Lecture 16 Big Data Computing Architecture

Part I

- A Global Challenge and Opportunity
- Standards and Core Technology

大数据计算架构

- What is big data?
- A National Strategic Plan
- Application Domain and Marketing
- A Big Data Computing Spectrum

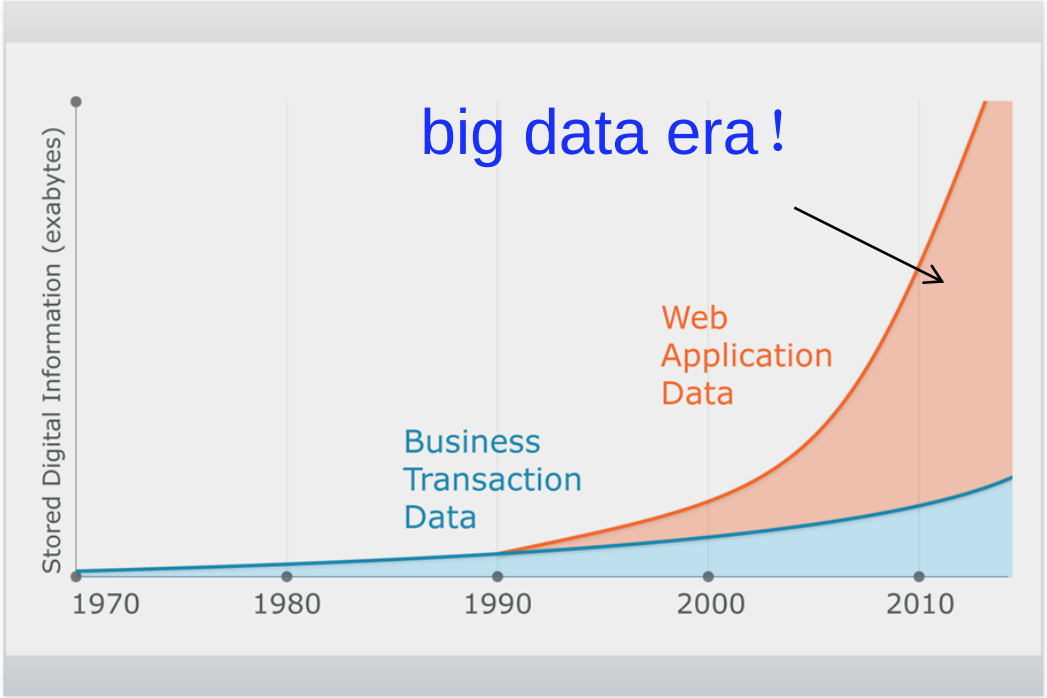
大数据计算架构

Big Data: a global challenge and chance

Like the flow of Yellow River from Heaven --- poem of Tang Dynasty

- Facebook daily processes 8 billions messages
- Google supports a billion searches everyday
- The volume of information doubles every two years
- 2011 global data volume: 1.8ZB
  2015 number: 8ZB
  2020 estimate: 5ZB!

大数据计算架构

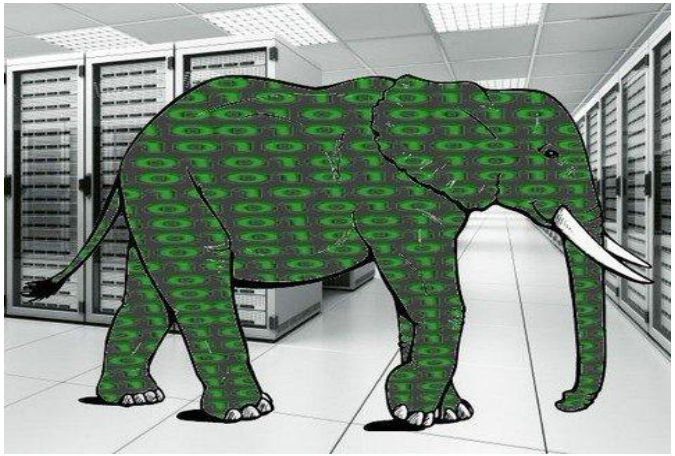


1 EB = 10^3 ZB = 10^6 PB = 10^9 TB = 10^{12} GB

大数据计算架构

Big Data's 4V Description

- **Volume**: size of data is too large to be processed normally
- **Variety**: various sources, heterogeneous types and cross-platform
- **Velocity**: online processing demand
- **Value**: single data is garbage, yet an extra large-scale dataset is a gold mine



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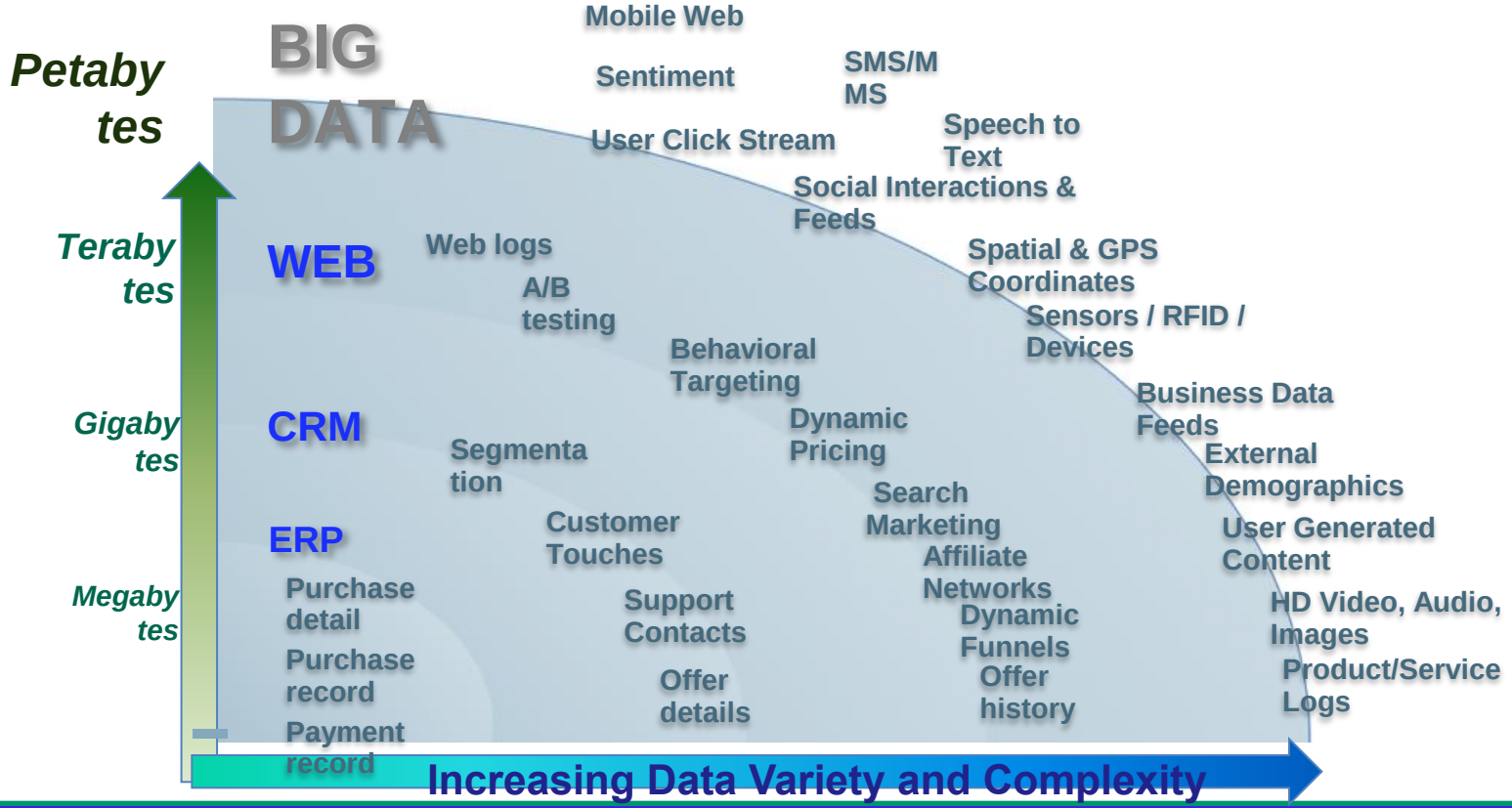
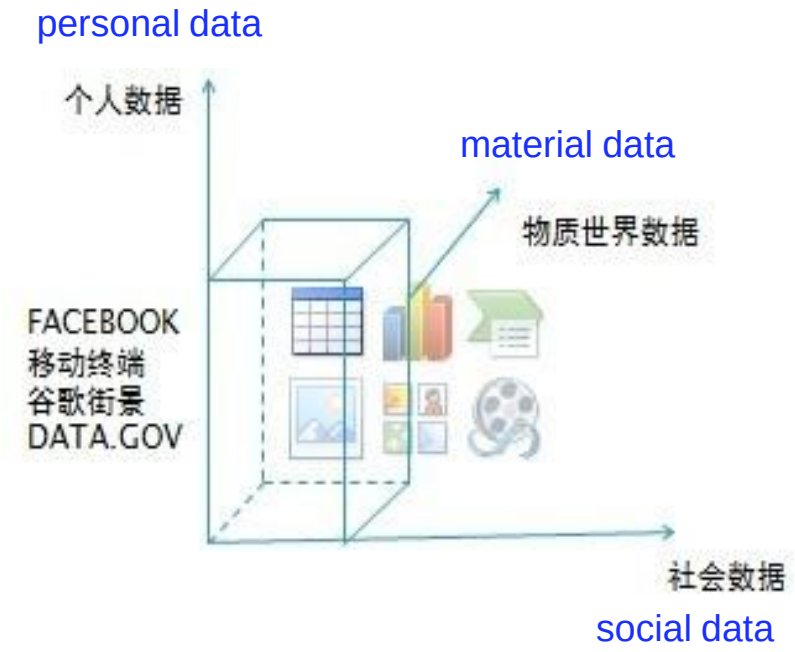

Petaby tes
Teraby tes
Gigaby tes
Megaby tes
BIG DATA
WEB
CRM
ERP
Mobile Web
Sentiment
SMS/MMS
User Click Stream
Speech to Text
Social Interactions & Feeds
Web logs
A/B testing
Spatial & GPS Coordinates
Sensors / RFID / Devices
Behavioral Targeting
Business Data Feeds
Dynamic Pricing
Segmentation
External Demographics
Search Marketing
Customer Touches
User Generated Content
Affiliate Networks
Purchase detail
Support Contacts
HD Video, Audio, Images
Dynamic Funnels
Purchase record
Offer details
Offer history
Product/Service Logs
Payment record
Increasing Data Variety and Complexity

大数据计算架构

■ Characters of Big Data

- data type: text, audio/video, image, etc.
- data class: personal data, business data, social or public data, nature data, material data, …
- data usage: from different sources that owned by individual unit, but shared and used by entire community



大数据计算架构

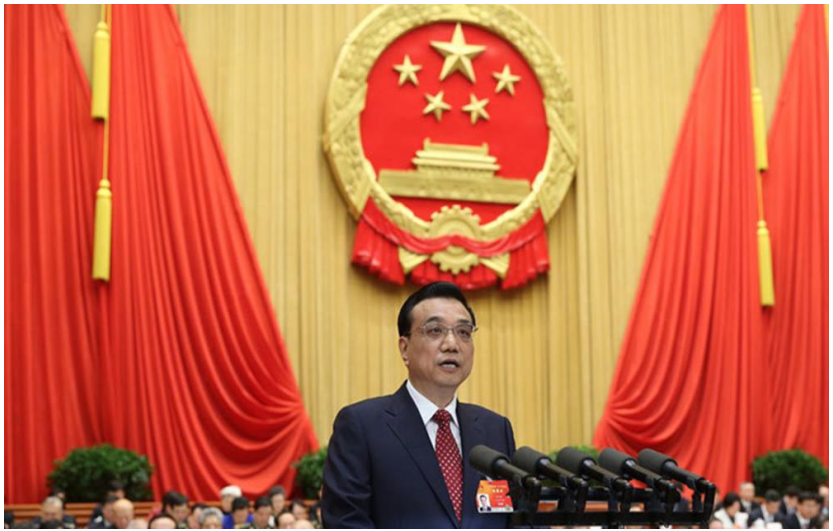
- Obama government's national strategic plan in the 21st century

In March 2012, US government launches "Big Data Research and Development Program", and the following federal agencies are spearheading this plan:

- National Scientific Funds（NSF）
- National Institute of Health（NIH）
- DoE and DoD
- DARPA and NGIA

大数据计算架构

- China's Big Data Plan



Primer Minister Li announces government's execution plan on massive innovation and a wide application of Big Data, cloud computing and Internet of Things, in the 4th meeting of the 12th National People's Congress Session, March 5th, 2016

In September 2015. the State Council of China published The Action Plan for Promotion of Big Data Development.

MIIT is leading compiling The Development Roadmap for Big Data Business for the 13th Five-Year Plan.

大数据计算架构

- Big Data Application Domain

Global positioning

Data mining

Statistics and analysis

Social network analysis

Smart power grids

Text decoding

Network flow control

Web context analysis

Smart transportation

Intelligent Medical Service

Intelligent City Systems

大数据计算架构

Case Study: Social network analysis

In a day in 2012 when Facebook got IPO, a social network platform DataSift announced its stock price estimate based on synthesis to social data on Twitter. It estimated that the Facebook stock price would turn around to drop since the Twitter data showed negative prior to the IPO. 25 minutes after IPO, Facebook price went down …

Big data conclusion：the swing of Facebook price largely synchronized to the trend of Twitter data, with a delay of 20 minutes.。

大数据计算架构

Case Study: Big Data service to personal

Google Trend http://www.google.com/trends/

Baidu Index http://zhishu.baidu.com/

大数据计算架构


百度指数搜索_大数据
新闻 网页 贴吧 知道 音乐 图片 指数 更多▼
大数据
百度一下
帮助
登录
通过关键词对比
通过地区对比
通过时间对比
关键词：大数据
添加对比关键词
选择时间：当月
选择地区：全国 所有省份
确 定
热点趋势
添加到您的网页
2012-10-08 至 2012-11-06
用户关注度
媒体关注度
相关趋势
用户关注度：1周 +14% 1月 +93% 1季度 +112%
媒体关注度：1周 +30% 1月 +23% 1季度 +25%
相关新闻
更多>>
机遇与挑战 大数据时代微博如何... IT专家网 2012-11-5 19:31
美财政部CIO:大数据好比“奥... 比特网 2012-11-4 22:21
王思远:大数据“裸婚”时代 新华网 2012-11-2 20:15
大数据+机器学习:微软重夺霸主... 虎嗅网 2012-11-1 19:25
手机上的大数据(一):移动互联... 财经网 2012-10-29 23:10
《巴伦周刊》:PC时代已经没落... 凤凰网 2012-10-22 23:19
10家大数据领域的出色公司 站长之家 2012-10-17 17:10
大数据给智能化商业带来不同 至顶网 2012-10-15 15:42
社交大数据掘金之路:隐私问题成... 腾讯网 2012-10-14 07:19
显示均值线 生成图片
BigDataReport
21:31
2012/11/7

大数据计算架构

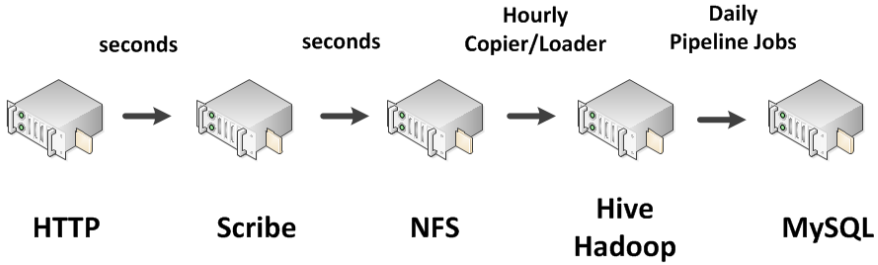
Case Study: multi-source data financial model

Traditional US banks make their decisions on credit card applications by input 15-20 FICO records into their financial model, which filters out about 15% applications.

A Silicon Valley based small company ZestCash builds its model based on thousands of input data and selects 5% applicants that have been turned down by traditional models, but are truly valuable customers. They found their cake and they succeed!

Case Study：Facebook's Challenge

Analytics based on Hadoop/Hive



- 3000-node Hadoop cluster
- Copier/Loader: Map-Reduce hides machine failures
- Pipeline Jobs: Hive allows SQL-like syntax
- Good scalability, but poor latency! 24-48 hours

Facebook's 3000-node Hadoop computing platform needs to process 8 billions messages and performs 75 billions read/write operations everyday，which leads to a processing delay of 24 ~ 48 hrs.

How does Facebook meet this big data challenge?

Challenges to Internet Enterprises

✓ Online business demands a fast and intelligent data analysis and mining, which is essential to on-spot marketing strategy and customer's online e-commerce experience;

✓ Dilemma: lack of on-time intelligent synthesis to big data on Internet, which leads to an unendurable delay that blocks a wide range of online applications.

大数据计算架构

Big Data Computing Spectrum

	Off-line Process	Interactive Process	In-mem Computing
Data Volume	> PB	TB~PB	GB~TB
Time	Off-line (hrs~days)	Online（min）	Real-time（sec）
Computing Model	MapReduce Pregel HAMA	Dremel Drill S4 Stream	MemCloud Hana
Architecture	Distributed	Distributed	Centralized
Technology	data block cycle a large volume of I/O operations	in-mem data rate data locality columnar data structure	one-time loading into memory expensive

大数据计算架构

Off-line Batch Processing Model

GFS/HDFS/Hbase/NoSQL/MapReduce，main stream model，reliable technology, very large-scale data, but long delay time

In-memory Computing Model

Hana, MemCloud，fast processing speed，but needs a large-scale centralized memory architecture，not matured technology

Interactive Processing Model

Google’s Dremel and PowerDrill, Open source Drill and Spark

Using the data locality/in-mem buffer/columnar data structure techniques to improve processing speed based on existing technologies, a near-future promising architecture

Big Data Computing Architecture

- Standards and Technology
- Enterprise Solutions
- Google vs. Open Source
- Interactive Processing Approach

Big Data Technical Standards

- ISO/IEC JTC1 SC32 (Data Management and Exchange Subcommittee)
  - Work Group for Next Generation Analytics and Big Data
  - Social Group for Metadata for Cloud Computing
  - Social Group for Meta-model for Fact Based Modeling

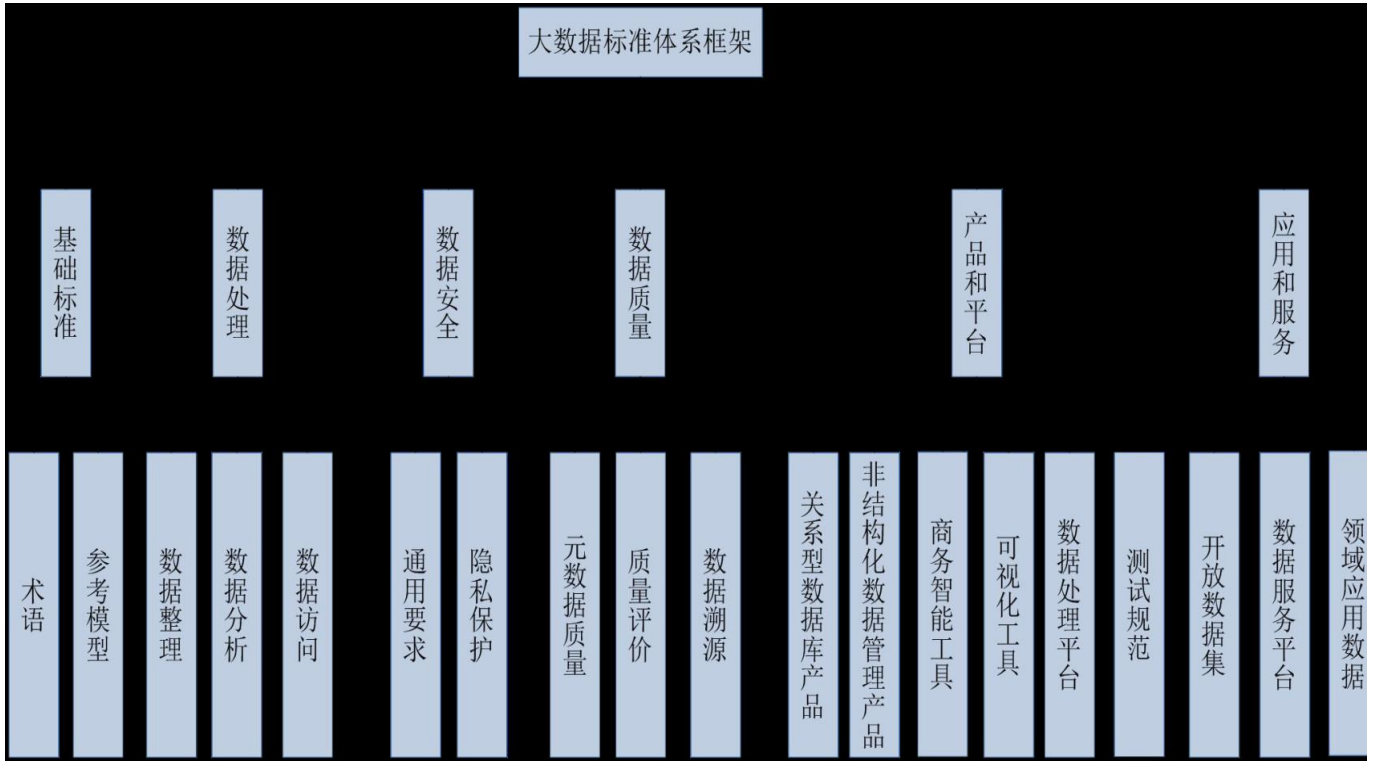
- NIST ‘s NBD-PWG (NIST Big Data – Public Working Group)

  Developing the standards of BD Specification, BD Vocabulary, BD Requirements, BD Security and Privacy, BD Reference Architecture, and BD Technology Roadmap.

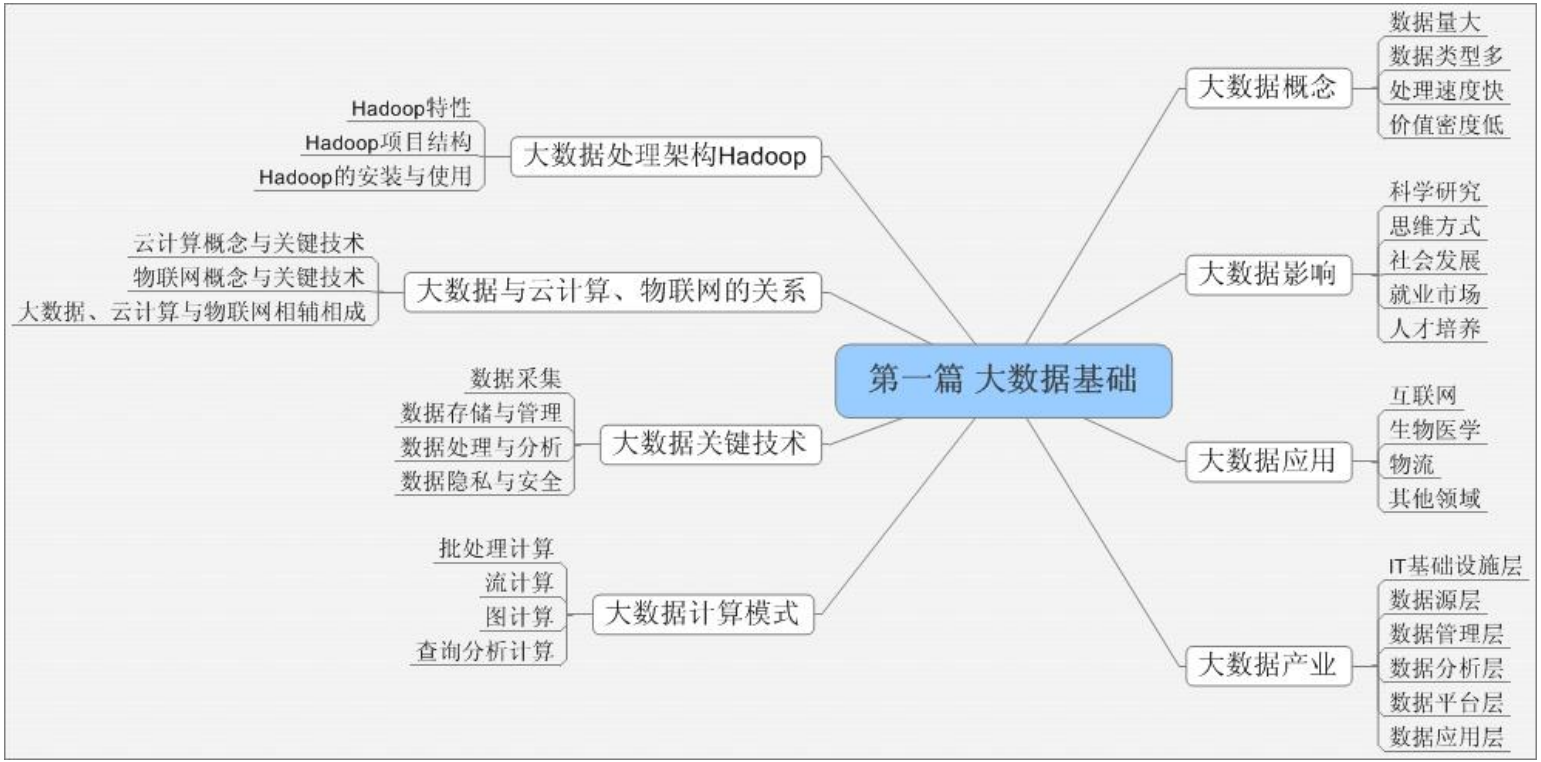
- China’s National Technical Committee on IT Standards established the Work Group on Non-structured Data Management in 2012

  Developing the standards of Non-structured Data Presentation, Access Interface for Non-structured Data, Technical Specifications on Bon-structured Data Management Ssytems.

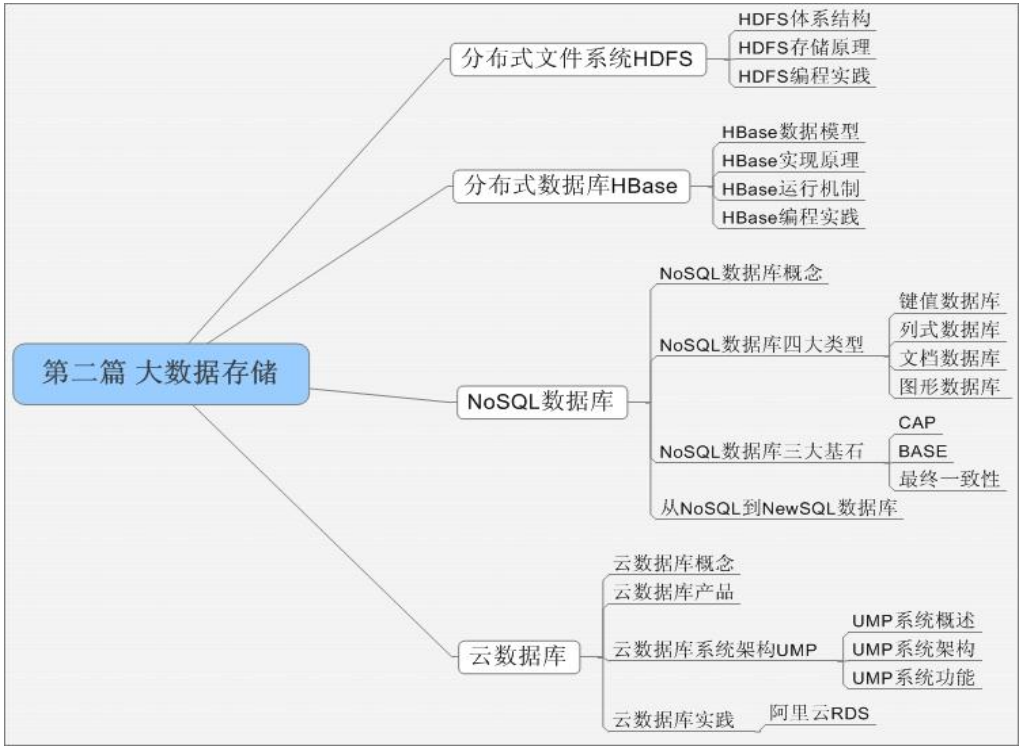
大数据计算架构


大数据标准体系框架
基础标准
数据处理
数据安全
数据质量
产品和平台
应用和服务
术语
参考模型
数据整理
数据分析
数据访问
通用要求
隐私保护
元数据质量
质量评价
数据溯源
关系型数据库产品
非结构化数据管理产品
商务智能工具
可视化工具
数据处理平台
测试规范
开放数据集
数据服务平台
领域应用数据

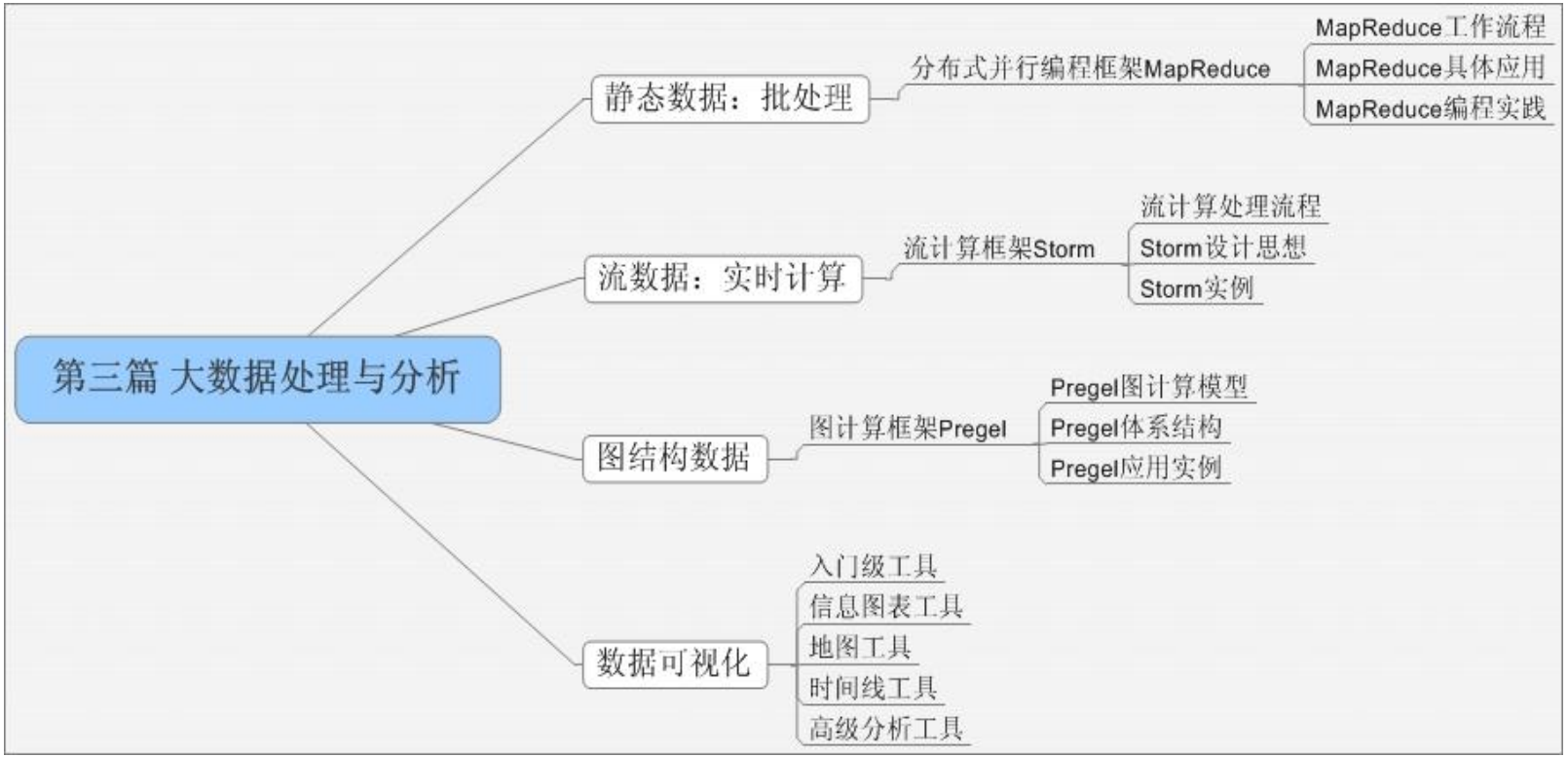
大数据计算架构


第一篇 大数据基础
大数据概念
数据量大
数据类型多
处理速度快
价值密度低
大数据影响
科学研究
思维方式
社会发展
就业市场
人才培养
大数据应用
互联网
生物医学
物流
其他领域
大数据产业
IT基础设施层
数据源层
数据管理层
数据分析层
数据平台层
数据应用层
大数据处理架构Hadoop
Hadoop特性
Hadoop项目结构
Hadoop的安装与使用
大数据与云计算、物联网的关系
云计算概念与关键技术
物联网概念与关键技术
大数据、云计算与物联网相辅相成
大数据关键技术
数据采集
数据存储与管理
数据处理与分析
数据隐私与安全
大数据计算模式
批处理计算
流计算
图计算
查询分析计算

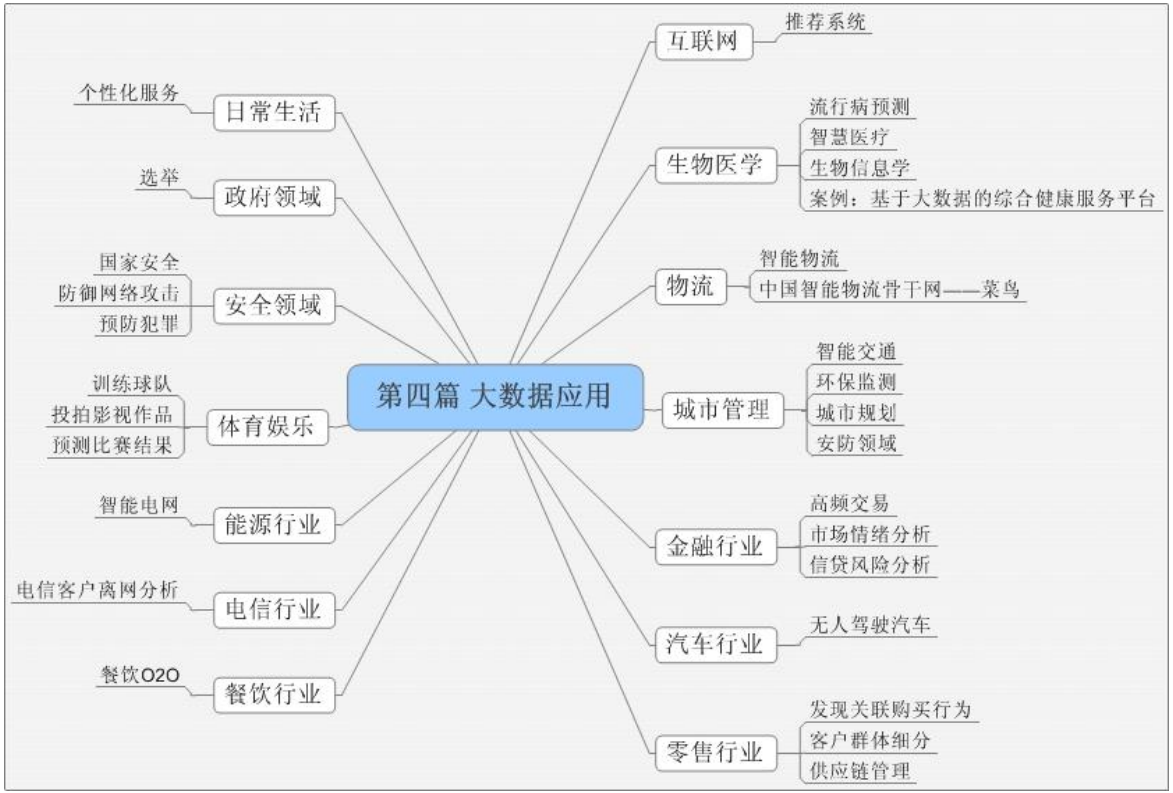
大数据计算架构


第二篇 大数据存储
分布式文件系统HDFS
HDFS体系结构
HDFS存储原理
HDFS编程实践
分布式数据库HBase
HBase数据模型
HBase实现原理
HBase运行机制
HBase编程实践
NoSQL数据库
NoSQL数据库概念
NoSQL数据库四大类型
键值数据库
列式数据库
文档数据库
图形数据库
NoSQL数据库三大基石
CAP
BASE
最终一致性
从NoSQL到NewSQL数据库
云数据库
云数据库概念
云数据库产品
云数据库系统架构UMP
UMP系统概述
UMP系统架构
UMP系统功能
云数据库实践
阿里云RDS

大数据计算架构

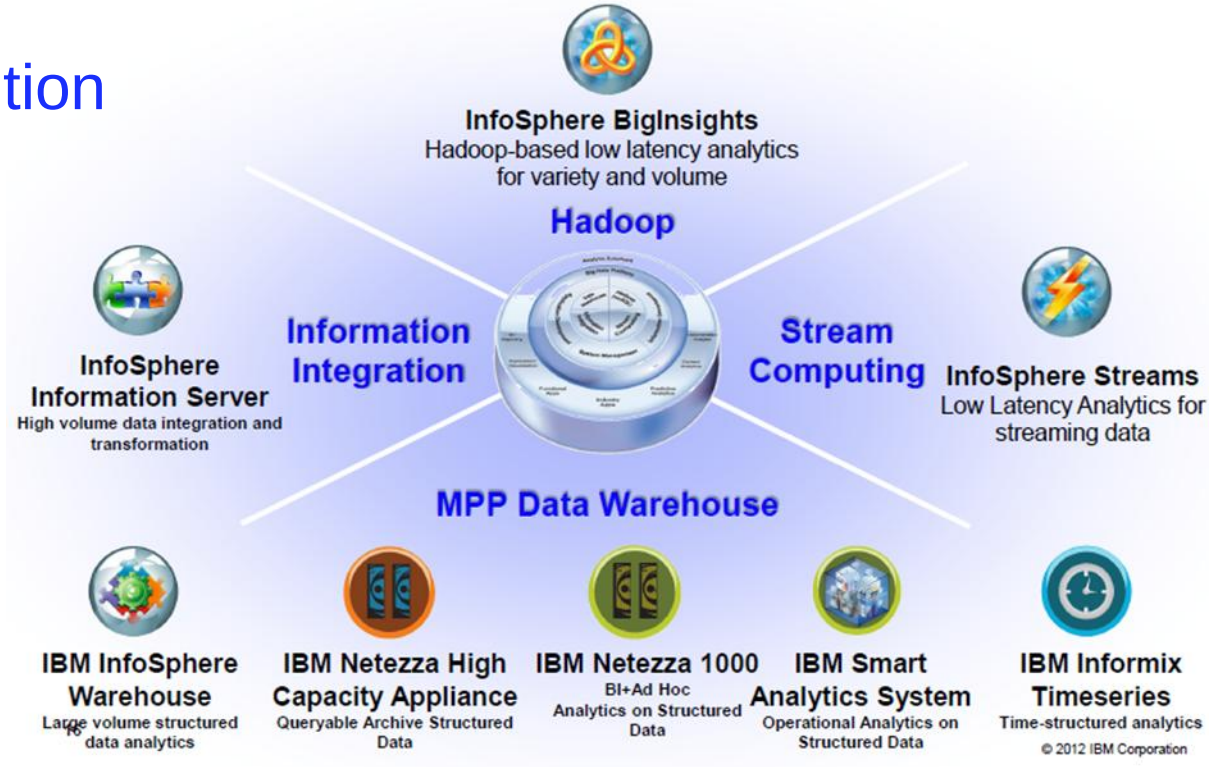

第三篇 大数据处理与分析
静态数据：批处理
分布式并行编程框架MapReduce
MapReduce工作流程
MapReduce具体应用
MapReduce编程实践
流数据：实时计算
流计算框架Storm
流计算处理流程
Storm设计思想
Storm实例
图结构数据
图计算框架Pregel
Pregel图计算模型
Pregel体系结构
Pregel应用实例
数据可视化
入门级工具
信息图表工具
地图工具
时间线工具
高级分析工具

大数据计算架构


第四篇 大数据应用
互联网
推荐系统
生物医学
流行病预测
智慧医疗
生物信息学
案例：基于大数据的综合健康服务平台
物流
智能物流
中国智能物流骨干网——菜鸟
城市管理
智能交通
环保监测
城市规划
安防领域
金融行业
高频交易
市场情绪分析
信贷风险分析
汽车行业
无人驾驶汽车
零售行业
发现关联购买行为
客户群体细分
供应链管理
餐饮行业
餐饮O2O
电信行业
电信客户离网分析
能源行业
智能电网
体育娱乐
训练球队
投拍影视作品
预测比赛结果
安全领域
国家安全
防御网络攻击
预防犯罪
政府领域
选举
日常生活
个性化服务

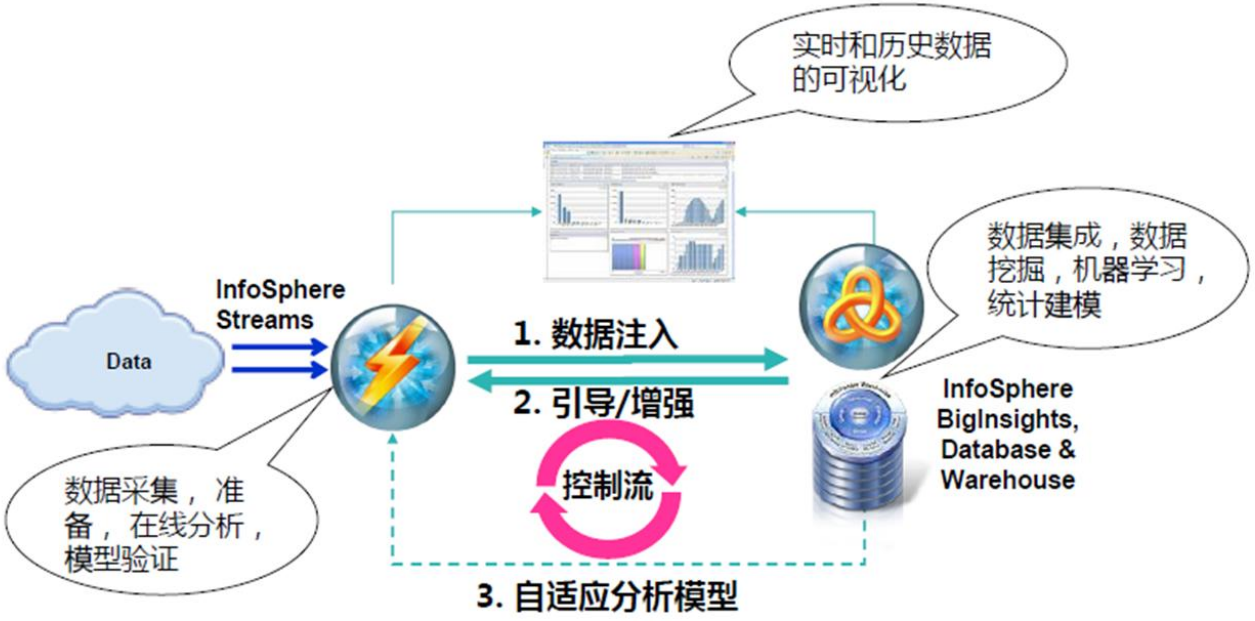
大数据计算架构

IBM Big Data Solution



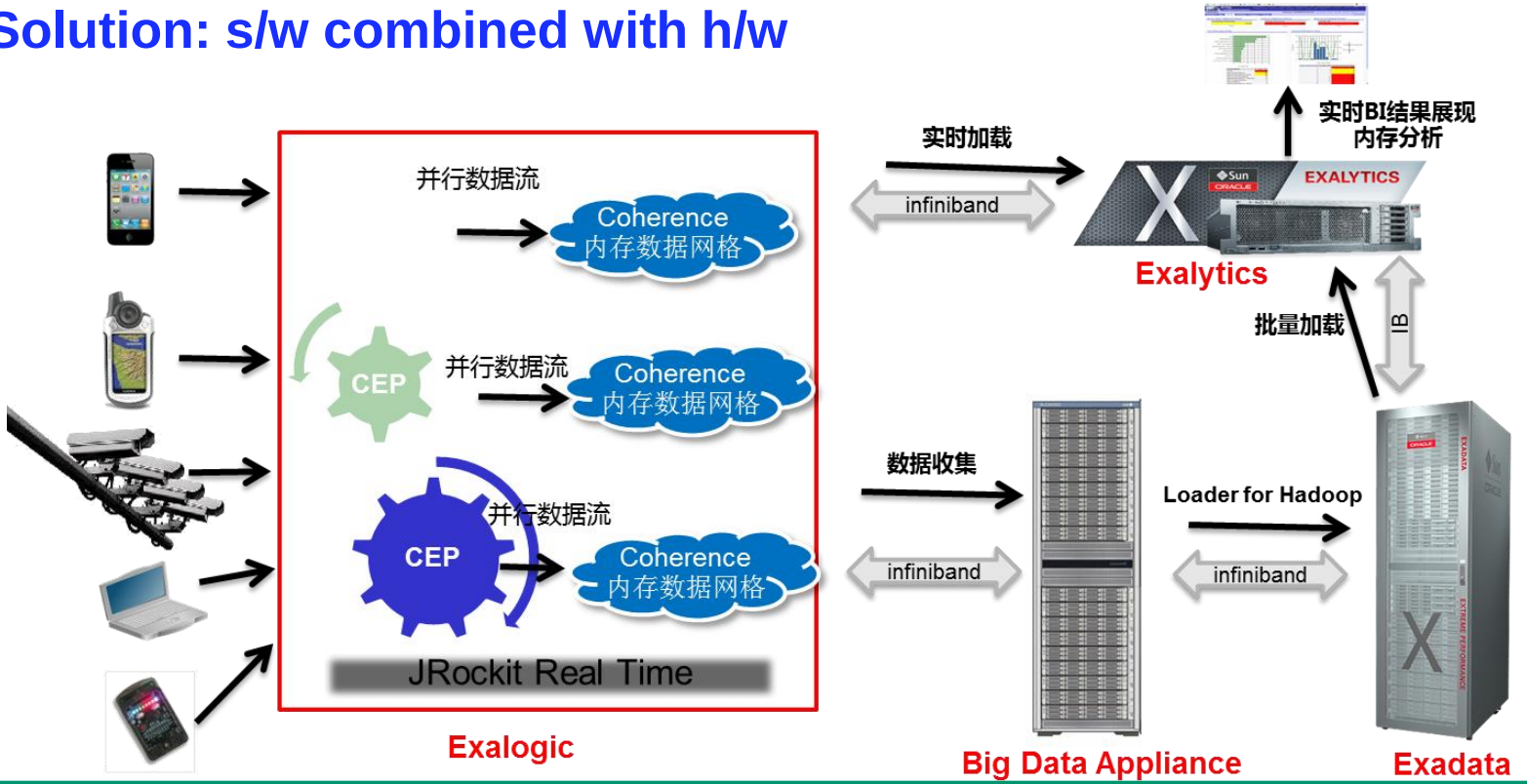
大数据计算架构

Streams and BigInsights



大数据计算架构

Oracle Solution: s/w combined with h/w



大数据计算架构

基于Azure云平台的Hadoop服务

与Vertica 6实现高级集成的大数据应用平台
HP AppSystem for Apache Hadoop

SAP HANA 基于内存的计算平台

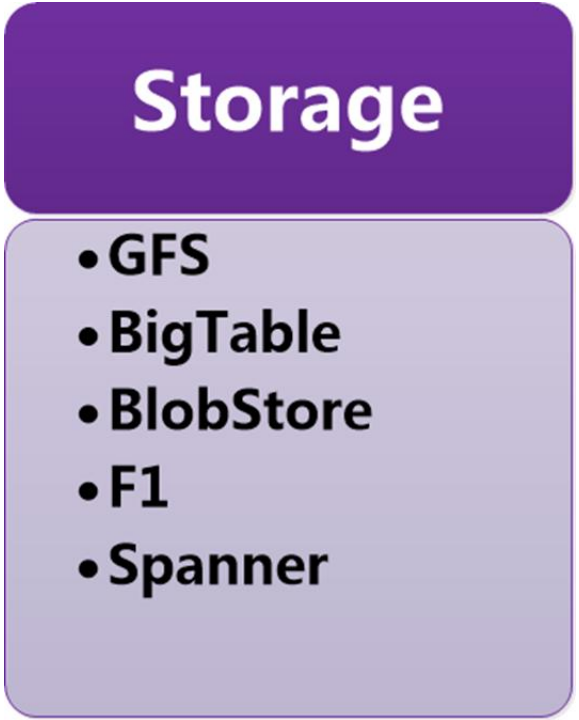
大数据计算架构

Two Technology Baseline: Google vs. Hadoop

Google	Description	Open Source
Google Cluster	集群架构	Hadoop Cluster
GFS	分布式文件系统	HDFS
MapReduce	分布式编程模型	Hadoop MapReduce
BigTable	分布式数据库	Hbase, Cassandra
Pregel	大规模图处理系统	Hama, Giraph
Dremel	大规模数据集交互式分析	Drill
PowerDrill	大数据交互式分析	Spark
Protocol Buffers	大数据交换协议	Avro, Thrift

大数据计算架构

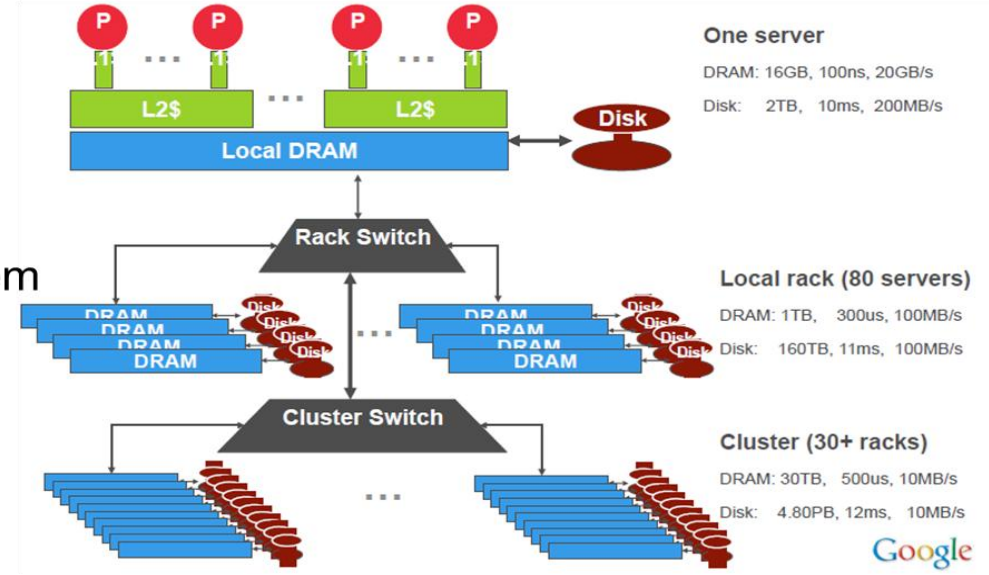
Google Storage System



大数据计算架构

■ Google Storage Hierarchy[1]

集群



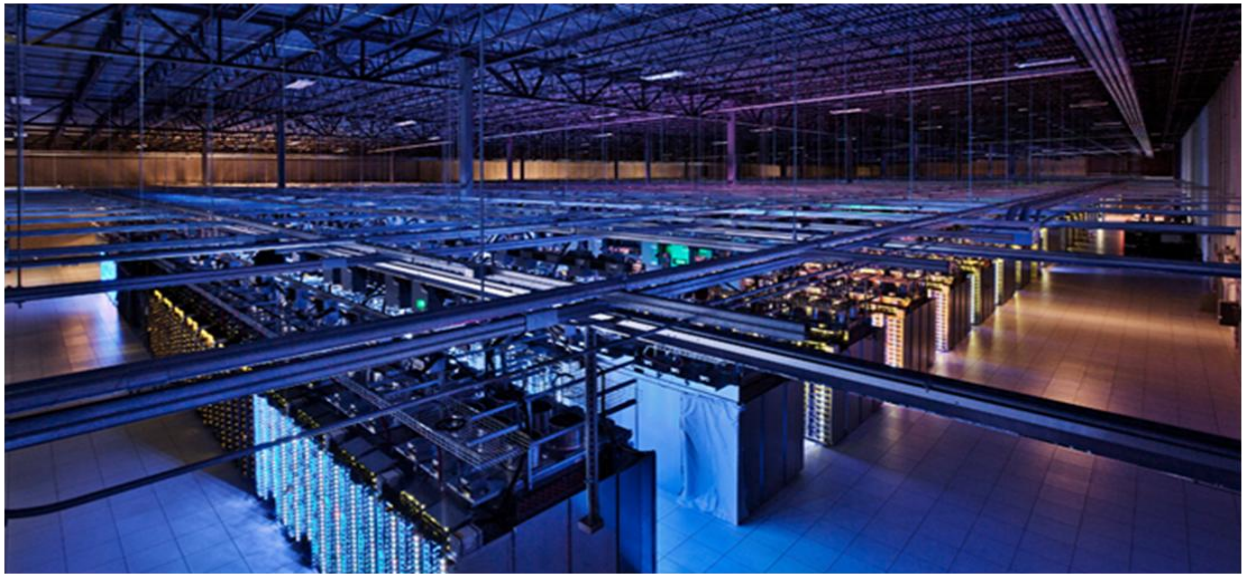
➢ Core Services

- GFS
- Cluster Scheduling System

[1] Jeff Dean: Designs, Lessons and Advice from Building Large Distributed Systems

大数据计算架构

■ Google Data Center



Americas, Europe, Asia

大数据计算架构

Google Data Center

Distributed File System

■GFS v.s HDFS

分布式文件系统

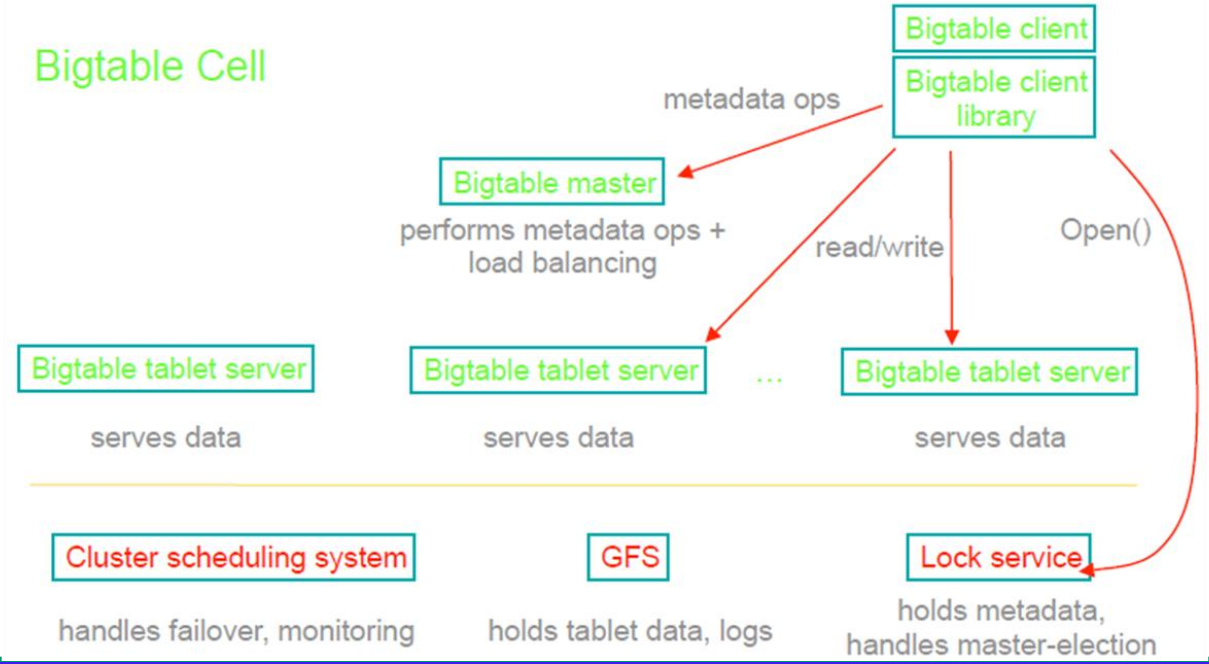
- Master Replicas：GFS Master主从模式备份， 2s恢复，HDFS磁盘备份，数小时恢复
- Snapshot：系统恢复、还原
- Append：GFS复杂的多客户端并发Append模型，一致性好

- HDFS设计目标与GFS一致，但实现简单、灵活，软件可扩展性好

大数据计算架构

■ Google BigTable

分布式结构化存储



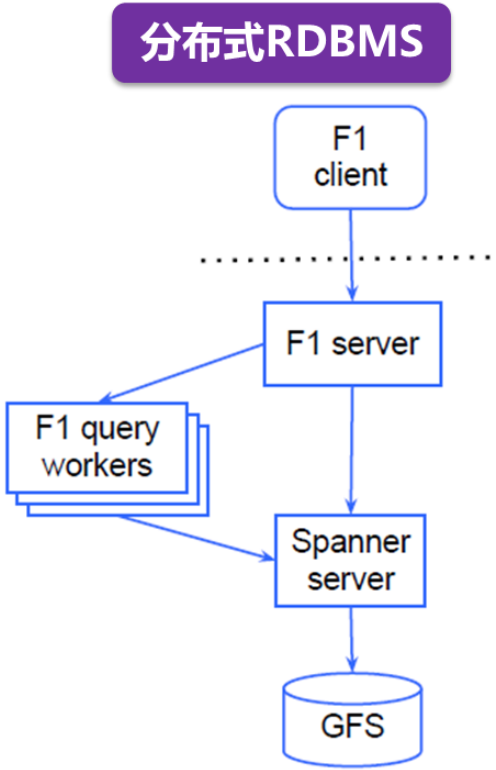
大数据计算架构

■ F1

BigTable的可扩展性 + SQL数据库功能

- 关系型Schema
- 可以同时提供强一致性和弱一致
- 可扩展
- 支持SQL和MapReduce
- 高吞吐、低延迟
- 应用：Google广告业务

- 开源实现：MySQL Cluster



大数据计算架构

■ Spanner

全球数据库

数百万机器，数百数据中心，上万亿行

- Globally distributed
- Synchronous cross-datacenter replication(Paxos)
- Transparent sharding, data movement
- General transactions
- Snapshot reads
- Application: Google Drive, Translation
- Next generation of Bigtable stack

Technical Summary on Big Data Storage System

- Stored Structure: Columnar storage structure
- Performance: High-throughput and Low-delay
- Scalability: Planet-scale
- Supporting Computing Model: MapReduce, SQL