The Internet of Things

The Internet of Things

- It can’t happen yet
- Web 2.0 is an emerging thing that is actually happening
- Internet of Things may take another 30 years
- We will find ourselves surrounded by things that are all trackable
- We can find our car keys by a simple Google search

Evolution of the Web

- Web 1.0
  - Web as information distribution, access
  - Content developed by providers, accessed by the masses
  - Impact: disintermediation
    - Examples: CD stores vanish, travel agent business hollowed out
- Web 2.0
  - Collaboration by the masses in developing content
  - Increased impact from Web participants
  - Impact: direct power of self-organized feedback
    - Examples: decline of newspapers, rise of blogs, impact of Facebook on businesses, Wikipedia
- The Internet of Things
  - Everyday objects are Internet hosts
  - Great impact on everyday life
  - Impact: new abilities to understand and control our surroundings
    - Examples: self-driving cars, new medical diagnosis, new levels of retail automation

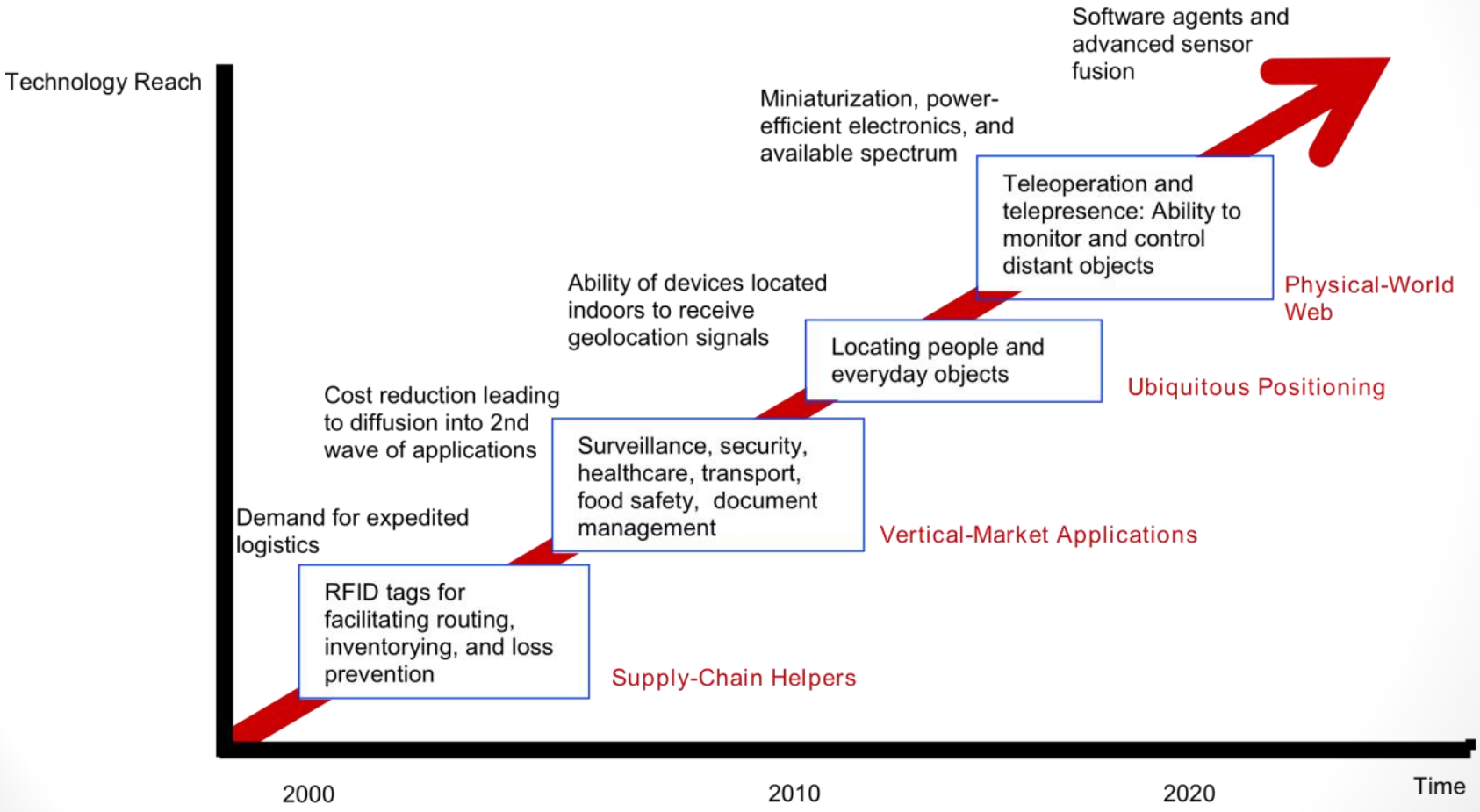
Consequences

- Think of all objects tagged with RFID tags
- All objects of daily life known by computers
- Life on Earth would change
- Companies never run out of stock or waste products in production
- Mislaid or stolen items are all found immediately
- Sensors and actuators embedded in physical objects are linked through wired and wireless connections
- Objects can sense the environment and communicate

Addressability of things

- Can make all things accessible through present naming protocols, through URI
- Objects don’t converse but can readily be referred to
- IPv6 has enough IP addresses to communicate with every object in the world
- Computers are developing the power to track every object in the world
- The Internet will provide the communication needed for this tracking

Technology Roadmap



Source: SRI Consulting Business Intelligence

Information and Analysis

1

Tracking behavior

Monitoring the behavior of persons, things, or data through space and time.

Examples:
Presence-based advertising and payments based on locations of consumers

Inventory and supply chain monitoring and management

2

Enhanced situational awareness

Achieving real-time awareness of physical environment.

Example:
Sniper detection using direction of sound to locate shooters

3

Sensor-driven decision analytics

Assisting human decision making through deep analysis and data visualization

Examples:
Oil field site planning with 3D visualization and simulation

Continuous monitoring of chronic diseases to help doctors determine best treatments

Information and Analysis

- Tracking behavior
  - Products with sensors can be tracked and interacted with
  - Business models can be fine-tuned to use this information
- Examples
  - Insurance companies offer to put location sensor into insured car, basing rates on actual driving measurements
  - Embed sensors in rental car, rent for short times to registered service users (Zipcar)
  - Makers of jet engines retain ownership of engines in planes, charge for hours used

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Enhanced Situational Awareness

- Heightened awareness
  - Large numbers of sensors in infrastructure or the environment report on conditions
  - Advanced display, visualization techniques used to show results
- Examples:
  - Security personnel use sensor networks that combine video, audio, vibration detectors to spot intruders into restricted areas
  - Logistics managers for airlines, trucking lines get up-to-the-second knowledge of weather, traffic patterns, vehicle locations
  - Law officers get instantaneous data from sonic sensors to pinpoint location of gunfire

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Sensor-Driven Decision Analytics

- Support for more complex human planning and decision making
  - Tremendous storage and computing resources are required (and available)
  - Advanced software systems produce displays for analysis
- Examples
  - Retail companies track behavior of shoppers inside stores, learn how long they pause where. Use this to drive simulations, redesign store layouts.
  - Patients with congestive heart failure are monitored continuously during daily activities, giving early warning to physicians
  - Extensive sensor networks in the soil can give more accurate readings of location, structure, dimensions of potential oil fields underground

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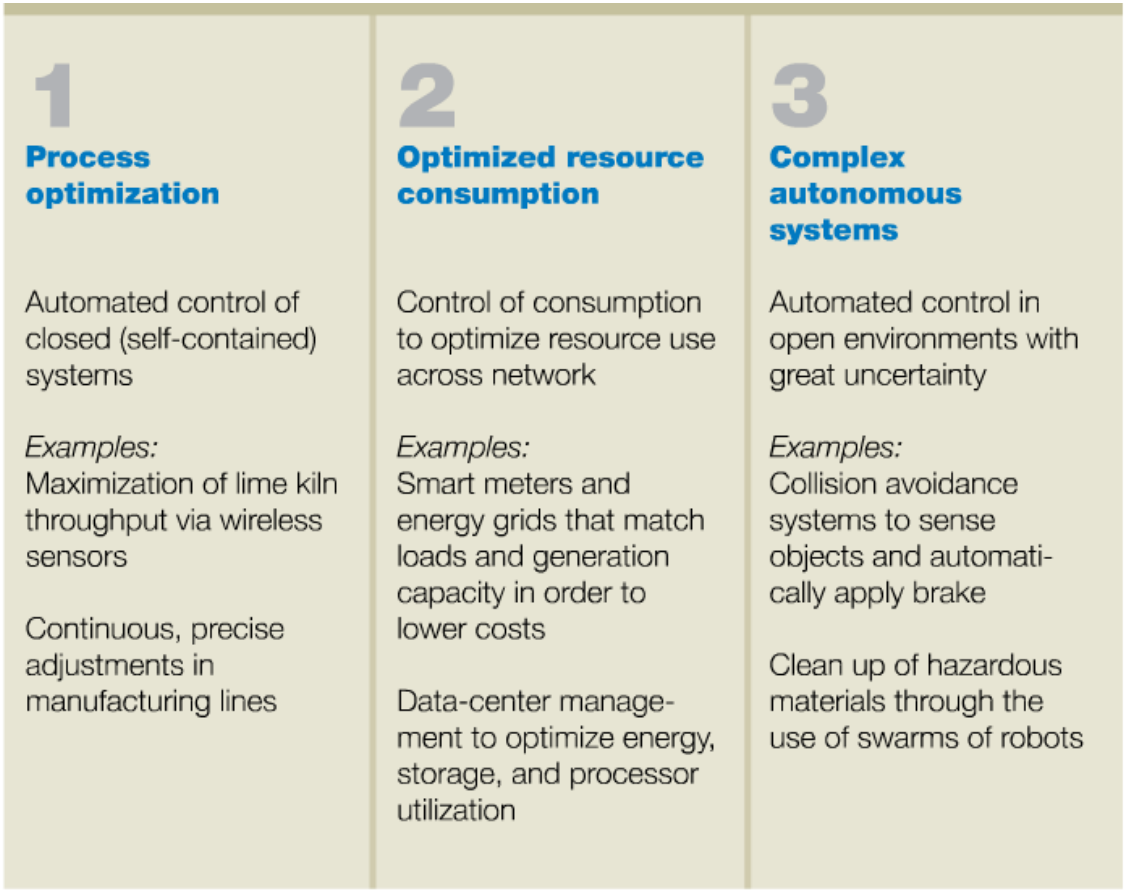
Automation and Control



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Process optimization

Automated control of closed (self-contained) systems

Examples:
Maximization of lime kiln throughput via wireless sensors

Continuous, precise adjustments in manufacturing lines

2

Optimized resource consumption

Control of consumption to optimize resource use across network

Examples:
Smart meters and energy grids that match loads and generation capacity in order to lower costs

Data-center management to optimize energy, storage, and processor utilization

3

Complex autonomous systems

Automated control in open environments with great uncertainty

Examples:
Collision avoidance systems to sense objects and automatically apply brake

Clean up of hazardous materials through the use of swarms of robots

Process Optimization

- Internet of Things opens new frontiers for improving processes
  - Greater granularity of monitoring provided by legions of sensors
  - Computer analysis in real time used to control processes
- Examples
  - Pulp and paper industry uses embedded temperature sensors to adjust flame shape, size in kilns to increase productivity
  - Sensors and activators can adjust position of an object as it moves down assembly line so that it meets machines at the correct orientation

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Optimized Resource Consumption

- Optimizing use of scarce resources
  - Networked sensors provide real-time consumption, demand data
  - Dynamic pricing can change demand patterns
- Examples
  - Utilizes are deploying smart meters that enable time-of-use pricing
  - Data centers include server power sensors to enable shutdown of servers that are not being used

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Complex Autonomous Systems

- Machine decision-making that mimics human reactions
  - Real-time sensing of unpredictable conditions
  - Instantaneous responses driven guided by automated systems
  - Mimics human response but at vastly better performance levels
- Examples
  - Experiments with automotive autopilot for networked vehicles at highway speeds
  - Tests of swarms of robots that maintain facilities or clean up toxic waste
  - Future systems to coordinate movements of groups of unmanned aircraft

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A Few More Prosaic Examples

- Shopping
- Water management
- Cities
- Food tracking

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Shopping

- Each shelf knows its contents
- Put an object into your cart and the cart tells you how much you're spending
- No cashier, the store collects automatically for what you've bought when you leave
- People are stocking shelves and cleaning the store but that's about it for people
- Currently, Wal-Mart is requiring its clothing suppliers to put RFID tags on all clothing
- They are reaching for this automation first in clothing and will achieve it in a few years

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Water Management

- Our large cities dump millions of gallons of sewage into rivers whenever there's a big rain
- If we track water flows and weather forecasts it's possible to manage all of this and keep sewage out of rivers
- Today only completely separate storm and sanitary systems permit that, at costs that can't be afforded
- A city becomes more like a living organism, temporarily storing water at various places

Cities

- When municipal data is open, cities become “smart cities” because of applications that integrate this data
- New York City opened up its data, has a contest for best new application
- “Roadify” has locations of moving buses, subways, parking spot locations; it’s crowd-sourced
- “Sportaneous” helps you get together a pick-up game in your sport of choice, finds venue and recruits players, notifies you when there are enough

Food Tracking

- Each food item can have an edible printed RFID tag
- We can track all food that we buy and everything we eat
- We'll know how many calories we've consumed and what nutrients, all the time
- If we eat sushi we can know when the fish was caught and when the roll was made
- We know exactly what nutrients to take based on what we have taken in

More Examples

- GPS-driven farm equipment can change how it treats fields based on information from overhead sensors
  - More fertilizer in some areas
  - Deeper or shallow tilling as needed
- Microcameras shaped like pills are swallowed
  - Relay thousands of images for diagnosis
  - Images are organized, displayed in real time
- Smart billboards
  - Sense who is nearby, possibly looking at them
  - Choose content tailored to the people in the area

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Issues

- Privacy
  - Genuine threats to liberty
    - Commercial
    - Government
- Security
  - It’s still the Internet
    - Designed for trusted participants
    - Not really suitable for public access

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Privacy Issues

- Today's privacy issues become much more severe
- Potential for exploitation by criminals and for government abuse
- Today, cell phone companies sell information about locations of their cell phone subscribers
- This is combined—today—with credit card purchase data to form very detailed profiles of our spending behavior
- Targeting ads to us is innocuous enough
- But we don't want the burglar to know when we're 150 miles from home
- We don't want the police to use our cell phone GPS to automatically give us a speeding ticket if we exceed the speed limit

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Risks to Liberty

- Real risks to liberty, not just from government
- What if all insurance companies insist that you put their GPS sensor on your car?
- What if every block on every street has a speeding ticket camera?
- What if bill collectors can purchase real-time information about where you are, hound you 24 hours a day?

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Surveillance

- Surveillance of public places is growing
- It has been shown to have great value for public safety
- But we don't today have enough limits on use of data
- How much privacy should individuals have?
- Is a camera in a public place producing data that should be public? Is it the same as a person standing outside looking around?
- What happens when faces can be recognized? When license plates can be read automatically?
- Today police cruisers carry automatic license plate readers, scan every plate that is passed, automatically
- Easy to find a stolen car. Hard to avoid abuse if the police become overzealous.

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Security

- The Internet was designed to serve trusted participants
  - At the outset, all participants knew each other personally
  - Design didn't need to consider someone trying to subvert the network or other hosts
  - Not suitable for public access
- Accountability is missing in the Internet
  - Too easy to pretend to be someone else
  - Hard to find bad guys and penalize them
  - Huge resources are being wasted

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CONCLUSION

Your Challenges

- First, you will choose where to work
- Work in companies that are dealing with these issues creatively
- Pay attention to technology/business directions so that you develop skills that fit into the developing environment
- Keep adapting to change and positioning yourself to take advantage of these shifts
- Know and understand the trends, be capable of helping to make sound decisions when your time comes

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references

- http://mckinseyquarterly.com The Internet of Things
- http://wikipedia.org The Internet of Things

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