Engineering challenges in mHealth systems

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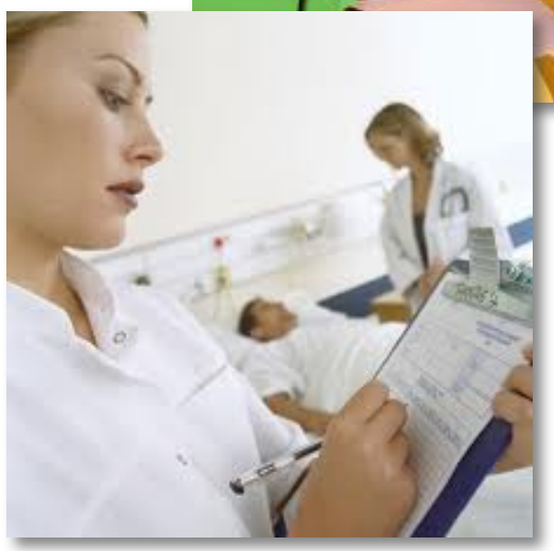
Patient behavior and health

- **Patient behavior and their health are inexorably linked**

- **Understanding behavior ⟺ health relationship would allow us to:**
  - **develop new diagnostics techniques**
    - e.g., assessment of memory, mood, activity level to detect onset of Alzheimer's disease
    - e.g., assessment of social interactions for depression in assisted living

  - **evaluate the efficacy/impact of medical treatment**
    - e.g., cognitive behavioral therapy for depression
    - e.g., impact of drugs on quality of life

Monitoring patient behavior with manual data collocation



- **Manual data collection is the gold standard ...**
  - subjective (e.g., memory bias, Hawthorne effects)
  - poor scalability
    - low temporal resolution
    - cannot monitor many subjects
  - people are expensive!

- **... but, our tools fundamentally limit our understanding**

We need better measurement tools!

New methods: Mobile Technology + Sensors

- **Assesses behavioral states**
  - with objective metrics
  - in real-time
  - in-situ
  - enable longitudinal studies with large patient populations

- **However, key engineering challenges remain**
  - reliable wireless communication
  - fault-tolerant and flexible design

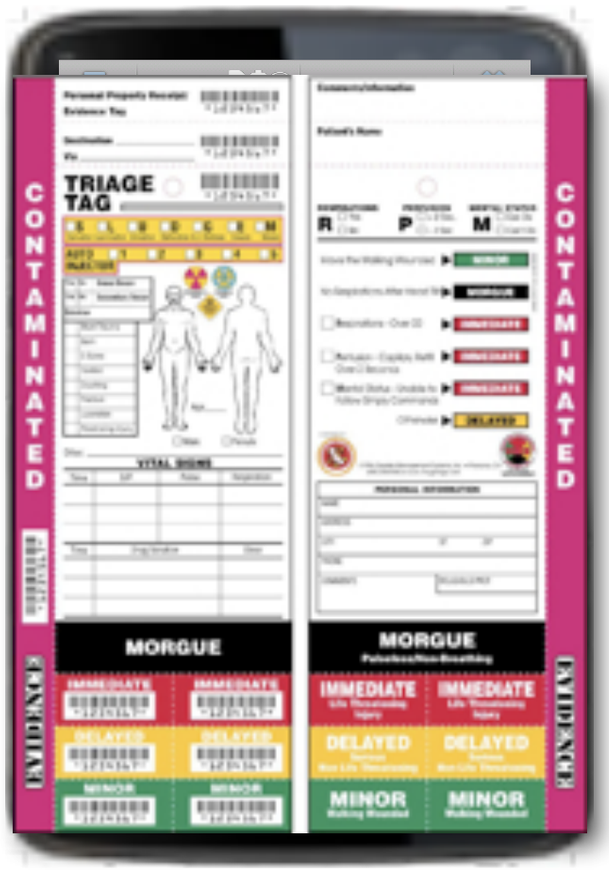
These challenges are shared by many mHealth systems!

Challenge:

Reliable wireless communication

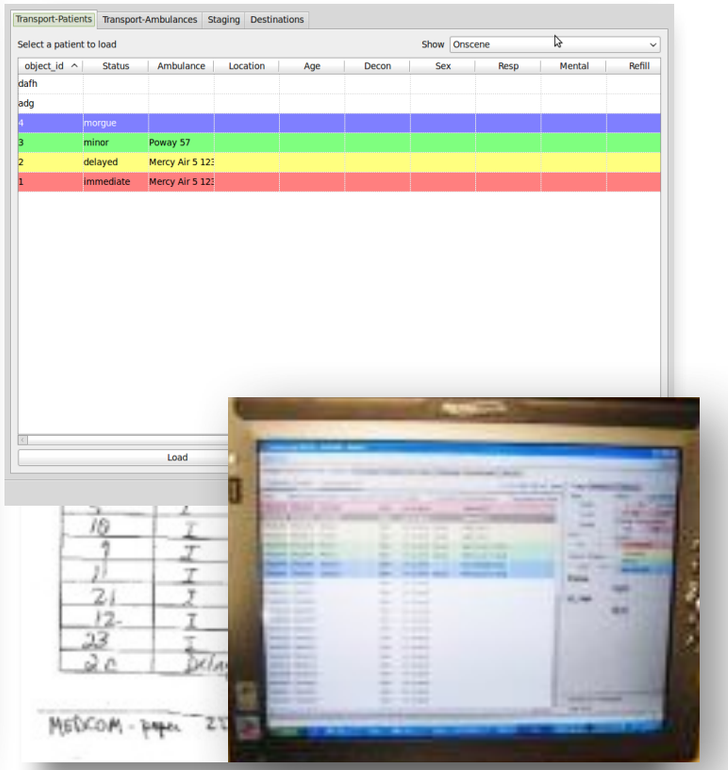
(without infrastructure)

Infusing technology into emergency response workflow



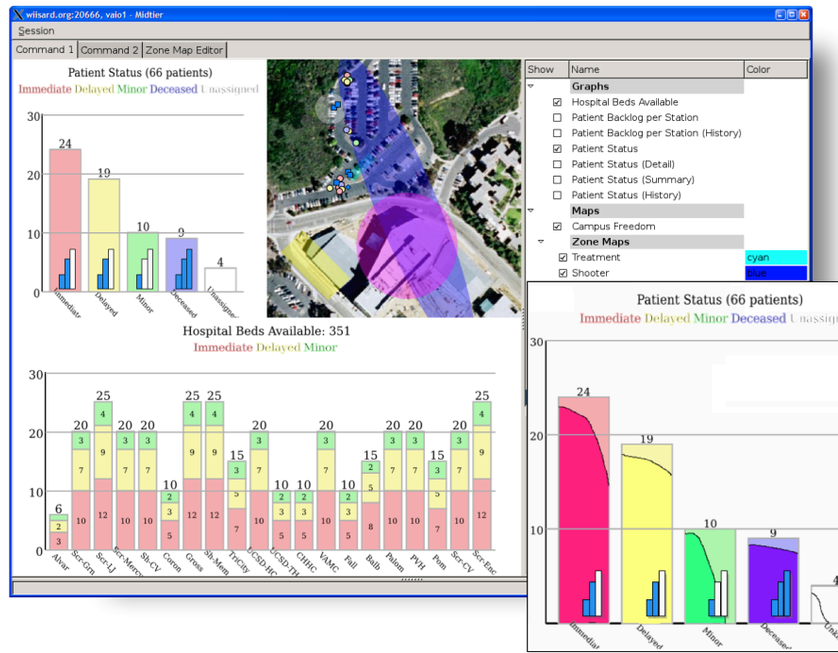
Triage tag

Example Coordination



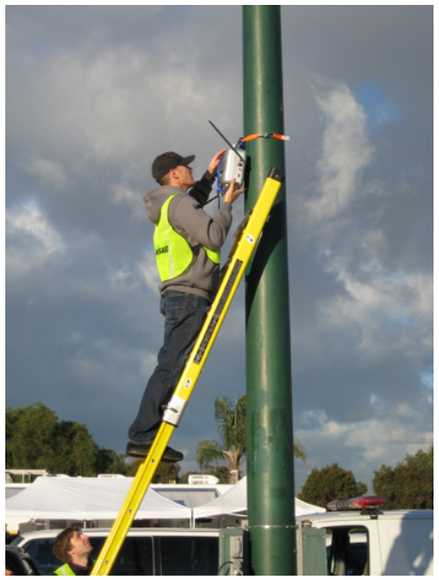
Medcom

- **Mobile technology improved information quality**
  - identical time to triage patients
  - reduced the rate of missing/duplicate patients



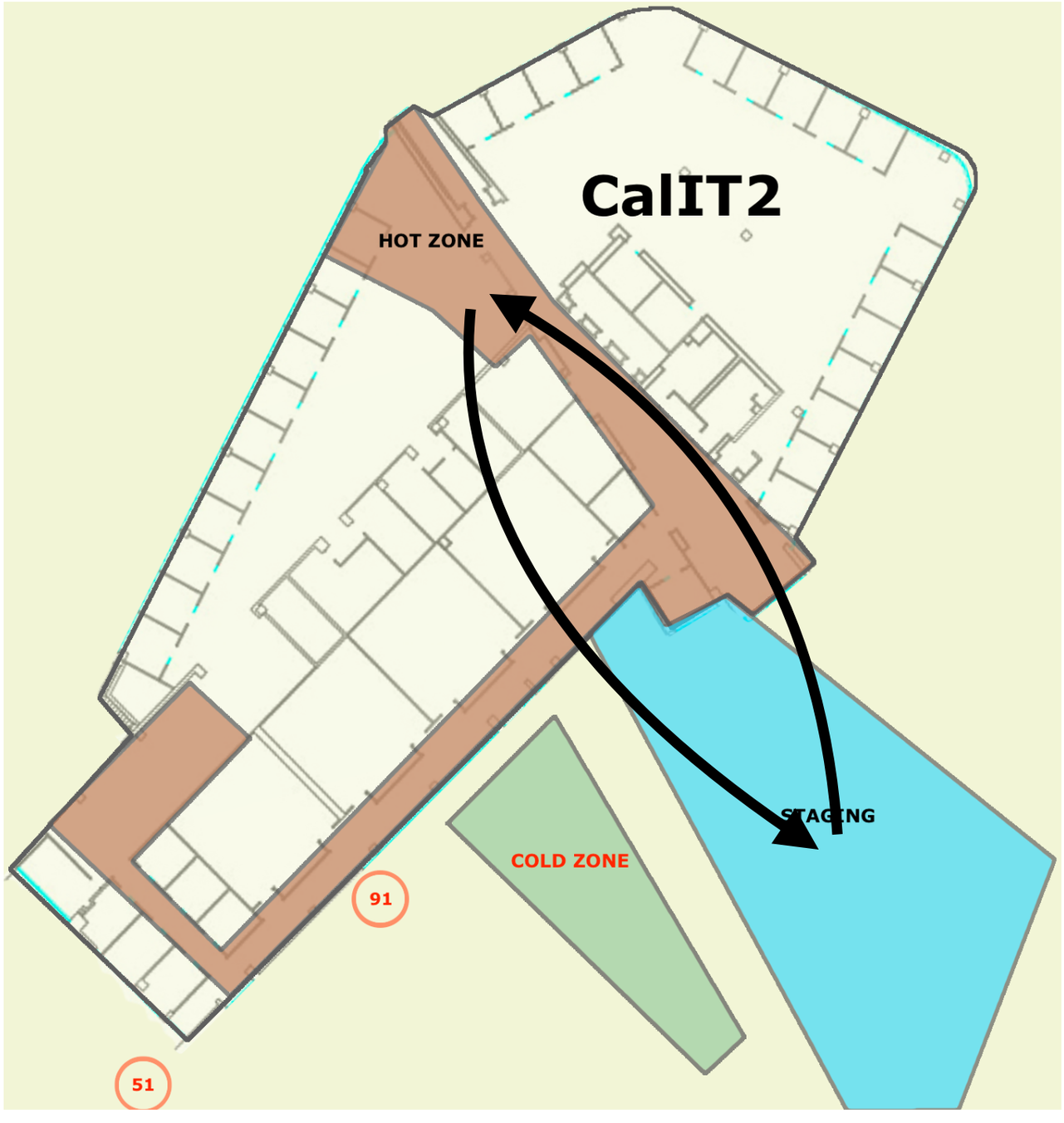
Challenge: Reliable communication

- **Initial approach: required deployment of infrastructure**



  - poor performance due to incomplete coverage
  - **as little as 10% of the data delivered**
- **Peer-to-peer communication architecture:**
  - requires no infrastructure, mobile phones communicate directly
  - epidemic propagation of information
  - **98% reliability during the drill**

Why does it work?



<u>Incident Command Structure (ICS)</u>

Staging:
- responders arrive on scene

Rescue:
- triage
- provide care
- evacuate

Treatment:
- re-triage
- provide additional care

Transport:
- transport to hospitals

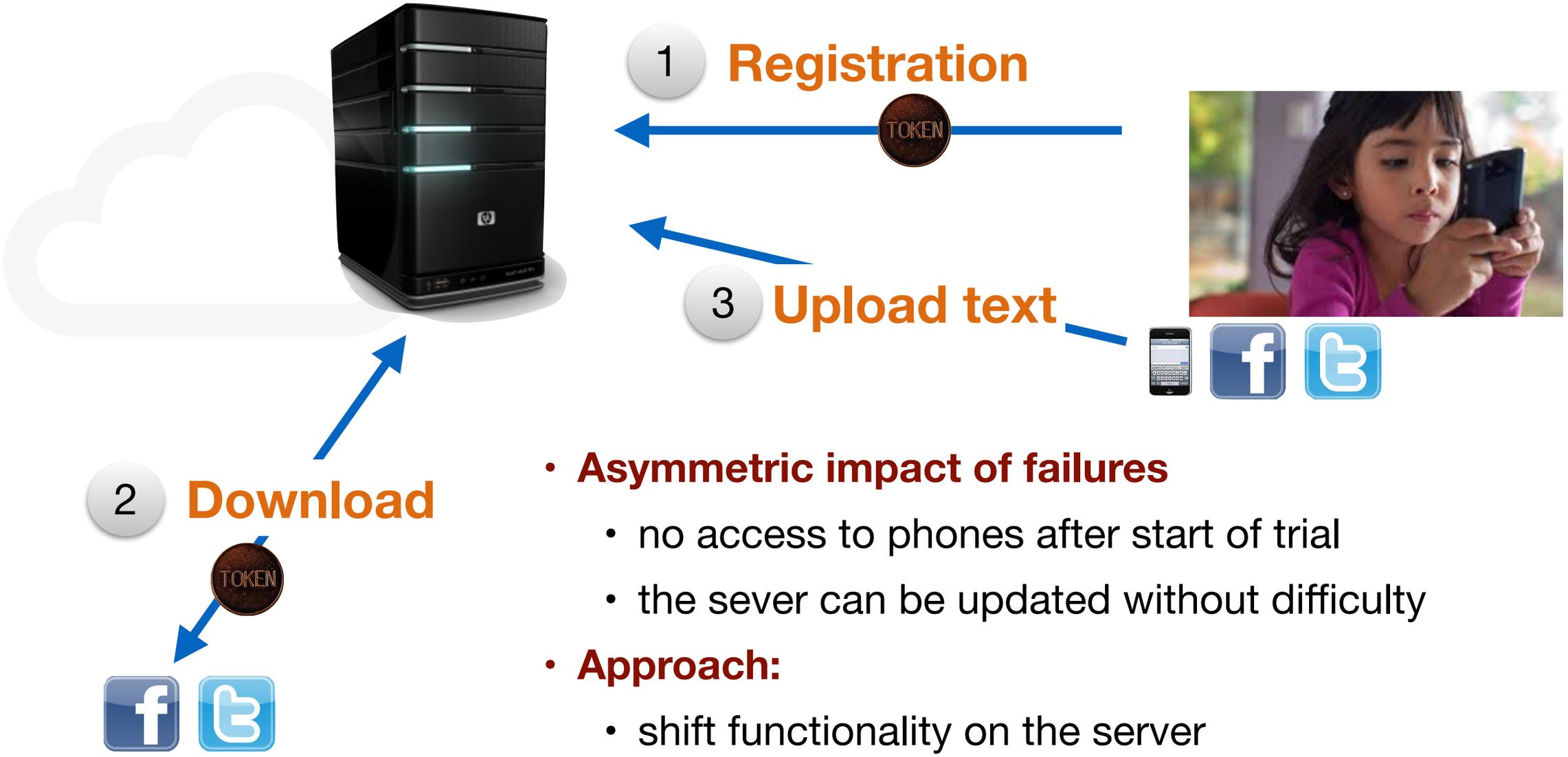
Challenge:

Fault-tolerant and flexible design

Cyber-bullying

- **A 2004 survey of 1,500 students between grades 4–8 found**
  - 42% of kids have been bullied while online
  - 58% of kids admit someone has said mean or hurtful things to them online
  - 21% of kids have received mean or threatening messages
  - 58% have not told their parents about these events
- **Goal:**
  - classify the contents of cyberbullying messages
  - assess their frequency and associations with offline bullying
  - examine whether and how peer groups promotes/mitigates bullying
- **Approach:**
  - combine traditional surveys methods + phone-based data collection
  - collect data from text messages, Facebook, Tweeter

System architecture



- **Asymmetric impact of failures**
  - no access to phones after start of trial
  - the sever can be updated without difficulty
- **Approach:**
  - shift functionality on the server
  - focus on a simple, throughly tested core of functions on mobile phone
  - reduces energy consumption and data plan utilization

Ongoing study

- **Started on January 15th**

iPhone	23	
Android	13	
Facebook	4481	
Twitter	481	
Text messages	7157	(Android only)

- **Software evolution**
  - no faults related on mobile phones
  - Facebook API changed a month prior to beginning of study
  - already fixed several bugs on the server-side
  - new features requested after the start of the study

Conclusions

- **Mobile technology and sensors will transform behavioral studies**
  - enable large-scale longitudinal studies
  - open new venues for diagnostic, measurement of patient outcomes, QOL

- **Significant engineering challenges remain:**
  - reliable wireless communication
  - developing fault-tolerant and flexible systems

- **Developing mHealth systems require engineers and clinicians to collaborate:**
  - understand what are the clinically relevant information that must be collected
  - develop a minimally invasive system to collect these measurements

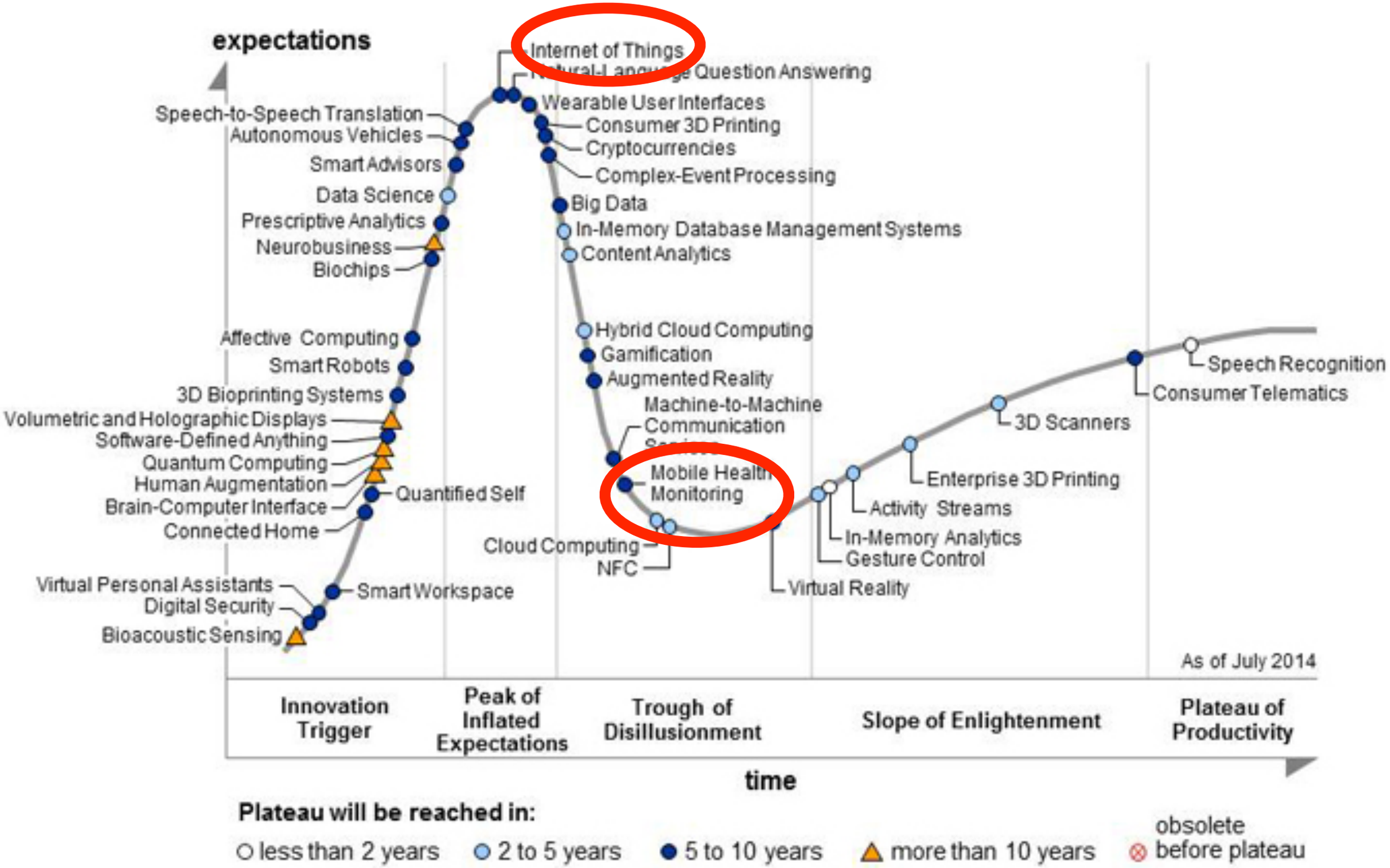
Acknowledgements

- **Students:**
  - Farley Lai, Syed Shabih Hasan, Austin Laugesen

- **CS Collaborators:**
  - Chenyang Lu, Washington University in St. Louis
  - William G. Griswold, University of California San Diego
  - Alberto Segre, University of Iowa

- **AMBI Collaborators:**
  - Michelle Voss (Department of Psychology),
  - Nazan Aksan, Steven W. Anderson, Matthew Rizzo (Department of Neurology),

- **Funding Agencies**
  - NSF
  - Roy J. Carver Foundation


expectations
Internet of Things
Natural-Language Question Answering
Wearable User Interfaces
Consumer 3D Printing
Cryptocurrencies
Complex-Event Processing
Big Data
In-Memory Database Management Systems
Content Analytics
Hybrid Cloud Computing
Gamification
Augmented Reality
Machine-to-Machine Communication
Mobile Health Monitoring
Speech-to-Speech Translation
Autonomous Vehicles
Smart Advisors
Data Science
Prescriptive Analytics
Neurobusiness
Biochips
Affective Computing
Smart Robots
3D Bioprinting Systems
Volumetric and Holographic Displays
Software-Defined Anything
Quantum Computing
Human Augmentation
Brain-Computer Interface
Connected Home
Quantified Self
Virtual Personal Assistants
Digital Security
Bioacoustic Sensing
Smart Workspace
Cloud Computing
NFC
Virtual Reality
3D Scanners
Enterprise 3D Printing
Activity Streams
In-Memory Analytics
Gesture Control
Speech Recognition
Consumer Telematics
As of July 2014
Innovation Trigger
Peak of Inflated Expectations
Trough of Disillusionment
Slope of Enlightenment
Plateau of Productivity
time
Plateau will be reached in:
less than 2 years
2 to 5 years
5 to 10 years
more than 10 years
obsolete before plateau