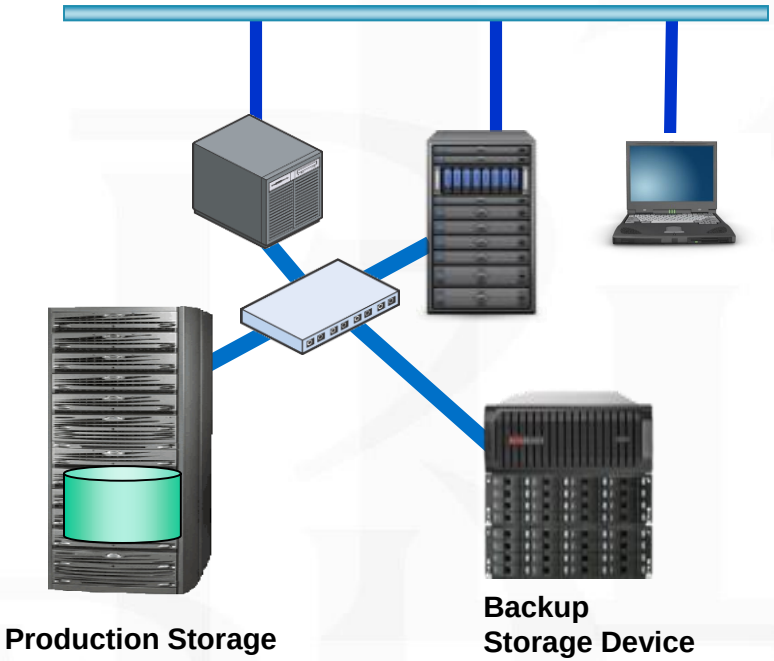
NATIONAL RESEARCH UNIVERSITY

Data processing. Data storages. Open Data approach

Dr. Dr. Mikhail Komarov

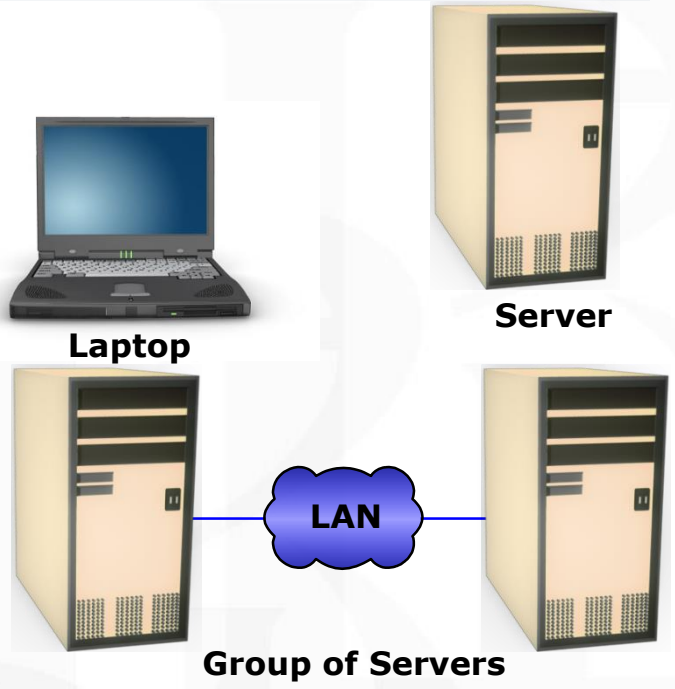
Major storage system components

- Hosts
- Connectivity
  - Interconnection between components
- Storage
  - Tapes
  - Disks
  - Intelligent storage systems



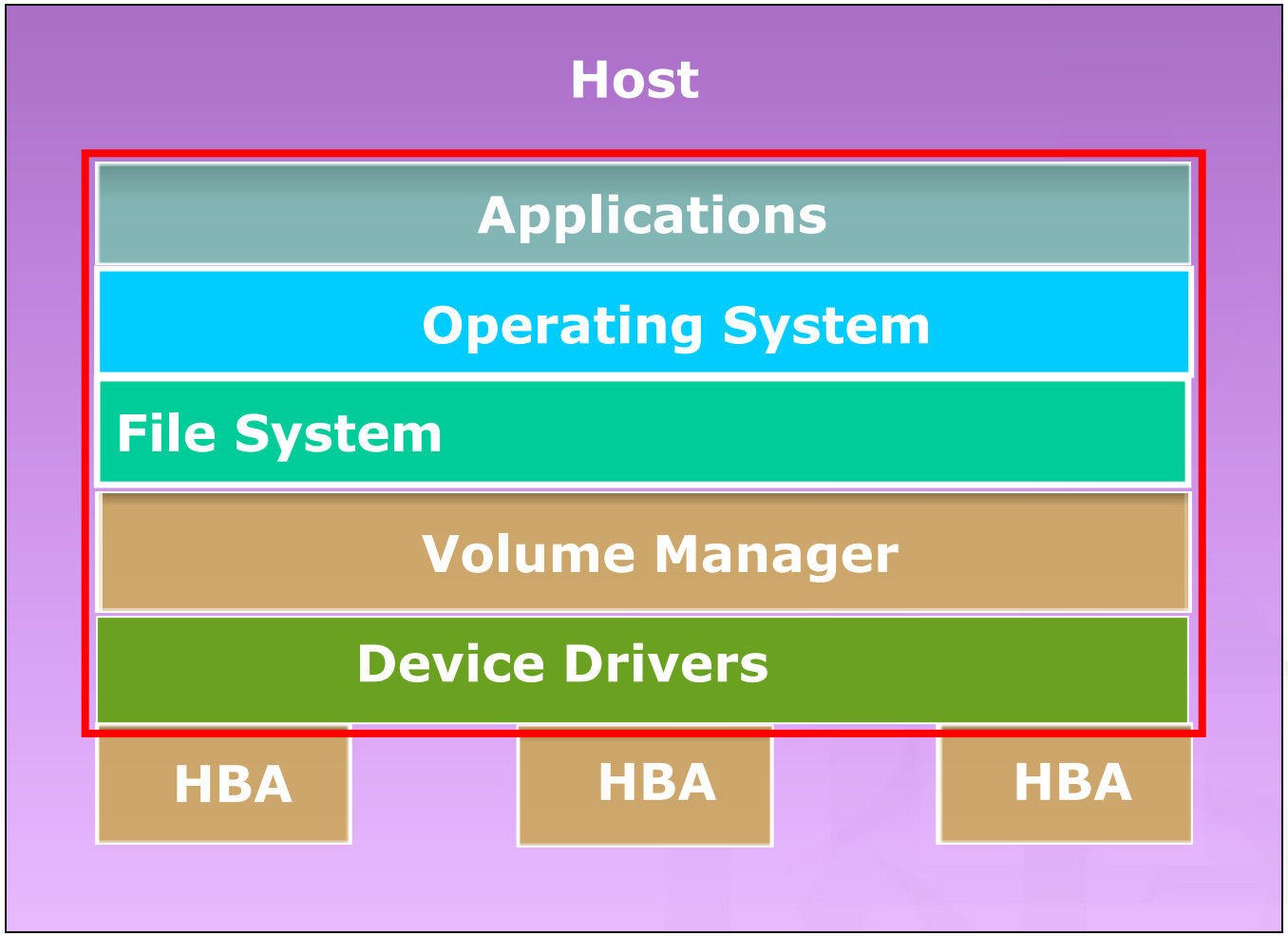
Hosts

- Applications run on hosts
- Hosts can range from simple laptops to complex server clusters
- Physical components of hosts:
  - CPU
  - Storage
    - Disk device and internal memory
  - I/O devices



Mainframe

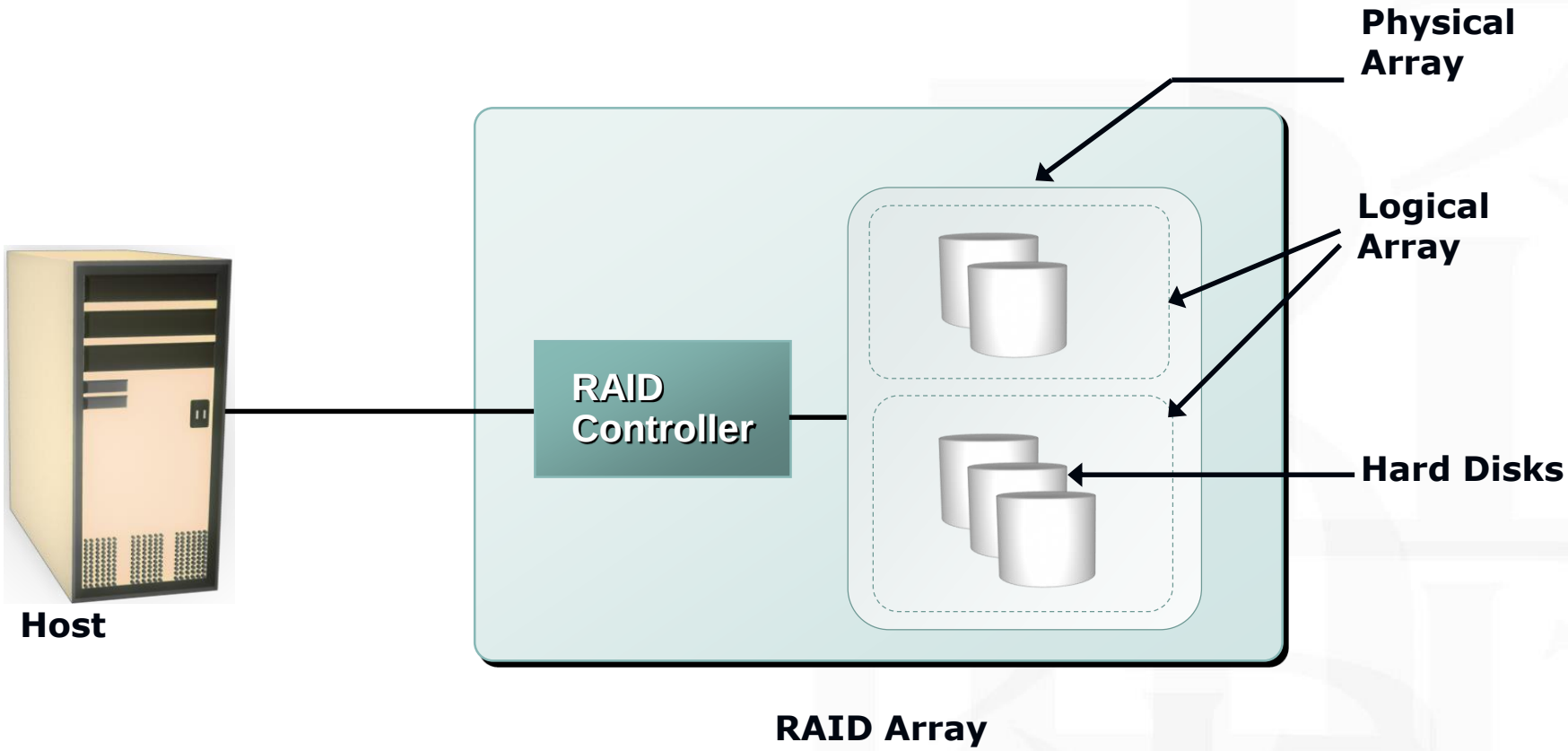
Hosts


Host
Applications
Operating System
File System
Volume Manager
Device Drivers
HBA
HBA
HBA

RAID?

- Performance limitation of disk drive.
- An individual drive has a certain life expectancy:
  - Measured in MTBF
  - Example:
    - If the MTBF of a drive is 750,000 hours, and there are 1000 drives in the array, then the MTBF of the array becomes 750,000 /1000, or 750 hours.
- RAID was introduced to mitigate this problem.
- RAID provides:
  - Increased capacity
  - Higher availability
  - Increased performance

RAID?

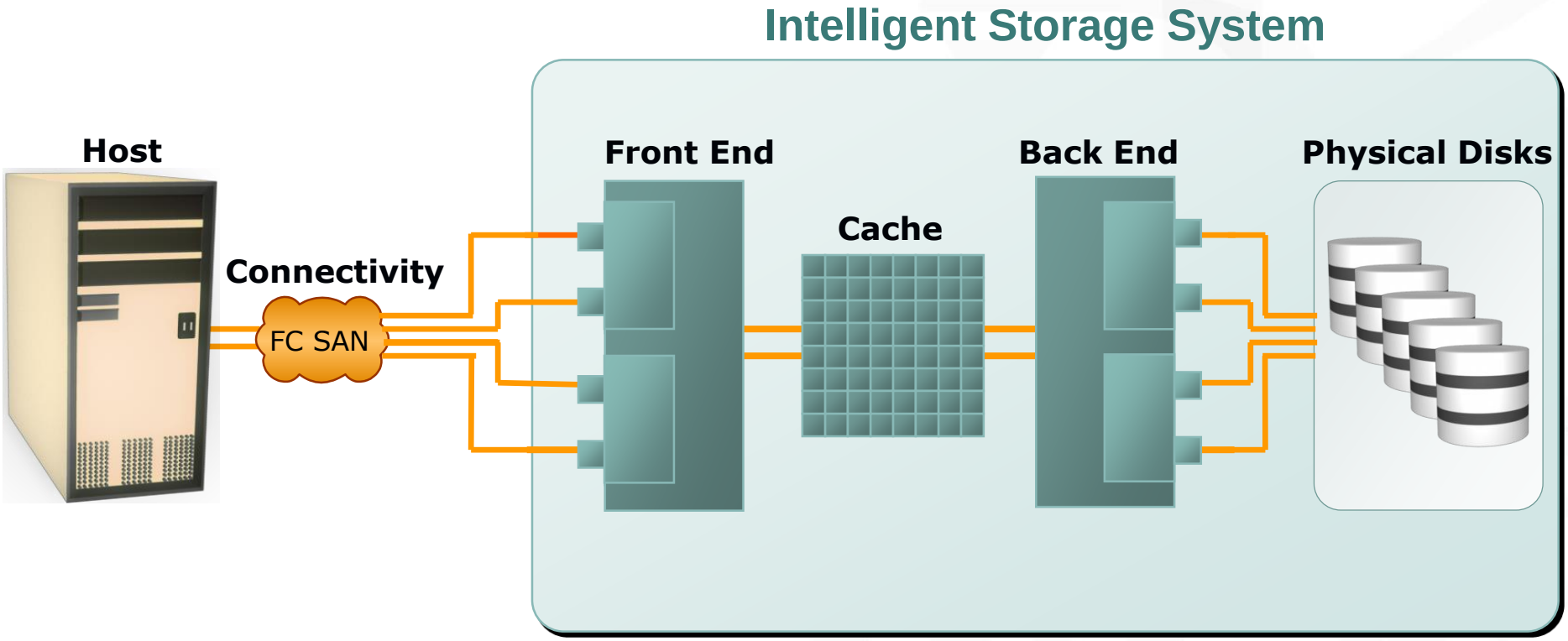

Physical Array
Logical Array
Hard Disks
RAID Controller
Host
RAID Array

Intelligent storage systems (ISS)

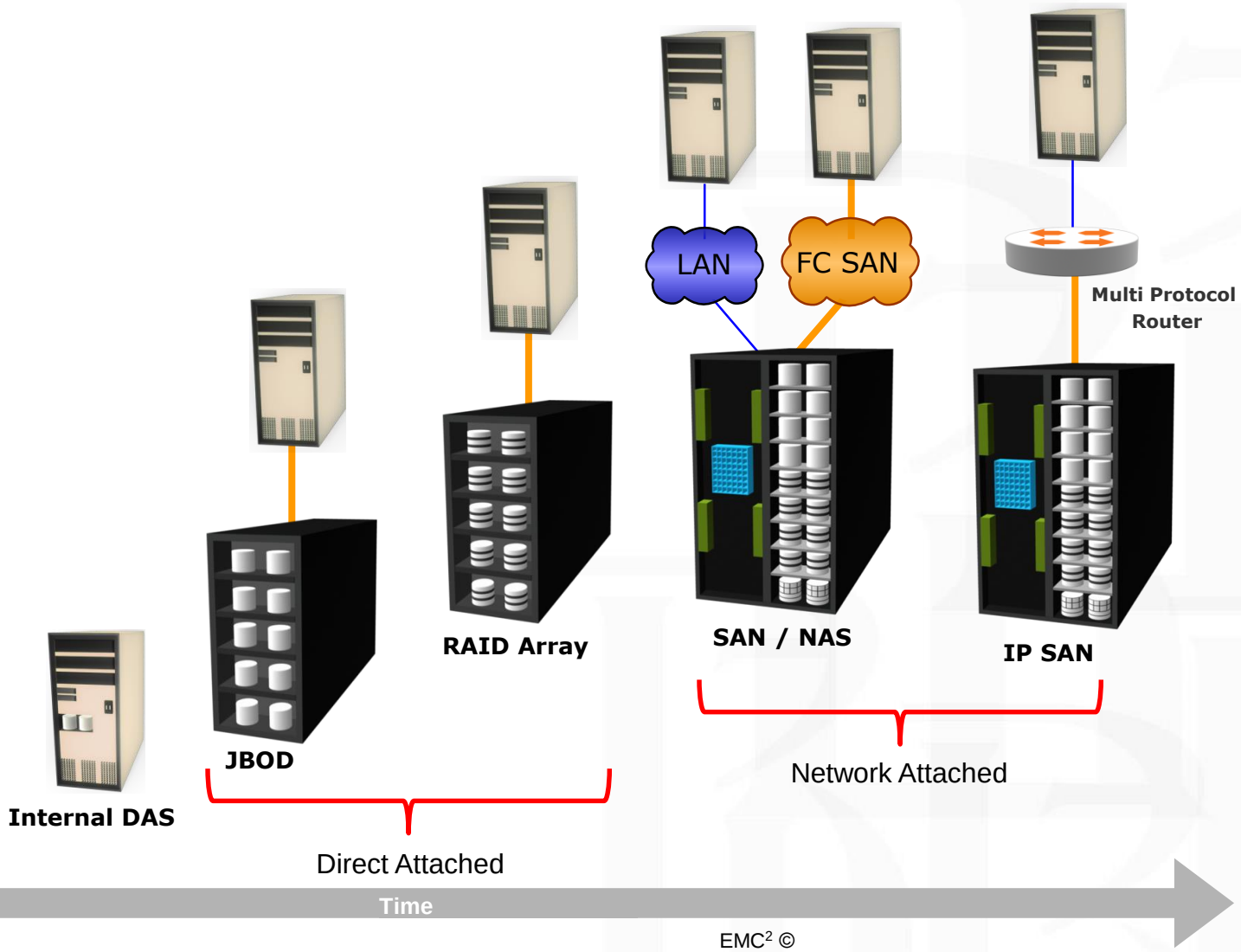
Intelligent Storage Systems are RAID arrays that are:

- Highly optimized for I/O processing
- Have large amounts of cache for improving I/O performance
- Have operating environments that provide:
  - Intelligence for managing cache
  - Array resource allocation
  - Connectivity for heterogeneous hosts
  - Advanced array based local and remote replication options

Intelligent storage systems (ISS)



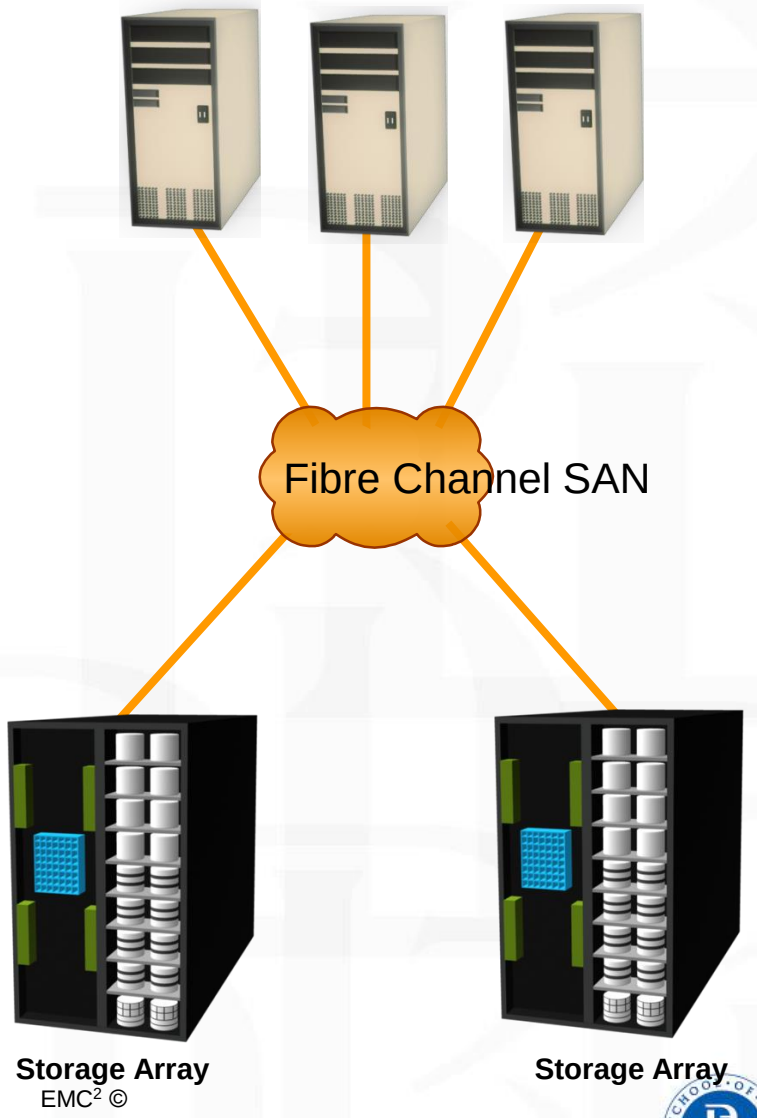
Architecture evolution



EMC² ©

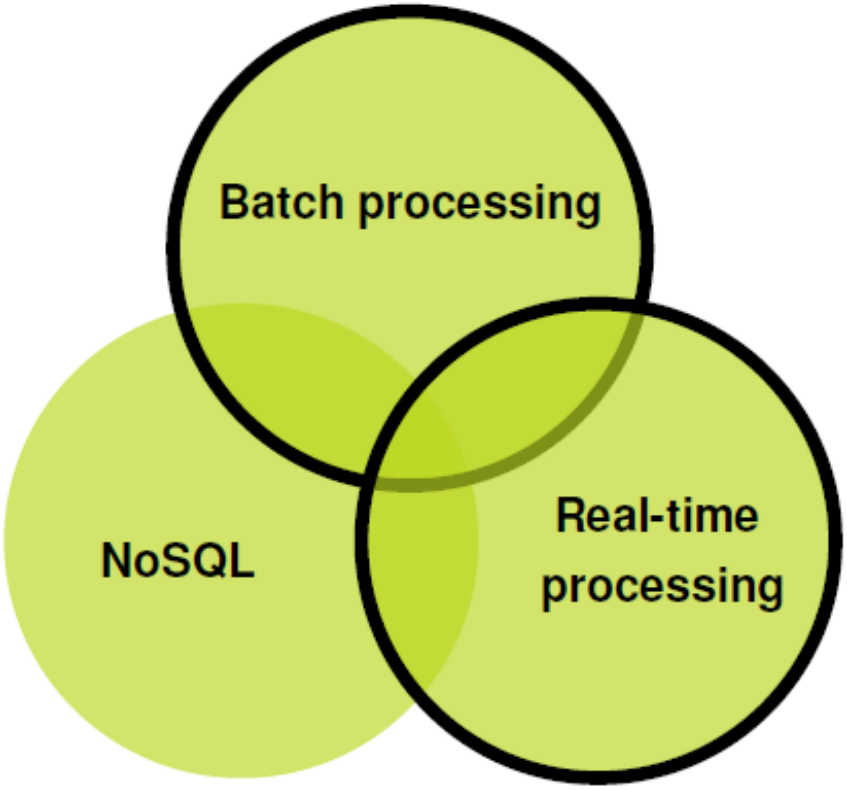
Storage area network (SAN)

- Dedicated high speed network of servers and shared storage devices.
- Block level data access.
- Resource consolidation:
  - Centralized storage and management
- Scalability:
  - Theoretical limit: Approximately 15 million devices
- Secure access



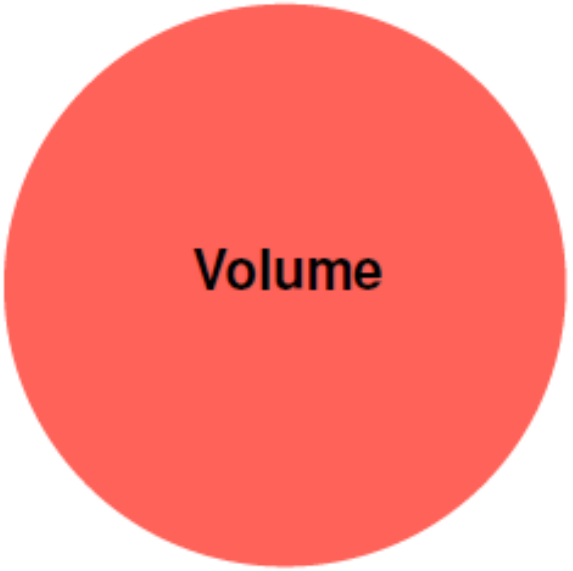
EMC² ©

Data Processing



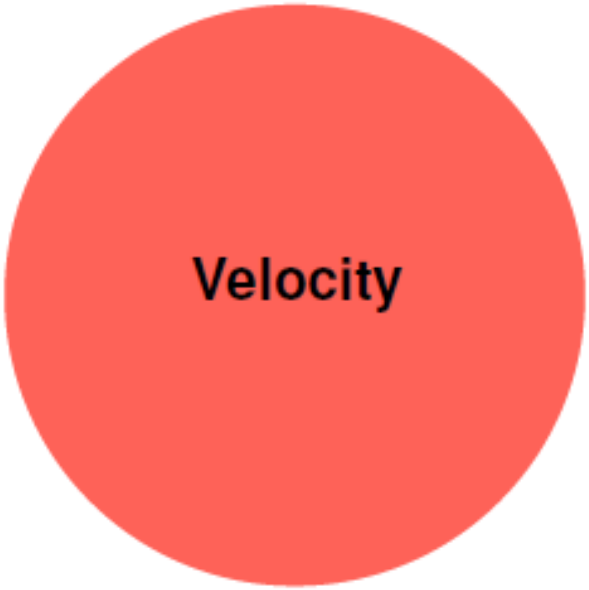
Batch Processing

- Scalable
- Large amount of static data
- Distributed
- Parallel
- Fault tolerant
- High latency



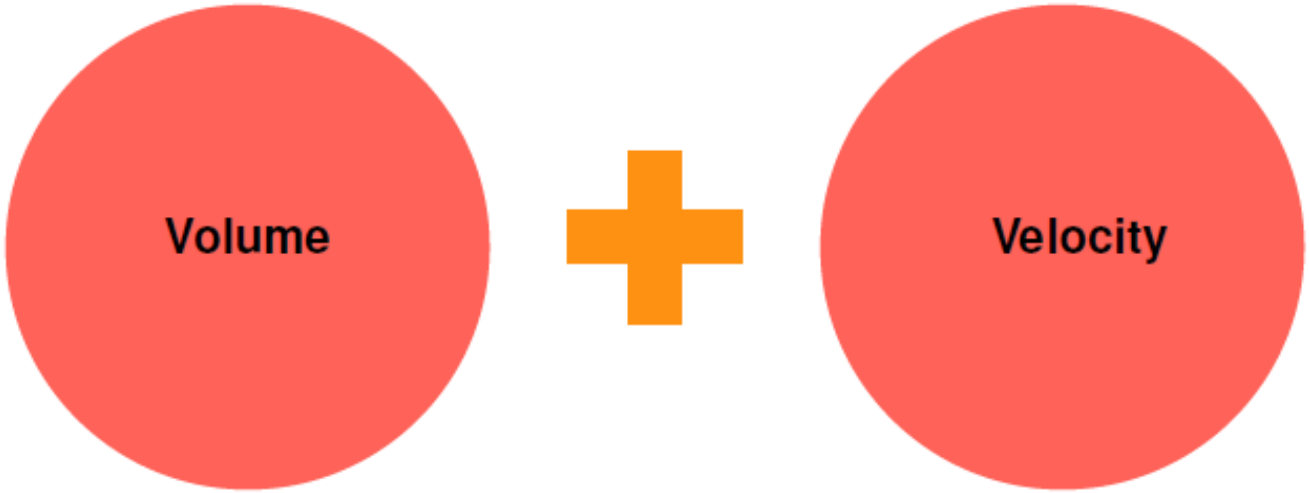
Real-time processing

- Low latency
- Continuous unbounded streams of data
- Distributed
- Parallel
- Fault tolerant

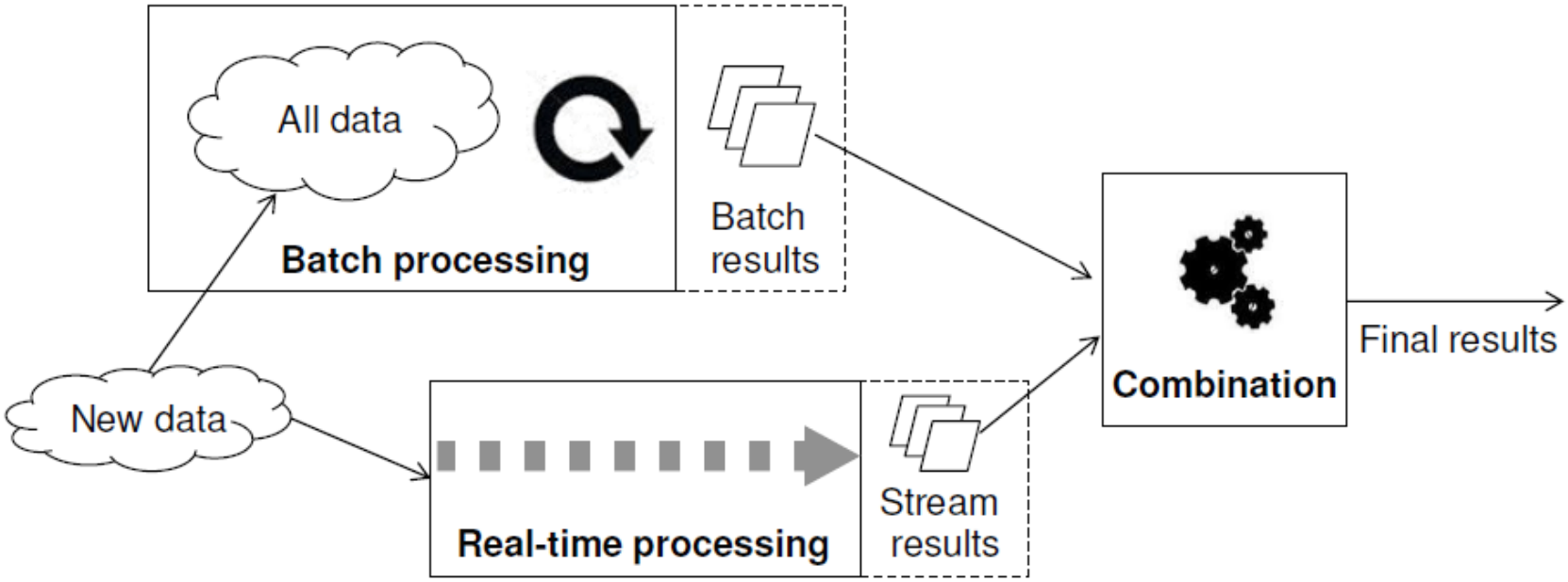


Hybrid computational model

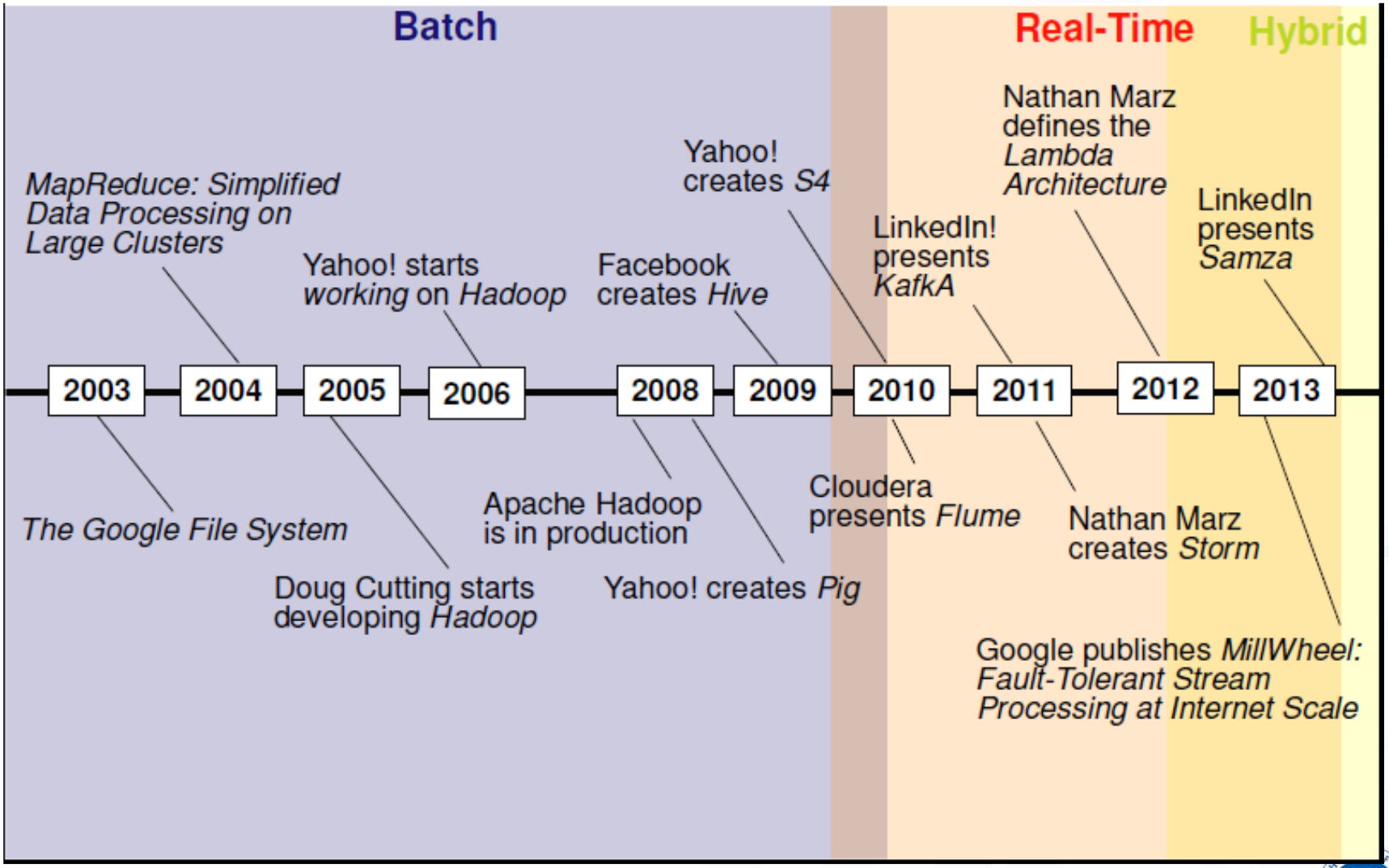
- Low latency
- Massive data + Streaming data
- Scalable
- Combine batch and real-time results



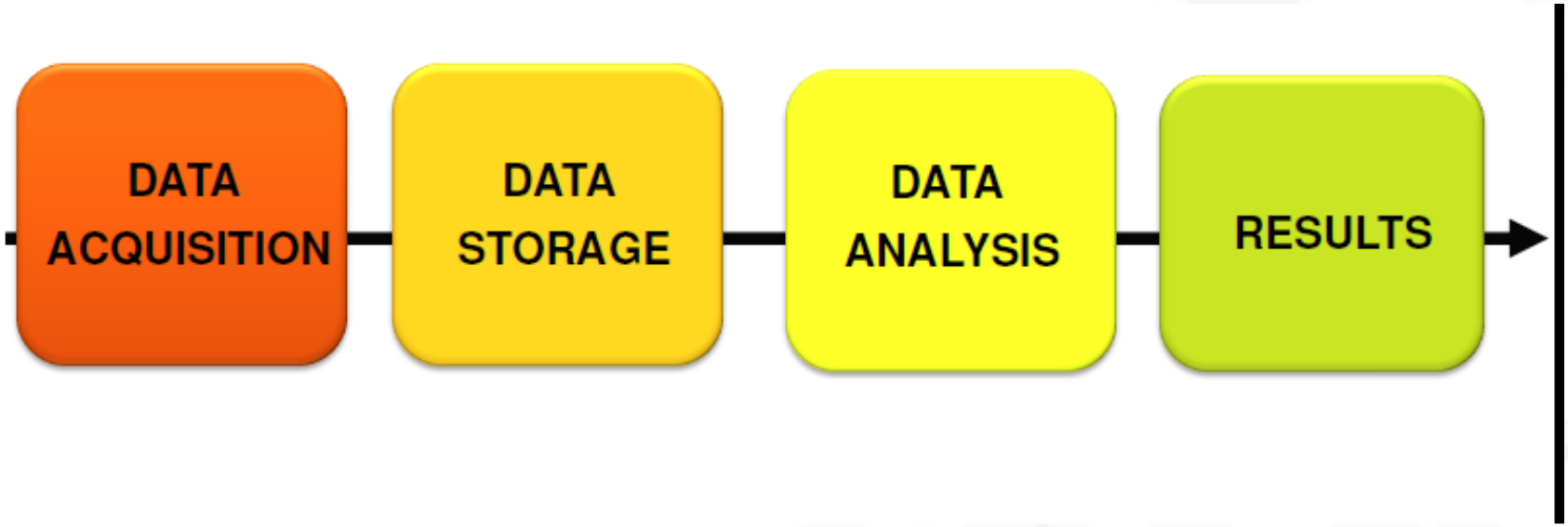
Hybrid computational model



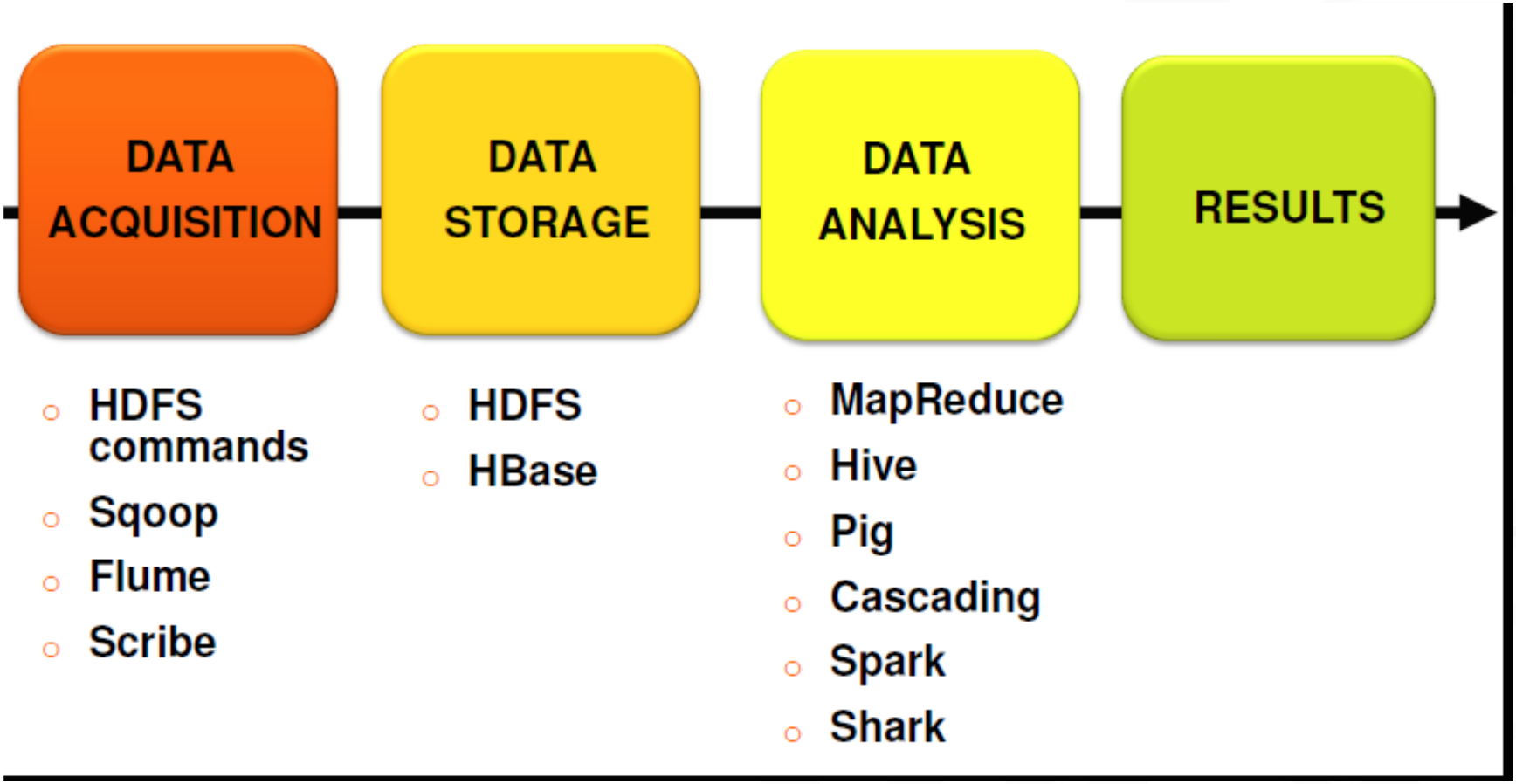
Evolution


Batch
Real-Time
Hybrid
MapReduce: Simplified Data Processing on Large Clusters
Yahoo! starts working on Hadoop
Facebook creates Hive
Yahoo! creates S4
LinkedIn! presents KafkA
Nathan Marz defines the Lambda Architecture
LinkedIn presents Samza
2003
2004
2005
2006
2008
2009
2010
2011
2012
2013
The Google File System
Doug Cutting starts developing Hadoop
Apache Hadoop is in production
Yahoo! creates Pig
Cloudera presents Flume
Nathan Marz creates Storm
Google publishes MillWheel: Fault-Tolerant Stream Processing at Internet Scale

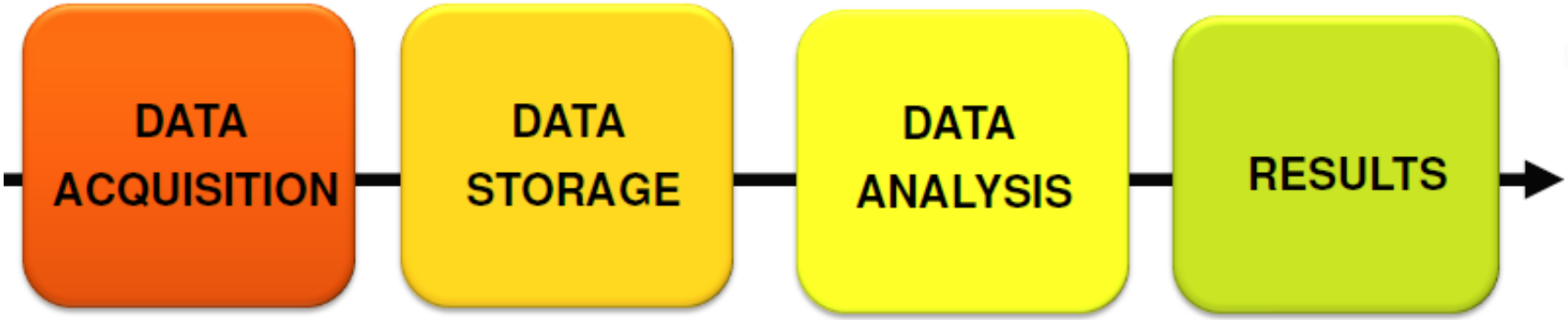
PipeLine



Batch Processing



Real-time processing



- Flume
- Kafka
- Kestrel
- Flume
- Storm
- Trident
- S4
- Spark Streaming

Hybrid computational model

- Short-term Big Data processing goal
- Abstraction layer over the Lambda Architecture

Promising technologies

- SummingBird
- Lambdoop

- MORE DETAILS at Treelogic.com (Check conference materials)

SoA

- **Potential to Transform Society and Businesses across Sectors**: Big data storage technologies are a key enabler for advanced analytics that have the potential to transform society and the way key business decisions are made. This is of particular importance in traditionally non-IT-based sectors such as energy. While these sectors face non-technical issues such as the lack of skilled big data experts and regulatory barriers, novel data storage technologies have the potential to enable new value-generating analytics in and across various industrial sectors.
- **Lack of Standards Is a Major Barrier**: The history of NoSQL is based on solving specific technological challenges which lead to a range of different storage technologies. The large range of choices coupled with the lack of standards for querying the data makes it harder to exchange data stores as it may tie application specific code to a certain storage solution.
- **Open Scalability Challenges in Graph-Based Data Stores**: Processing data based on graph data structures is beneficial in an increasing amount of applications. It allows better capture of semantics and complex relationships with otherpieces of information coming from a large variety of different data sources, and has the potential to improve the overall value that can be generated by analyzing the data. While graph databases are increasingly used for this purpose, it remains hard to efficiently distribute graph-based data structure across computing nodes.

SoA

- **Privacy and Security Is Lagging Behind**: Although there are several projects and solutions that address privacy and security, the protection of individuals and securing their data lags behind the technological advances of data storage systems. Considerable research is required to better understand how data can be misused, how it needs to be protected and integrated in big data storage solutions.

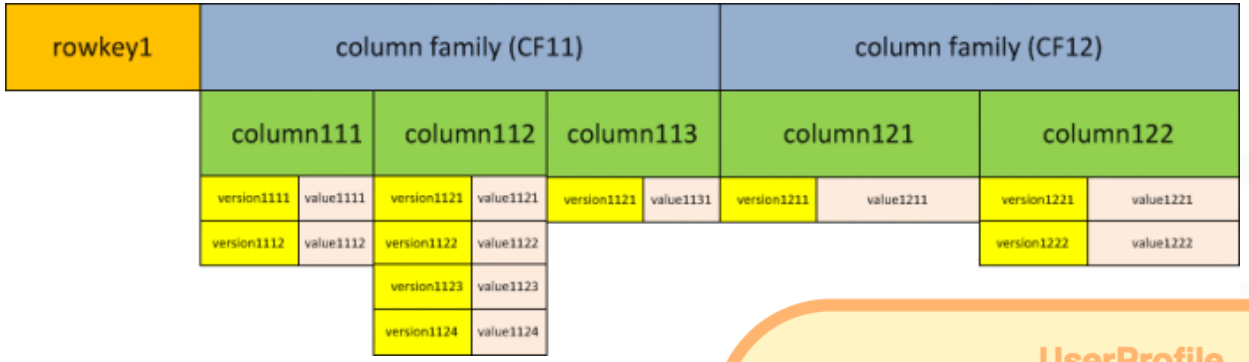
SoA - Technologies

- **Distributed File Systems**: File systems such as the Hadoop File System (HDFS) offer the capability to store large amounts of unstructured data in a reliable way on commodity hardware. Although there are file systems with better performance, HDFS is an integral part of the Hadoop framework and has already reached the level of a de-facto standard. It has been designed for large data files and is well suited for quickly ingesting data and bulk processing.
- **NoSQL Databases**: Probably the most important family of big data storage technologies are NoSQL database management systems. NoSQL databases use data models from outside the relational world that do not necessarily adhere to the transactional properties of atomicity, consistency, isolation, and durability (ACID).
- **NewSQL Databases**: A modern form of relational databases that aim for comparable scalability as NoSQL databases while maintaining the transactional guarantees made by traditional database systems.
- **Big Data Querying Platforms**: Technologies that provide query facades in front of big data stores such as distributed file systems or NoSQL databases. The main concern is providing a high-level interface, e.g. via SQL3 like query languages and achieving low query latencies

NoSQL

- **Key-Value Stores**: Key-value stores allow storage of data in a schema-less way. Data objects can be completely unstructured or structured and are accessed by a single key. As no schema is used, it is not even necessary that data objects share the same structure.
- **Columnar Stores**: According to Wikipedia "A column-oriented DBMS is a database management system (DBMS) that stores data tables as sections of columns of data rather than as rows of data, like most relational DBMSs" (Wikipedia). Such databases are typically sparse, distributed, and persistent multi-dimensional sorted maps in which data is indexed by a triple of a row key, column key, and a timestamp. The value is represented as an uninterrupted string data type. Data is accessed by column families, i.e. a set of related column keys that effectively compress the sparse data in the columns. Column families are created before data can be stored and their number is expected to be small. In contrast, the number of columns is unlimited. In principle columnar stores are less suitable when all columns need to be accessed. However in practice this is rarely the case, leading to superior performance of columnar stores.
https://www.youtube.com/watch?v=8KGVFB3kVHQ

NoSQL


rowkey1
column family (CF11)
column family (CF12)
column111
column112
column113
column121
column122
version1111
value1111
version1112
value1112
version1121
value1121
version1122
value1122
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version1124
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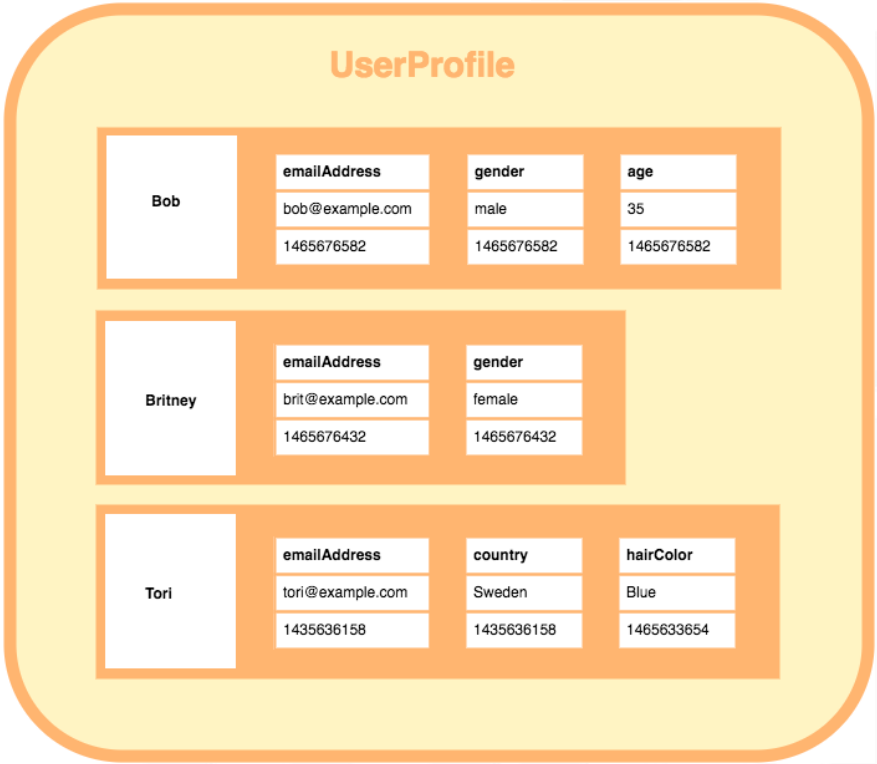
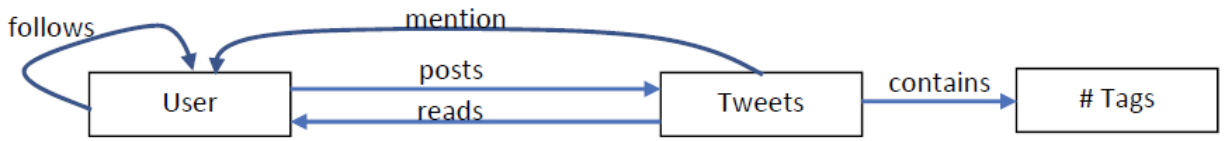
value1131
version1211
value1211
version1221
value1221
version1222
value1222


UserProfile
Bob
emailAddress
bob@example.com
1465676582
gender
male
1465676582
age
35
1465676582
Britney
emailAddress
brit@example.com
1465676432
gender
female
1465676432
Tori
emailAddress
tori@example.com
1435636158
country
Sweden
1435636158
hairColor
Blue
1465633654

NoSQL

- **Document Databases**: In contrast to the values in a key-value store, documents are structured. However, there is no requirement for a common schema that all documents must adhere to as in the case for records in relational databases. Thus document databases are referred to as storing semi-structured data. Similar to key-value stores, documents can be queried using a unique key. However, it is possible to access documents by querying their internal structure, such as requesting all documents that contain a field with a specified value. The capability of the query interface is typically dependent on the encoding format used by the databases. Common encodings include XML or JSON.
- **Graph Databases**: Graph databases, such as Neo4J, store data in graph structures making them suitable for storing highly associative data such as social network graphs. A particular flavour of graph databases are triple stores such as AllegroGraph and Virtuoso that are specifically designed to store RDF triples. However, existing triple store technologies are not yet suitable for storing truly large datasets efficiently.

https://www.youtube.com/watch?v=u-RnFs9dby4



NoSQL

NoSQL Database	Use cases	Remarks
KV Stores	Shopping carts, User session info, User Preferences, Profiles	Highly scalable data model for both reads and writes
Column family	Content management, Blogging sites, Web counters	Provides greater flexibility to query based on column values
Document databases	Content management, Event logging, User registrations, Reviews, Comments	Useful for handling highly semi-structured content unlike column stores where the value has to be a sorted map
Graph databases	Social network details, Location based services, Recommendations engines	Useful for handling complex data relationships. The data cannot be easily sharded (or partitioned) to achieve higher scalability

NewSQL

- NewSQL databases are a modern form of relational databases that aim for comparable scalability with NoSQL databases while maintaining the transactional guarantees made by traditional database systems. They have the following characteristics:
- SQL is the primary mechanism for application interaction
- ACID support for transactions
- A non-locking concurrency control mechanism
- An architecture providing much higher per-node performance
- A scale-out, shared-nothing architecture, capable of running on a large number of nodes without suffering bottlenecks

The expectation is that NewSQL systems are about 50 times faster than traditional OLTP RDBMS (Online Transaction Processing). For example, VoltDB (2014) scales linearly in the case of non-complex (single-partition) queries and provides ACID support. It scales for dozens of nodes where each node is restricted to the size of the main memory.

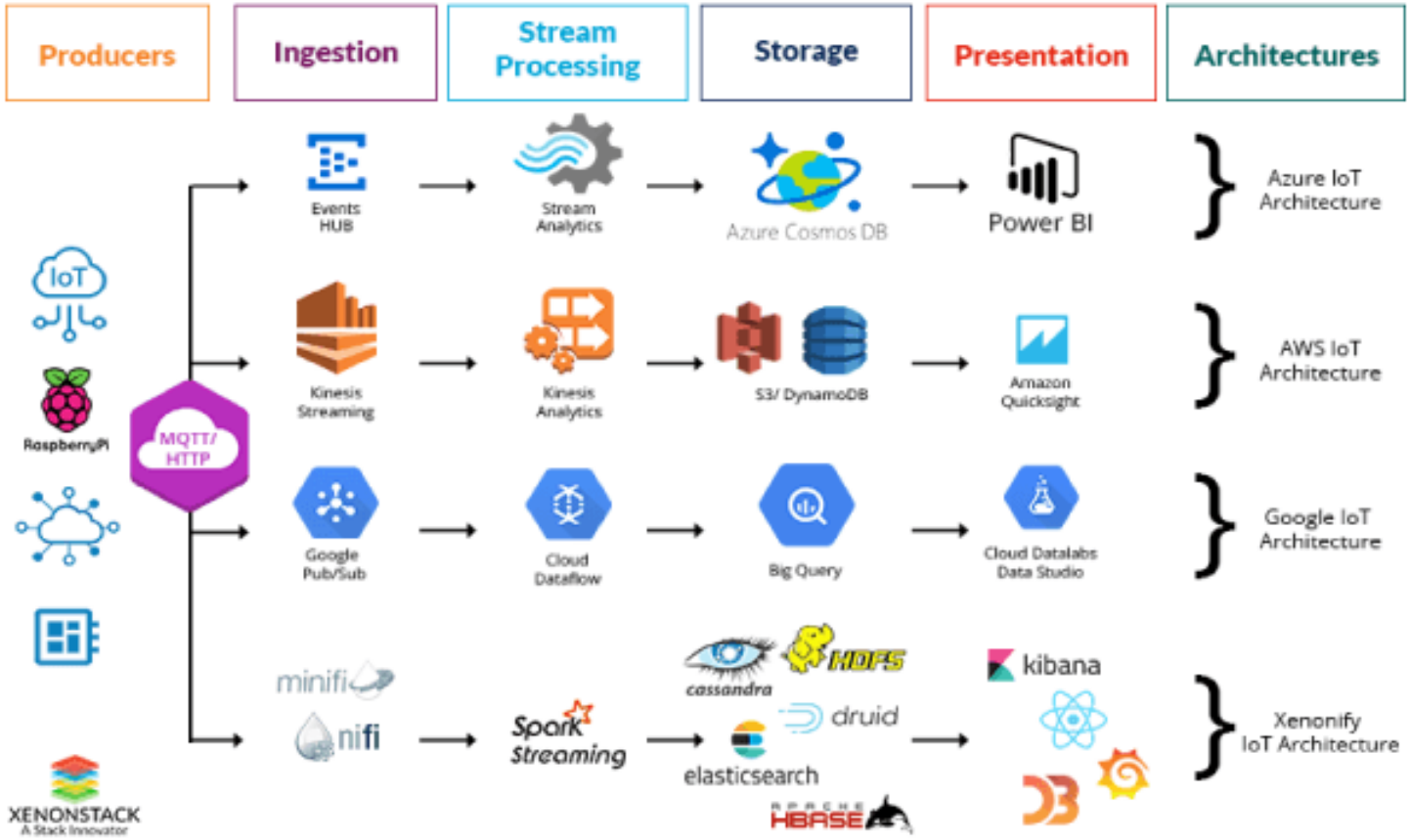
Big Data Query Platforms

Big data query platforms provide query facades on top of underlying big data stores that simplify querying the underlying data stores. They typically offer an SQL-like query interface for accessing the data, but differ in their approach and performance. Hive provides an abstraction on top of the Hadoop Distributed File System (HDFS) that allows structured files to be queried by an SQL-like query language.

Tool	Built for	Key Advantage
Hive (on MapReduce or Spark)	Batch Data Preparation and ETL	Scheduled processing of ingested data into cleaned, consumable forms for upstream users and applications. Typical job: Many minutes - Hours
Impala	Multi-user Interactive BI and Analytics	Low BI latency with high concurrency. Typical job: <10s
Spark SQL (and Spark)	Data scientists and data engineers	Developer productivity with mixed procedural and SQL applications. Typical Job: Few Minutes

Cloud storage

As cloud computing grows in popularity, its influence on big data grows as well. While Amazon, Microsoft, and Google build on their own cloud platforms, other companies including IBM, HP, Dell, Cisco, Rackspace, etc., build their proposal around OpenStack, an open source platform for building cloud systems.



And what about business?

Cloud-based storages…

Data analytics…

Data exchange – Recovery?

http://www.computerworld.com/article/2883759/vint-cerf-fears-a-digital-dark-age-and-your-data-could-be-at-risk.html

Vinton Cerf, often called "the father of the Internet," has other ideas.

Now chief Internet evangelist at Google, Cerf spoke this week at the annual meeting of the American Association for the Advancement of Science, and he painted a very different picture.

Rather than a world where longevity is a given, Cerf fears a "digital dark age" in which the rapid evolution of technology quickly makes storage formats obsolete thanks to a phenomenon he calls "bit rot."

In that world, the applications needed to read files we so confidently store today could be lost because they're incompatible with new hardware technologies that emerge. The result, he contends, could be that many of our those files will be rendered useless, inaccessible to future generations.

Cerf's proposed solution is something he calls "digital vellum" -- essentially, a tool for preserving old technologies so that even obsolete files can be recovered.

Introduction to Open Data

Most of the people use cellphones 24h/365d and 20% would rather use Internet instead of buying chocolate bar (2012, Statistics by Google).

Open data is the idea that certain data should be freely available to everyone to use and republish as they wish, without restrictions from copyright,patents or other mechanisms of control (WiKi).

Open Government Data and Services by the UN (DPADM-UNDESA) –

allows citizens to monitor data streams and thereby improves the accountability and transparency of government. OGD also allows citizens to be aware of important issues and to be part of the decision-making process to address policy issues (e-participation). DPADM's work on open government is divided in four pillars: policies and regulatory framework; organizational framework; channels & modalities; and case studies.

Introduction to Open Data

04.2013 (Peter Sayer , IDG News Service).

The French National Commission on Computing and Liberty (CNIL) studied the behavior of 189 apps on six cellphones equipped with monitoring software and analysis tools developed by the French National Institute for Research in Computer Science and Control (INRIA).

- Mobile phone apps are accessing users' private data and transmitting it to remote servers far more than appears strictly necessary.
- One in 12 of the apps accessed the address book, and almost one in three accessed location information. On average, the users had their location tracked 76 times a day during the study.
- The data accessed by far the most in the study was the Universal Device Identifier (UDID), a serial number permanently associated with a particular phone. Almost half the apps accessed it, and one in three of those sent it over the Internet unencrypted. The app of one daily newspaper accessed the UDID 1,989 times during the study, sending it 614 times to its publisher.

IoS, IoT – personal data generation

Governmental level of data generation

- Policy-making applications and services (crowd-based platform etc.).
- Educational services (signing for the education, education for far-located villages and towns etc.).
- Culture and traditions – oriented applications and services (local rules and policies, local culture etc.).
- Medical applications and services (far-located villages and refugee camps etc.).
- Banking applications and services (remote banking, e-payments etc.).
- Information-support applications and service (connection with relatives, news-terminals etc.).

Open Government Data principles

1. Data Must Be Complete
2. Data Must Be Primary
3. Data Must Be Timely
4. Data Must Be Accessible
5. Data Must Be Machine processable
6. Access Must Be Non-Discriminatory
7. Data Formats Must Be Non-Proprietary
8. Data Must Be License-free

A contact person must be designated to respond to people trying to use the data.
A contact person must be designated to respond to complaints about violations of the principles.
An administrative or judicial court must have the jurisdiction to review whether the agency has applied these principles appropriately.

Open Government Data principles

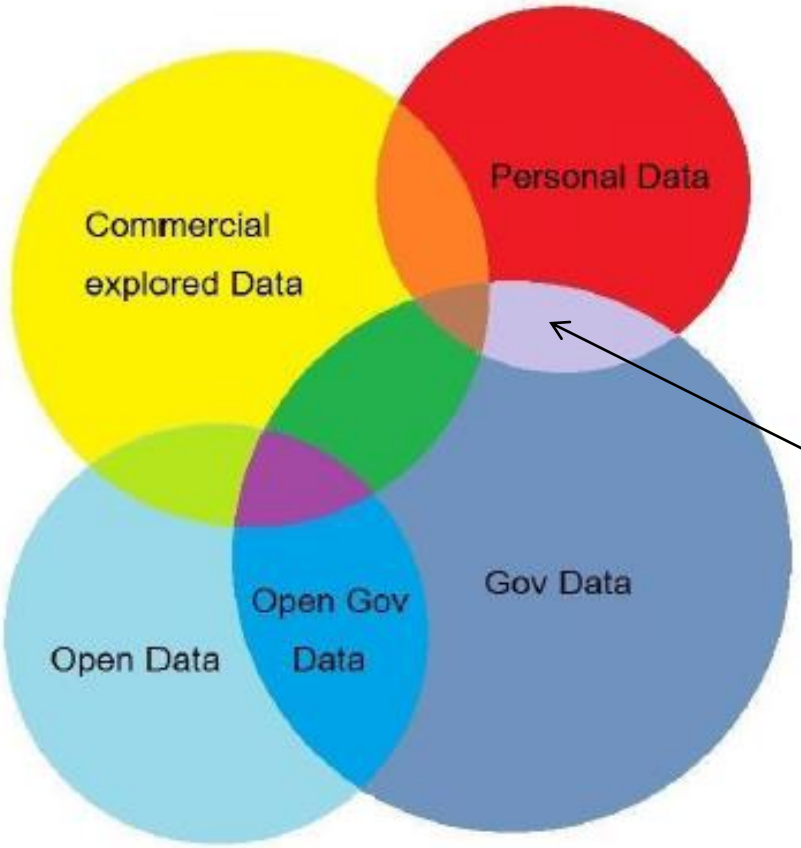


Image source: DPADM/UMU

Open Private Data?

1. If the personal data is violated and we can not prevent it - we should make in some points open private data (which wouldn't point to particular person, but would use persons data for statistics, analysis etc.). Controlled open private data distribution.
2. Centralized open private data storage would lead to simplification of registration procedures and services utilization.
3. There should be encrypted references (logins, IDs etc.) to particular open private data blocks to make it anonymous.
4. It will help with open-source and free software distribution which requires private data collection?

https://www.pinterest.com/socrata/open-data-applications/
http://www.socrata.com/products/custom-web-and-mobile-apps-government-data/

http://www.opendata500.com/

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Thank you for your attention!

If you have any questions,
please do not hesitate contacting me:

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