

Toward a Comprehensive Data Analytics Framework for Smart Healthcare Services

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Why bother introducing smart healthcare?

- Costs continue to increase, leading to a need to change our approach in managing healthcare
- Hence, we need to shift from a reactive model to a predictive model
- To successfully have this predictive model, we need to monitor and analyse various data sources

So... what do we want to achieve?

- Healthcare services need to be predictive and proactive to limit expensive acute health episodes
- Individualise health services, and decentralise the delivery of care from hospitals to the community and the home.

Cyber Physical System

System of collaborating computing elements controlling physical entities. Usually as a network of interacting elements.

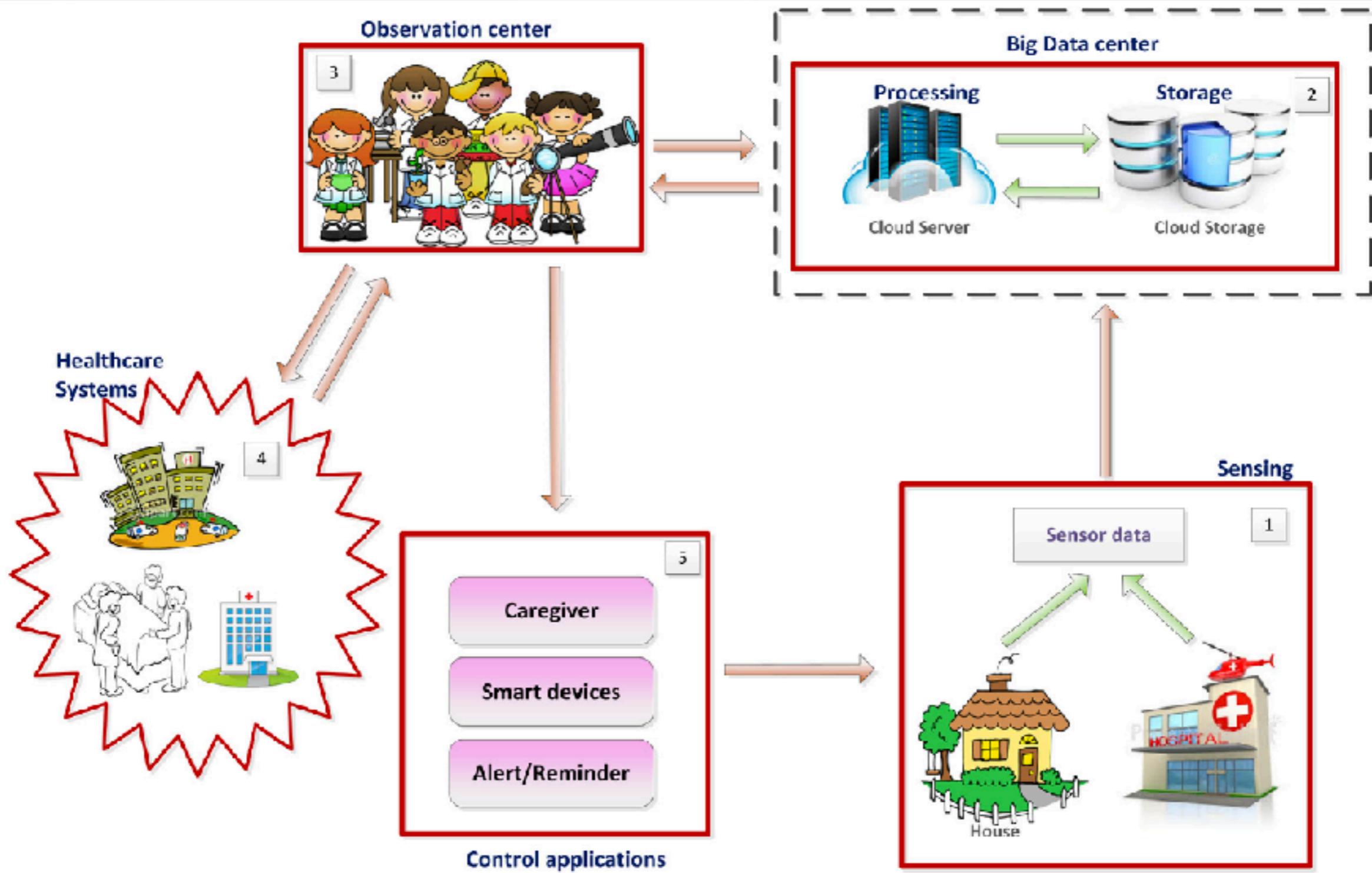


Fig. 1. A CPS for healthcare monitoring.

Enablers for CPS

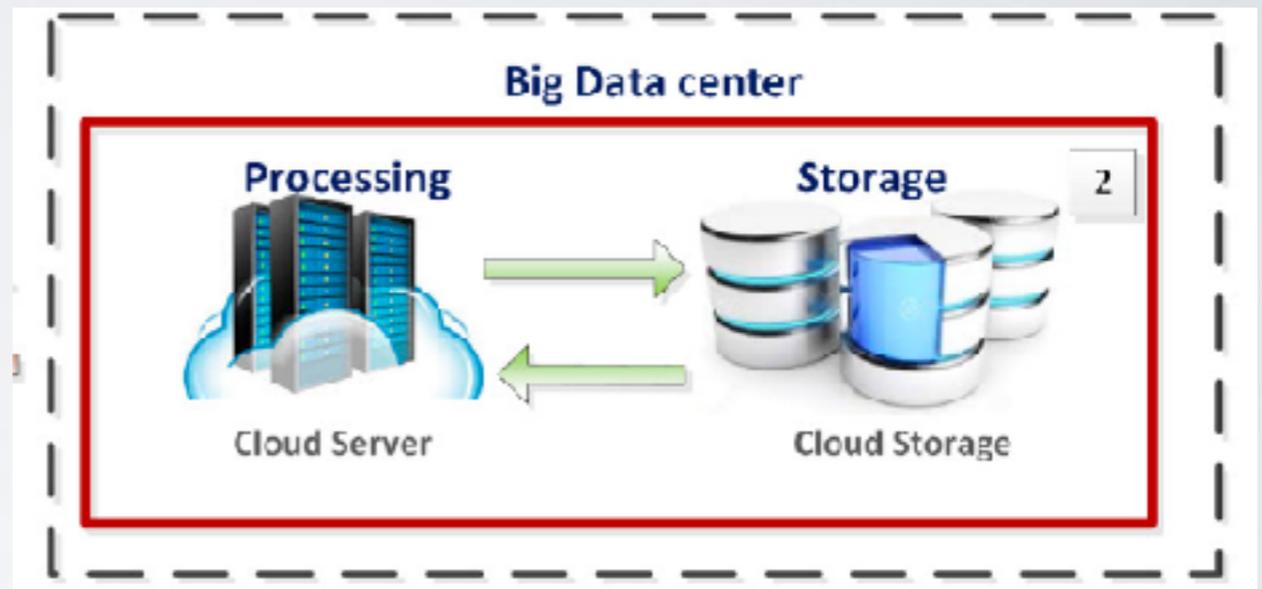
- Sensing technologies
- Internet of Things
- Cloud Computing

- *Sensing technologies*

- Increased smartphone penetration and reduced sensor costs enabling more users to carry sensors for long periods of time

- *Internet of Things (IoT)*
 - Provides rich connectivity between devices, services and systems

- Cloud computing
- Allows computing service to be provided over a network



Sensing Technologies

- Sensors: Devices that convert a physical measure into a signal
- Application areas of sensors in clinical healthcare:
 - Imaging (ultrasounds, smart pills for intestinal imaging)
 - Screening and Diagnostics (biosensors to detect bacterial levels and hormones)
 - Motion and Kinematics (Accelerometers and gyroscopes worn to determine balance and fall risk)
 - Physiological (physiological indicator of health like blood pressure)

Sensing Technologies

- Networked sensors are designed to extend the functionality of smart sensors by supporting more features, like in the form of communication and data collection
- One thing to note: readings from one sensor alone wouldn't be able to provide the comprehensive measurements needed to make decisions on the necessary target actions.

Sensing Technologies

- We need the right services to support the sensors in order to ensure we can achieve a patient care model that is based on predictive, proactive, preventive and personalised medication

Cloud Computing

- Advantages of the cloud :
 - Scalable and flexible storage and computing resources
 - Optimised utilisation of resources
 - Reduced costs
- Allows for the health sensors to be a part of a geographically distributed network

Cloud Computing

- Cloud allows for the combining of sensor-based data with other sources of data in order to gain new insights - which in turn allows for better decisions and predictions
- An example would be Microsoft's HealthVault
 - Connects with medical devices and consumer devices to automatically import data
 - Doctors and the individual can add in data too into a the individual's HealthVault
 - Essentially a centralised personal medical record



← | → Saturday SEPTEMBER 24

September 24



13,877 steps



2,638 cals

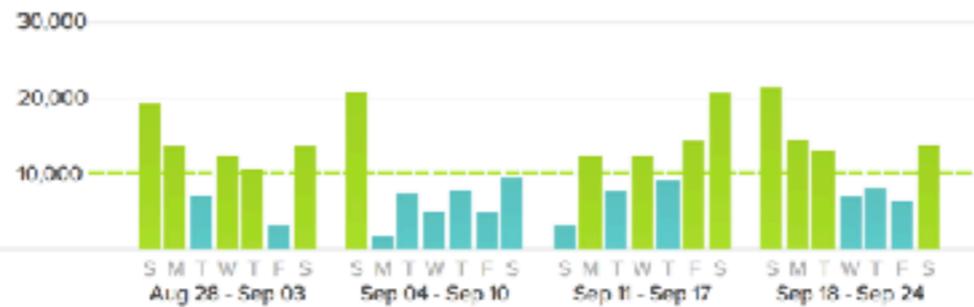


9.75 km



80 active mins

Steps



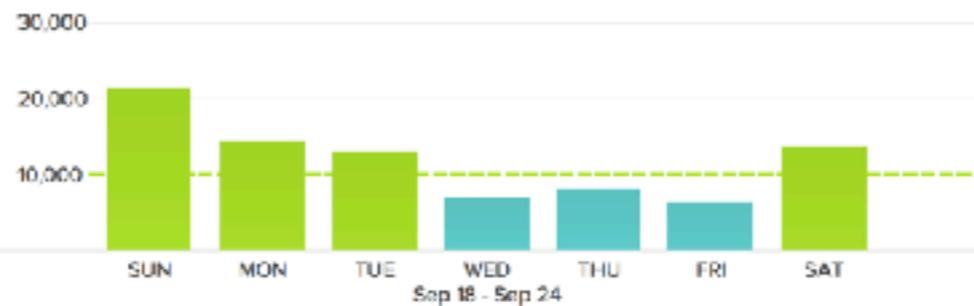
28 Days

28-Day Average
10,626 steps

Increase Over Previous 28 Days
1% more steps

Best Day: Sun, Sep 18
21,431 steps

This Week's Activity



GOAL 84,458 of 70,000

Friends

Previous days aren't viewable for this tile.

Recent Exercise

Big Data Storage and Processing Systems

- Healthcare systems are experiencing an overload of information
- Healthcare analytics : computerised methods and processes for transforming raw health data into meaningful insights

Big Data Storage and Processing Systems

- Health data forms
 - structured (electronic medical records)
 - semi-structured (instrument readings, data from paper records)
 - unstructured (fitness devices)

“In practise, we are now data rich, but information poor”

-Sakr & Elgamaal

Big Data Storage and Processing Systems

- Big data analytics is the platform to deliver five values to healthcare:
 - Right living
 - Right care
 - Right provider
 - Right value
 - Right innovation

Big Data Storage and Processing Systems

- Long term benefits of healthcare analytics include:
 - Ability to optimise and tailor care for patients based on analysis of multiple factors
 - Uncover relationships between factors that affect health of the population
 - More accurately estimate patient risk

Big Data Storage and Processing Systems

- Solving machine learning and statistical analysis problems:
 - Apache Mahout
 - Open source
 - Designed to allow users to build easily machine learning apps to solve practical and scalable problems
 - SQL-like interface, translates machine learning tasks expressed in Java into MapReduce jobs

Big Data Storage and Processing Systems

- Solving machine learning and statistical analysis problems:
 - MLbase (similar to Mahout)
 - Deep Learning (new technique, learning multiple levels of representation to understand various types of data, like images and sound)
 - R
 - Open source, cross platform software package for statistical analysis, most popular
 - Allows data scientists to conduct statistical analysis on data and discover new insights using techniques like clustering, regression, classification & text analysis
 - Also has additional features like data extraction & cleaning, predictive modelling and data visualisation

SmartHealth

Why do we need this?

- Electronic Medical Records can't handle large volumes of data coming in with high velocity and variety - not designed to analyse data
- Types of analysis we need:
 - Descriptive analysis : "What has happened/is happening?"
 - Diagnostic analysis: "Why did something happen?"
 - Predictive analysis: "What's going to happen in the future?"
 - Prescriptive analysis: Suggest the best course of action to take to optimise decision outcomes

Goal of SmartHealth

Integrate various nearby big data sources (i.e. hospital information systems) to allow for powerful analytics functions be applied onto the consolidated data

Layers in SmartHealth

Presentation Layer

Display results of the analytics engine, giving physicians with insights

Analytics Layer

Use multiple engines to analyse data and identify patterns/relations

Data Storage and Management Layer

Provide scalable data storage, capable of handling large amounts of data

Data Connection Layer

Plug and play compatibility of heterogeneous data sources

Benefits of SmartHealth

- Big data-driven decision making
- Patient profile analytics
- More effective public health strategies
- Cost reductions
- Evidence-based medicine
- Genomic analytics
- Improved remote patient monitoring

Conclusion

- Exploiting sensor technologies, cloud computing, IoT and big data analytics can improve the efficiency of healthcare systems
- SmartHealth as a framework acts as a roadmap for implementing a smart healthcare network and further research

Strengths & Weaknesses

- Strengths

- Good diagrams
- Goals and motivations clearly identified
- High level of detail (especially for the SmartHealth framework), good analysis of existing systems and statistics

- Weaknesses

- Quite a lot of background information being re-presented in the paper
- SmartHealth itself is only a framework, implementation details missing
- Security issues not considered

Related Work

[1]M. Khoury and J. Ioannidis, "Big data meets public health", Science, vol. 346, no. 6213, pp. 1054-1055, 2014

- *Good introduction and summary into big data in the context of public health*

[2]W. Raghupathi and V. Raghupathi, "Big data analytics in healthcare: promise and potential", Health Inf Sci Syst, vol. 2, no. 1, 2014

- *Looks mainly at the potential of big data in the context of public health*

[3]E. Vayena, M. Salathé, L. Madoff and J. Brownstein, "Ethical Challenges of Big Data in Public Health", PLOS Computational Biology, vol. 11, no. 2, p. e1003904, 2015

- *Outlines some of the ethical risks related to digital disease detection and how to address them*

[4]S. Hay, D. George, C. Moyes and J. Brownstein, "Big Data Opportunities for Global Infectious Disease Surveillance", PLoS Med, vol. 10, no. 4, p. e1001413, 2013.

- *Presents new and interesting ways to study the distribution of infectious diseases globally*

Future Work

- An actual implementation of SmartHealth
- How much of an improvement in costs are we looking at?
- More detailed studies on how to maintain user privacy and security when they participate in systems like SmartHealth

Questions

- Do you think big data in public health will really take off (especially considering the costs)?
- In the context of developing markets, would it lead to a greater divide in healthcare quality in comparison to developed markets?
- Do you have experience using tools that support statistical analysis and machine learning?
- Any other ideas on how healthcare analytics could be beneficial?