CPS in Social Spaces (Continued):
Rise of the Internet of Things

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Publications on the Internet of Things

- According to the Engineering Village database (computing and Engineering publications)
Publication Venues

- 2012: Launch of the IEEE Internet of Things Journal
- 2013: 1st IEEE Conference on IoT Design and Implementation
- 2014: 1st Internet of Things Conference
- 2014: 1st International Conference on Mobility in IoT
- 2015: 1st World Forum on IoT
- 2015: Launch of the IEEE Internet of Things Journal
- 2016: New IoT Track at ACM/IEEE IPSN
- 2016: 1st World Forum on IoT
- 2016: Launch of the ACM Transactions on CPS
Enabling Technologies

Source: Texas Instruments

Wearables
- Entertainment
- Fitness
- Smart watch
- Location and tracking

Building & Home Automation
- Access control
- Light & temp control
- Energy optimization
- Predictive maintenance
- Connected appliances

Smart Cities
- Residential E-meters
- Smart street lights
- Pipeline leak detection
- Traffic control
- Surveillance cameras
- Centralized and integrated system control

Smart Manufacturing
- Flow optimization
- Real time inventory
- Asset tracking
- Employee safety
- Predictive maintenance
- Firmware updates

Health Care
- Remote monitoring
- Ambulance telemetry
- Drugs tracking
- Hospital asset tracking
- Access control
- Predictive maintenance

Automotive
- Infotainment
- Wire replacement
- Telemetry
- Predictive maintenance
- C2C and C2I
IoT Projections

- Estimated IoT Devices Growth (according to Business Insider)

![IoT Device Growth Graph]

*Source: BI Intelligence Estimates*
IoT Projections

- Estimated IoT Devices Growth (according to Cisco)

Source: Cisco IBSG, 2011
Application Domains
(Source: Goldman Sachs)
## Application Categories
*(Source: IBM)*

<table>
<thead>
<tr>
<th>Monetize</th>
<th>Optimize</th>
<th>Extend</th>
<th>Control</th>
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</thead>
<tbody>
<tr>
<td>Banking</td>
<td>Healthcare</td>
<td>Automotive</td>
<td>Retail</td>
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<tr>
<td>Cash replacement solutions</td>
<td>Paid home care family services</td>
<td>Pay-per-drive car rental</td>
<td>Cash replacement</td>
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<tr>
<td>Mobile Banking</td>
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<td>Sensor enabled Loyalty cards</td>
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<tr>
<td>Optimized Cash management</td>
<td>ER Bed Resource Mgmt</td>
<td>Component predictive replacement</td>
<td>Delivery and stock replenishment optimization</td>
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<td>Fleet mgmt</td>
<td>Store layout optimization</td>
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<td>Banking the un-banked</td>
<td>Life style monitoring</td>
<td>In-car Movies, Music, Games</td>
<td>Smart Vending Machines</td>
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<td>Biometrics</td>
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<td>Highly Automated Driving</td>
<td>Delivery Lockers</td>
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<td>Smarter Subsidies</td>
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<td>Mobility Services</td>
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<tr>
<td>Remote ATM Management</td>
<td>Remote Hospital environment Mgmt</td>
<td>Remote Drive-train optimization</td>
<td>Crowd mgmt</td>
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<td>Dynamic Authorization</td>
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<td>Timetable mgmt</td>
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<td>Asset mgmt</td>
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<td>Remotely control consumer devices</td>
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</tbody>
</table>
## Application Settings
(Source: McKinsey)

<table>
<thead>
<tr>
<th>Settings</th>
<th>Description</th>
<th>Examples</th>
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</thead>
<tbody>
<tr>
<td><strong>Total</strong></td>
<td>$3.9 trillion–11.1 trillion</td>
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<tr>
<td><strong>Human</strong></td>
<td>170–1,590</td>
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<tr>
<td><strong>Home</strong></td>
<td>200–350</td>
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<tr>
<td>Retail environments</td>
<td>410–1,160</td>
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<tr>
<td><strong>Offices</strong></td>
<td>70–150</td>
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<tr>
<td>Factories</td>
<td>1,210–3,700</td>
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<tr>
<td><strong>Worksites</strong></td>
<td>160–930</td>
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<tr>
<td><strong>Vehicles</strong></td>
<td>210–740</td>
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<tr>
<td><strong>Cities</strong></td>
<td>930–1,660</td>
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<tr>
<td><strong>Outside</strong></td>
<td>560–850</td>
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Smart Cars

Converging Technologies
- Electric Vehicle
- Electric Smart Grid
- Connected Vehicle
- Autonomous Vehicle

Internet of Vehicles
- Vehicle to Vehicle (V2V)
  - Communication
- Vehicle to Device (V2D)
  - Telematics
- Vehicle to Grid (V2G + G2V)
  - Charging Stations
- Vehicle to Infrastructure (V2I)
  - Communication
Smart Cars

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

*(ABI Research)*
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 schedule 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)
Autonomous Cars

*Morgan Stanley report, 2014:*

“[Autonomous cars] are no longer just the realm of science fiction. They are real and will be on roads sooner than you think. Cars with basic autonomous capability are in showrooms today, semi-autonomous cars are coming in 12-18 months, and completely autonomous cars are set to be available before the end of the decade.”
Today
(Semi-autonomous Cars)

2015 Infiniti Q50S
2015 Tesla Model S P85D
2015 Mercedes-Benz S65 AMG
2016 BMW 750i xDrive
Autonomous Cars

*Morgan Stanley report, 2014:*
- Fuel savings
- Reduction in accident costs
- Productivity gains

**Estimated Fuel Savings (Assuming 30% increase in efficiency)**
- $158bn Total Fuel Savings
- 251mn Total US registered vehicles
- 11,684 Average yearly driven miles
- $4 Fuel price per gallon
- 21.9 Average US MPG

**Estimated Accident Cost Savings (Assuming elimination of driver error)**
- $563bn Total Savings from Accident Assistance
- 2.24mn Injuries from motor vehicle accidents
- 32,885 Total motor vehicle deaths
- $7.9mm Cost per death
- $163,152 Cost per accident

**Estimated Productivity Gain from Autonomous Cars**
- $422bn Productivity gain from autonomous cars
- 18.8bn Total hours spent working in vehicle
- 25.03/hour Average cost of time
- 90% Productivity
(Early) Smart Home Devices
Top 7 by Fortune Magazine (2014)

- Security Alarm
- Smart Slow-cooker
- Connected Smoke Detector
- Smart Air Conditioner
- Remote Temperature Controller
- Weather-based Sprinkler Controller
- Water Leak Detector
Top Smart Home Device of 2016 (CNet)


Amazon Echo

Always ready, connected, and fast. Just ask.
In the next 5 years, would you purchase:

- A smart thermostat?
- A smart refrigerator?
- A wearable fitness device?
- A smart watch?
- A self-driving vacuum cleaner?
- A wearable head-mounted display?
- An item of smart clothing?
Smart Home Devices

- Percentage of consumers projected to buy some connected home device in the near future

(Acquity Group, 2014)
Smart Home Markets

- Revenue projections from different smart home application areas

(Goldman Sachs, 2015)
Example: 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)
Health and Wellness

- Adoption of wearable health and wellness products (McKinsey)
Examples: Pedometers

- Do you own one?
- 1 in 10 do.
Security in Personal and Implantable Devices

- Online murder?
Security in Personal and Implantable Devices

- Former US Vice President disables wireless on his pacemaker

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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:
More on Social CPS?

- There is a class on Social Sensing in Spring:
  
  CS 598tar