Introducing the Internet of Things

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Smart and Connected Products

"Some have suggested that the internet of things 'changes everything', but that is a dangerous oversimplification. As with the internet itself, smart, connected products reflect a whole new set of technological possibilities that have emerged."
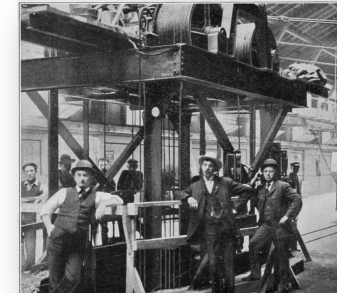
From: "How Smart Connected Products are Transforming Competition" Harvard Business Review

A few products: not smart or connected
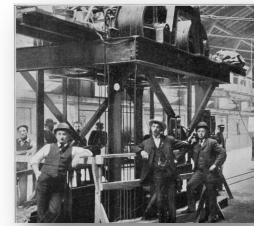
Let's add some "smarts" to the products…

Smarts added to the products

Talking doll

Power brakes on the jeep
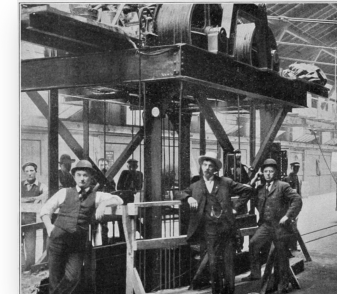
Microcontrollers
in the coffee pot

No elevator operator needed

Let's connect these things to the internet…

Connectivity added to smart products

Smart and Connected

My Friend Cayla, which costs $59.93 at Walmart.com, is billed as "a wonderful choice for a young child who needs a companion."

The Electronic Privacy Information Center (EPIC) claims the toys allegedly send recordings to speech-to-text software company Nuance Communications, which the complaint notes has contracts with military and law enforcement agencies.

Smart and Connected

"Connect your vehicle to Alexa via an Amazon Echo that syncs with any Uconnect®- equipped Jeep®Cherokee. Use your voice to start your vehicle, check fuel levels, send an address directly to your Navigation system and more, all from your home." From An advertisement describing connected Jeeps at https://www.jeep.com/uconnect.html/

Modern cars collect as much as 25 gigabytes of data per hour, the consulting firm McKinsey estimates, and it's about much more than performance and maintenance. NYT May 20, 2019. Data is collected about a driver's performance. That data can be sold.

"Though I hadn't touched the dashboard, the vents in the Jeep Cherokee started blasting cold air at the maximum setting, chilling the sweat on my back through the in-seat climate control system. Next the radio switched to the local hip hop station and began blaring Skee-lo at full volume. I spun the control knob left and hit the power button, to no avail. Then the windshield wipers turned on, and wiper fluid blurred the glass." From Wired https://www.wired.com/2015/07/hackers-remotely-kill-jeep-highway/

One thing they found were a bunch of unauthenticated RPC services in Lua… ready to be called.

Smart and Connected

"It's great for the person who is looking to buy smarter; it monitors your supply of coffee, and sends push notifications to your phone when it is time to pick up fresh beans or ground coffee."

From https://ideaing.com/ideas/best-smart-coffee-makers

"A coffee-machine hack may seem harmless, but the Dyn attack proved how easily IoT devices can cause damage at a grand scale."

From https://qz.com/901823/the-easy-way-your-smart-coffee-machine-could-get-hacked-and-ruin-your-life/

The attack caused major Internet platforms and services to be unavailable to large swathes of users in Europe and North America.Wikipedia

David Fidler, adjunct senior fellow for cybersecurity at the Council on Foreign Relations, said he couldn't recall a DDoS attack even half as big as the one that hit Dyn.

From https://www.theguardian.com/technology/2016/oct/26/ddos-attack-dyn-mirai-botnet

Smart and Connected

Proactive maintenance is available. Dashboards showing location and status of elevator fleet. A rules engine is used to detect and respond to emergency conditions. API's and SDK's are provided for developers. Users are able to find an appropriate elevator within a bank of elevators using a smart phone. Improve operating capabilities and efficiency to obtain real-time accurate information remotely.

"The idea of a hackable elevator, where someone can trap and move around its occupants on a whim, maybe while watching the whole thing via the security camera, is just horrifying."
From https://www.infosecurity-magazine.com/slackspace/connected-elevators-iot-doomsday/

What does Bruce Schneier say about security and IoT?

"Our problem right now isn't that we don't know how to secure these devices, it's that there is no economic or regulatory incentive to do so."

"Fast, cheap, or secure ? Choose two."

Some tools include encryption, signatures, key management, device inspection and the credentialing of devices, two factor authentication, frequent firmware updates, monitoring of the device for potential compromise, changing passwords, disabling unused features, hardware security modules (HSMs) for tamper detection and erase, Intrusion Detection Systems (IDS), etc.

Probably not "deploy and walk away."

But smart, connected products can add value

Monitoring	Control	Optimization	Autonomy
1 Sensors and external data sources enable the comprehensive monitoring of: • the product's condition • the external environment • the product's operation and usage Monitoring also enables alerts and notifications of changes	**2** Software embedded in the product or in the product cloud enables: • Control of product functions • Personalization of the user experience	**3** Monitoring and control capabilities enable algorithms that optimize product operation and use in order to: • Enhance product performance • Allow predictive diagnostics, service, and repair	**4** Combining monitoring, control, and optimization allows: • Autonomous product operation • Self-coordination of operation with other products and systems • Autonomous product enhancement and personalization • Self-diagnosis and service

From HBR article by Porter and Heppelmann

Monitoring

- In some cases, such as medical devices, monitoring is the core element of value creation. Medtronic's digital blood-glucose meter uses a sensor inserted under the patient's skin to measure glucose levels in tissue fluid and connects wirelessly to a device that alerts patients and clinicians up to 30 minutes before a patient reaches a threshold blood-glucose level, enabling appropriate therapy adjustments.

From HBR article by Porter and Heppelmann

Control

- Users can adjust their Philips Lighting Hue lightbulbs via smartphone, turning them on and off, programming them to blink red if an intruder is detected, or dimming them slowly at night.

- Doorbot, a smart, connected doorbell and lock, allows customers to give visitors access to the home remotely after screening them on their smartphones.

From HBR article by Porter and Heppelmann

Optimization

- The rich flow of monitoring data from smart, connected products, coupled with the capacity to control product operation, allows companies to optimize product performance in numerous ways, many of which have not been previously possible.

- Diebold, for example, monitors many of its automated teller machines for early signs of trouble. After assessing a malfunctioning ATM's status, the machine is repaired remotely if possible, or the company deploys a technician who has been given a detailed diagnosis of the problem, a recommended repair process, and, often, the needed parts.

- TinyML provides machine learning with TensorFlow Lite on microcontrollers. Training is done on the cloud and the model is deployed to the device. Example usage: detect a barking dog or a machine that is about to fail.
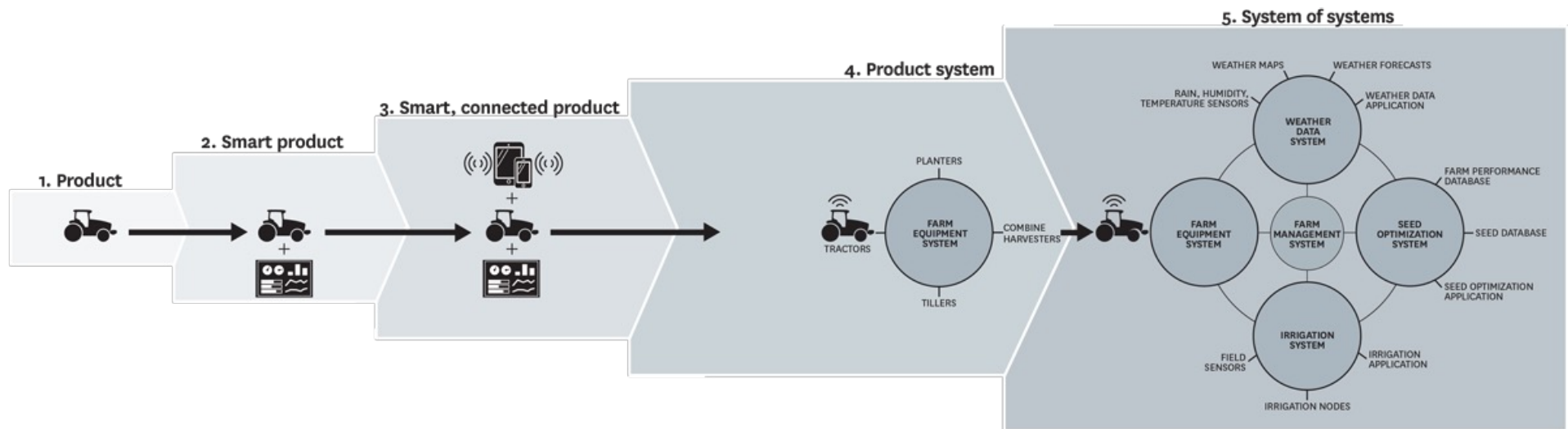
From HBR article by Porter and Heppelmann

Autonomy

- More-sophisticated products are able to learn about their environment, self-diagnose their own service needs, and adapt to users' preferences. Autonomy not only can reduce the need for operators but can improve safety in dangerous environments and facilitate operation in remote locations.

- Joy Global's Longwall Mining System, for example, is able to operate autonomously far underground, overseen by a mine control center on the surface. Equipment is monitored continuously for performance and faults, and technicians are dispatched underground to deal with issues requiring human intervention.

From HBR article by Porter and Heppelmann

We Used to Make Tractors!

From HBR article by Porter and Heppelmann

To build such system of systems, systems need to interoperate well with others.

Principles from the World Wide Web, provide us with guidance on the construction of interoperable systems.

Digital Twins - A Key Architectural Idea

- An important idea for the IoT architecture is to register every device with a cloud service and communicate with that service alone. From the article on "Enabling the Internet of Things"
- Users or other computers would then interact with this service to determine the device's status or control its behavior.
- This approach provides economics of scale, automatic backup of data, and security provided by providers on the cloud.
- See General Electric's PREDIX platform. Digital Twins are described as :
    - providing a software representation of a physical asset.
    - providing a single source of truth about the asset
    - holding data about past and present state, condition, and performance of the asset and providing analytics
- We know how to interact with objects made available on the Web.
- The web has been hugely successful.

Types of Connectivity

- One-to-one: An individual product connects to the user, manufacturer or another product.

- Examples: a car connected to a diagnostic machine, a light sensor communicates with a
  window shade.

- Many-to-one: A central system collects data from many products simultaneously. For example,
  a Tesla car makes reports to a single system – monitoring performance, providing
  remote services and upgrades.

- Many-to-many: Multiple products connected to many other types of products and to the cloud
  as well. For example, automated tillers inject nitrogen fertilizer at precise depths and intervals,
  and seeders follow, placing corn seeds directly in the fertilized soil.

Summary: Smart and Connected Products

- IT is revolutionizing products.

- Once, solely mechanical and electrical parts.

- Now, complex systems with connectivity.

- Smart, connected products are unleashing a new era of competition.

- Some companies will ask "What business am I in ?"

- Many products will contain a computer or microcontroller and have a representation in the cloud (Digital Twin).

- This changes product design, marketing, manufacturing, and after sales service.

- This creates opportunities for rich data analytics and machine learning.

- Security and privacy concerns are significant but will probably not be a show stopper.

- Lessons learned from the WWW may help us achieve a more interoperable IOT.

- We can build a Web of Things.