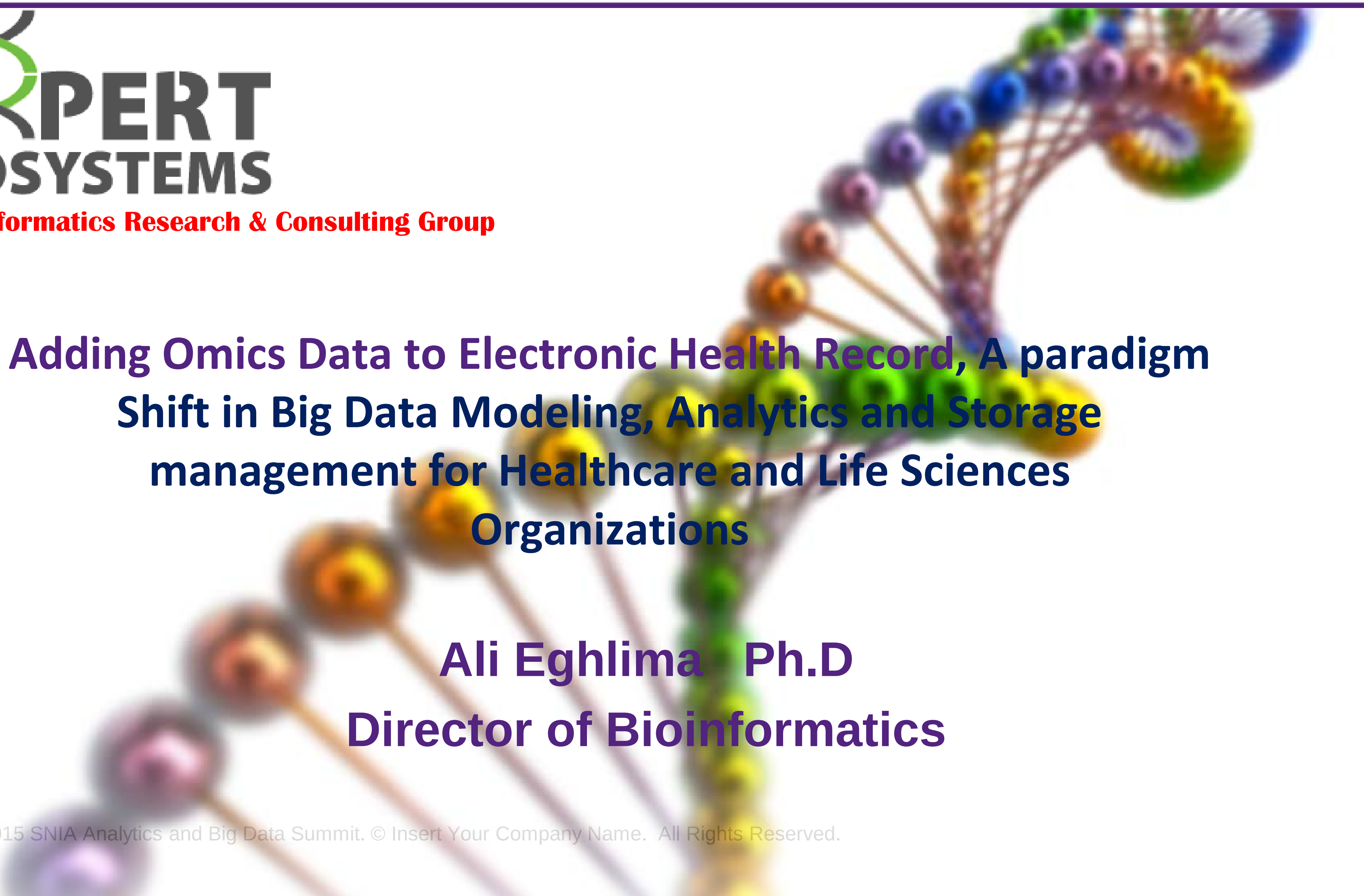
EXPERT BIOSYSTEMS

A Bioinformatics Research & Consulting Group



Adding Omics Data to Electronic Health Record, A paradigm Shift in Big Data Modeling, Analytics and Storage management for Healthcare and Life Sciences Organizations

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Director of Bioinformatics

Before we start: About me

- Ali Eghlima
- Expert BioSystems, EVP, and Director of Bioinformatics
- Data Scientist, Software/System/Solution Architect
- Five Years as Sr. Principal Engineer at Raytheon
  - Leading R&D Projects in Enterprise Architecture, Cyber Security, "Huge" Big Data Analytics, Real-Time Distributed Big Data Collection and Analysis
- 20-years Career as Senior Consulting Engineer at DEC, Compaq, and HP
- Primary Technical Expertise –
  - Big Data Analytics, Real-time Distributed Computing, High Availability, Cyber Security, Cluster and Cloud Technology, High Performance Computing, Numerical Analysis
- Pioneer and Advocate in Cluster & Cloud Computing
- Ph.D from RPI, MS and Engineering degrees from MIT

Agenda

- Characteristics of Healthcare & life sciences data
- Review, Data integrity/Privacy/Cyber Security concerns of major healthcare/research Centers
- Review current technology, and common systems architecture used for Big Data Analytics in Health Sciences vs other industries.
- Issues, challenges and potential solutions for real-time and archived data storage managements
- Present scalable open source computing platform to manage Exabyte class datasets
- Concluding Remarks

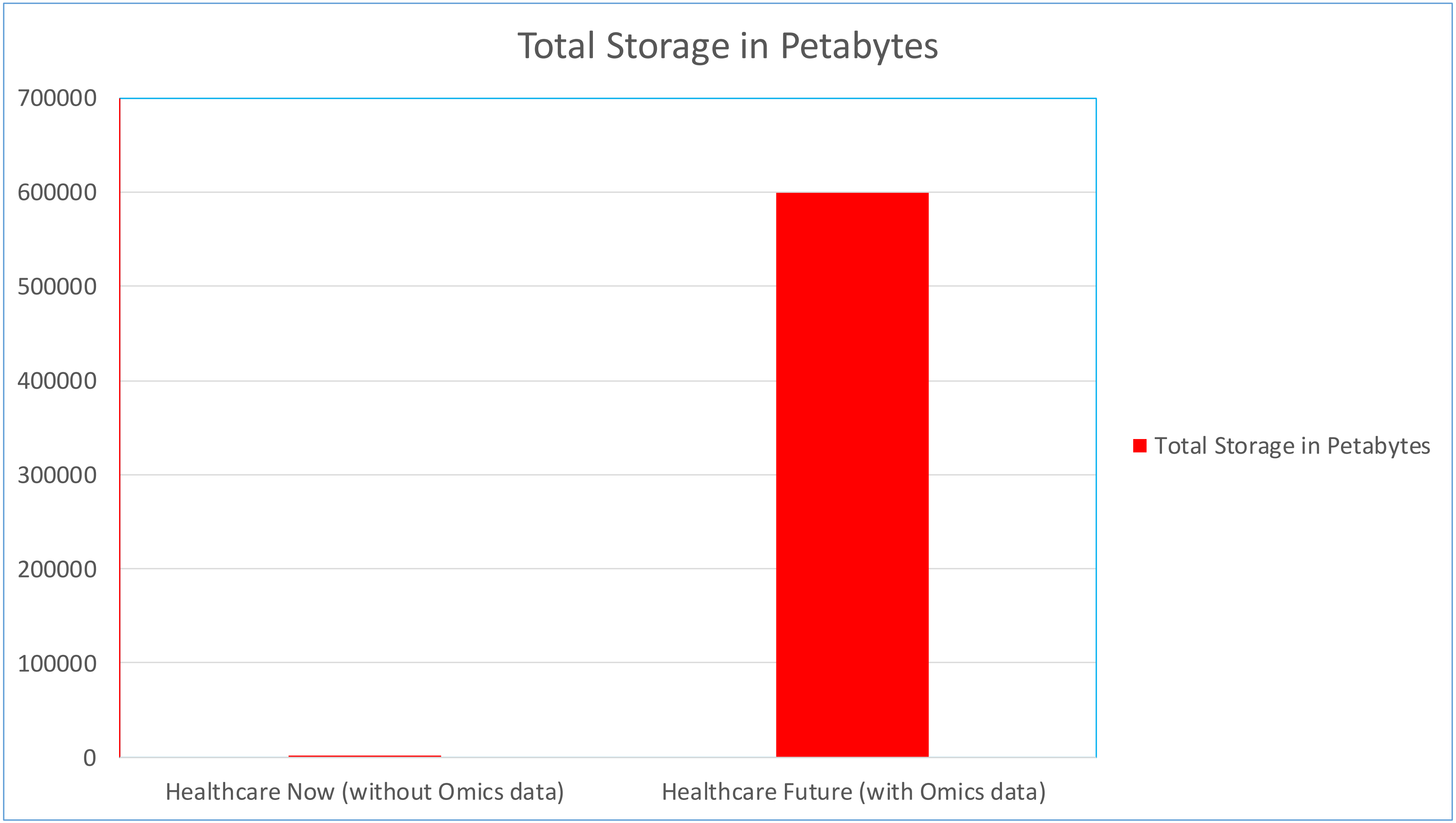
Characteristics of Healthcare Data vs Other Data

- Almost permanent
- It is being owned by individual
- Data ownership after individual death is unknown (offspring, siblings, other family members)

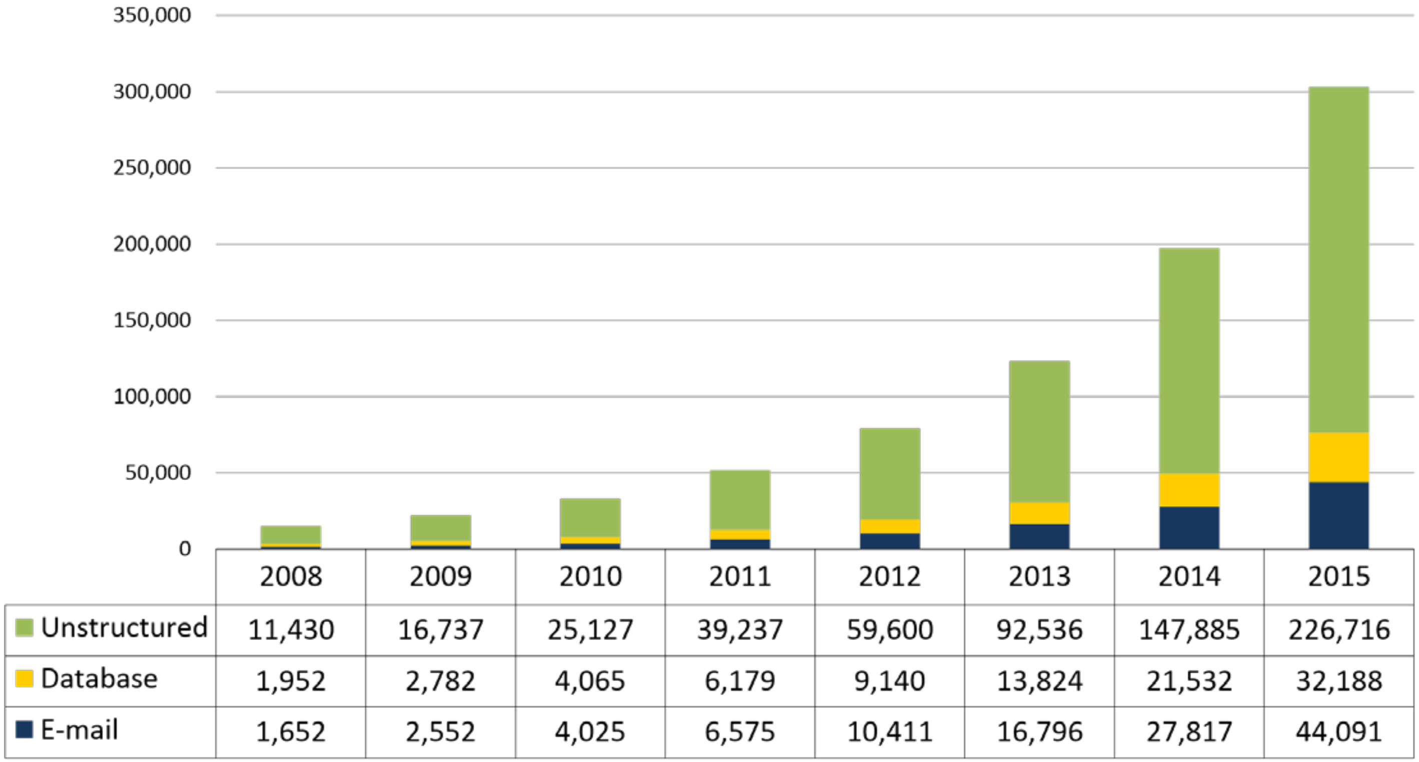
Example: Storage/Dataset Size Health Sciences vs Other Industries

- Financial
  - Number of Accounts – From 10000 to 300 Millions
  - Storage per Account - ~Gigs or less
  - Total Storage – From ~Tens of Terabytes to ~300 Petabytes
- Healthcare
  - Number of Patients – From 10000 to 300 Millions
  - Storage per Patient – From ~Gigabytes Today to ~ Many Terabytes in future
  - Total Storage – From ~ 20 Petabytes to ~600 Exabyte

Example: Storage/Dataset Size Healthcare: Now vs. Future



Total Archived Capacity



	2008	2009	2010	2011	2012	2013	2014	2015
🟩 Unstructured	11,430	16,737	25,127	39,237	59,600	92,536	147,885	226,716
🟨 Database	1,952	2,782	4,065	6,179	9,140	13,824	21,532	32,188
🟦 E-mail	1,652	2,552	4,025	6,575	10,411	16,796	27,817	44,091

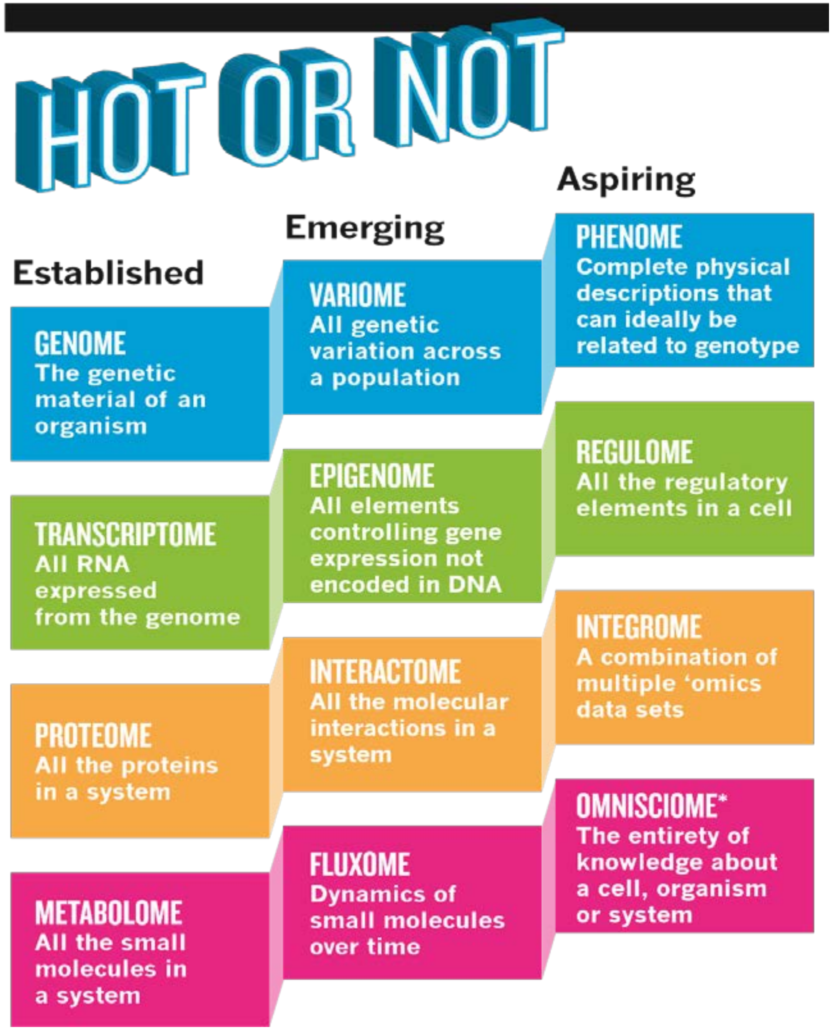
Source: Enterprise Strategy Group, 2010.

Total Archived Capacity, by Content Type, Worldwide, 2008-2015 (Petabytes)

It is not just genomic data

Nature – 494
February 2013

Big biology: The ’omes puzzle
Where once there was the genome, now there are thousands of ’omes. *Nature* goes in search of the ones that matter.



HOT OR NOT

Established

GENOME
The genetic material of an organism

TRANSCRIPTOME
All RNA expressed from the genome

PROTEOME
All the proteins in a system

METABOLOME
All the small molecules in a system

Emerging

VARIOME
All genetic variation across a population

EPIGENOME
All elements controlling gene expression not encoded in DNA

INTERACTOME
All the molecular interactions in a system

FLUXOME
Dynamics of small molecules over time

Aspiring

PHENOME
Complete physical descriptions that can ideally be related to genotype

REGULOME
All the regulatory elements in a cell

INTEGROME
A combination of multiple ‘omics data sets

OMNISCIOME*
The entirety of knowledge about a cell, organism or system

Data integrity/Privacy/Cyber Security concerns of major healthcare/research Centers

Theft of Healthcare Identity Data Consequences

- Medical services, devices and prescription drugs
- Physician information to create fake prescriptions and then resell the medicine online.
- File false claims to insurance companies and government agencies

Theft of Healthcare Identity Data Value

- ❐ Credit Card info $1
- ❐ Personal Identification Information (PII) for $10-$12
- ❐ Patient Records for $50

Source:
1 - Medical Identity Fraud Alliance, “The Growing Threat of Medical Identity Fraud: A Call To Action,” July 2013, accessed at http://medidfraud.org/wp-content/uploads/2013/07/MIFA-Growing-
Threat-07232013.pdf.
2 - David Carr, “Healthcare Data Breaches to Surge in 2014,” InformationWeek Healthcare, Dec. 26, 2013, accessed at
http://www.informationweek.com/healthcare/policy-and-regulation/healthcaredata-breaches-to-surge-in-2014/d/d-id/1113259.

Theft of Healthcare Identity Data is Growing

- 2010 – 1.42 Million
- 2011 – 1.49 Million
- 2012 – 1.85 Million

Source:
Ponemon Institute, "Fourth Annual Benchmark Study on Patient Privacy and Data Security," March 2014, accessed at http://lpa.idexpertscorp.com/acton/attachment/6200/f-012c/1/-/-/-/-/ID%20 Experts%204th%20Annual%20Patient%20Privacy%20%26%20Data%20Security%20Report%20FINAL%20%281%29.pdf

Healthcare Data Security Threat
(reported by healthcare provider)

- ❒ **Employee negligence**
- ❒ **Unsecured mobile devices**
- ❒ **Security gaps with business associates**
- ❒ **Evolving criminal threats**
- ❒ **New vulnerabilities under the Affordable Care Act**

Survey participants had strong reservations about the security of Health Information Exchanges (HIEs): **A third** said they don't plan to participate in HIEs because they are not confident enough in the security and privacy of patient data shared on the exchanges

http://www2.idexpertscorp.com/ponemon-report-on-patient-privacy-data-security-incidents/

Technology, and Common Systems Architecture used for Big Data Analytics in Health Sciences vs other industries

Cloud Computing ?

- Private
- Public
- Community

Private cloud ?

From Webopedia

- *Private cloud* is the phrase used to describe a cloud computing platform that is implemented within the corporate firewall, under the control of the IT department.
- A private cloud is designed to offer the same features and benefits of public cloud systems, but removes a number of objections to the cloud computing model including control over enterprise and customer data, worries about security, and issues connected to regulatory compliance.

Cloud or Public cloud

- **Network Cloud**

  In telecommunications, a cloud refers to a public or semi-public space on transmission lines (such as T1 or T3) that exists between the end points of a transmission

- **Cloud Computing**

  Cloud computing is a type of computing that relies on *sharing computing resources* rather than having local servers

  - **Consumer -** **S**oftware **as a S**ervice (**SaaS**)
  - **Developers and Architects** – **P**latform **as a** Service (**PaaS**)
  - **IT Pros and system administrators** - **I**nfrastructure **as a S**ervice (**IaaS**)

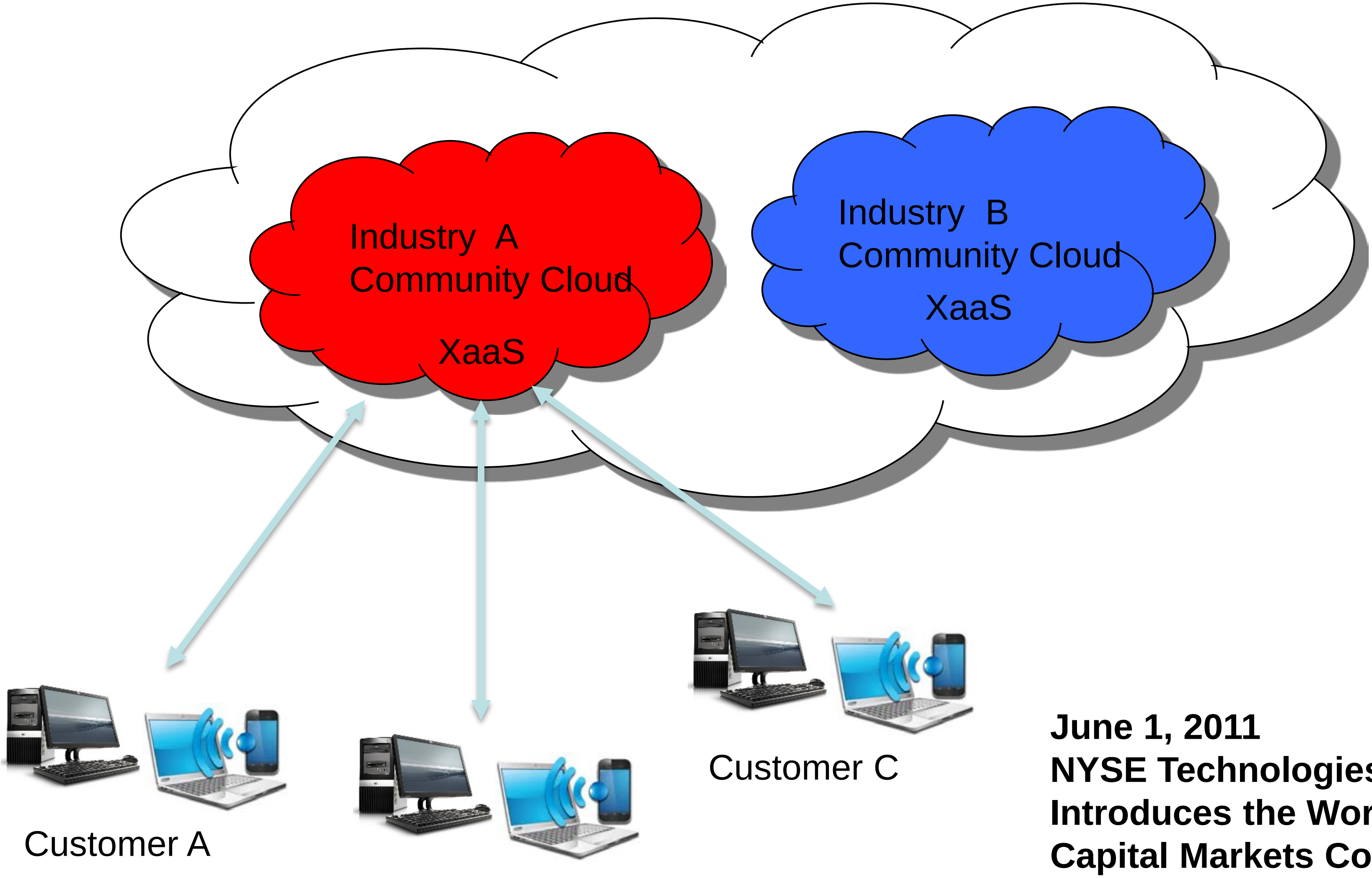
Community Cloud ?

- Centralized
- Distributed

Centralized Community Cloud ?

- Multi-Tenant Infrastructure
- Shared Among Several Organizations with Common Computing Concerns/Requirements
- Higher Level of Security, Privacy, and Performance (Compare to Public Cloud)
- Pay-as-you-go Billing Structure
- Cost, less than Private more than Public

Examples: Centralized Community Cloud



Industry A
Community Cloud
XaaS

Industry B
Community Cloud
XaaS

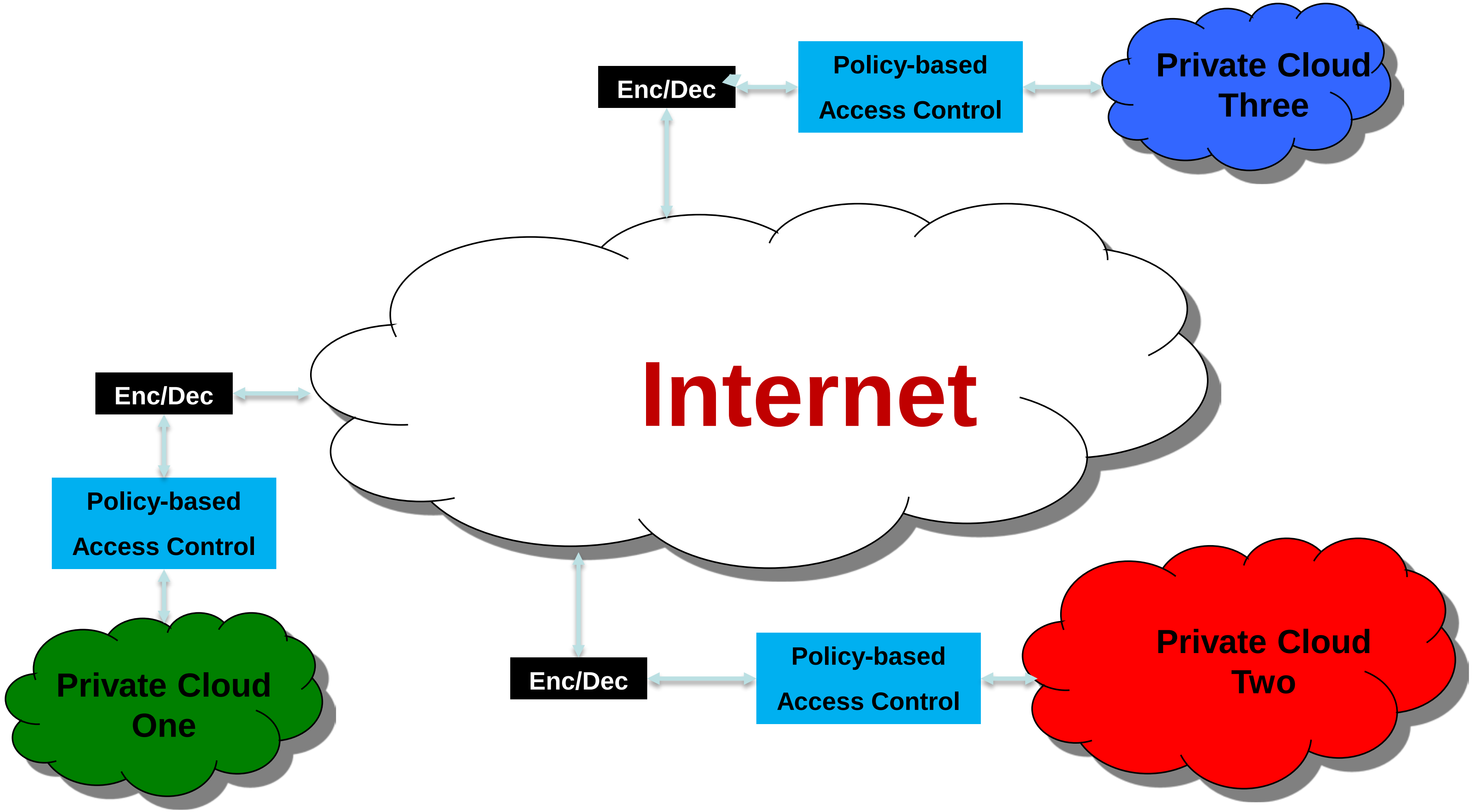
Customer A

Customer B

Customer C

June 1, 2011
NYSE Technologies Introduces the World's First Capital Markets Community Platform

“Secure/Trusted” Distributed Community Cloud



Enc/Dec

Policy-based Access Control

Private Cloud Three

Internet

Enc/Dec

Policy-based Access Control

Private Cloud One

Enc/Dec

Policy-based Access Control

Private Cloud Two

Issues, challenges and potential solutions for real-time and archived data storage managements

Archiving, Tape Technology

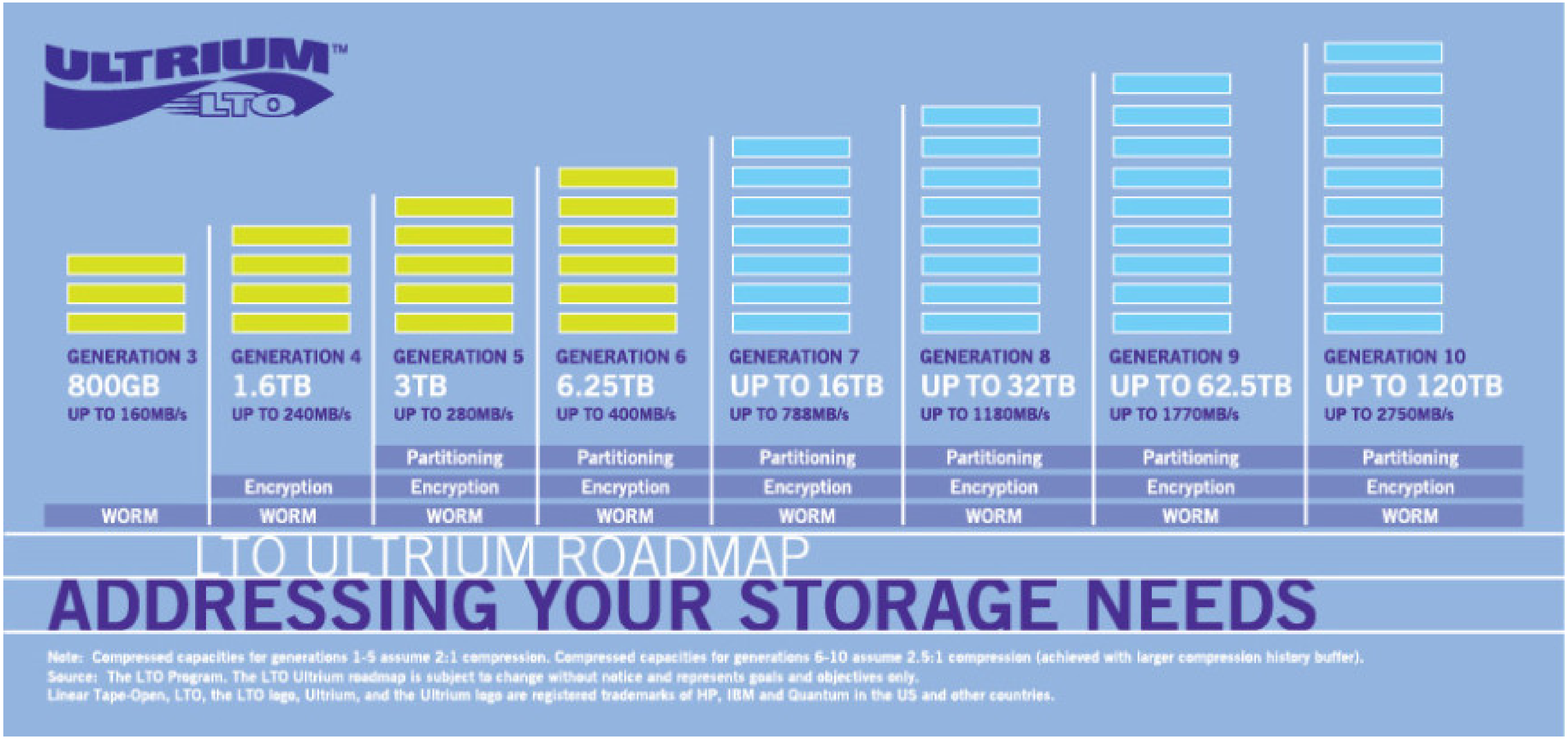
Ultirum LTO:

- Capacity per Tape – 6.25 Terabytes
- Cost (tape) – 1.3 cent per GB
- 250 million LTO tapes have been shipped
- Total, shipped Capacity ~ 100 Exabyte's

Sony's new magnetic tape technology:

- Capacity - 185 TB per cartridges
- Announced at the INTERMAG Europe 2014

LTO ULTRIUM Technology Roadmap



GENERATION 3	GENERATION 4	GENERATION 5	GENERATION 6	GENERATION 7	GENERATION 8	GENERATION 9	GENERATION 10
800GB	1.6TB	3TB	6.25TB	UP TO 16TB	UP TO 32TB	UP TO 62.5TB	UP TO 120TB
UP TO 160MB/s	UP TO 240MB/s	UP TO 280MB/s	UP TO 400MB/s	UP TO 788MB/s	UP TO 1180MB/s	UP TO 1770MB/s	UP TO 2750MB/s
		Partitioning	Partitioning	Partitioning	Partitioning	Partitioning	Partitioning
	Encryption	Encryption	Encryption	Encryption	Encryption	Encryption	Encryption
WORM	WORM	WORM	WORM	WORM	WORM	WORM	WORM

LTO ULTRIUM ROADMAP

ADDRESSING YOUR STORAGE NEEDS

Note: Compressed capacities for generations 1-5 assume 2:1 compression. Compressed capacities for generations 6-10 assume 2.5:1 compression (achieved with larger compression history buffer).
Source: The LTO Program. The LTO Ultrium roadmap is subject to change without notice and represents goals and objectives only.
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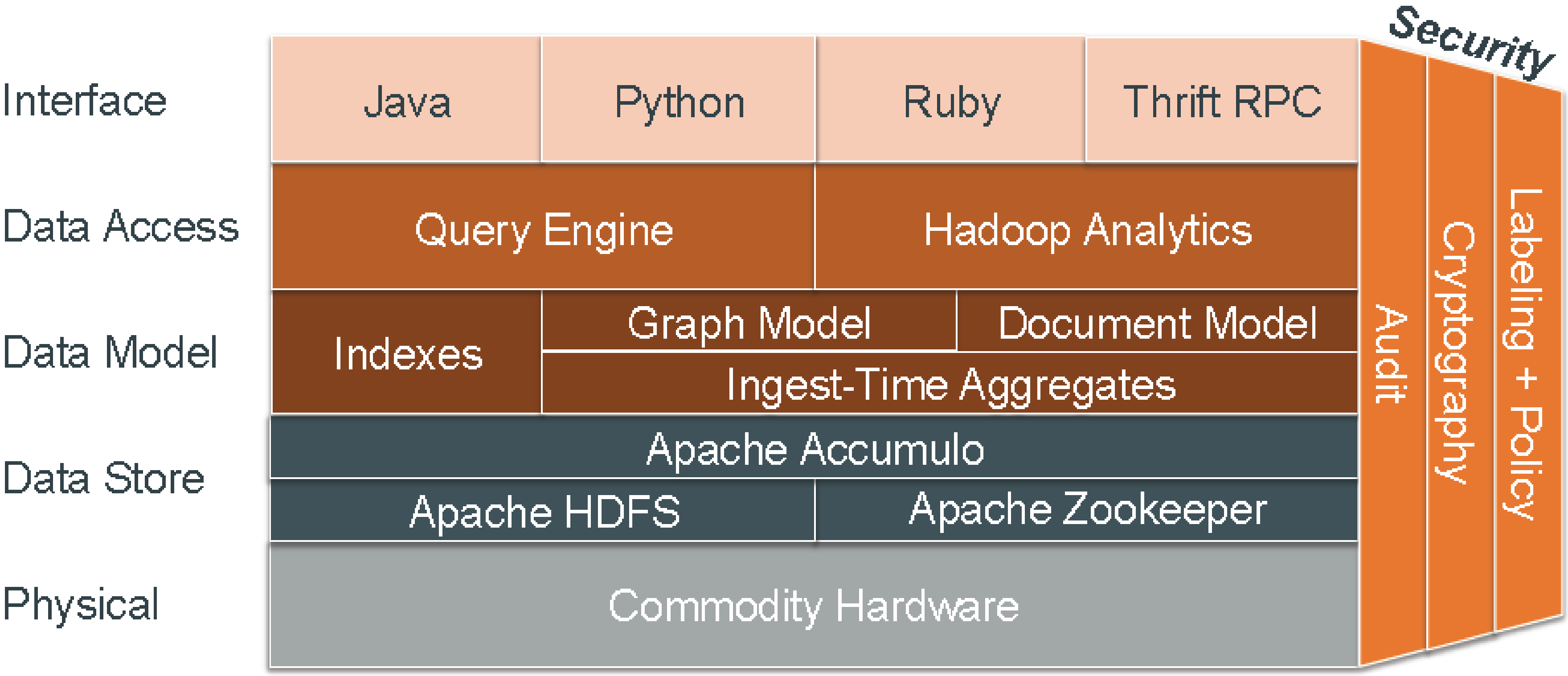
Scalable Open Source Computing Platform to manage Exabyte class datasets

- Linux
- Hadoop
- MapReduce
- R
- Accumulo

Technology Stack



Source: SQRRL Enterprise 2014

Partial listing of NoSQL database engines for managing Exabyte class datasets

- Accumulo
- Cassandra
- Couchbase
- CouchDB
- ElasticSearch
- Hbase
- Hypertable
- MongoDB
- Neo4j
- Redis
- Riak
- Scalaris
- VoltDB

Summary

- Challenges; System performance and Storage Management

Storage requirements, and associated computing power and network infrastructure performance will increase by at least three order of magnitude, just to keep up with today computing systems performance

Total Patient EHR, Data Storage ~ Zettabyte

Summary (cont.)

- Main challenge; Common data model and data store technology

Standardizations and adaptation of common data store and data model technologies

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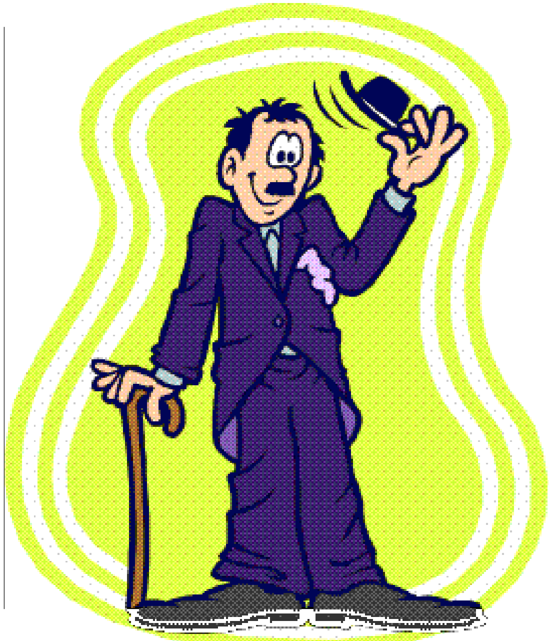
Concluding Remarks



5 V's of Big Data

- Volume: From Terabytes, Petabytes, Exabytes,...
- Variety: Structured data, semi-structured date, unstructured data and images.
- Velocity: Conducting real-time analytics and ingesting streaming data feeds in addition to batch processing.
- Value: Using commodity hardware instead of expensive specialized appliances.
- Veracity: Leveraging data from a variety of domains.