HEALTHCARE DOES HADOOP: AN ACADEMIC MEDICAL CENTER'S FIVE-YEAR JOURNEY

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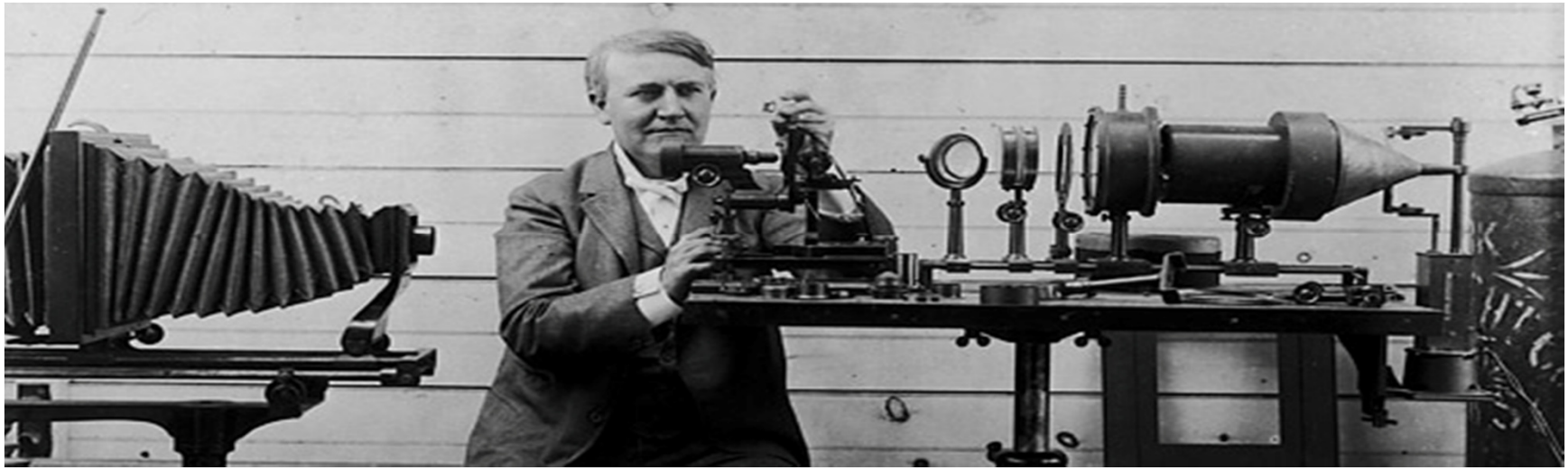
Clearsense

UC Irvine Health

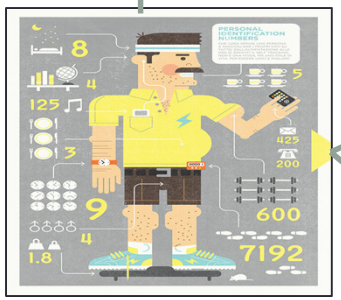
Stony Brook Medicine

The doctor of the future will give no medicine, but instead will interest his patients in the care of human frame, in diet, and in the cause and prevention of disease.

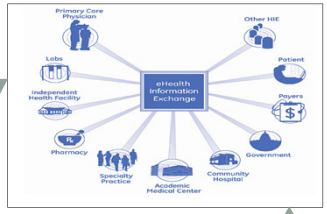
Thomas Edison (1847 – 1931)



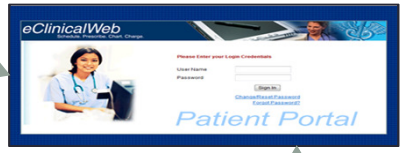
PHR Centric Health

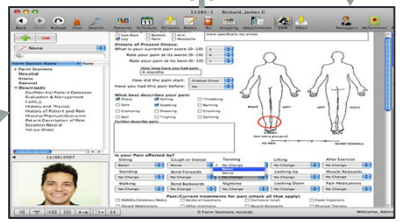


Modern HDP



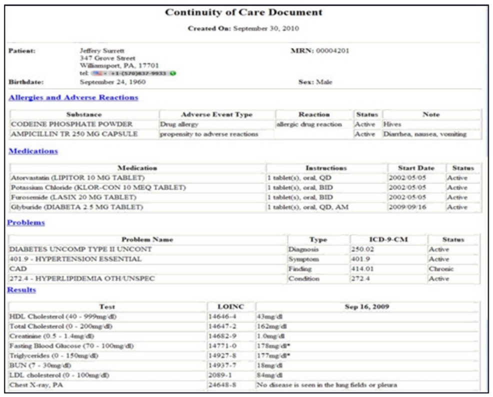
HIE





EMR

Early Days - 2010



Continuity of Care Document

Created On: September 30, 2010

Patient: Jeffery Surrett
347 Grove Street
Williamsport, PA, 17701
tel: +1-(570)837-9933

MRN: 00004201

Birthdate: September 24, 1960

Sex: Male

Allergies and Adverse Reactions

Substance	Adverse Event Type	Reaction	Status	Note
CODEINE PHOSPHATE POWDER	Drug allergy	allergic drug reaction	Active	Hives
AMPICILLIN TR 250 MG CAPSULE	propensity to adverse reactions		Active	Diarrhea, nausea, vomiting

Medications

Medication	Instructions	Start Date	Status
Atorvastatin (LIPITOR 10 MG TABLET)	1 tablet(s), oral, QD	2002/05/05	Active
Potassium Chloride (KLOR-CON 10 MEQ TABLET)	1 tablet(s), oral, BID	2002/05/05	Active
Furosemide (LASIX 20 MG TABLET)	1 tablet(s), oral, BID	2002/05/05	Active
Glyburide (DIABETA 2.5 MG TABLET)	1 tablet(s), oral, QD, AM	2009/09/16	Active

Problems

Problem Name	Type	ICD-9-CM	Status
DIABETES UNCOMP TYPE II UNCONT	Diagnosis	250.02	Active
401.9 - HYPERTENSION ESSENTIAL	Symptom	401.9	Active
CAD	Finding	414.01	Chronic
272.4 - HYPERLIPIDEMIA OTH/UNSPEC	Condition	272.4	Active

Results

Test	LOINC	Sep 16, 2009
HDL Cholesterol (40 - 999mg/dl)	14646-4	43mg/dl
Total Cholesterol (0 - 200mg/dl)	14647-2	162mg/dl
Creatinine (0.5 - 1.4mg/dl)	14682-9	1.0mg/dl
Fasting Blood Glucose (70 - 100mg/dl)	14771-0	178mg/dl*
Triglycerides (0 - 150mg/dl)	14927-8	177mg/dl*
BUN (7 - 30mg/dl)	14937-7	18mg/dl
LDL cholesterol (0 - 100mg/dl)	2089-1	84mg/dl
Chest X-ray, PA	24648-8	No disease is seen in the lung fields or pleura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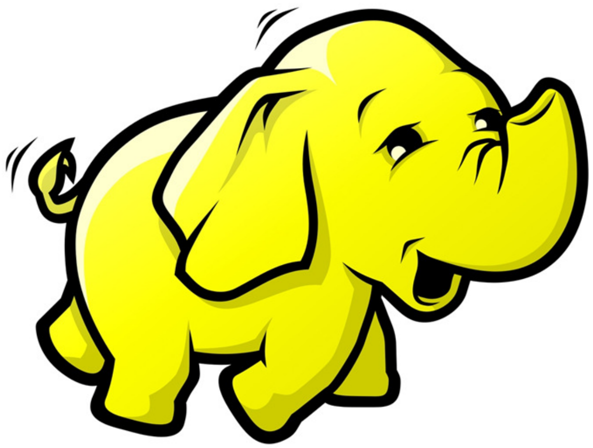
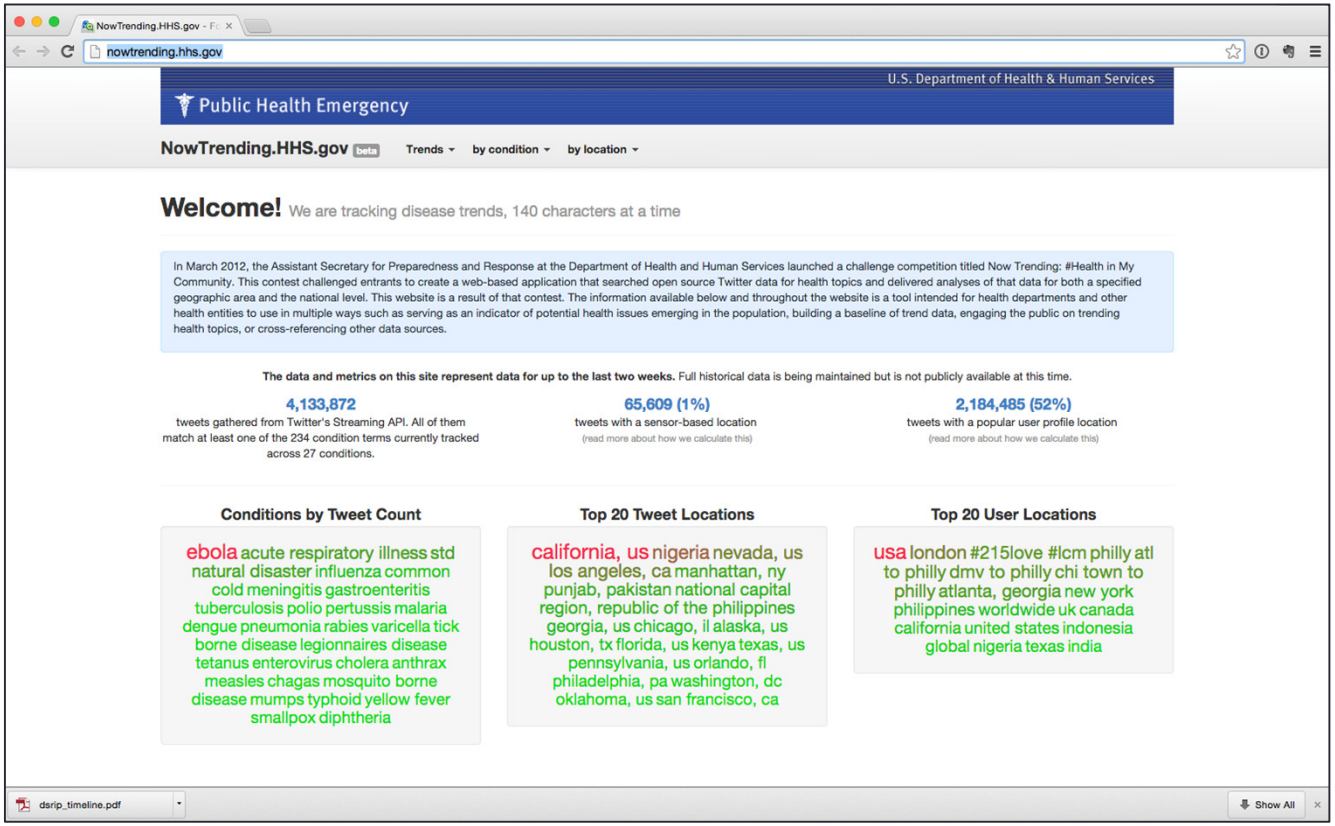


Naveen Ashish, PhD

NowTrending 2012



Current Environment

Electronic Medical Record

- Not designed to process high volume/velocity data
- Not intended to handle complex operations
  - Such as:
    - Anomaly detection
    - Machine learning
    - Building complex algorithms
    - Pattern set recognition

Enterprise Data Warehouse

- Suffer from a latency factor of up to 24 hours
- The EDW serves all of the following retrospectively as opposed to in real time
- Clinicians
- Operations
- Quality and research

Big Data = Interoperability

- Big Data Ecosystem that Supports:
  - Hadoop (HDFS)
  - Hbase
  - Hive
  - Pig
  - MapReduce
  - Mahout
  - MongoDB (NoSQL)
  - Neo 4j (Graph Database)
  - Relational Data Base
  - R
  - Spark
  - Storm
  - Weka

Big Data = Complete Data

- The Electronic Medical Record is primarily transactional taking feeds from source systems via an interface engine
- The Enterprise Data Warehouse is a collection of data from the EMR and various source systems in the enterprise
- In both cases decisions are made concerning data acquisition
- A Big Data system is capable of ingesting and storing healthcare data in total and in real time

Modern Healthcare Data Platform

A healthcare information ecosystem built on "Big Data" technologies should:

- Be capable of serving the needs of clinicians, operations, quality and research
- And should do so in real time and in one environment

Should be:

- Able to ingest all healthcare generated data both internal and external in native format

Should be:

- A platform for advanced analytics such as early detection of sepsis & hospital acquired conditions
- Be enabled to predict potential readmissions
- Leverage complex algorithms and be a machine learning platform

Architecture Guiding Principles

- Architecture to minimize encumbrance on IT staff
- Ability to store all healthcare date in native form and complete
- Use of supported open source code
- Ensure architectural compatibility with commercial applications

Infrastructure

- Low Cost of Entry & Scalable
  - Open Source
  - Commodity Hardware
    - UCI Hadoop Ecosystem
      - 10 nodes
      - 5 terabytes
    - Yahoo Hadoop Ecosystem
      - 60K nodes
      - 160 petabytes
- Cloud Ready

Data Sources

- Legacy Systems
  - Print to Text or Delimited String
- All HL7 Feeds (EMR source systems)
- All EMR Initiated Data (Stored Procedures)
- Device Data (in one minute intervals)
- Physiological Monitors (HL7)
- Ventilators (HL7)
- Smart Pumps
- Social Media (POC)
- Healthcare Organization Sentiment Analysis
- Patient Engagement
- Home Monitoring (POC)
- Real Time Location System (RFID)
- Hospital Sensors

Newer Data Sources

- External Streaming Device Data
- Wearables
- Home Devices
- Social Media
- Geographic Information System (GIS) Data
- Omic Data
- Open Data
  - www.data.gov
- Adverse Drug Event
  - www.researchae.com
- ***Internet of Things (IoT)***
  - Telematics
  - 5G

Use Cases

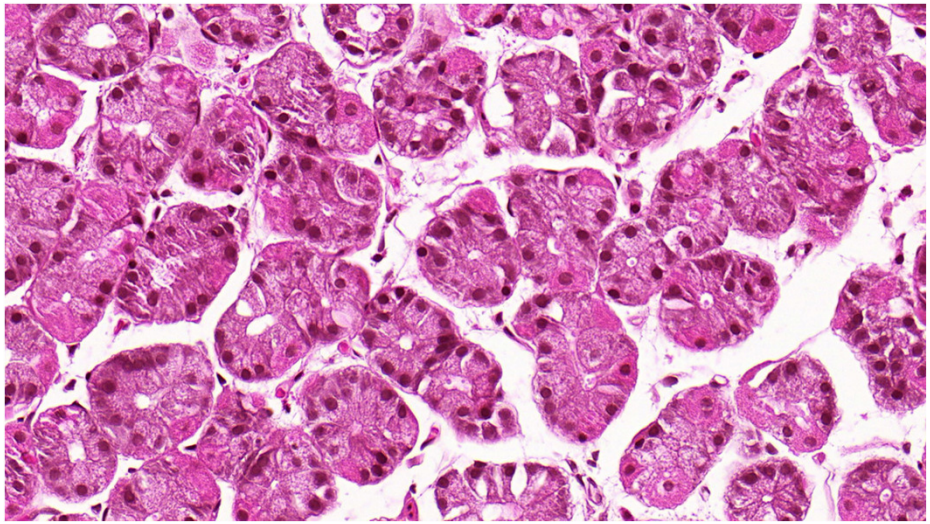
- Legacy System Retirement
- ***Patient Condition Changes***
  - ***RRT***
- ***Early Sepsis Detection***
- ***Environmental Response***
- Real Time Nursing Unit Utilization
  - Staffing and Resource Allocation
- Social Media Sentiment Analysis
- Research
  - Cohort Discovery
  - Data Science
- Clinician Aware Applications
- Patient Monitoring External to Traditional Healthcare Setting
- ***Event Driven Care & Real Time Quality Monitoring***
- ***Personal Health Record***

Future Use Cases

- Ventilator Management
  - Vent dashboard in EMR
- Hospital Acquired Infections (HAI)
- VTE Surveillance
- Sensium Vitals Digital Patch
- Patient-Generated Data
  - Home Devices (Scale, Vital Signs, Glucose)
  - Exercise & Diet (Fit Bit, Jawbone, Nike)
- Combining Phenotype Data with Genotype Data
- Patient Threat Analysis
- Edge and Vertices Analysis
  - Patient caregivers and outcomes

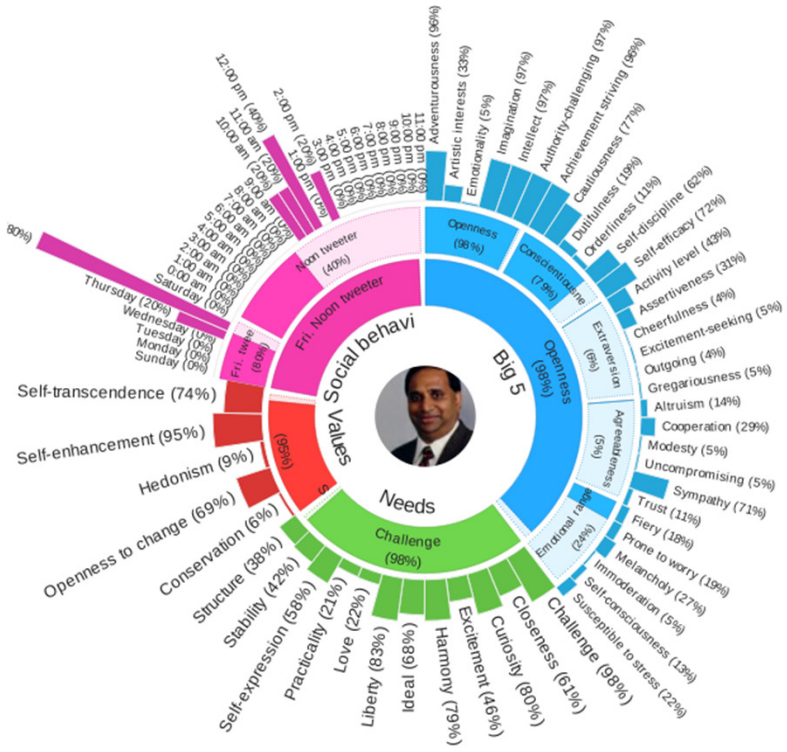
Imaging Analytics

- NIH Funded U24 Grant
- Joel Saltz, PhD

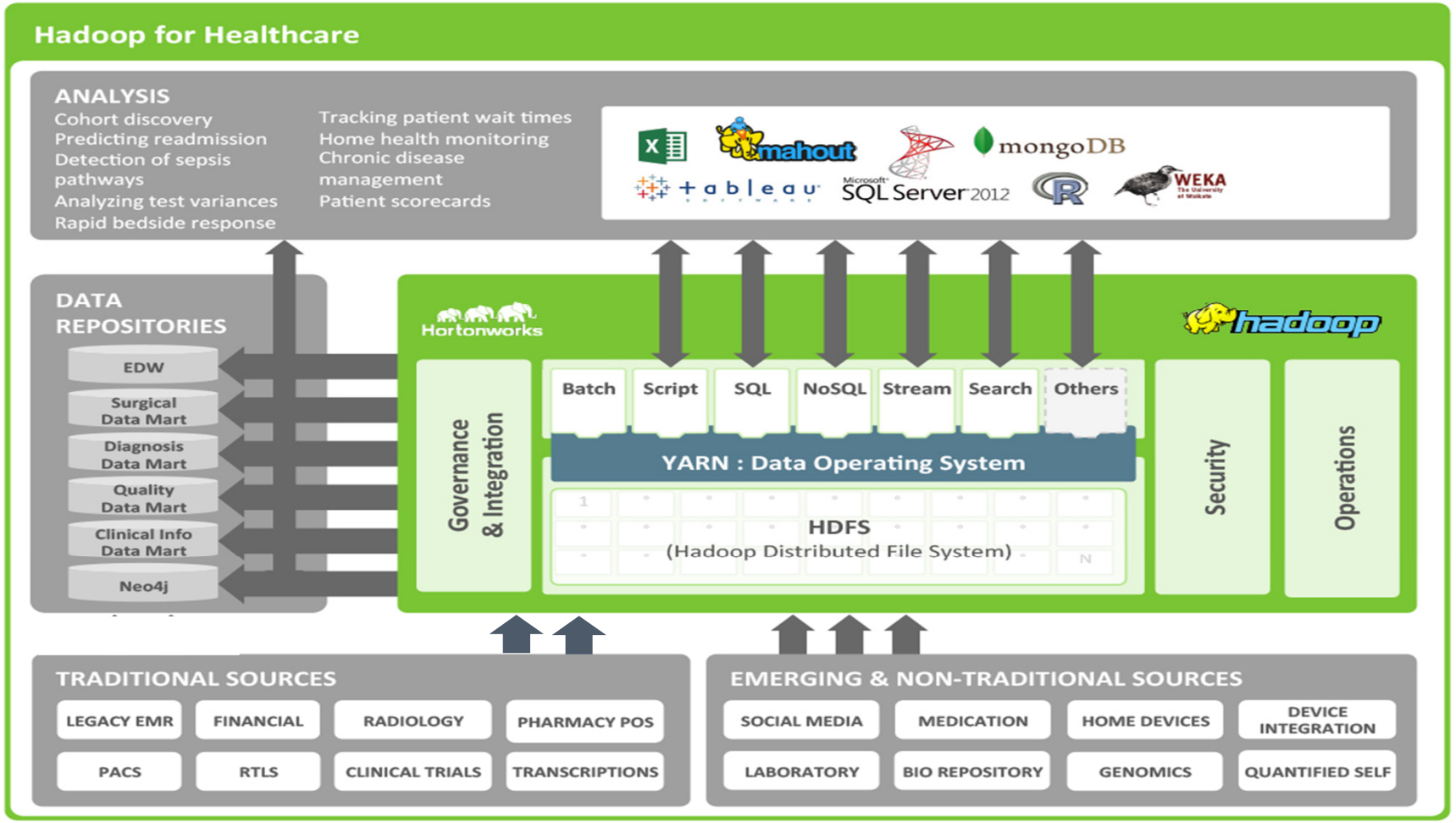


- This project is to develop, deploy, and disseminate a suite of open source tools and integrated informatics platform that will facilitate multi-scale, correlative analyses of high resolution whole slide tissue image data, spatially mapped genetics and molecular data for cancer research.

Patient Persona



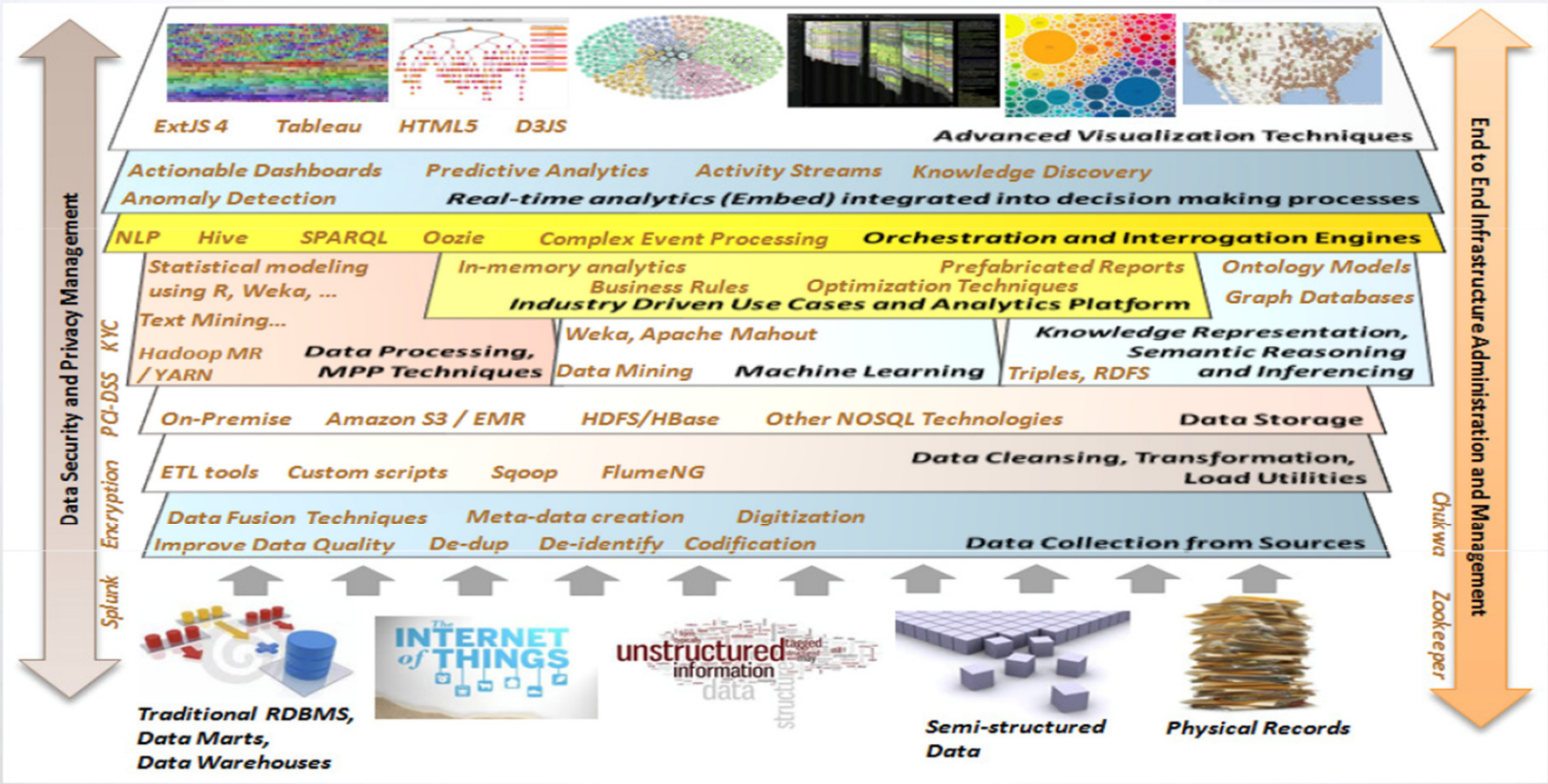
- Surveys
- Questionnaires
- Clinic Notes
- External Sources
  - IoT
  - Social Media
  - Credit
  - Telemetrics


Hadoop for Healthcare
ANALYSIS
Cohort discovery
Predicting readmission
Detection of sepsis pathways
Analyzing test variances
Rapid bedside response
Tracking patient wait times
Home health monitoring
Chronic disease management
Patient scorecards
mahout
mongoDB
tableau
SQL Server 2012
WEKA
DATA REPOSITORIES
EDW
Surgical Data Mart
Diagnosis Data Mart
Quality Data Mart
Clinical Info Data Mart
Neo4j
Hortonworks
hadoop
Governance & Integration
Batch
Script
SQL
NoSQL
Stream
Search
Others
YARN : Data Operating System
HDFS
(Hadoop Distributed File System)
Security
Operations
TRADITIONAL SOURCES
LEGACY EMR
FINANCIAL
RADIOLOGY
PHARMACY POS
PACS
RTLS
CLINICAL TRIALS
TRANSCRIPTIONS
EMERGING & NON-TRADITIONAL SOURCES
SOCIAL MEDIA
MEDICATION
HOME DEVICES
DEVICE INTEGRATION
LABORATORY
BIO REPOSITORY
GENOMICS
QUANTIFIED SELF

FOSS Driven Protean

- Is a centrally-hosted, instrumented “Smart and Connected” platform servicing real time business event streams using high-speed MPP Compute and Storage Grids
- Primarily based on the concepts and principles of Event Driven Architecture (EDA), Complex Event Processing (CEP) and Multi-Agent-Systems (MAS)
- Support for high speed data ingestion - Structured and Unstructured (Textual)
- Core Advanced Analytics enabled through Model Building, Data Mining and Machine Learning techniques (Supervised and Unsupervised)
- Context modeling creation across Time-Space-Value dimensions
- Enables creation of a Central Enterprise Data Refinery to enable “Source of Truth” for transactional information within the Healthcare Enterprise

A reference architecture blueprint for realizing the Big Data platform leveraging Free and Open Source Software (FOSS)….The platform has been deployed successfully across 4 large client implementations across various business domains….



FHIR – The "Public API" for Healthcare?

FHIR = Fast Health Interoperability Resource

- Emerging HL7 Standard (DSTU 2 soon)
- More powerful & less complex than HL7 V3

ReSTful API

- ReST = Representational State Transfer – basis for Internet Scale
- Resource-oriented rather than Remote Procedure Call (nouns > verbs)
- Easy for developers to understand and use

FHIR Resources

- Well-defined, simple snippets of data that capture core clinical entities
- Build on top of existing HL7 data types
- Resources are the "objects" in a network of URI reference links

Huff, S., McCallie, D HIMSS 2015

SMART Platform – Open Specification for Apps

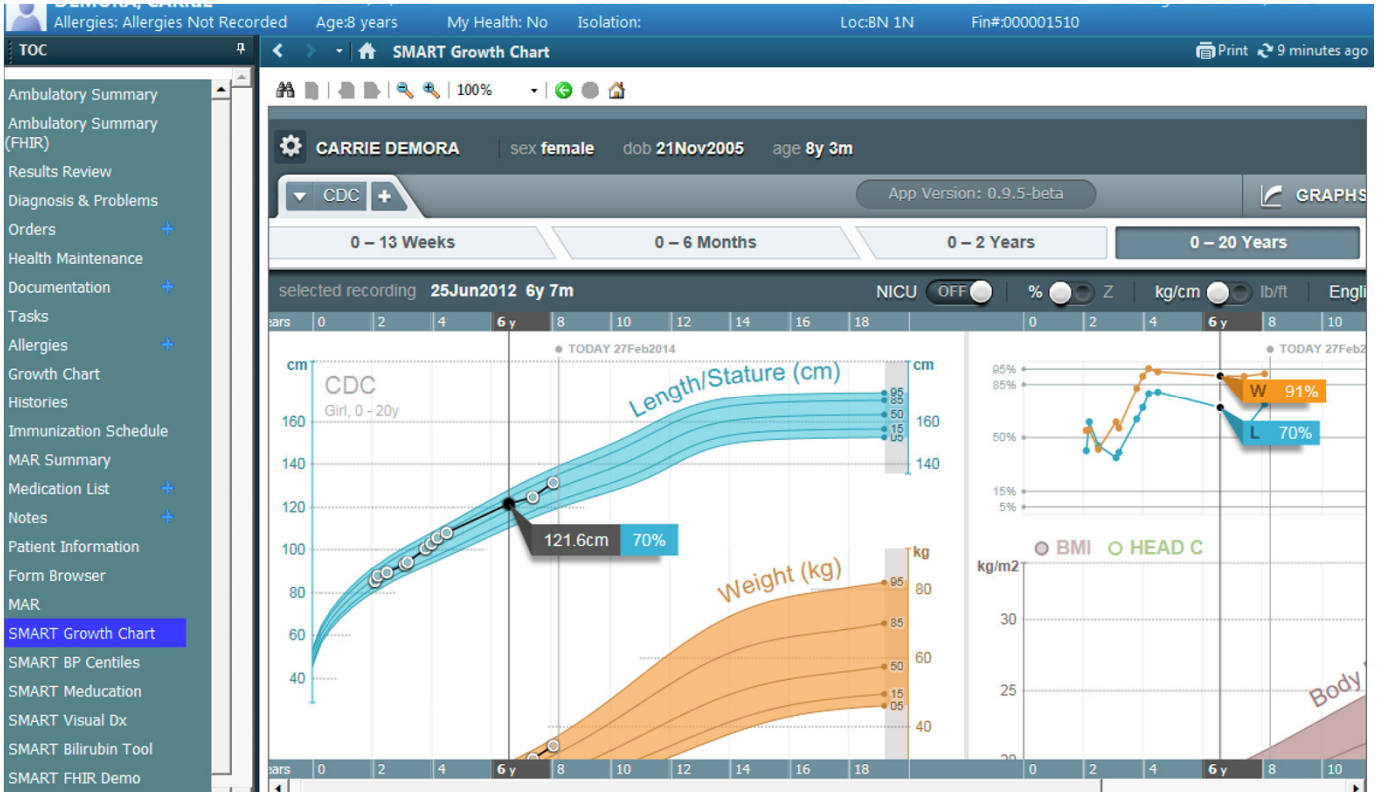
- "Substitutable Medical Apps"
  - Kohane/Mandl – NEJM (2009)
- A SMART App is a Web App
  - HTML5 + JavaScript
  - Remote or embedded in EHR
  - URL passes context & FHIR li nk
- EHR Data Access via FHIR
- OAuth2 / OIDC for security

Huff, S., McCallie, D HIMSS 2015

Some SMART Hotbeds

Huff, S., McCallie, D HIMSS 2015

Boston Childrens: SMART Growth Chart



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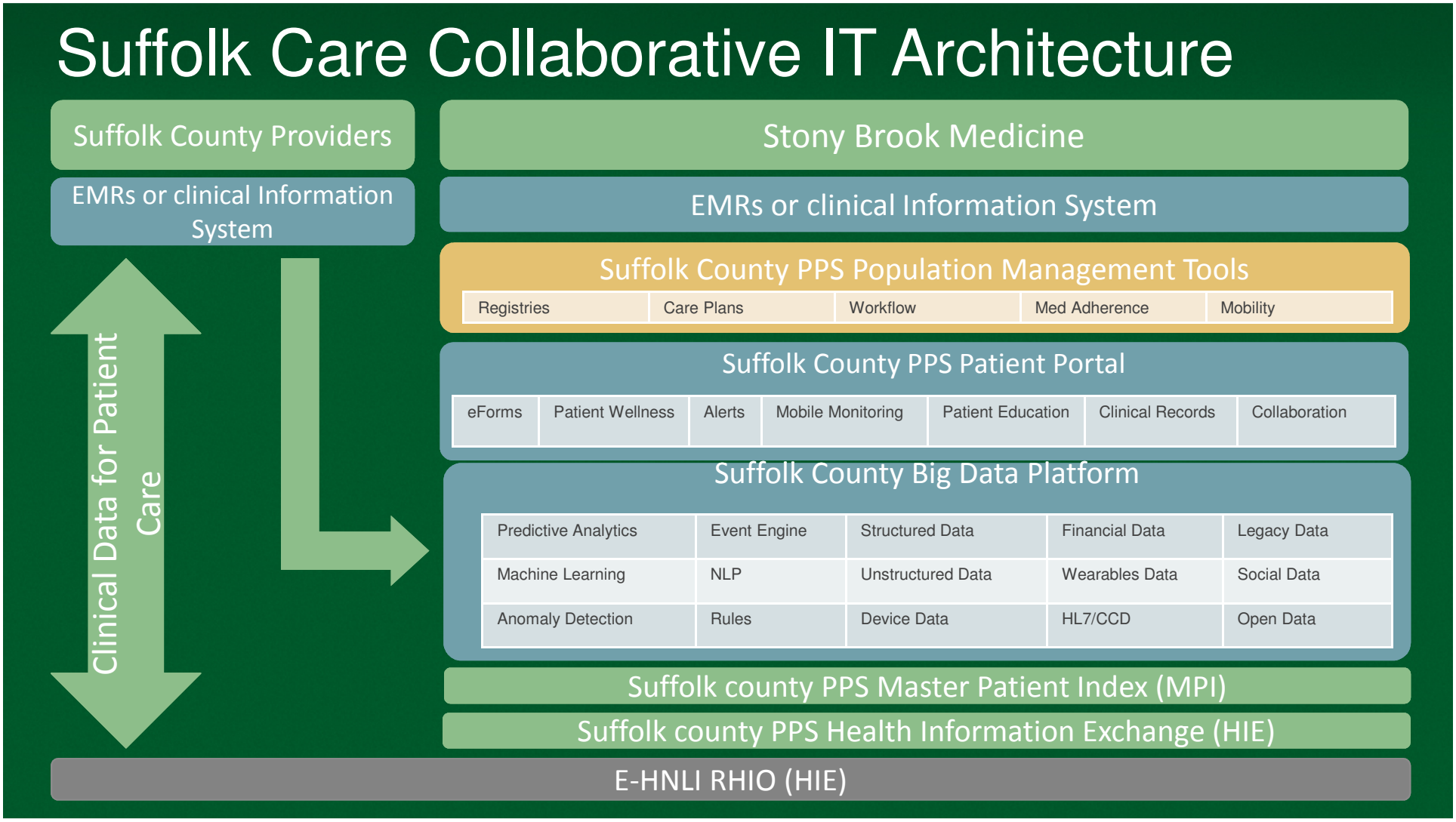
DSRIP

- 8 billion dollar grant (Medicaid waiver) from CMS to NY State
  - 25% reduction over five years in avoidable hospitalizations and ER visits in the Medicaid and uninsured population
  - Collaborative effort to implement innovative projects focused on
    - System transformation
    - Clinical improvement
    - Population health improvement

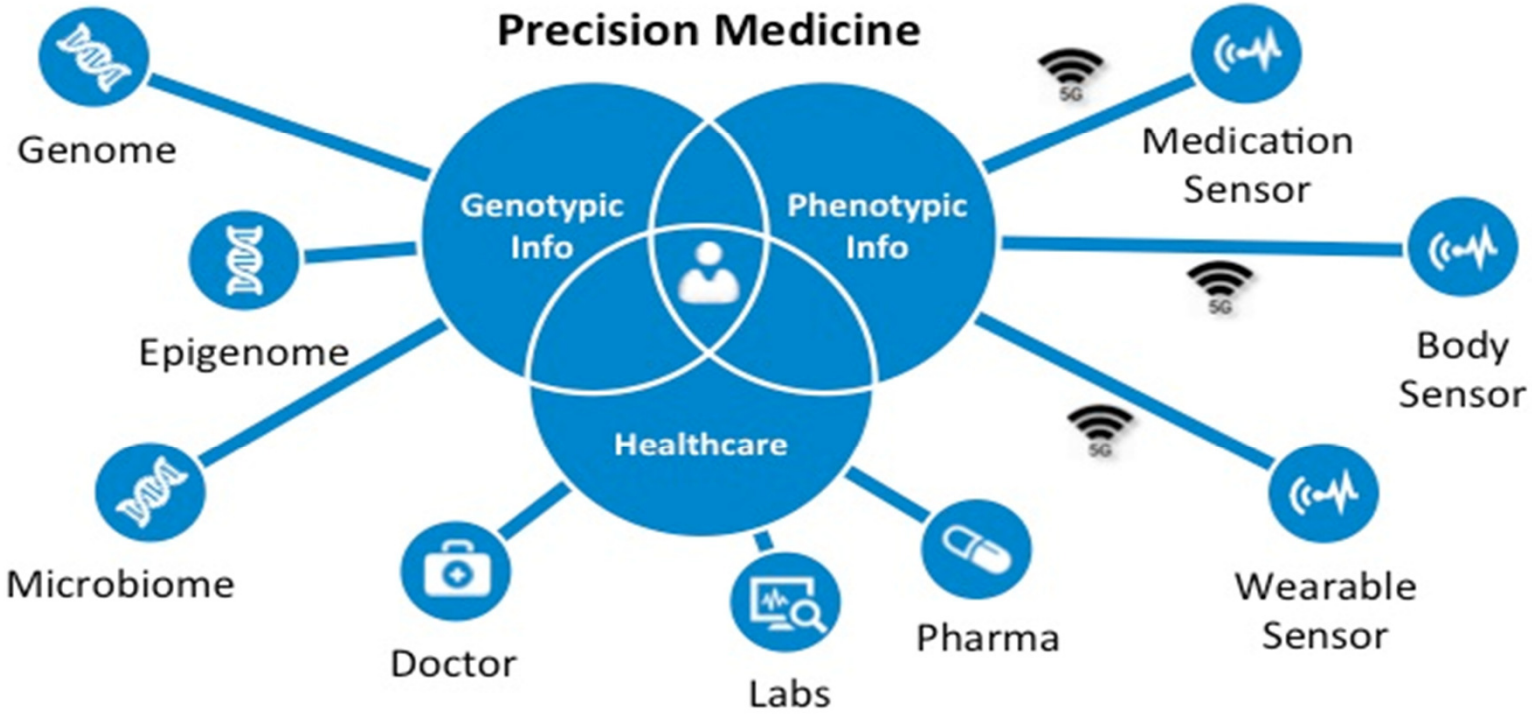
5 Year Goals

- Create integrated Suffolk County care delivery system for 387K lives anchored by safety net providers
- Engage partners across the care delivery spectrum to create a countywide network of care
- After five years, transition this network to an ACO which will contract with insurance providers on an at risk basis

Suffolk Care Collaborative IT Architecture



The Future of Genomic Medicine



Gavin Stone, edico genome 5G Summit May, 14, 2015

New Team Members

- Data Scientist
- Developers
- Cognitive and Behavioral Psychology
- User Experience
- Human & Computer Interaction
  - Devices
  - Wearables
- ***Patients & Family***

Trends: Big Data

- **Definition:** Evolving
- **Creation & Management:** Distributed and augmented
- **Information Governance:** Shared
- **Meaningful Analysis:** Beyond PnL, Reporting, Connections, Correlations, Pattern Recognition, Machine Learning, Natural Language Processing
- **Business Requirements:** Blank Page; We don't know what we want we will figure it out once we look at the data, the data will lead the way, AKA, Data Science

Trends: Healthcare

- Content Analytics – Suggestive Analytics* – Prescriptive Analytics
- Imaging Analytics
- Moving Analytics out of the EMR Environment
- Graph Data Mart
  - Edge and Vertices Analysis
- Omic & Phenotype Combines
- Sentiment Analysis

Takeaways

- Underpinning platforms may change but concept is here to stay, abstract where possible.
- Machine learning will lead to the evolution of Data Science and eventual use of AI in Healthcare.
- Get used to source now, ask questions later: Healthcare evolves with data and it is not a point in time construct any longer.
- Get used to working with constant change, disruptive trends and something new that will make your “frameworks” obsolete.

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