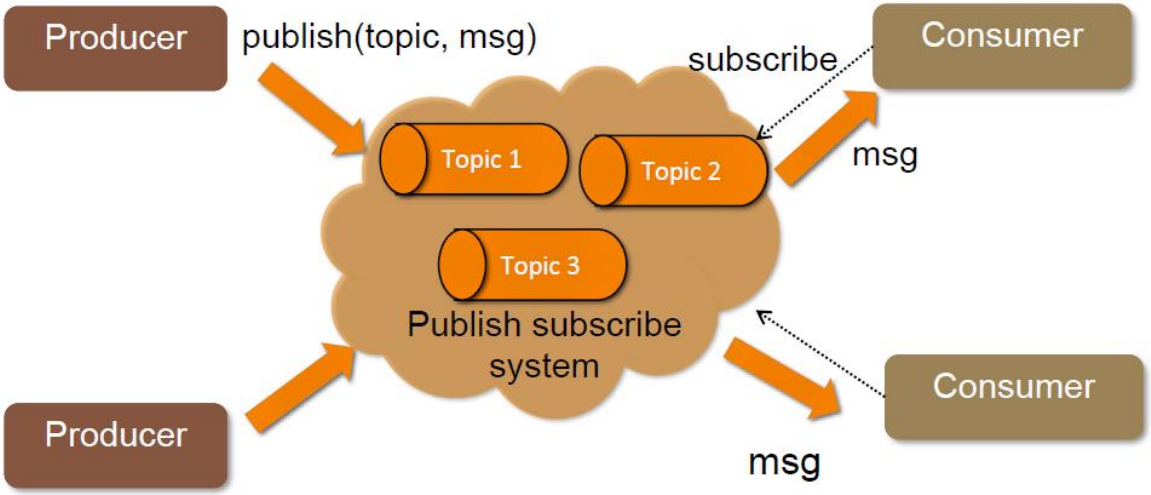
Stream sources and analytics

- Decouple event streams from consumers



Apache Kafka

- An open-source distributed streaming platform developed by LinkedIn and donated to the Apache Software Foundation.
  - https://kafka.apache.org/
- Aims to provide a unified, high-throughput, low-latency platform for handling real-time data feeds through message broker and publish/subscribe functionalities

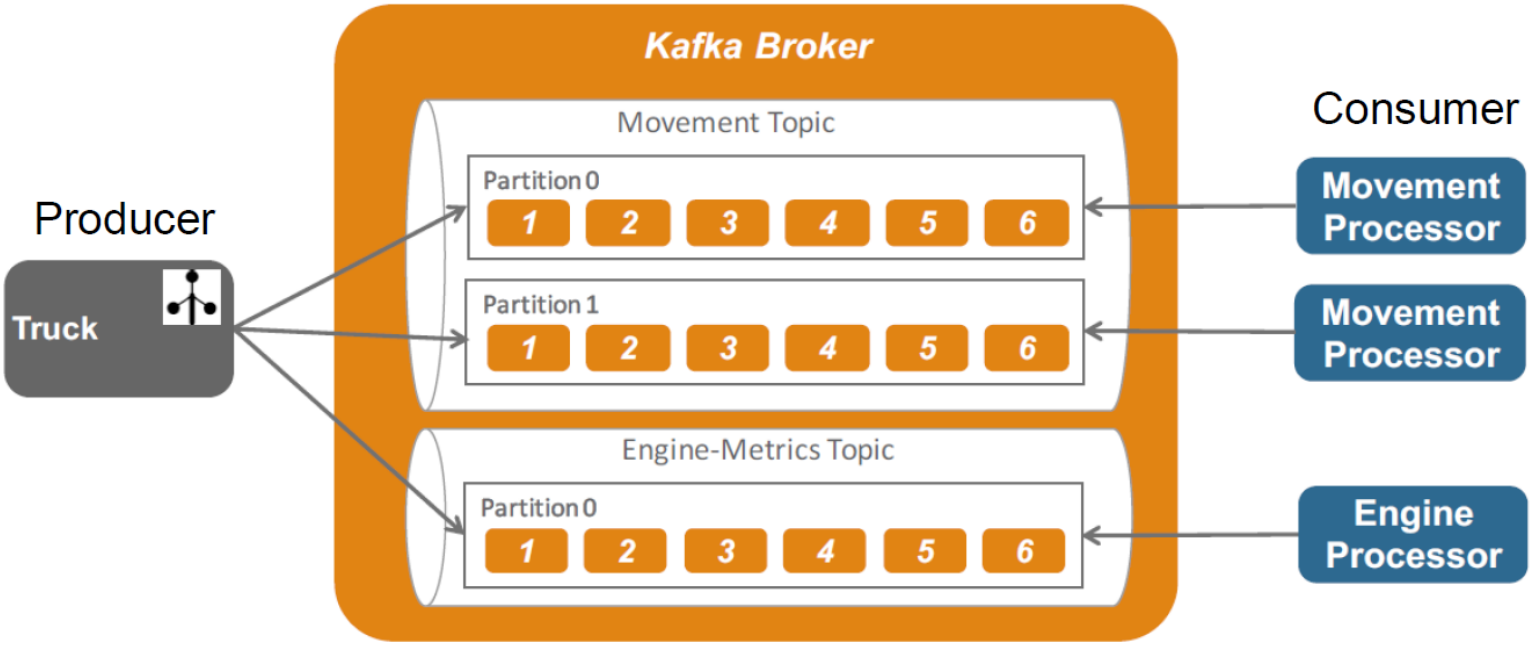


Kafka characteristics

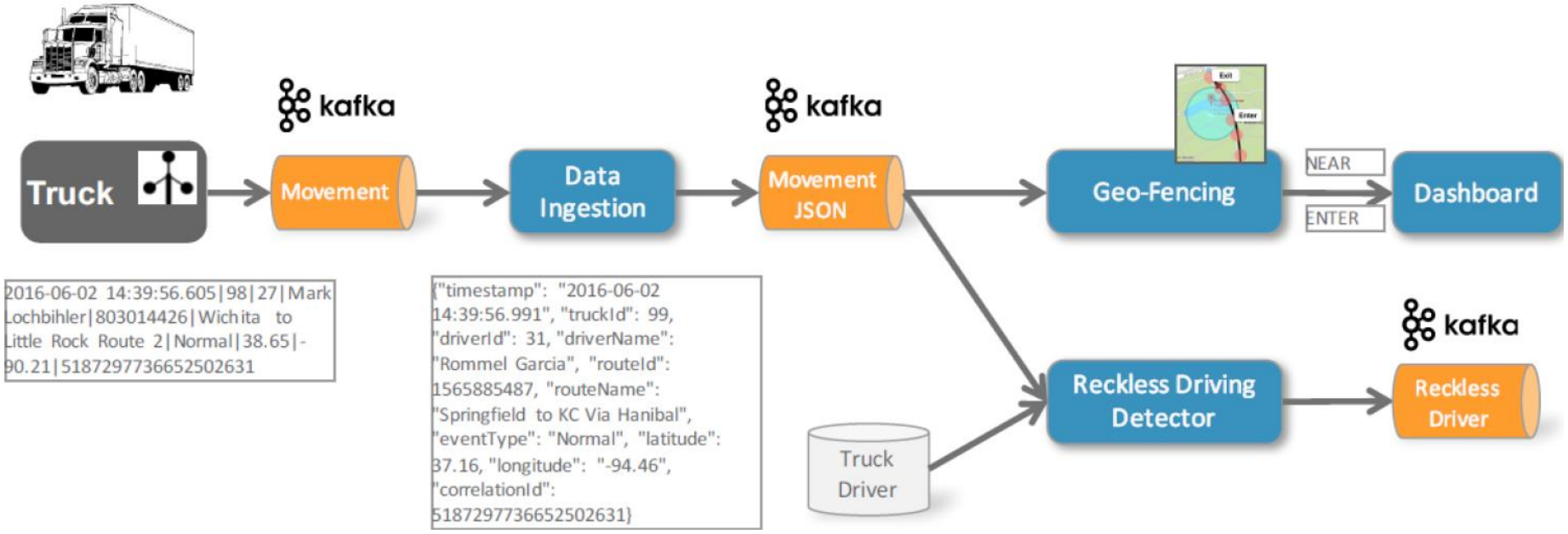
- Fast
  - Kafka can handle hundreds of megabytes of reads and writes per second from a large number of clients.
  - Designed for real time activity streaming.
- Distributed and highly scalable
  - Kafka has a cluster-centric design offers strong durability and fault-tolerance guarantees.
  - Messages partitioning spread over a cluster of machines
- Durable
  - Message persisted to disk and replicated within cluster to prevent data loss.
  - Each broker can handle terabytes of messages without performance impact

Kafka architecture

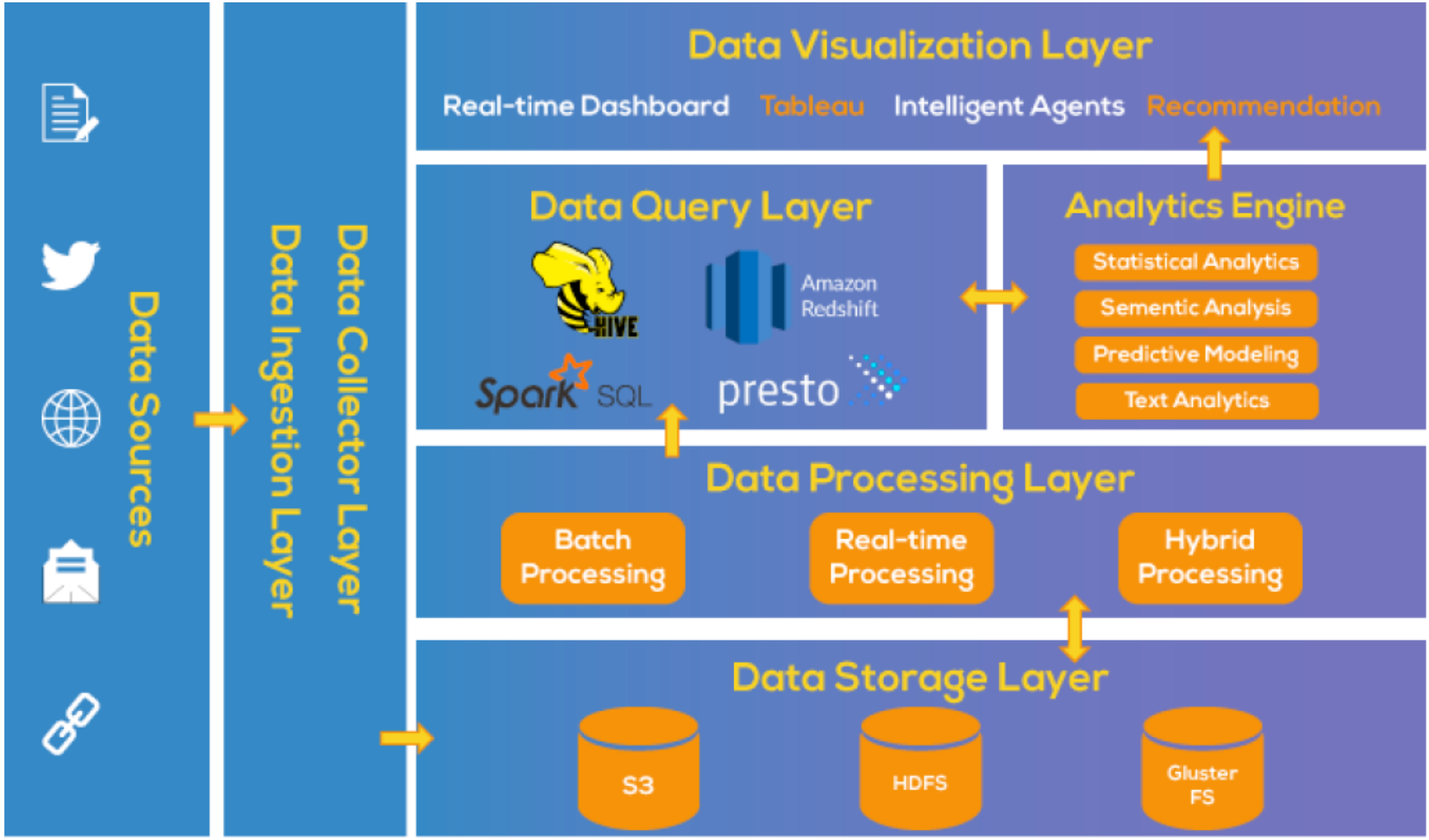
- Kafka Cluster is made up of multiple Kafka Brokers
- Producers and Consumers exchange messages via Topics
- Apache Zookeeper keeps track of status of the Kafka cluster nodes and it also keeps track of Kafka topics, partitions etc.



Truck monitoring – Use Case

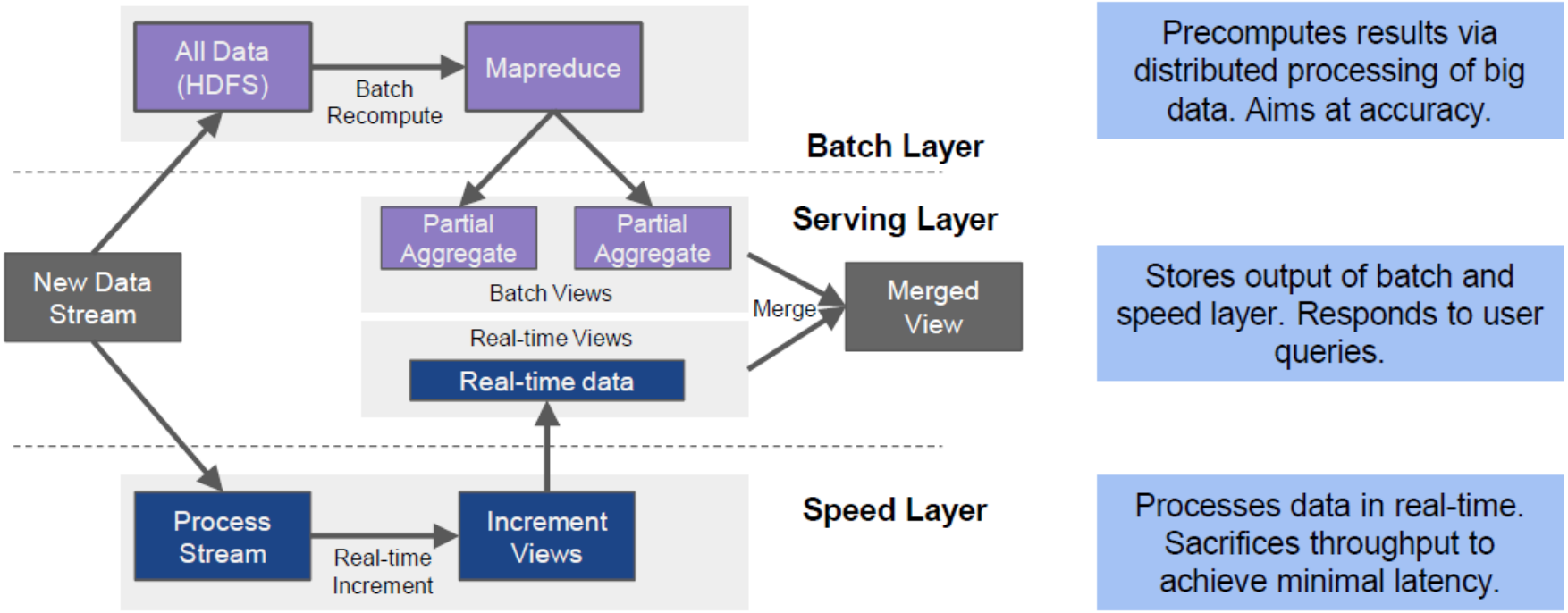


Big Data platform architecture



The Lambda architecture

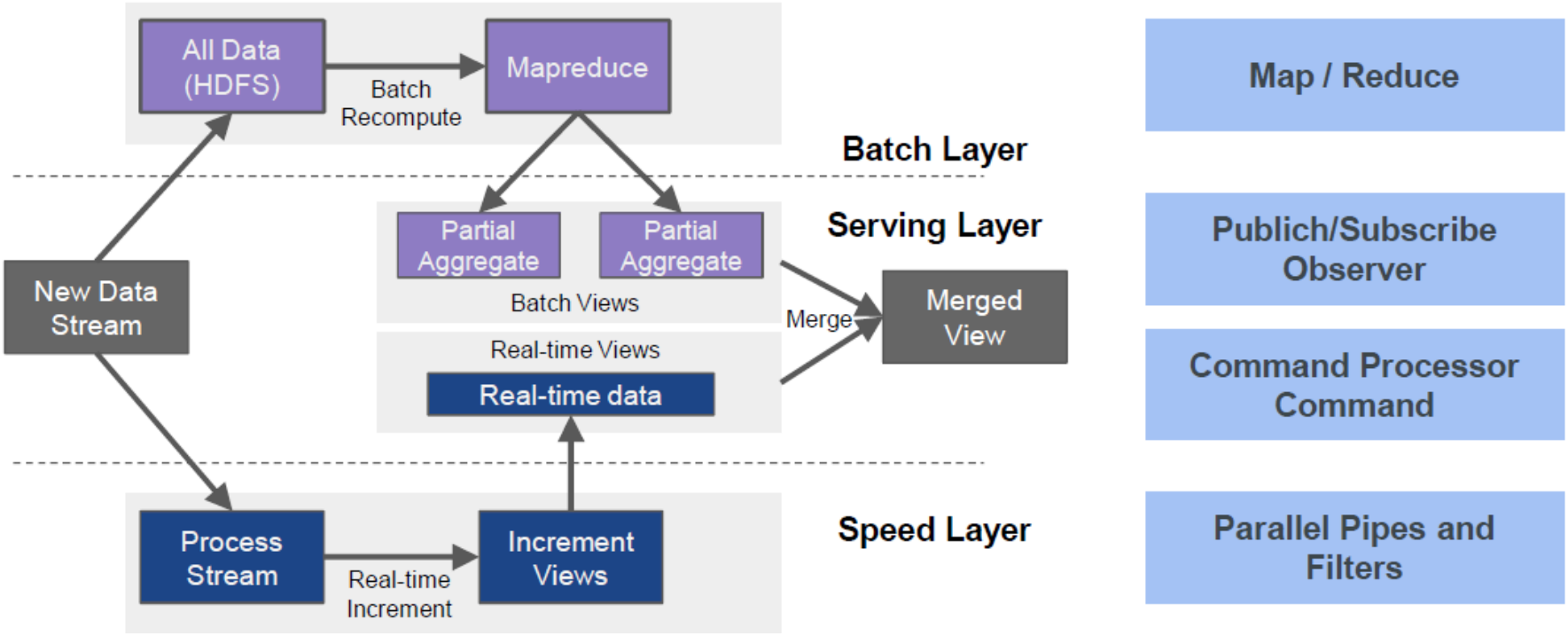
- The Lambda Architecture for Big Data processing and analytics applications



Originally designed by Nathan Marz for Twitter; now adopted by many companies

The Lambda architecture

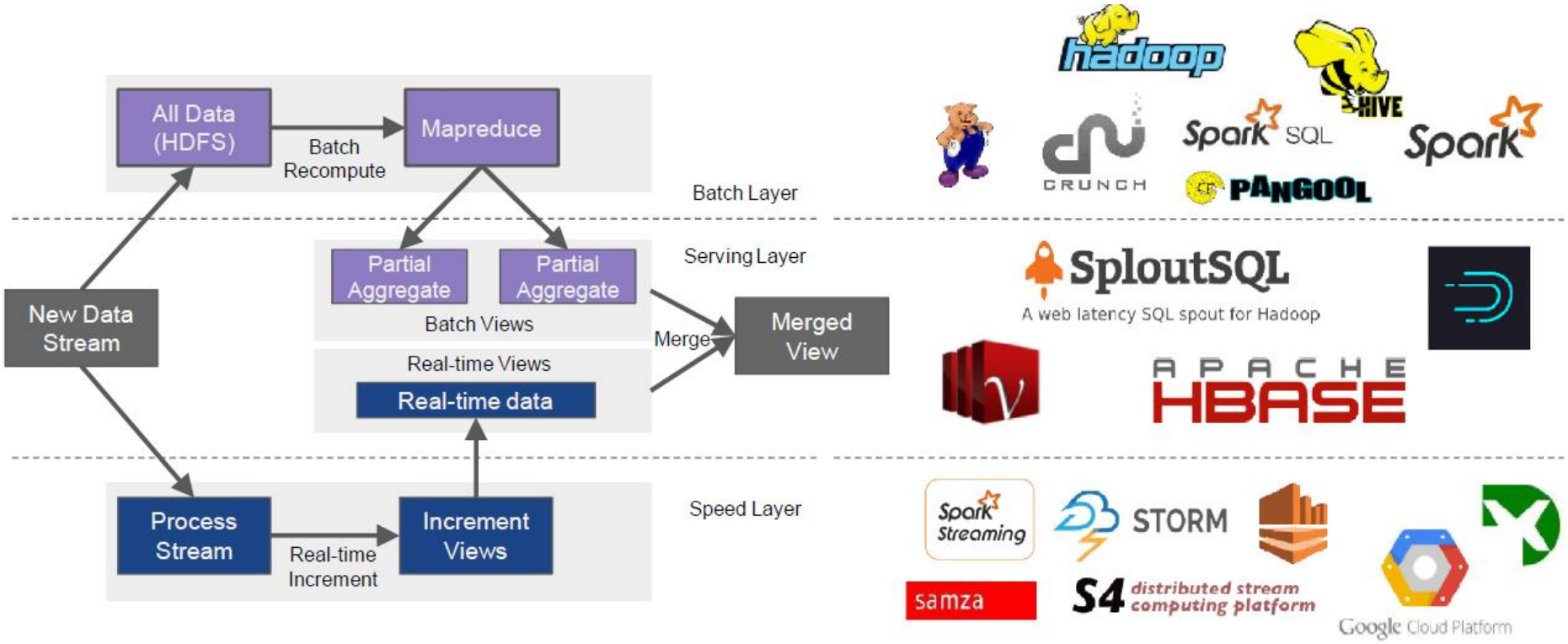
- Multiple architecture styles define the Lambda architecture



Originally designed by Nathan Marz for Twitter; now adopted by many companies

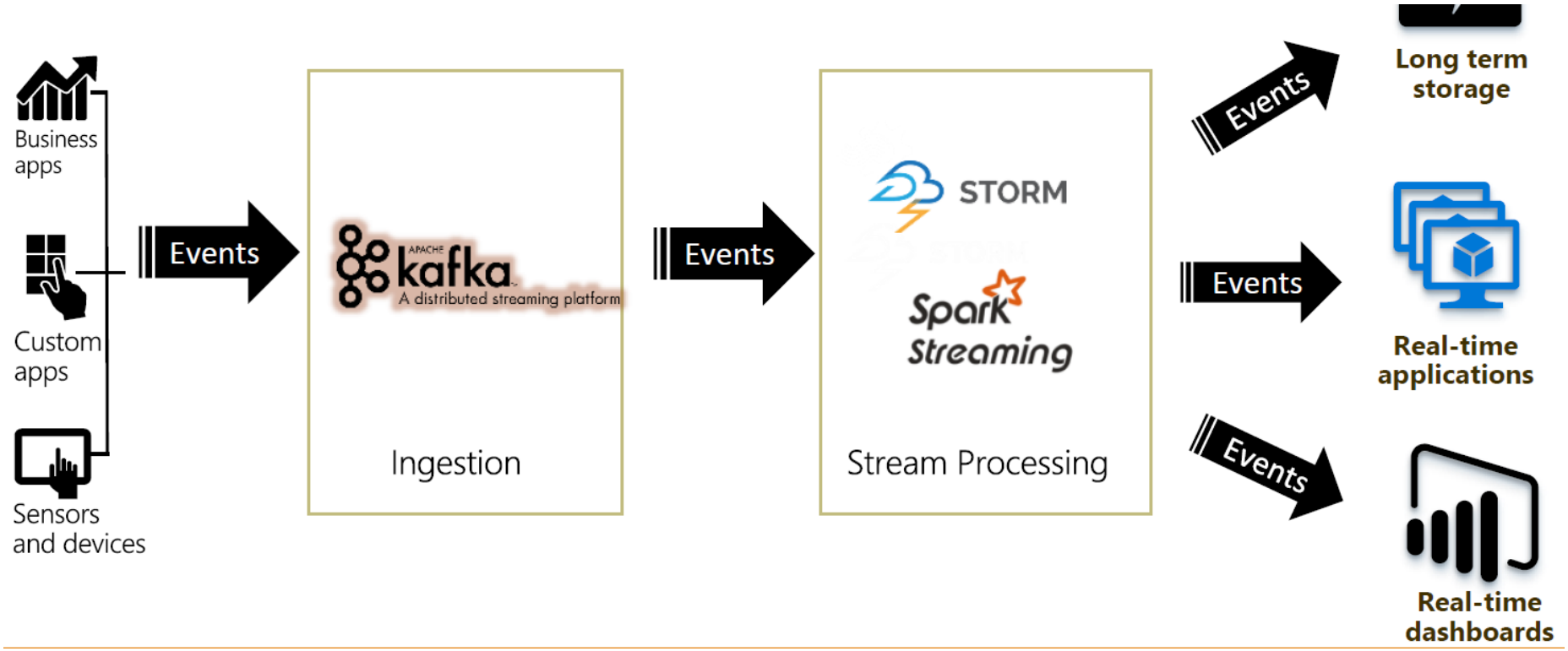
The Lambda architecture

- Many off-the-shelf and open source Big Data are technologies and frameworks available



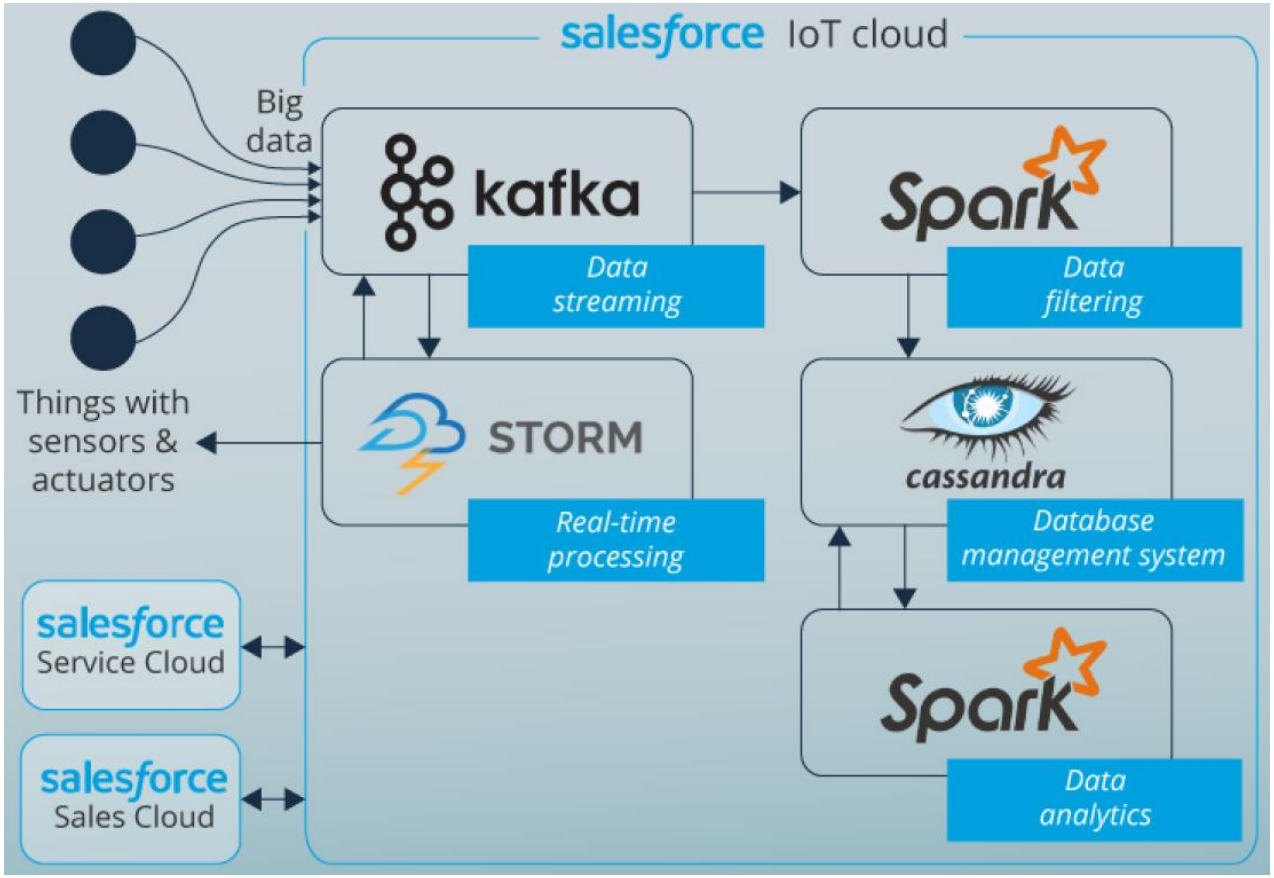
IoT Big Streaming Data

- Big Streaming Data flow and processing patterns



IoT Big Data - Example

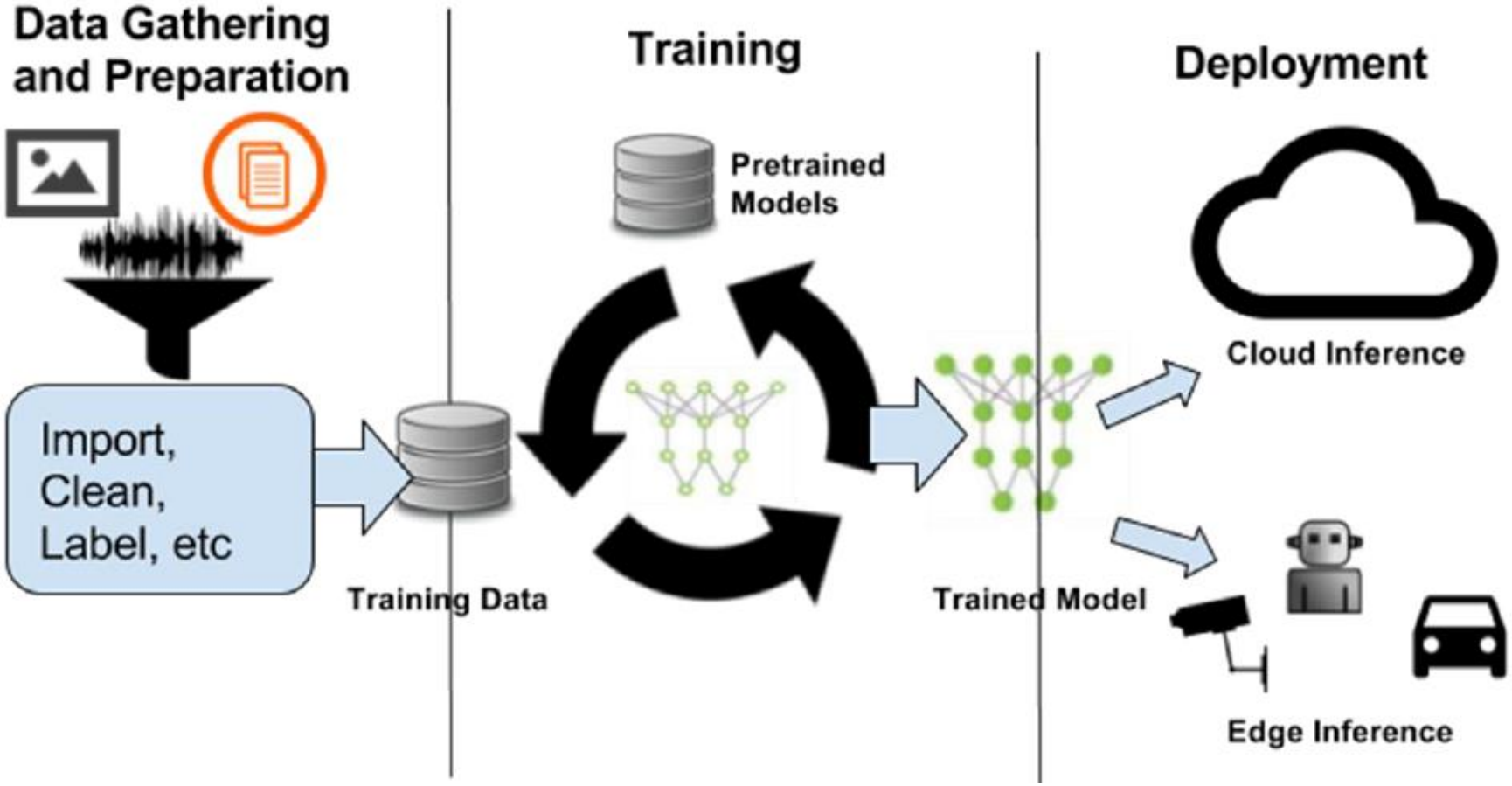
- Salesforce IoT Cloud: benefits and limitations



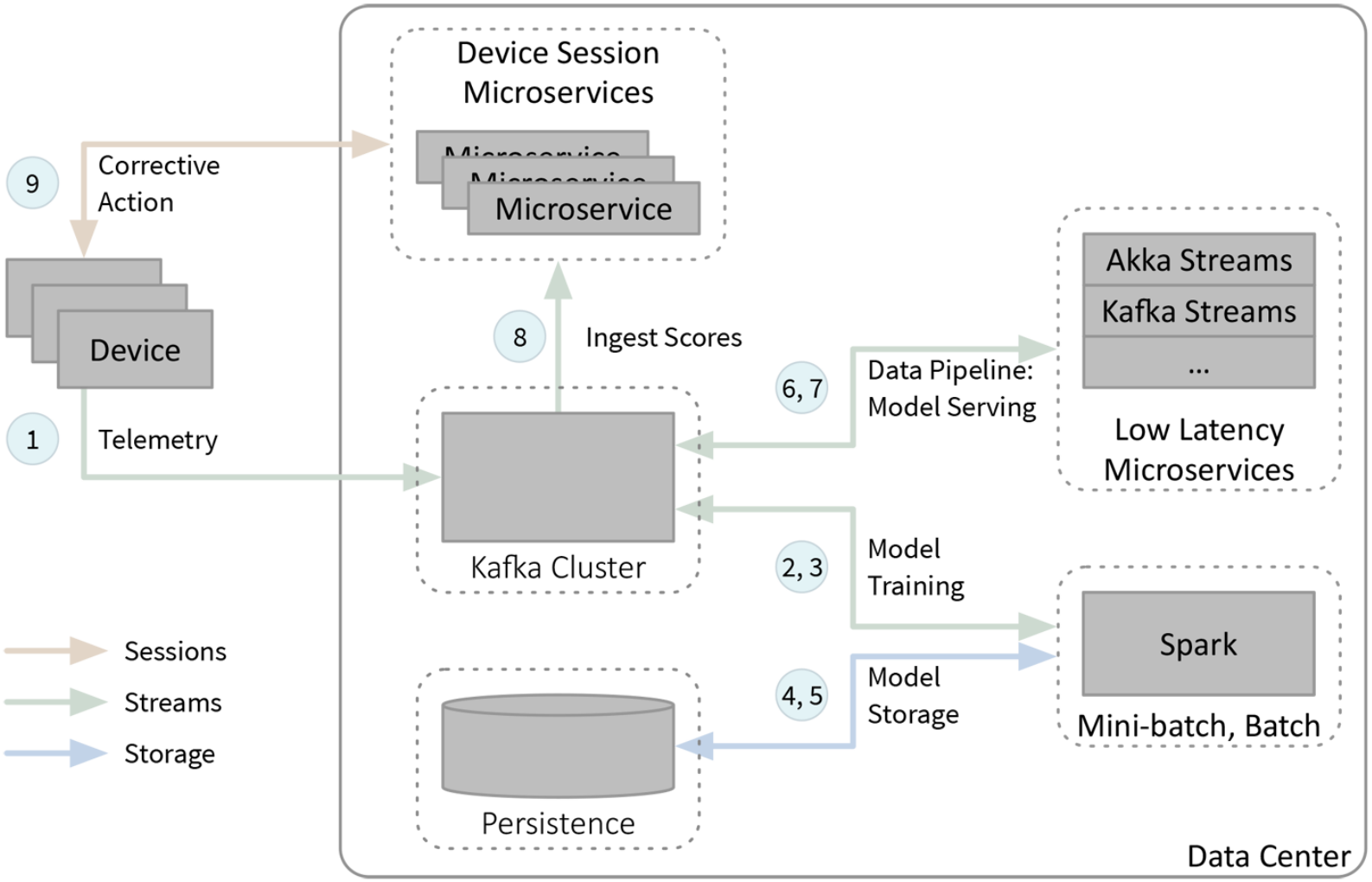
https://www.scnsoft.com/blog/salesforce-iot-cloud-benefits-and-limitations

IoT Big Data analytics

- Machine Learning in IoT Applications



IoT anomaly detection - Example



Dean Wampler, Fast Data Architectures for Streaming Applications, 2nd edition

Challenges and future directions

- Large and fast IoT datasets
  - More data is needed to achieve more accuracy
- Preprocessing
  - More complex since the system deals with data from different sources that may have various formats
- Secure and privacy preserving machine learning
  - Developing further techniques to defend and prevent the effect of this sort of attacks on models is necessary for reliable IoT applications.
- Machine learning for IoT devices
  - Consider the requirements of handling Machine learning in resource-constrained devices and Edge computer nodes.

References

- Perry Lea, ***IoT and Edge Computing for Architects,*** 2nd Edition, Packt Publishing, 2020
  - Chapter 12: Data Analytics and Machine Learning in the Cloud and in the Edge
- Dean Wampler, *Fast Data Architectures for Streaming Applications*, 2nd edition, O'Reilly Media, 2019.
- Gerard Maas, Stavros Kontopoulos, and Sean Glover, *Designing Fast Data Application Architectures*, O'Reilly Media, 2018.