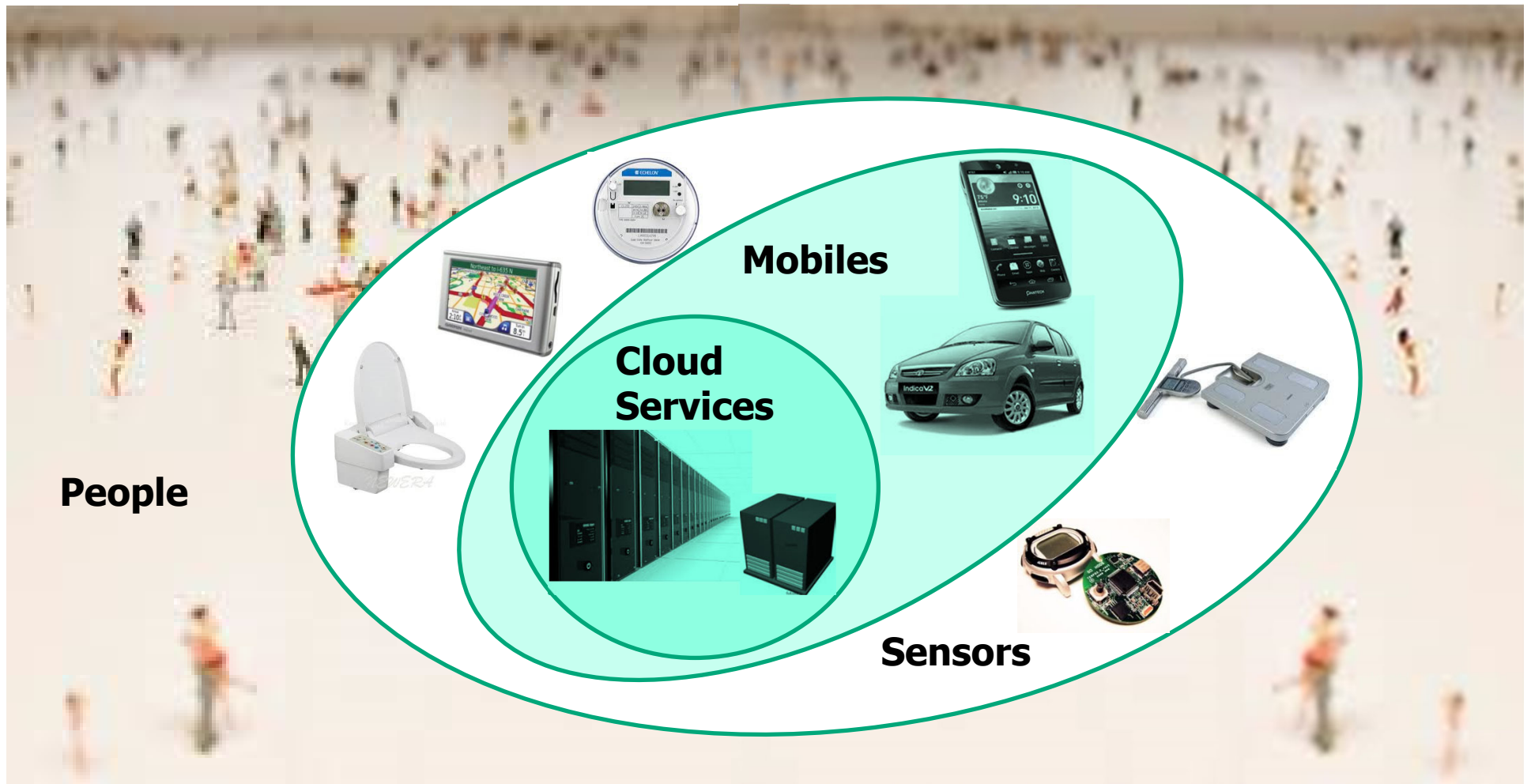# Next for RT and CPS

Tarek Abdelzaher

Dept. of Computer Science
University of Illinois at Urbana Champaign
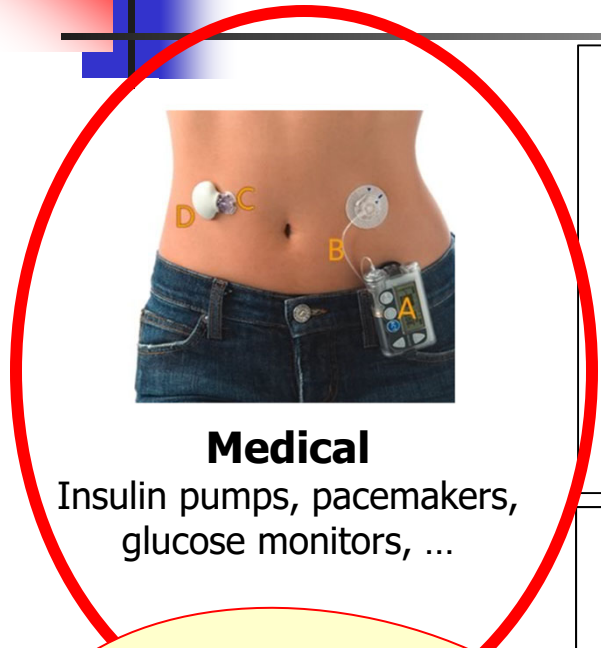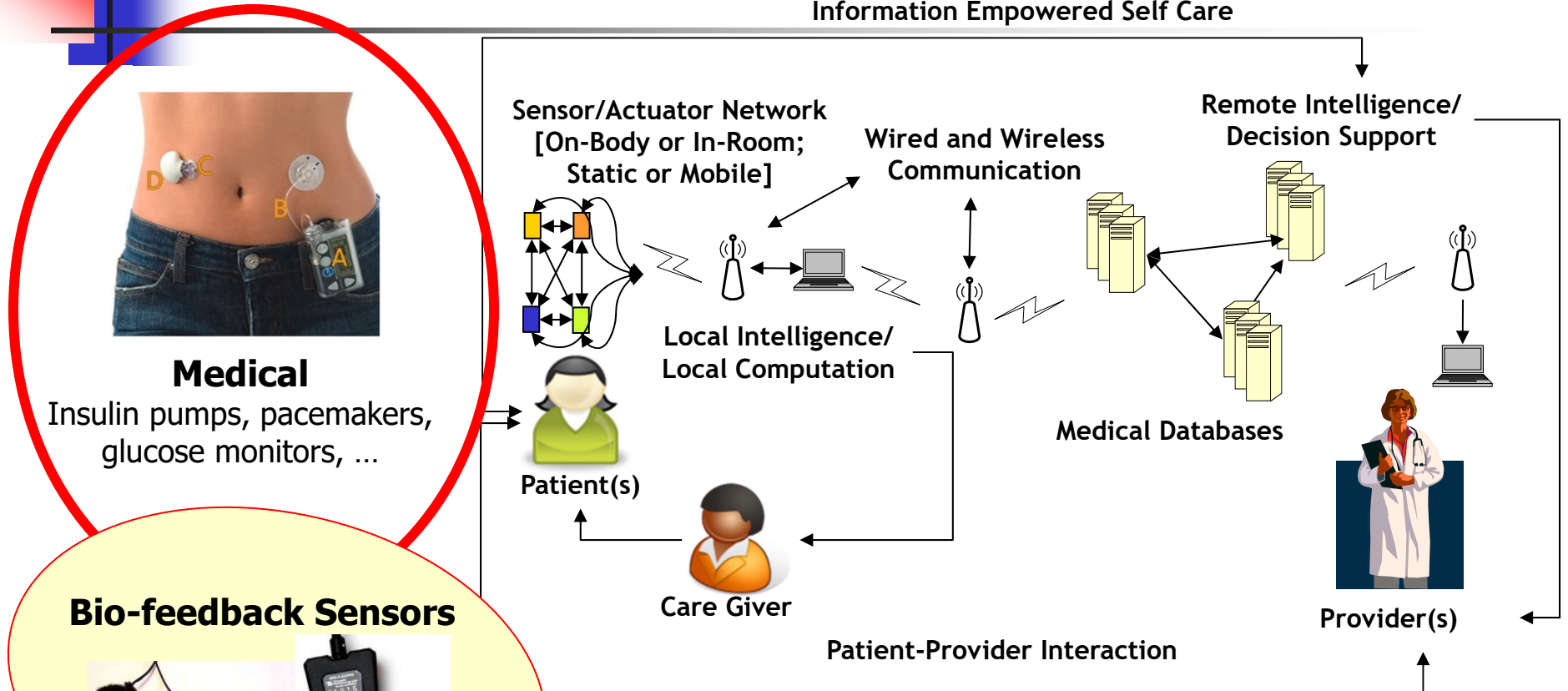
Big Trends: IoT + AI
Cloud + Mobiles + Sensors + AI

People

Mobiles

Cloud Services

Sensors

Applications: Personal (e.g., Medical/Tele-health)

Information Empowered Self Care

Medical
Insulin pumps, pacemakers, glucose monitors, …
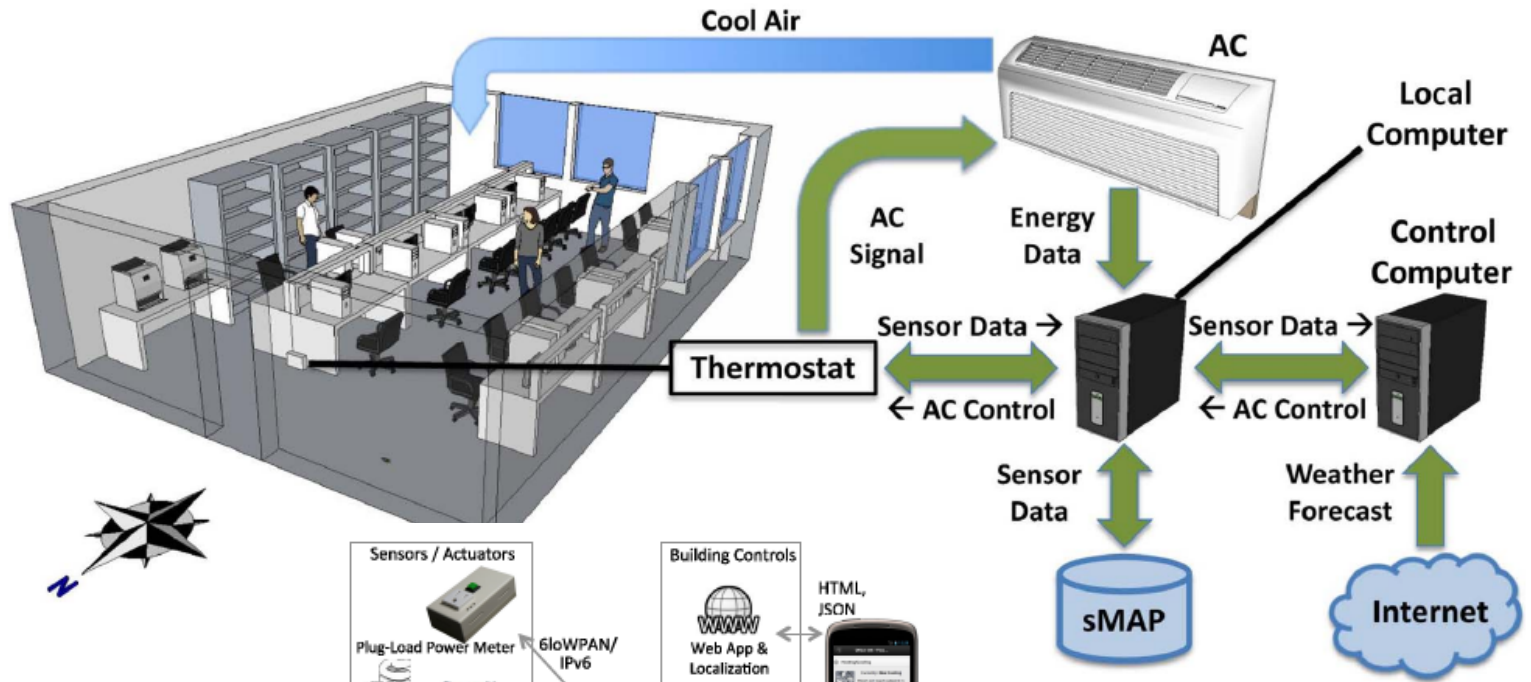
Bio-feedback Sensors

Sensor/Actuator Network [On-Body or In-Room; Static or Mobile]

Wired and Wireless Communication

Remote Intelligence/ Decision Support

Local Intelligence/ Local Computation

Medical Databases
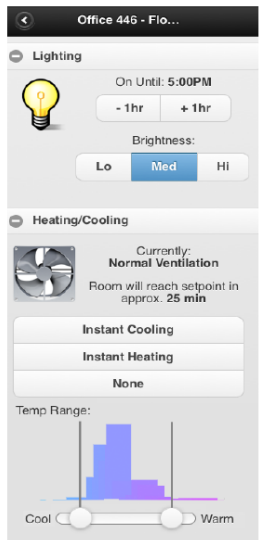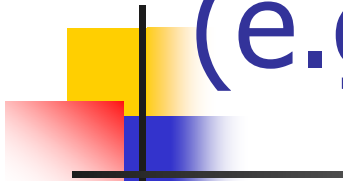
Patient(s)

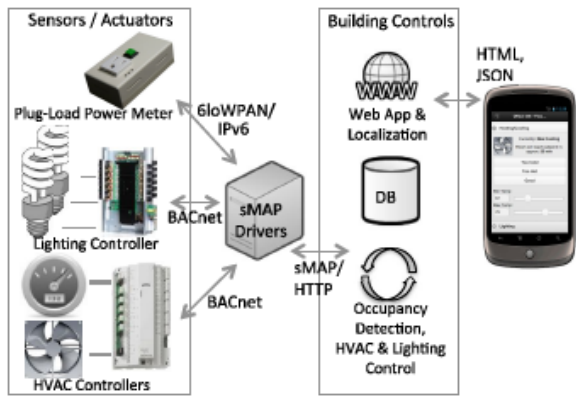Care Giver

Provider(s)

Patient-Provider Interaction

Figure courtesy of Mark Spong and Bill Sanders

Medical

3

Applications: Group-oriented (e.g., Building Management)

Zero-energy Building: Science House at the Science Museum of Minnesota

Residential Energy
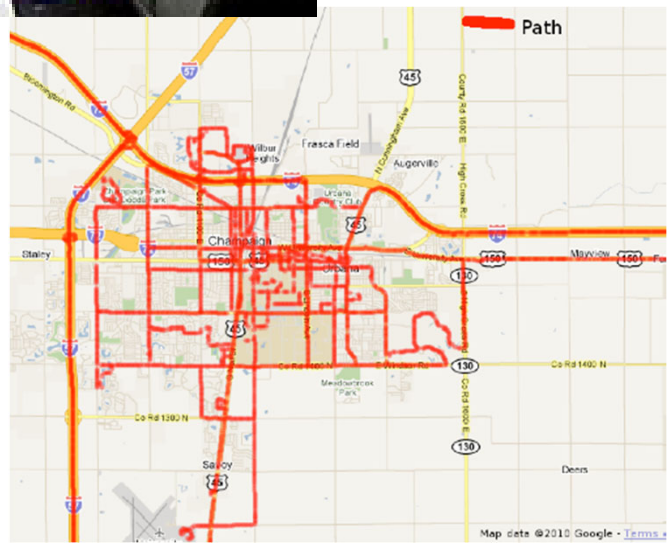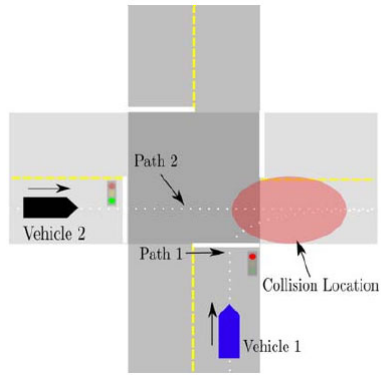
Figures courtesy of Berkeley BRITE Lab

4

Applications: Urban Efficiency (e.g., Transportation)

$$F_{engine} = \frac{\Gamma(\omega)Gg_k}{r}$$

$$F_{air} = \frac{1}{2}c_d A \rho v^2$$

$$F_{friction} = c_{rr}mg\cos(\theta)$$

$$F_g^g = mg\sin(\theta)$$

$$F_{car} = F_{engine} - F_{friction} - F_{air} - F_g$$

Path 2

Path 1

Vehicle 2

Vehicle 1

Collision Location

Path
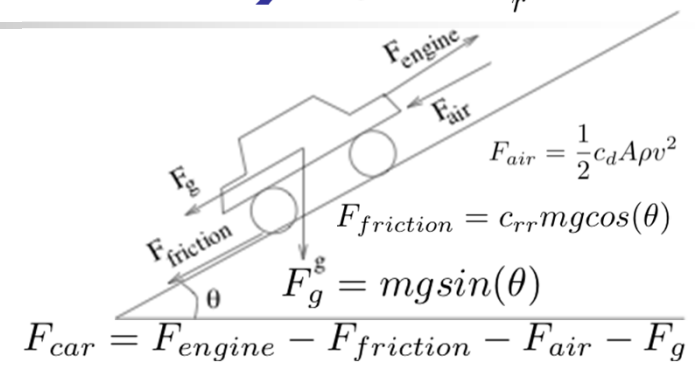
Transportation

Applications: Urban Efficiency (e.g., Disaster Response)

Japan's Tsunami and Nuclear Event, 2011

Applications:
Urban Sustainability

Uppsala Glacier (Time Magazine, Special Issue on Global Warming, March 26, 2006)
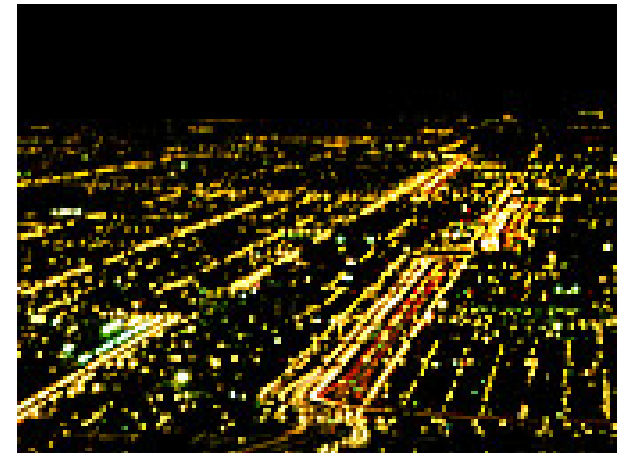

1928

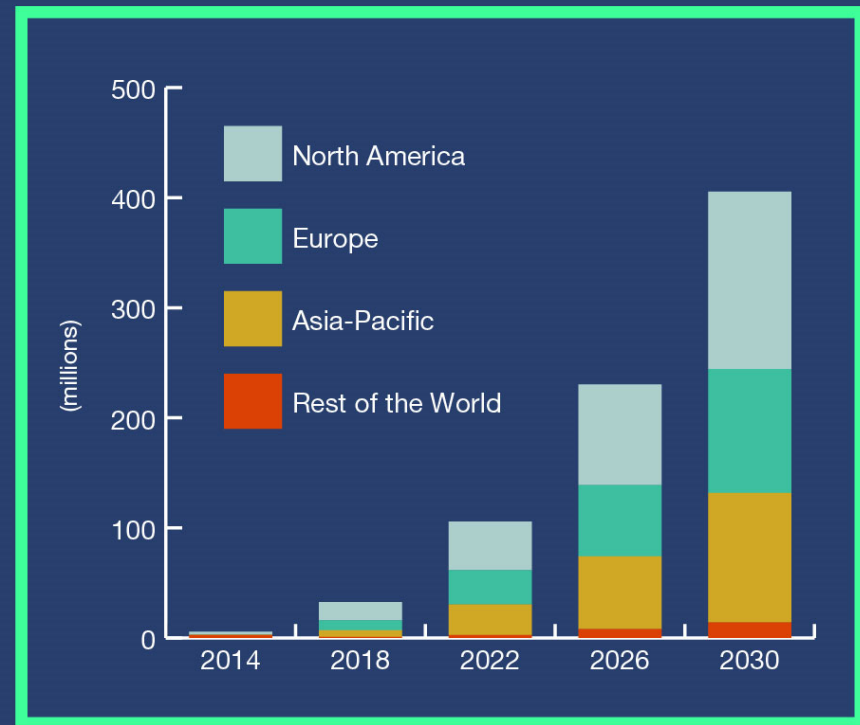Today

Sustainability

Intelligent Cars

- Cars will become connected to the "cloud" and share driving data.

(ABI Research)

Registered Vehicles with IoT Application by Region
World Market, Forecast: 2013 - 2030

Legend:
- North America
- Europe
- Asia-Pacific
- Rest of the World

(millions) — Y axis: 0, 100, 200, 300, 400, 500
X axis: 2014, 2018, 2022, 2026, 2030

Source: ABI Research

The First Semi-autonomous Cars

2015 Infiniti Q50S

AMG2016 BMW 750i xDrive

2015 Tesla Model S P85D

2015 Mercedes-Benz S65 AMG

Smart Home Devices
Top 7 by Fortune Magazine (2014)

Connected Smoke Detector

Security
Alarm

Smart Slow-
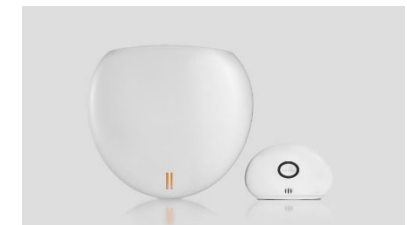cooker

Water Leak
Detector

Smart Air
Conditioner

Remote
Temperature
Controller

Weather-based Sprinkler Controller

Smart Home Device of 2016 (CNet)

- https://www.cnet.com/topics/smart-home/best-smart-home-devices/
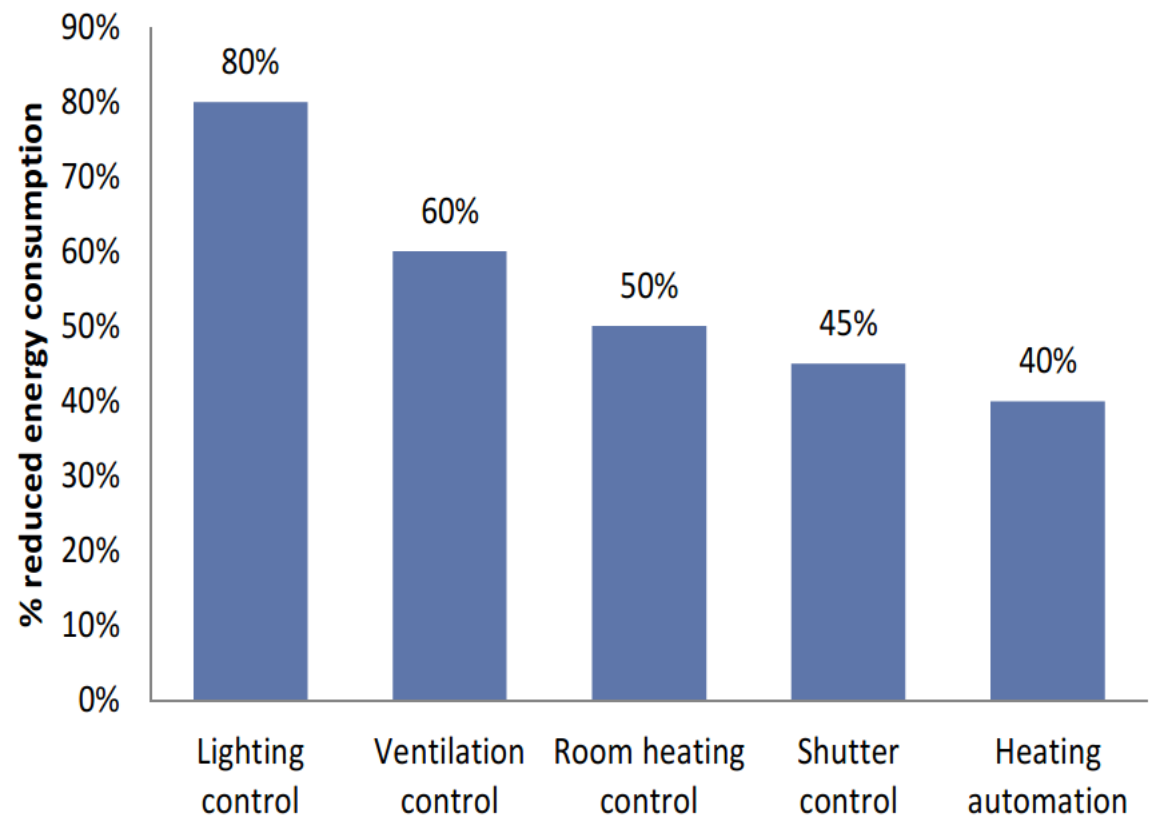
Today's Top Categories
(PC Magazine, 2019)

- Hubs and controllers: Amazon Echo Family, Google Home, etc
- Wink Hub, Brilliant Control, etc
- Smart outlets
- Surveillance cameras
- Locks and home security systems
- Smart heating and cooling
- Smart lighting
- Smart cookware
- Cleaning
- Health and fitness (a BIG category)
- Outdoor gadgets

Building Energy Savings

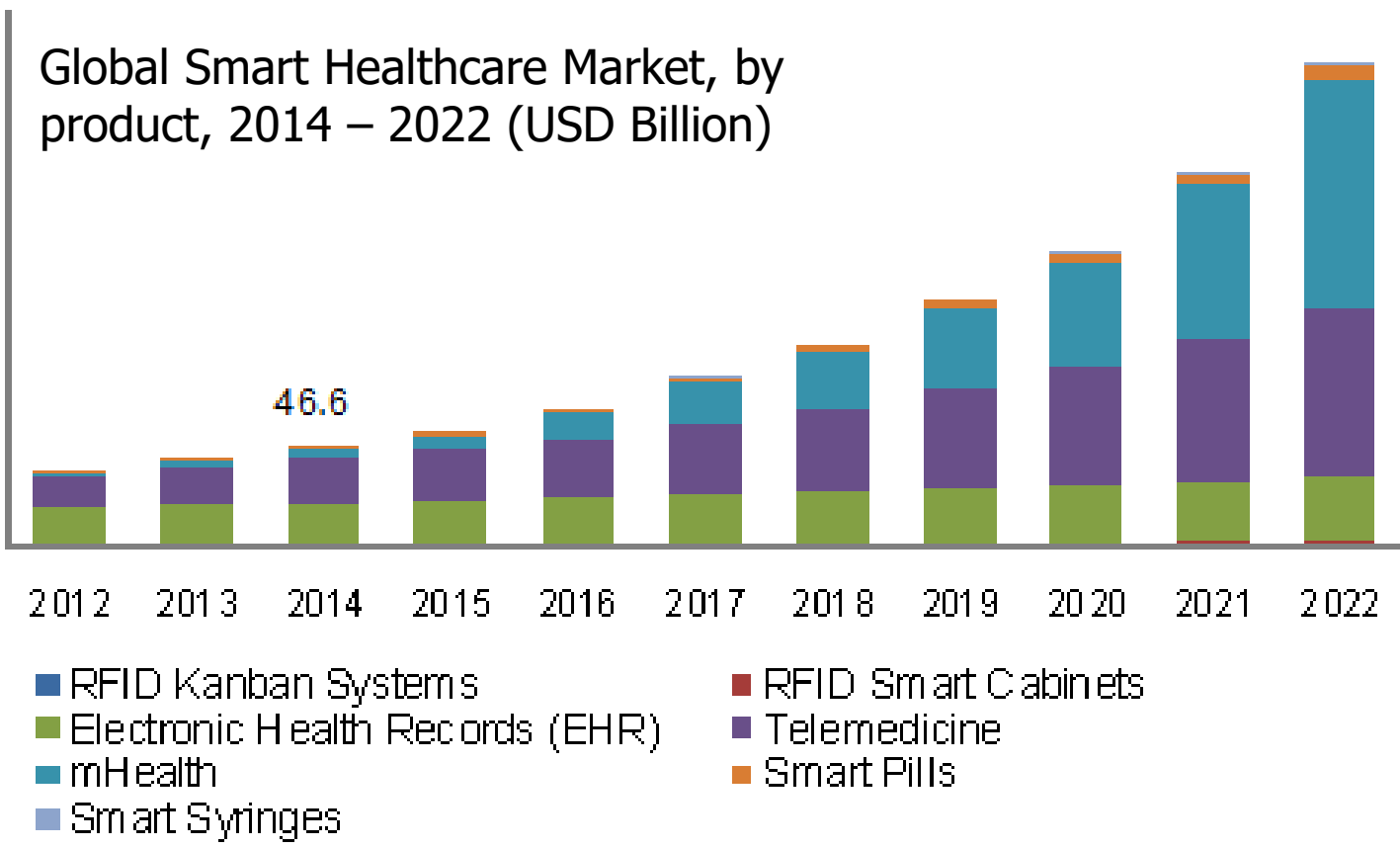- Significant savings are expected thanks to sensing and automation

(Goldman Sachs)

Health and Wellness

- ## Healthcare products

Global Smart Healthcare Market, by
product, 2014 – 2022 (USD Billion)

46.6

2012　2013　2014　2015　2016　2017　2018　2019　2020　2021　2022

- RFID Kanban Systems
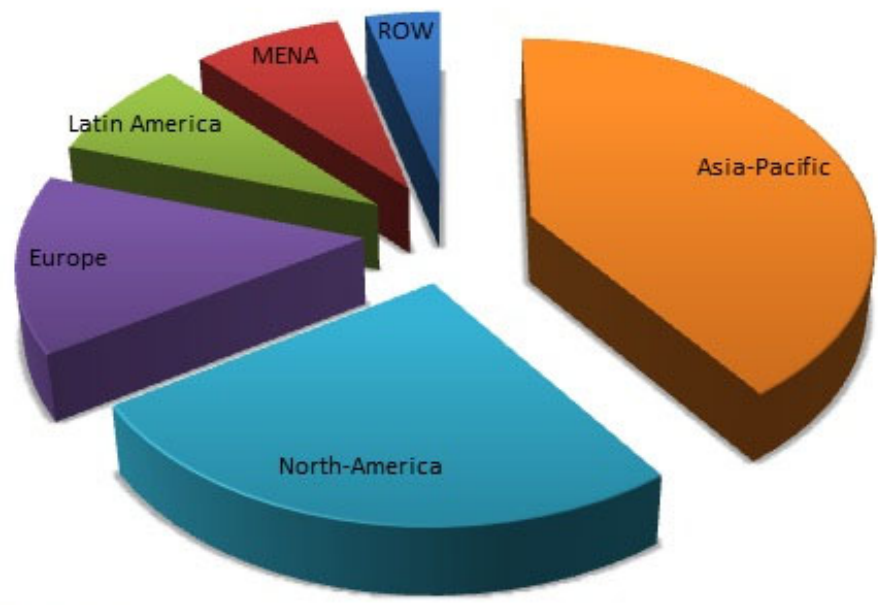- Electronic Health Records (EHR)
- mHealth
- Smart Syringes
- RFID Smart Cabinets
- Telemedicine
- Smart Pills

Health and Wellness

- Adoption of wearable health and wellness products (McKinsey)

Wearable adoption
Million users

— High
— Low

Advanced economies

800		
600		
400		
200		
0		
2015	2020	2025

Developing economies

800		
600		
400		
200		
0		
2015	2020	2025
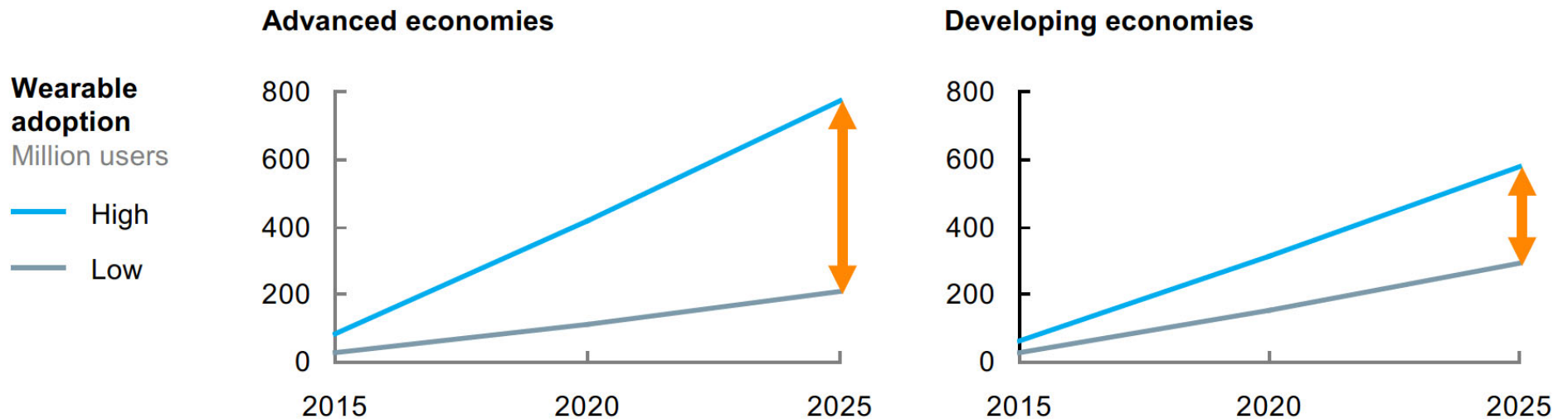
IoT Revenue

Global Internet of Things (IoT) Market Revenue Share (%)
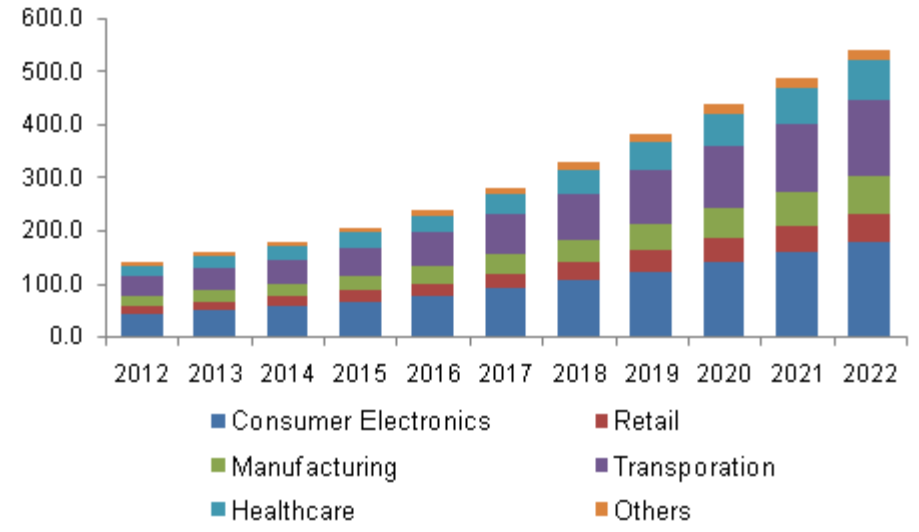
Source: Research Nester

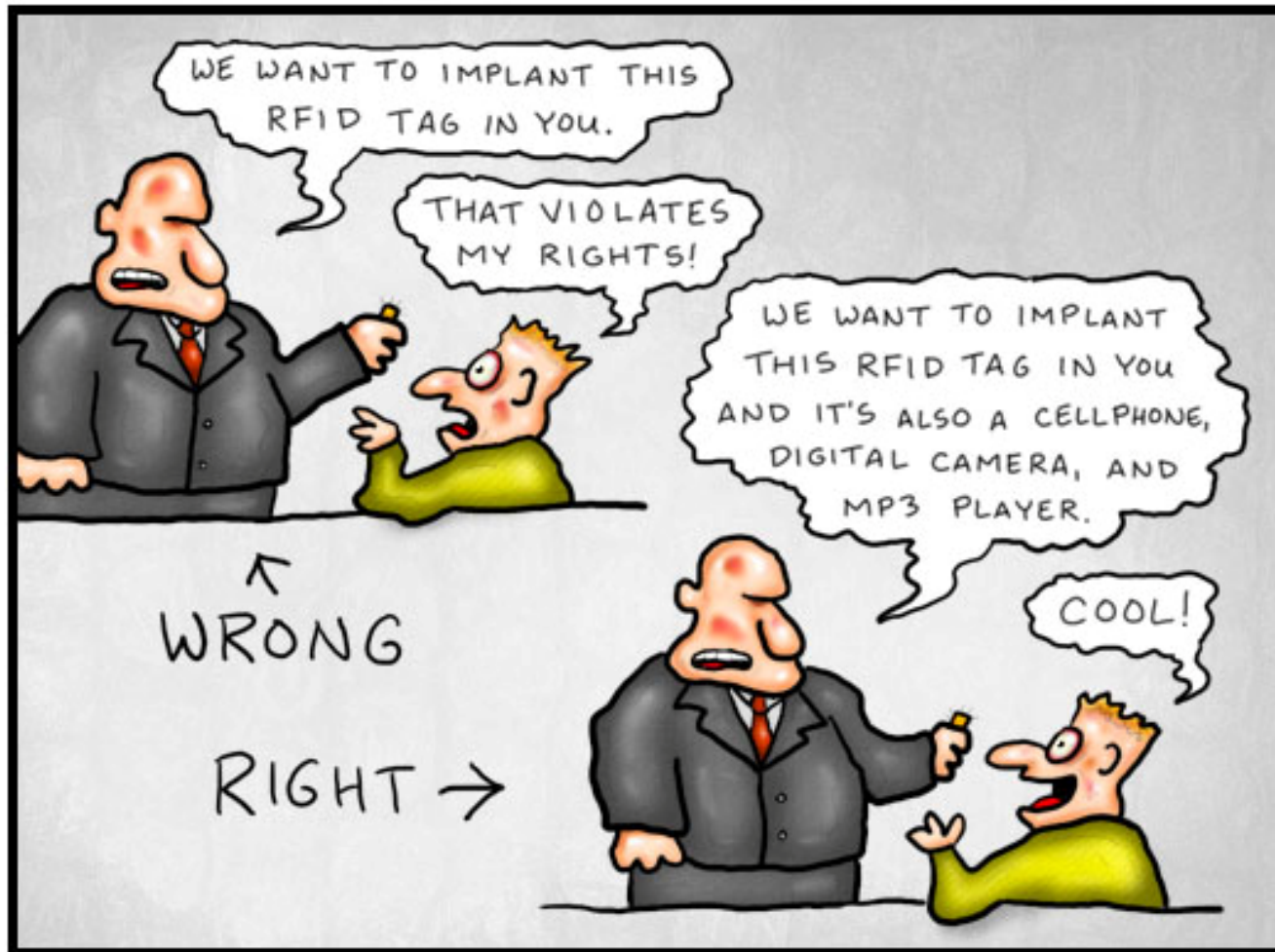# Privacy Concerns? Smart Car Applications and Data Privacy

Smart Car Applications and Data Privacy

- Would you share data from your car with the manufacturer if
  - It warmed and defrosted automatically depending on your schedule?
  - It told you the best routes to avoid congestion?
  - It told you the best place to get the least expensive gas on your route?
  - It sent vehicle health reports to your smart phone and reminded you of maintenance?
  - It automatically scheduled maintenance appointments?
  - It gave you a free maintenance session a year?
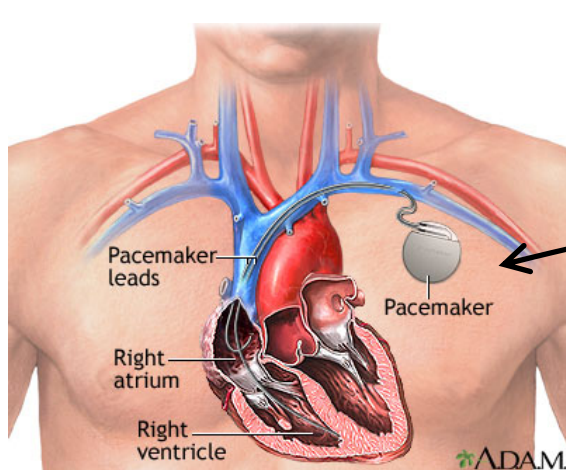
Smart Car Applications

- Why would you buy a car that shares data with the manufacturer?

(Acquity Group, 2014)

I WOULD BE WILLING TO SHARE DATA FROM MY CAR
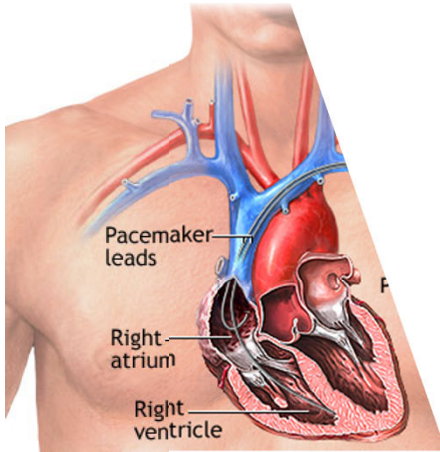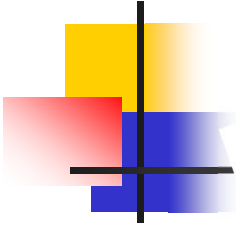WITH THE CAR'S MANUFACTURER, IF_____ .
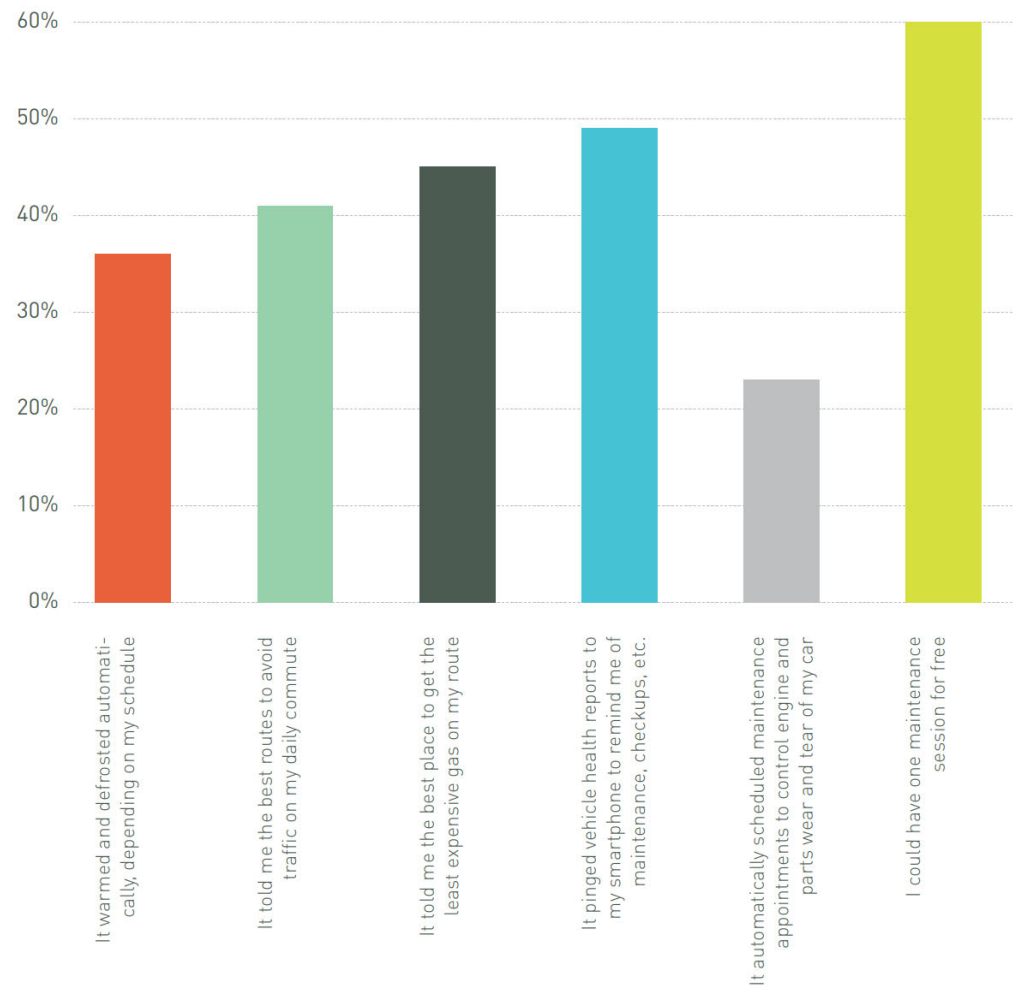
Security Concerns:
Online Murder via Implantable Devices?

Security Concerns

Online M[...] [...]table

The Guardian

Pacemaker leads

Right atrium

Right ventricle

St. Jude Medical™
Sylmar, CA USA
ACCENT MRI™
PM2224 DDDR

This article is more than **2 years old**

Hacking risk leads to recall of 500,000 pacemakers due to patient death fears

FDA overseeing crucial firmware update in US to patch security holes and prevent hijacking of pacemakers implanted in half a million people

Alex Hern
Thu 31 Aug 2017 08.23 EDT

Almost half a million pacemakers have been recalled by the US Food and Drug Administration (FDA) due to fears that their lax cybersecurity could be hacked to run the batteries down or even alter the patient's heartbeat.

Security in Personal and Implantable Devices

- Former US Vice President disables wireless on his pacemaker

Doctors disabled wireless in Dick Cheney's pacemaker to thwart hacking

by Lisa Vaas on October 22, 2013 | 1 Comment
FILED UNDER: Celebrities, Data loss, Denial of Service, Featured, Malware, Security threats, Vulnerability

Former US Vice President Dick Cheney's doctors disabled his pacemaker's wireless capabilities to thwart possible assassination attempts, he said in an interview with CBS's "60 Minutes" that aired on Sunday.

Cheney's heart problems were bad: between 1978 and 2010, he suffered five heart attacks, underwent quadruple bypass surgery, and had a pump implanted directly to his heart. A defibrillator was implanted to regulate his heartbeat in 2007.

Cheney told his 60 Minutes interviewer, CNN Chief Medical Correspondent Dr. Sanjay Gupta, that at the time of the pacemaker implant, he was concerned about reports that attackers could hack the devices and kill their owners:

Challenges?

- Massive scale
- Architecture/interactions/dependencies
- Big data analytics
- Robustness/entropy
- Openness
- Security
- Privacy
- Humans in the loop