

SOFTWARE ENGINEERING IMPACT THE FUTURE OF HEALTH IT

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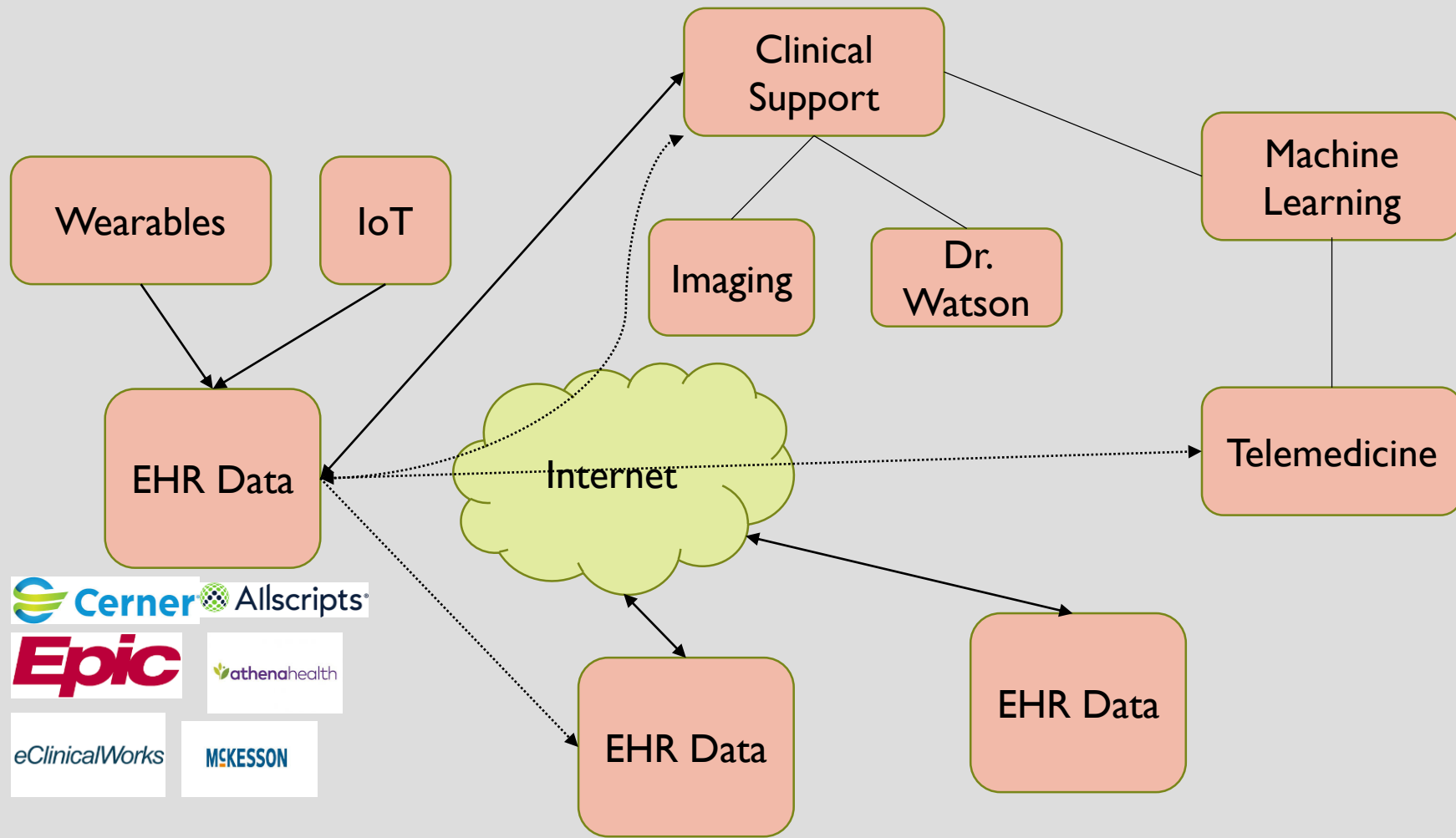
Saint Louis University

Presented at Becker's 4th Annual Health IT and Revenue Cycle 2018

OUTLINE

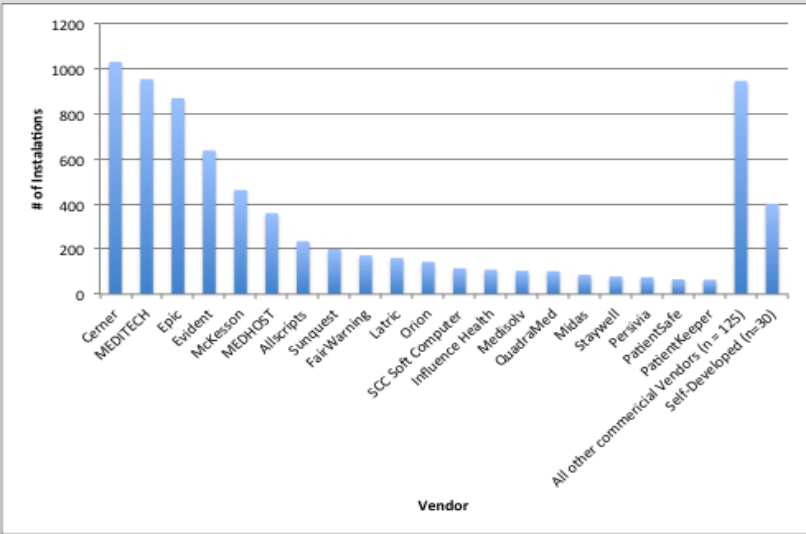
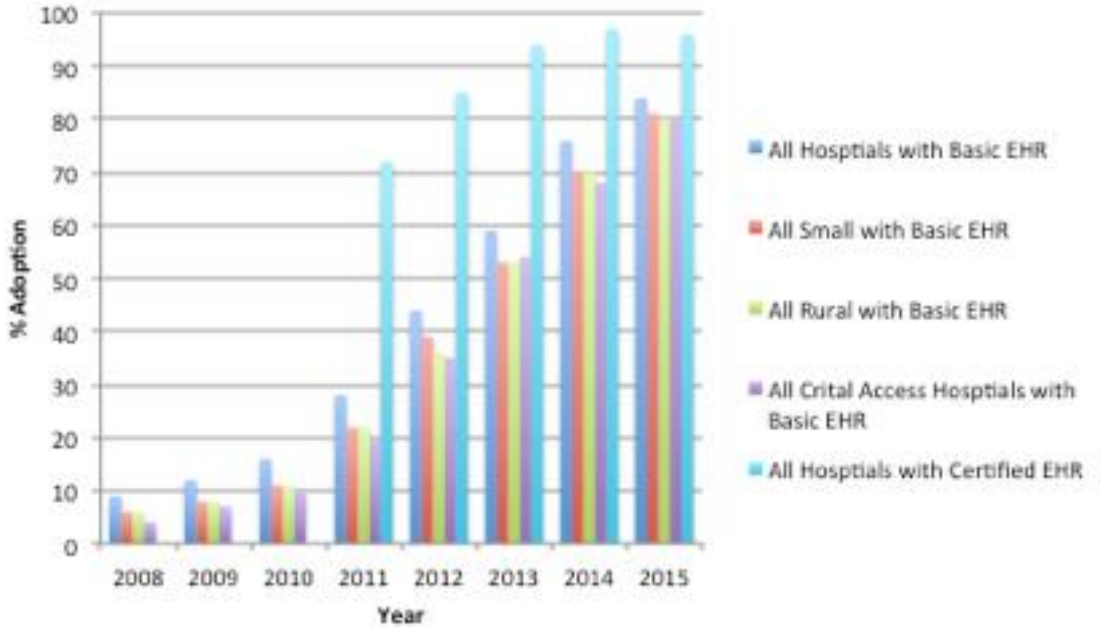
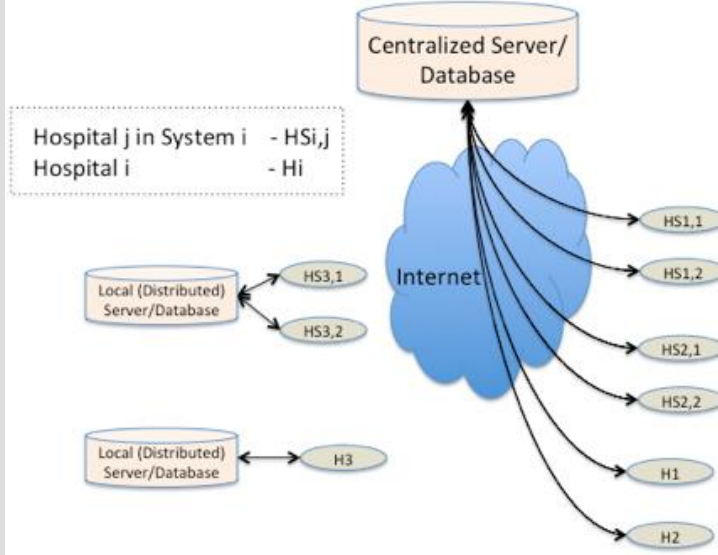
- EHRs of Tomorrow
 - Interoperability (FHIR and SMART on FHIR)
 - Cloud Based EHRs
- Clinical Support Systems
- Deep Machine Learning
 - Imaging
 - IBM Dr. Watson
 - Sensing, Learning, and Suggesting
- Distributed Database Technology
 - Blockchain
- Telemedicine
- IoMT

SOFTWARE OVERVIEW FOR HEALTHCARE



EHRS OF TOMORROW

- We have the DATA!!!!
- Can we use it?
- On-Site Vs Cloud
- Best of Breed Vs Single Vendor



NEW DIRECTIONS IN INTEROPERABILITY

- Report to the president realizing the full potential of health information technology
 - Move from a “Data as Document” model to “Metadata-Tagged Data Element” model
- Data as Document Model
 - Medical data is contained in a EHR document with fields
 - CDA is one example of this
- Metadata-Tagged Data Model
 - Every piece of medical information has a name, attributes, and a value

FHIR - NEW HL7 GENERATION OF STANDARDS

- Fast Healthcare Interoperability Resources (FHIR)
 - Best features of HL7 and CDA
- Focused more on exchange of “resources” not “documents”
- Many resource libraries
- Based on Web standards (XML, JSON, HTTP, ..)
- Different methods to exchange data including RESTful web services.
- Human-readable

PATIENT RESOURCE

```

<Patient xmlns="http://hl7.org/fhir">
  <extension url="http://www.goodhealth.org/consent#trials">
    <valueCode value="renal"/>
  </extension>
  <text>
    <status value="generated"/>
    <div xmlns="http://www.w3.org/1999/xhtml">
      <p>Henry Levin the 7th</p>
      <p>MRN: 123456</p>
    </div>
  </text>
  <identifier>
    <use value="usual"/>
    <label value="MRN"/>
    <system value="http://www.goodhealth.org/identifiers/mrn"/>
    <value value="123456"/>
  </identifier>
  <name>
    <family value="Levin"/>
    <given value="Henry"/>
    <suffix value="The 7th"/>
  </name>
  <gender>
    <text value="Male"/>
  </gender>
  <birthDate value="1932-09-24"/>
  <managingOrganization>
    <reference value="Organization/2"/>
    <display value="Good Health Clinic"/>
  </managingOrganization>
  <active value="true"/>
</Patient>
    
```

Extension with URL to definition

Human Readable Summary


Standard Data:

- MRN
- Name
- Gender
- Birth Date
- Provider

Name



Clinic



MEDICATION RESOURCE TEMPLATE

Common Drug
Name

```

<Medication xmlns="http://hl7.org/fhir">
  <!-- from Resource: extension, modifierExtension, language, text, and contained -->
  <name value="[string]"/><!-- 0..1 Common / Commercial name § -->
  <code><!-- 0..1 CodeableConcept Codes that identify this medication § --></code>
  <isBrand value="[boolean]"/><!-- 0..1 True if a brand § -->
  <manufacturer><!-- 0..1 Resource(Organization) Manufacturer of the item § --></manufacturer>
  <kind value="[code]"/><!-- 0..1 product | package § -->
  <product> <!-- 0..1 Administrable medication details -->
    <form><!-- 0..1 CodeableConcept powder | tablets | carton + --></form>
    <ingredient> <!-- 0..* Active or inactive ingredient -->
      <item><!-- 1..1 Resource(Substance|Medication) The product contained --></item>
      <amount><!-- 0..1 Ratio How much ingredient in product --></amount>
    </ingredient>
  </product>
  <package> <!-- 0..1 Details about packaged medications -->
    <container><!-- 0..1 CodeableConcept E.g. box, vial, blister-pack --></container>
    <content> <!-- 0..* What is in the package? -->
      <item><!-- 1..1 Resource(Medication) A product in the package --></item>
      <amount><!-- 0..1 Quantity How many are in the package? --></amount>
    </content>
  </package>
</Medication>

```



Drug Strength

How Many

PENICILLIN EXAMPLE

General Person Example (id = "example")

Raw XML


```
<Medication xmlns="http://hl7.org/fhir">

  <!-- insert contents here -->

  <text>
    <status value="generated"/>
    <div xmlns="http://www.w3.org/1999/xhtml">123456789: Penicillin VK oral suspension 12
5mg/5ml</div>
  </text>

  <name value="Penicillin VK oral suspension 125mg/5ml"/>
  <code>
    <coding>
      <system value="http://snomed.info/sct"/>
      <code value="323418000"/>
      <display value="Phenoxymethylpenicillin 125mg/5mL oral solution (product)"/>
    </coding>
    <coding>
      <system value="http://nehta.gov.au/amt/v2"/>
      <code value="22571011000036102"/>
      <display value="phenoxymethylpenicillin 125 mg / 5 mL oral liquid, 5 mL measure"/>
    </coding>
  </code>
  <isBrand value="false"/>
  <kind value="product"/>
  <product>
    <form>
      <coding>
        <system value="http://snomed.info/sct"/>
        <code value="37595005"/>
        <display value="Suspension"/>
      </coding>
    </form>
  </product>
</Medication>
```

Common Drug
Name



Drug Strength

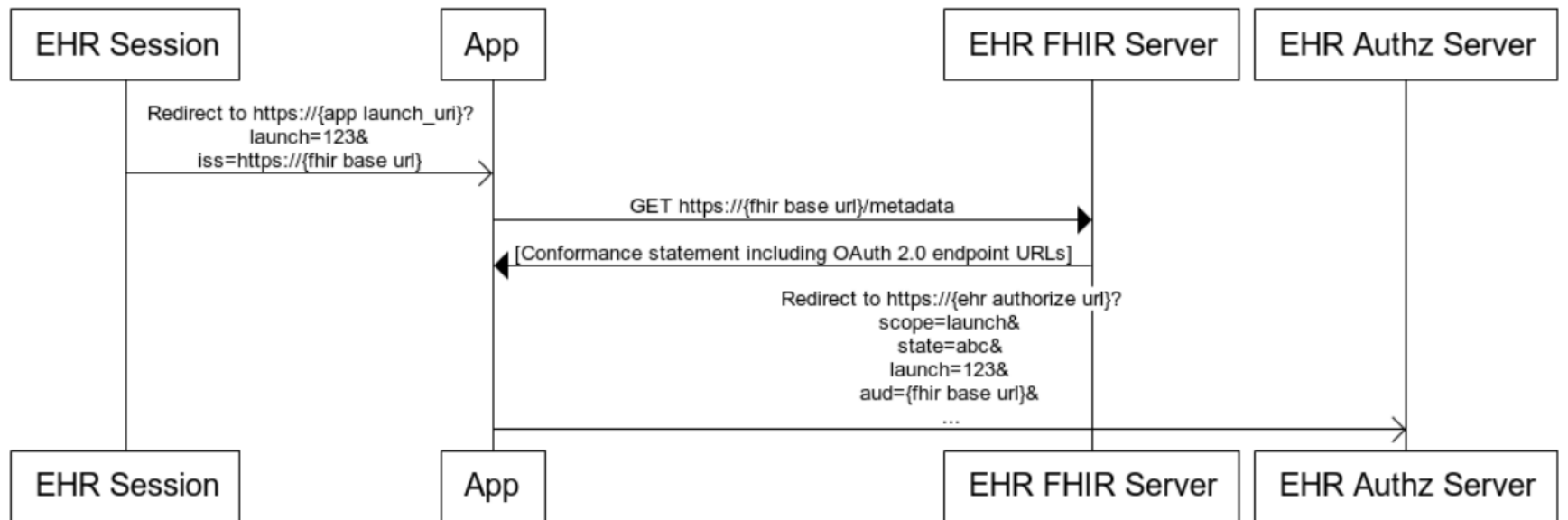


SMART ON FHIR

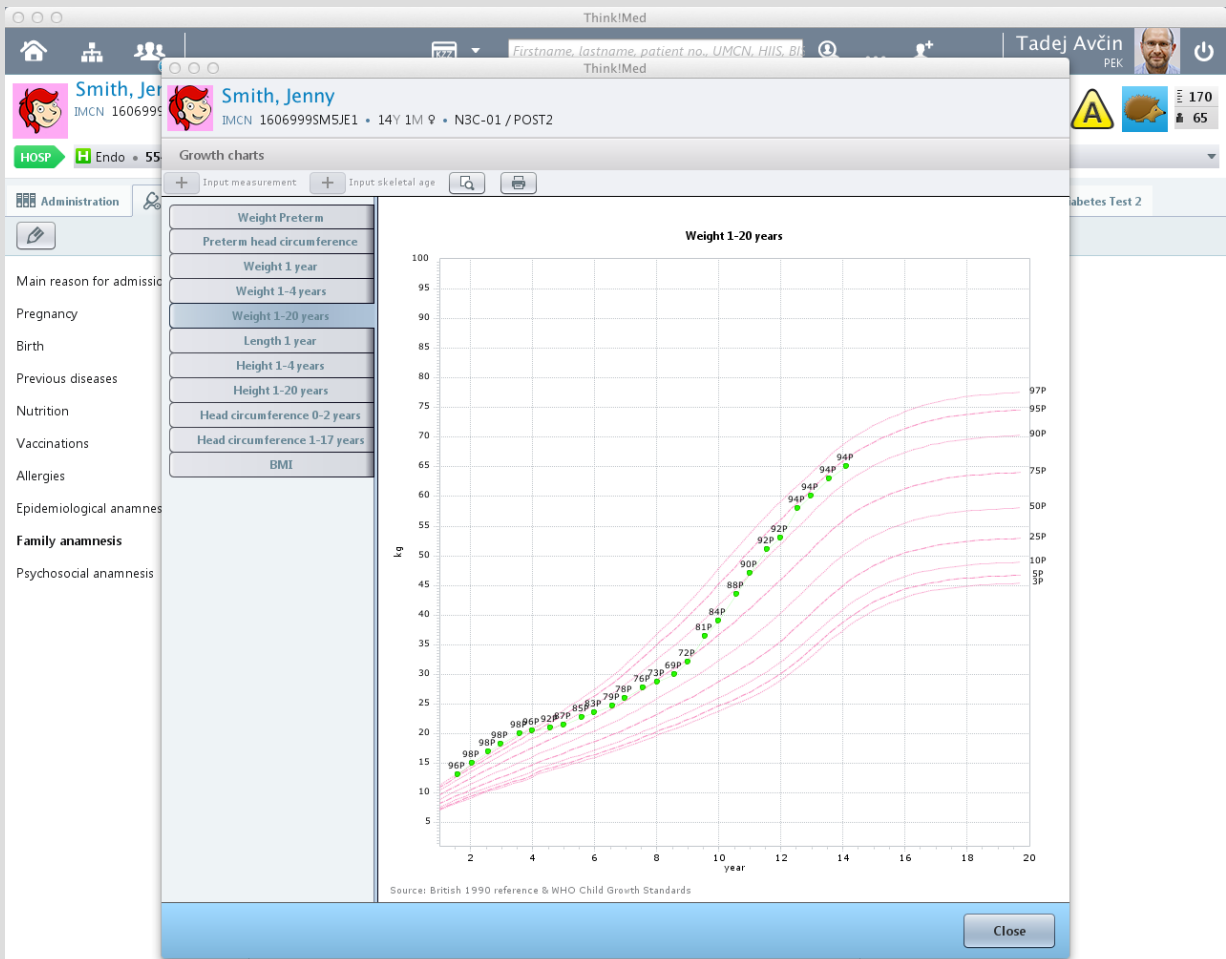
- SMART is Open Standard to integrate apps with EHRs, portals, and other Health IT systems
- FHIR is and HL7 standard to encode health care information
- SMART on FHIR is a framework to build applications that exchange data with health care providers
- <https://apps.smarthealthit.org/>
- Watch YouTube Videos:
 - *Intro to Background of FHIR* (<https://www.youtube.com/watch?v=PbiNZqGX5Yw>)
 - *FHIR and SMART on FHIR* (<https://www.youtube.com/watch?v=2eEtntT2Md4>)

SMART ON FHIR

EHR launch sequence



FHIR PEDIATRIC GROWTH WITH SEVERAL RELATED METRICS



ARTIFICIAL INTELLIGENT

- We have made great leaps in AI
 - Google ads, Amazon
- We have not advanced much with AI in the last 20 years
 - While a computer can pick out a picture of a cat, it does not understand what a cat is
 - What if I dress the cat up like a dog?

MACHINE LEARNING

- Deep machine learning with neural networks
- A randomized controlled trial for an AI system to evaluate brain tomography was 150 times as fast as experts (<https://theweeklyobserver.com/artificial-intelligence-system-makes-neurological-diagnoses-much-faster-doctor/62083/>)
- Dr. Alexia can you help me?

CLINICAL SUPPORT SYSTEMS

- According to the ONC
 - Clinical decision support (CDS) provides clinicians, staff, patients or other individuals with knowledge and person-specific information, intelligently filtered or presented at appropriate times, to enhance health and health care. CDS encompasses a variety of tools to enhance decision-making in the clinical workflow. These tools include computerized alerts and reminders to care providers and patients; clinical guidelines; condition-specific order sets; focused patient data reports and summaries; documentation templates; diagnostic support, and contextually relevant reference information, among other tools. <https://www.healthit.gov/topic/safety/clinical-decision-support>
- According to AHRQ
 - Clinical decision support (CDS) provides timely information, usually at the point of care, to help inform decisions about a patient's care. CDS tools and systems help clinical teams by taking over some routine tasks, warning of potential problems, or providing suggestions for the clinical team and patient to consider. <https://www.ahrq.gov/professionals/prevention-chronic-care/decision/clinical/index.html>
- Internal to the EHR
- External to the EHR (Via FHIR)
- Obvious choices such as checking for adverse drug interaction and allergy since medication errors is a leading cause of death. <https://ehrintelligence.com/news/top-clinical-decision-support-system-cdss-companies-by-ambulatory-inpatient>



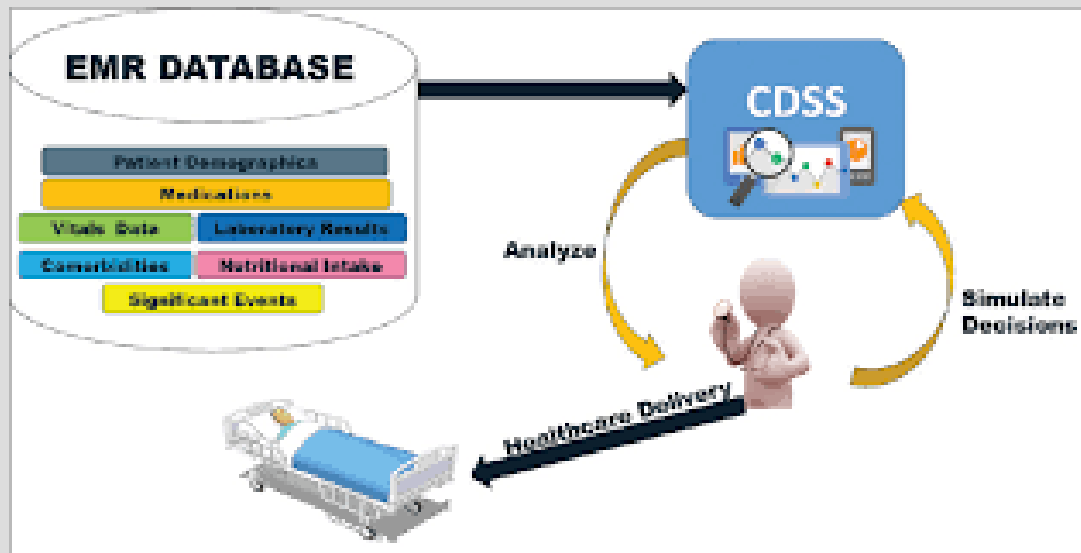
CDS SYSTEMS

- Order set for labs and medications for common conditions such as stroke
- Obvious choices such as checking for adverse drug interaction and allergy since medication errors is a leading cause of death.

<https://ehrintelligence.com/news/top-clinical-decision-support-system-cdss-companies-by-ambulatory-inpatient>

Top Clinical Decision Support System Companies by Setting

Inpatient CDS	Ambulatory CDS
1. Cerner	1. First Databank
2. First Databank	2. Medispan
3. Medispan	3. Allscripts
4. Truven	4. Cerner
5. Zynx Health	5. Elsevier



IMAGING

- Stanford University Center for Artificial Intelligence in Medicine & Imaging (<https://aimi.stanford.edu>)
 - Deep learning for computer vision projects include:
 - Automatically Staging Osteoarthritis from X-rays and MRIs
 - Identify chest radiographs for misplaced endotracheal tubes, central lines, and pneumothorax
 - Estimate skeletal maturity
 - Predict “brain age” using MRI data
 - AI to improve mammogram interpretation (<https://medicalxpress.com/news/2018-06-ai-mammogram.html>) and (<http://news.mit.edu/2017/artificial-intelligence-early-breast-cancer-detection-1017>)

DR. WATSON

- How is Dr. Watson doing? No published research showing improved patient outcomes!
- IBM thinks it is doing well (2x revenue per year), others are not so sure
 - It depends on the training data
- Watson Oncology at the Memorial Sloan Kettering Cancer Center
 - Gives cancer treatment advise
 - Training was based on hypothetical patient recommendations
 - It gave “multiple examples of unsafe and incorrect treatment recommendations
 - Watson will start using localized treatment and real patient data
 - Dr. Bob Kocher believes that until there is better data about patients, genetics, environmental, lifestyle, and health information Oncology is not a great space for AI
 - Dr. Kelly said “There’s a lot of promise for AI, but for now that promise is not realized (<https://www.wsj.com/articles/ibm-bet-billions-that-watson-could-improve-cancer-treatment-it-hasnt-worked-1533961147>)

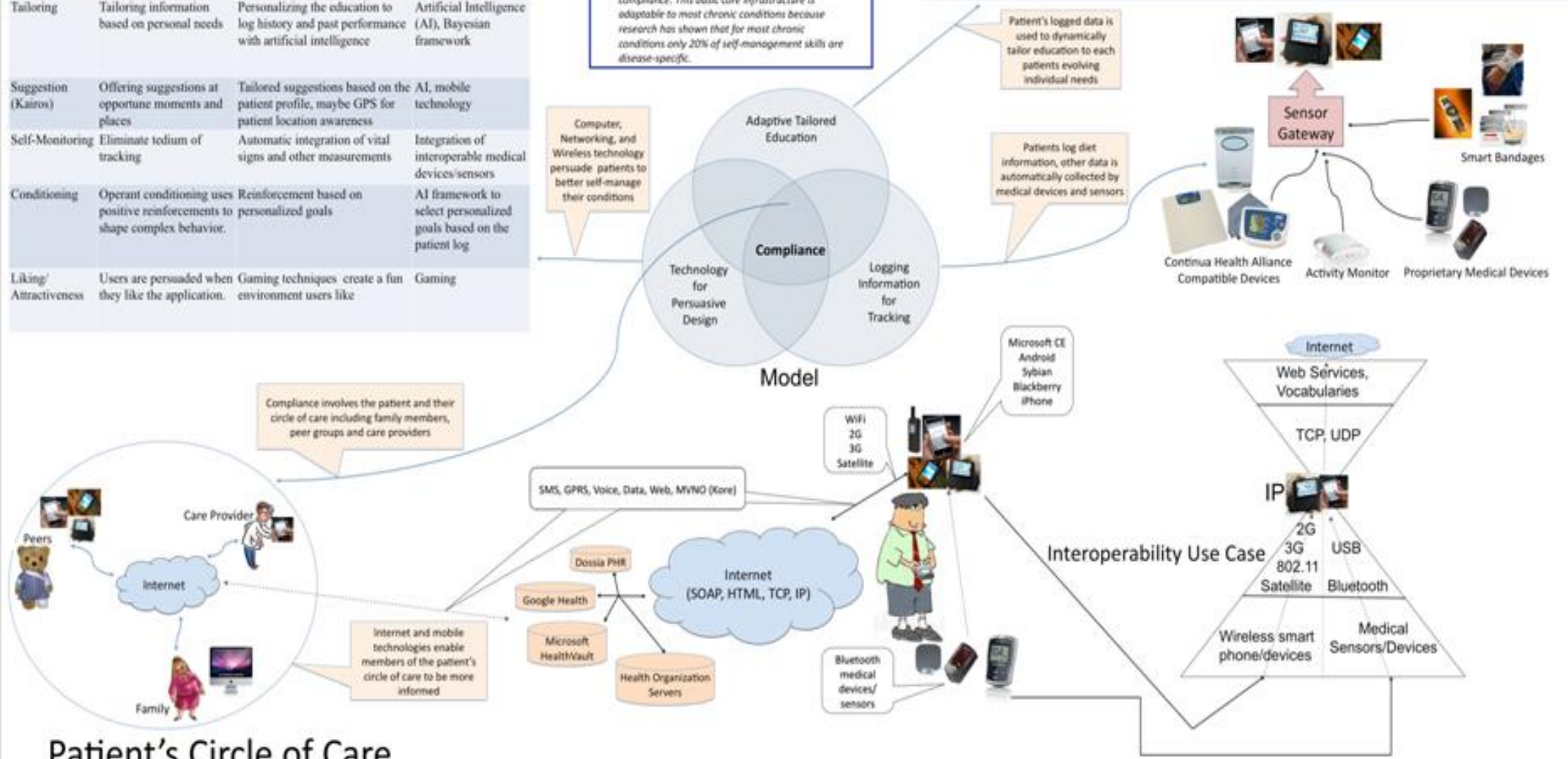
Infrastructure for Dynamic Interactive Self-Management of Chronic Disease

Mark Gaynor (mgaynor@slu.edu) (Saint Louis University School of Public Health), Cynthia LeRouge (cynthialerouge@mac.com) Saint Louis University John Cook School of Business and School of Public Health)

Persuasive Consumer Health Technology Design			
Persuasion Design Principles	Definition	Manifestation in Proposed System	Technology
Reduction	Making complex tasks simpler	Reduction of the time and effort to enter information with auto entry, pull-down menus, and automatic collection of vital signs	Integration of interoperable medical devices/sensors
Tailoring	Tailoring information based on personal needs	Personalizing the education to log history and past performance with artificial intelligence	Artificial Intelligence (AI), Bayesian framework
Suggestion (Kairos)	Offering suggestions at opportune moments and places	Tailored suggestions based on the patient profile, maybe GPS for patient location awareness	AI, mobile technology
Self-Monitoring	Eliminate tedium of tracking	Automatic integration of vital signs and other measurements	Integration of interoperable medical devices/sensors
Conditioning	Operant conditioning uses positive reinforcements to shape complex behavior.	Reinforcement based on personalized goals	AI framework to select personalized goals based on the patient log
Liking/ Attractiveness	Users are persuaded when they like the application.	Gaming techniques create a fun environment users like	Gaming

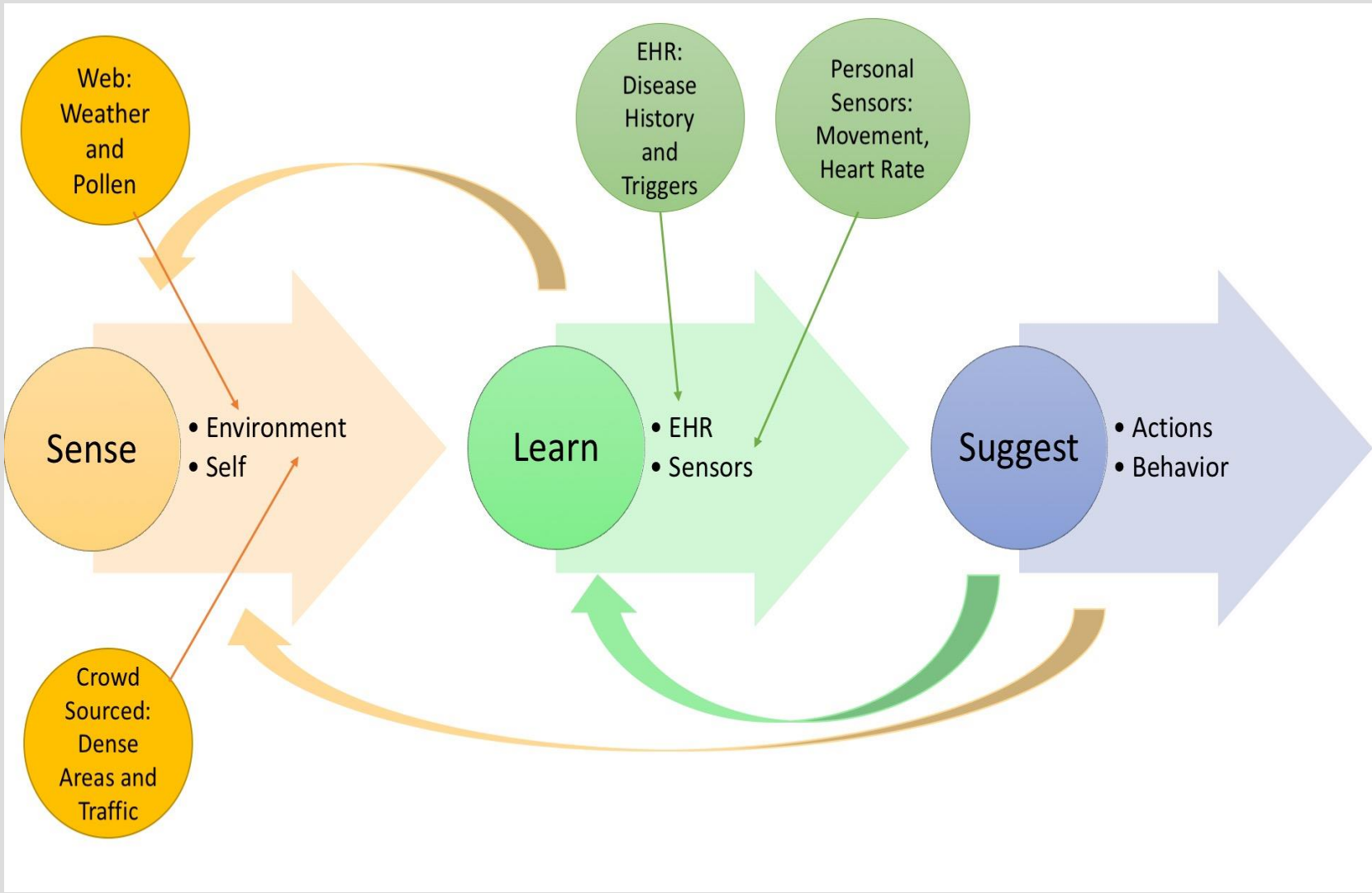
Introduction
 We present a conceptual interoperable framework designed to persuade patients with chronic medical conditions to better self-manage their disease. Our framework innovatively uses technologies such as gaming, mobile computing and wireless connectivity to equip the chronically ill with the tools and resources to improve their quality of life. Our infrastructure includes logging patient information, education tailored to the patient, and persuasive design to improve patient compliance. This basic care infrastructure is adaptable to most chronic conditions because research has shown that for most chronic conditions only 20% of self-management skills are disease-specific.

Tailoring Content Based on Patient Log		
Content Area	Based On	Probability
Nutrition	Patient entered diet and goals	If patient has improper diet or not meeting goals
Exercise	Patient entered activities and goals	If patient is missing exercise goal
Medication	Patient/auto-entered medications	If not complying to medication schedule
Measurement	Patient/auto-entered blood pressure, pulse, diet, weight and other vital signs	If patient not keeping log, or measurements need improvement
Complications	Log analysis	If patient at risk based on log analysis



Patient's Circle of Care

SENSING, LEARNING, SUGGESTING CLINICAL SUPPORT SYSTEMS



APPLICATION ARCHITECTURE

Website Data



HTTP, REST, SOAP

Proprietary



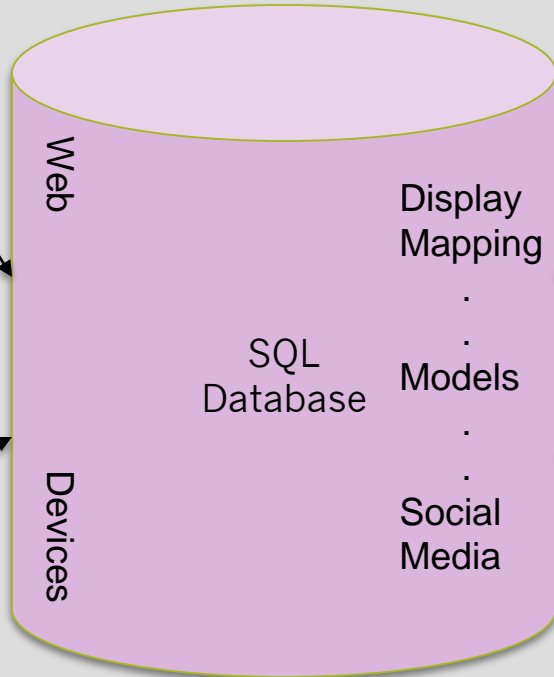
Heterogeneous data



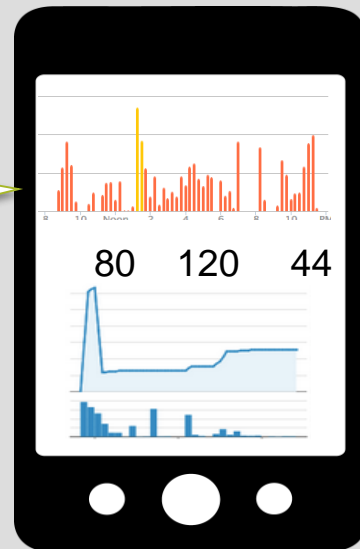
Devices into databases



Standards Based



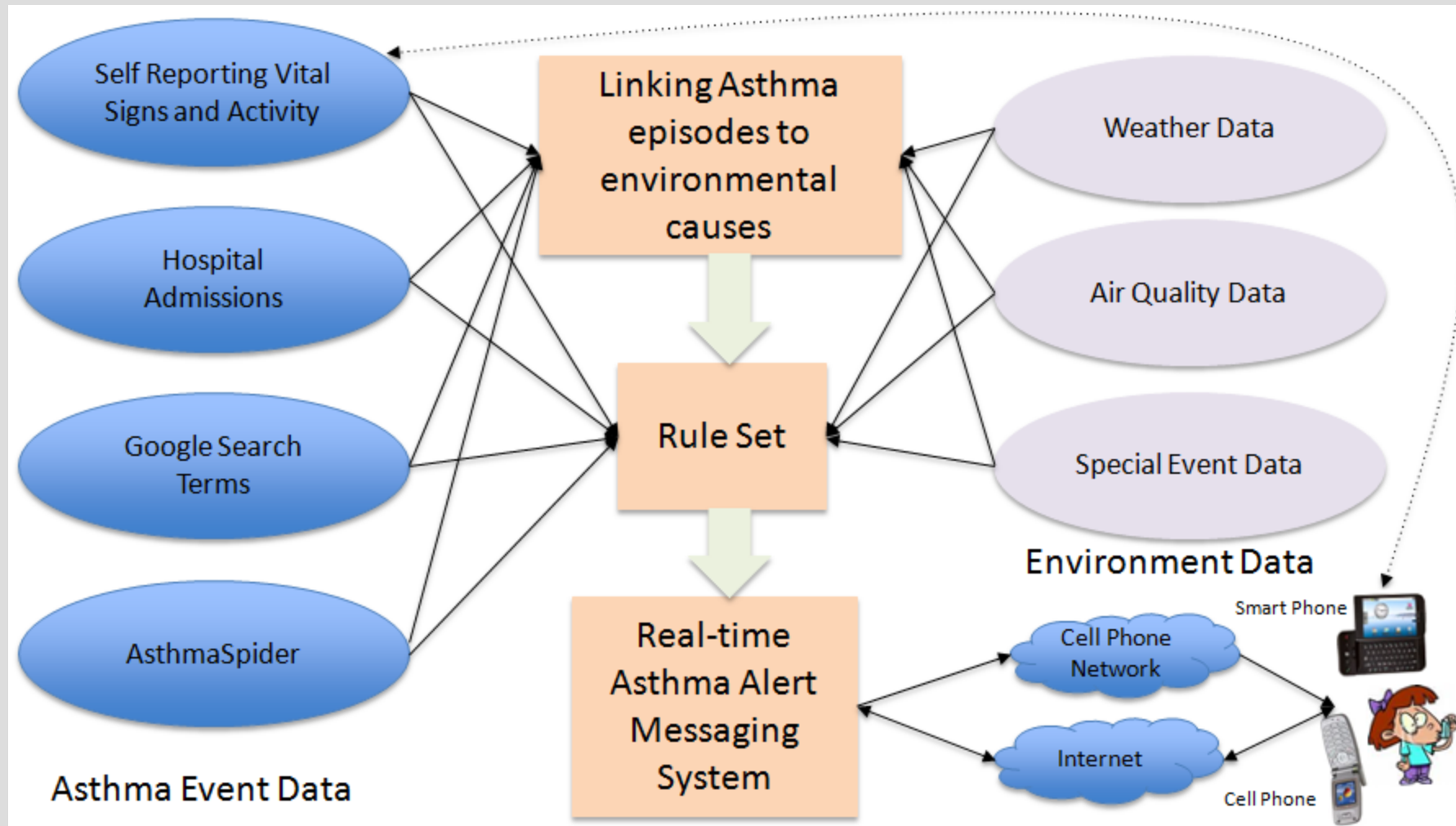
Library for displaying text and graphical data



Common API



SENSE, LEARN, SUGGEST



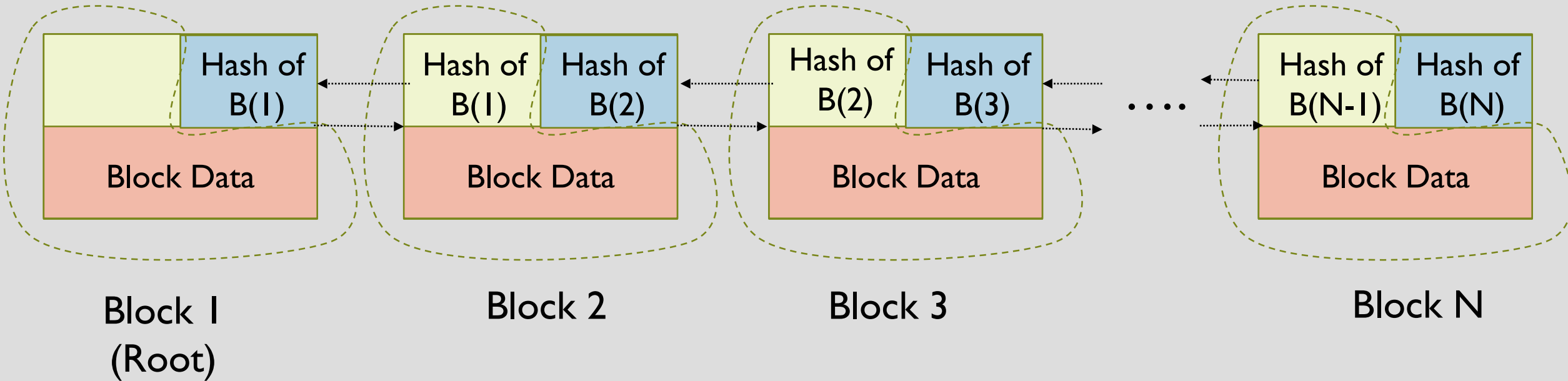
DISTRIBUTED DATABASE TECHNOLOGY

- Entire data is distributed over many locations
- Need to make sure the data can not be changed
 - Even when you have “bad actors”
- Many applications including the cyber currency bitcoin
- What is DDT good for?
 - Storing EHR data?
 - Tracking use of EHR data?

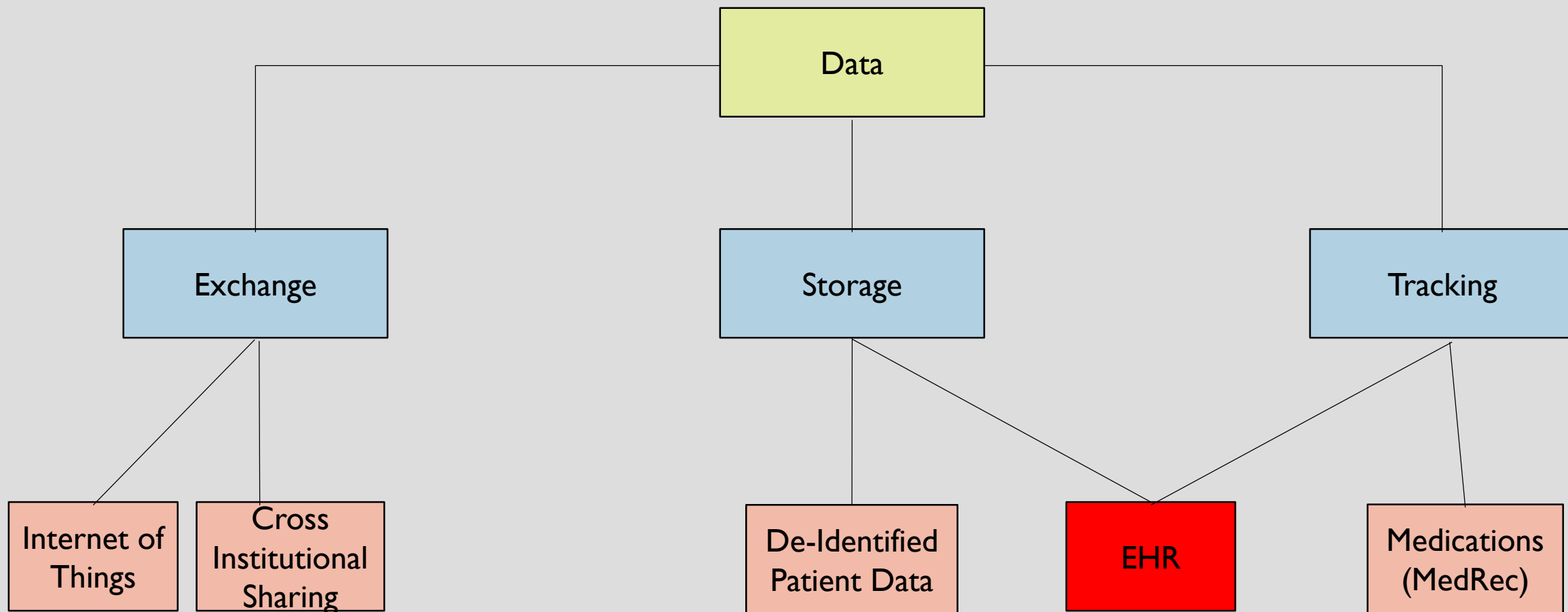
BLOCKCHAIN

- Distributed cryptographic secure database
- Linked set of data blocks with a cryptographic hash
- Used in fishing, diamond, fashion, shipping, banking, and medical industry
- High-byzantine fault tolerance
- Public and Private Blockchain
- Could be used for data management/tracking, supply chain, and smart contracts
- Is Blockchain overhyped?
 - Unlikely that your EHR will be stored in a distributed blockchain

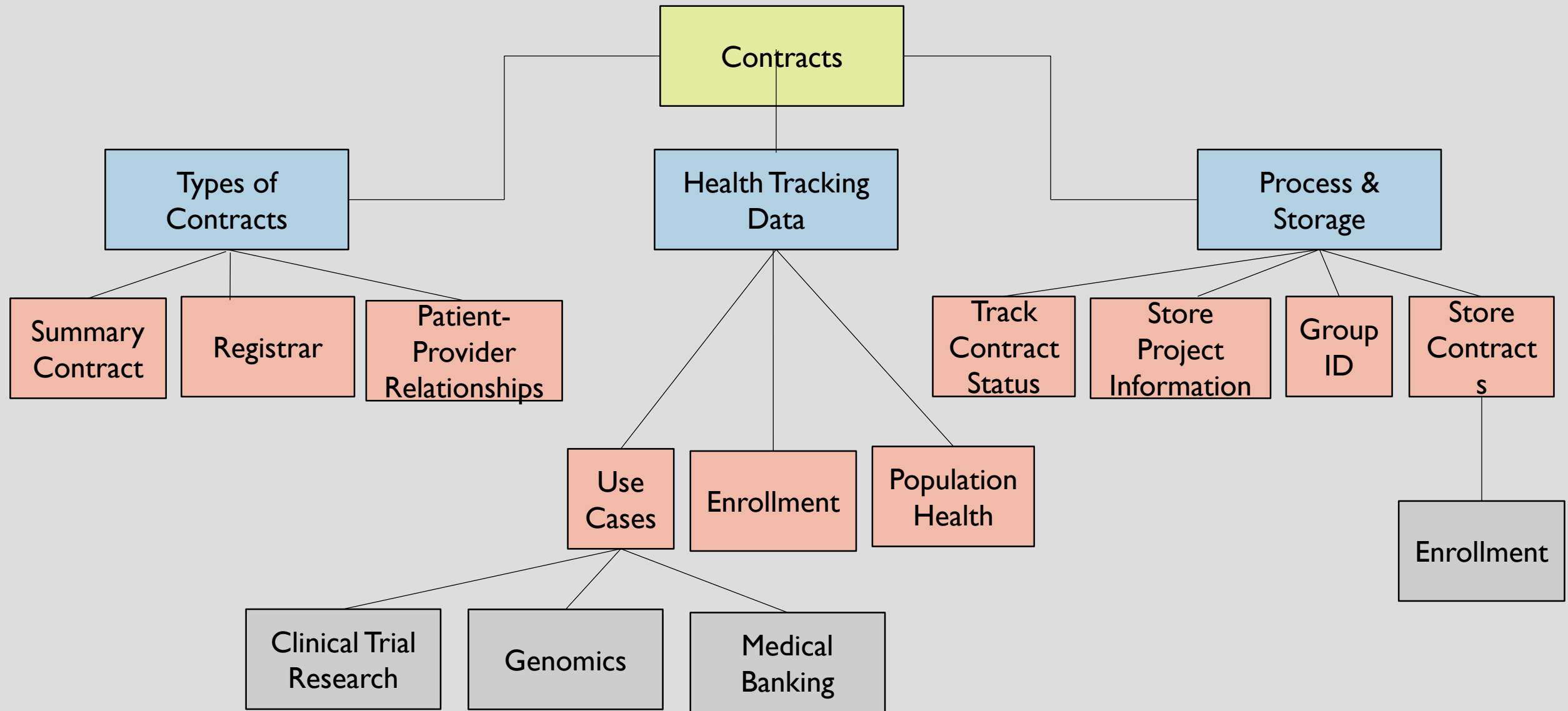
BLOCKCHAIN EXAMPLE



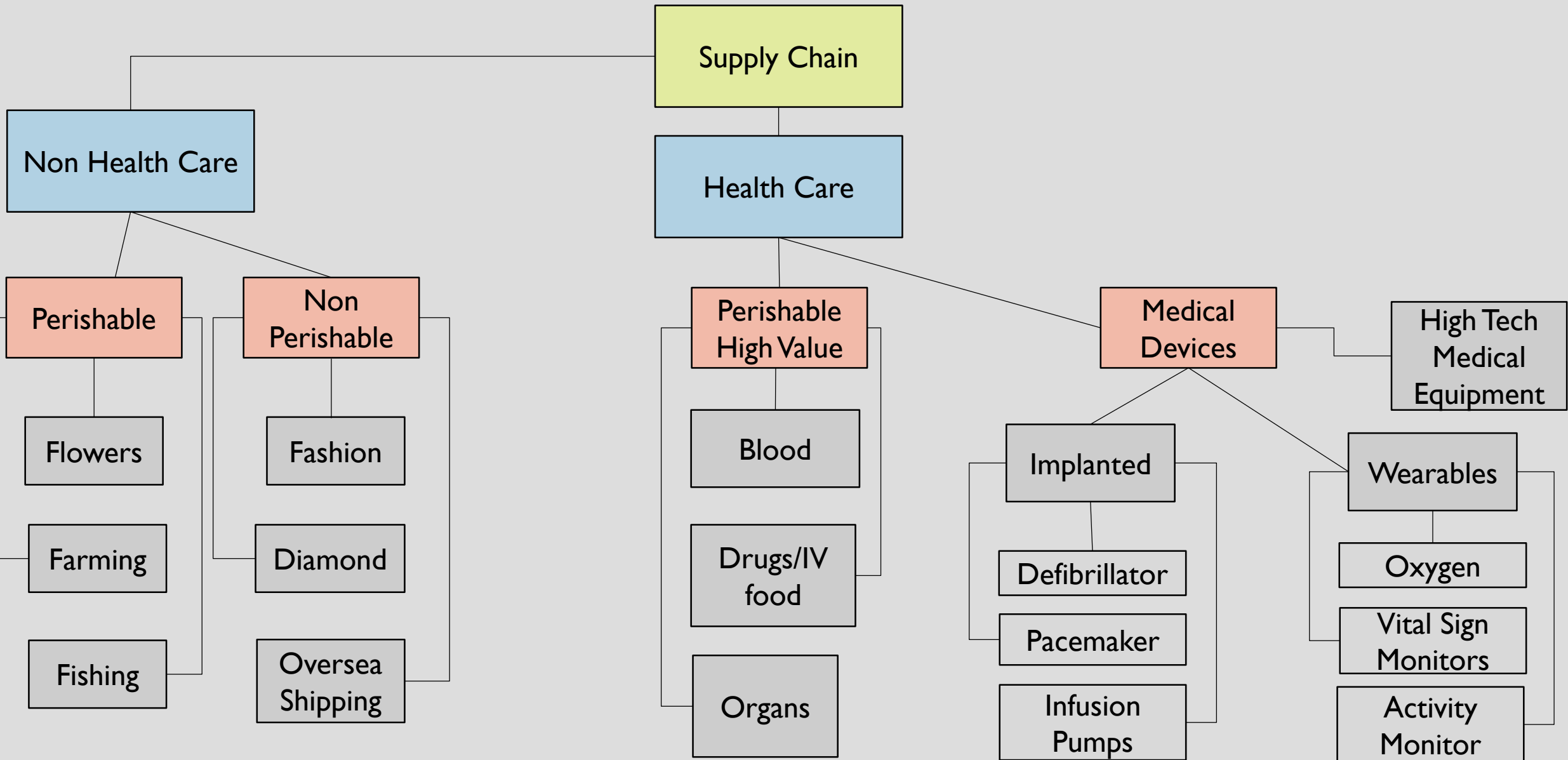
BLOCKCHAIN FOR DATA



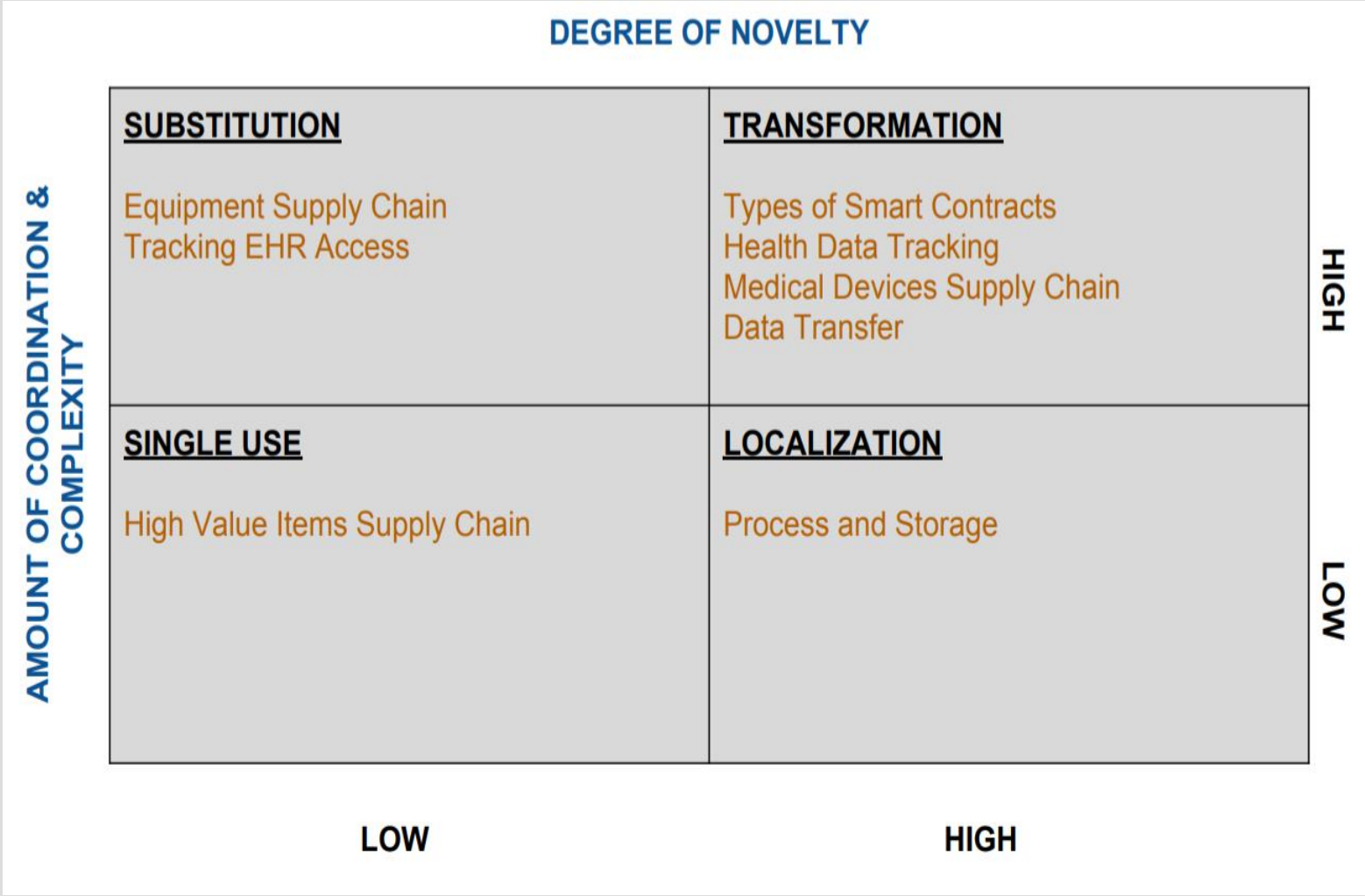
BLOCKCHAIN FOR CONTRACTS



BLOCKCHAIN FOR SUPPLY CHAIN

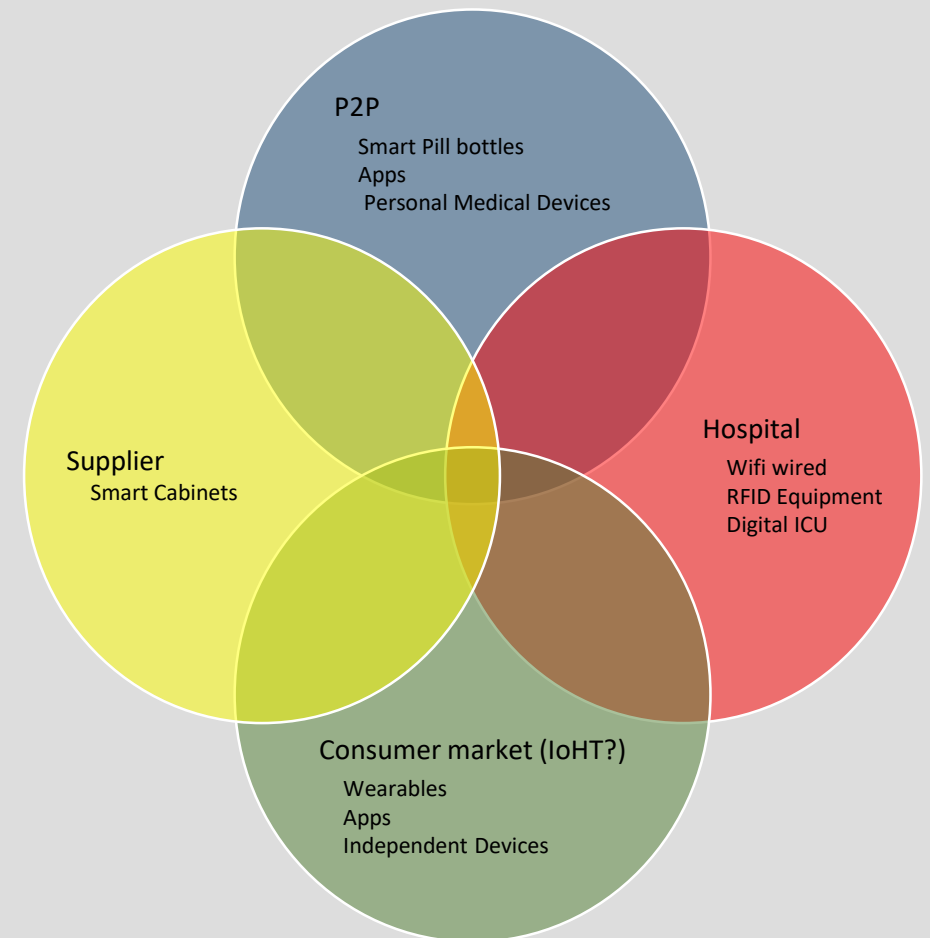
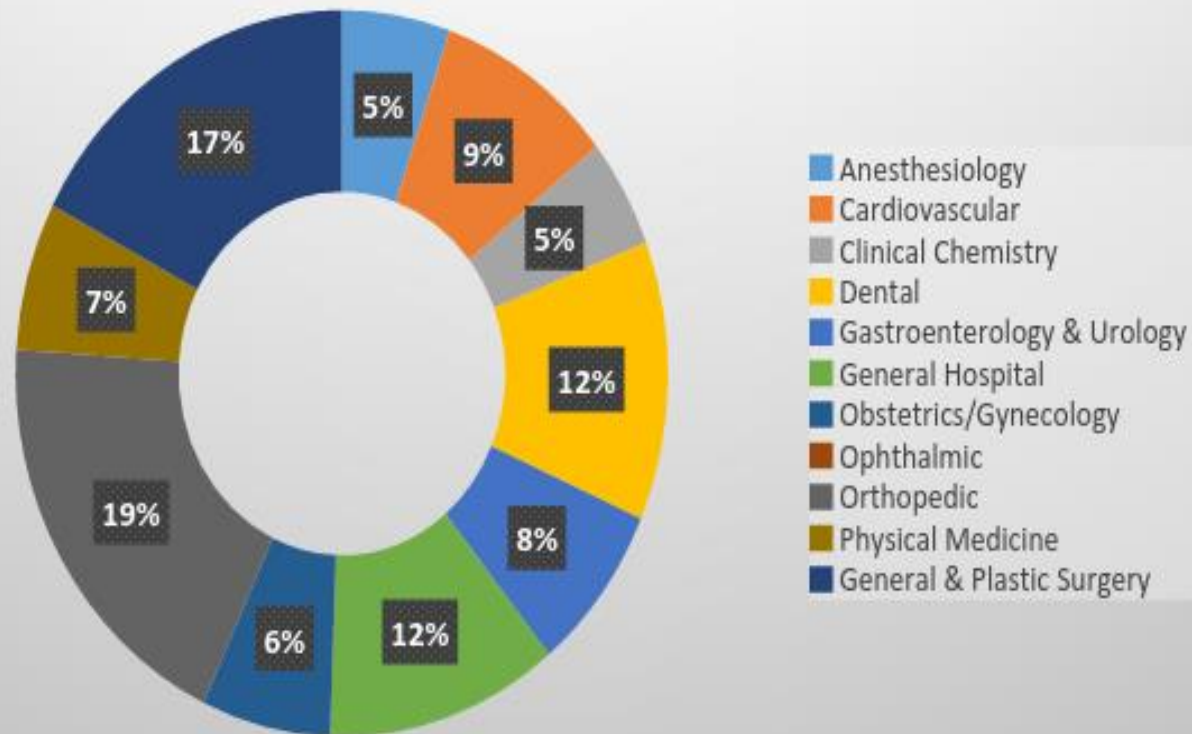


ADOPTION OF BLOCKCHAIN IN HEALTHCARE



INTERNET OF MEDICAL THINGS (IOMT)

Registered IoMT devices with the FDA



EXAMPLES OF IOMT



Apple Series I
\$179



Fitbit Versa
\$199



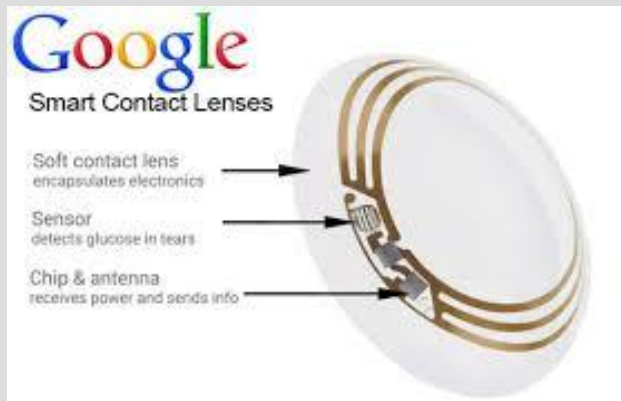
EKG watchband
\$39



Bluetooth Scale
\$39



Bluetooth Blood Pressure
\$69



Bluetooth Glucose
\$39



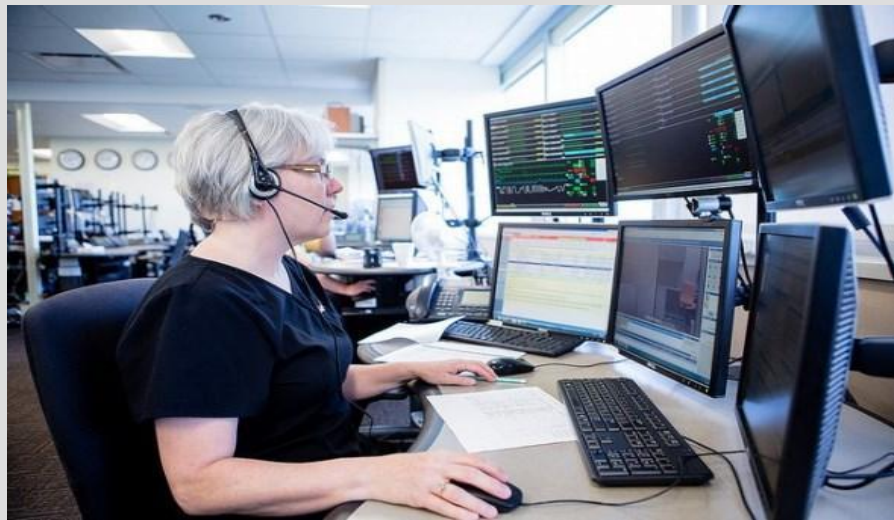
Bluetooth Continuous Glucose
Medtronics
\$39

BedMonitor



- I-TRACK**
The I-Track system monitors the layout of beds in the hospital department. It ensures that the mass of beds on the Bed Monitor is always accurate.
- BED MONITOR CONTROL**
Bed monitor in bedside, setting controls of safety parameters for bed.
- MOBILE DEVICE**
Mobile application for smartphones, information whenever needed.
- NURSE STATION MONITOR**
It also monitors the data given here on their nurse station monitor simple and clear information about the used beds, setting and their patients on them.

TELEMEDICINE



TECHNOLOGY FOR TELEMEDICINE IS HERE

- Most patients have HD video cameras, displays, and board band Internet access
- Mercy Virtual opened in 2015 (<http://www.mercyvirtual.net/>)
 - Many services from nurse-on-call to tele stroke
- According to carecloud 4 usefully applications are: (<https://www.carecloud.com/continuum/4-most-useful-applications-of-telemedicine/>)
 - Chronic Health Management – home monitoring systems for vital/active
 - cardiovascular diseases, diabetes, respiratory diseases and kidney diseases
 - <https://www.sciencedirect.com/science/article/pii/S1959031815000305>
 - Prescription Compliance – check in with patients
 - Store-and-Forward – interoperability of medical data and images
 - Sleep Disorders – monitor sleep

CONCLUSION

- Its all about the data!!
- Collecting the data
- Exchanging the data
- Learning from the data
- Making suggestions based on the data