Internet of Everything

Part One

-- Adapted from M. Porter's article:

https://hbr.org/2014/11/how-smart-connected-products-are-transforming-competition

November 2014 Issue

Topics

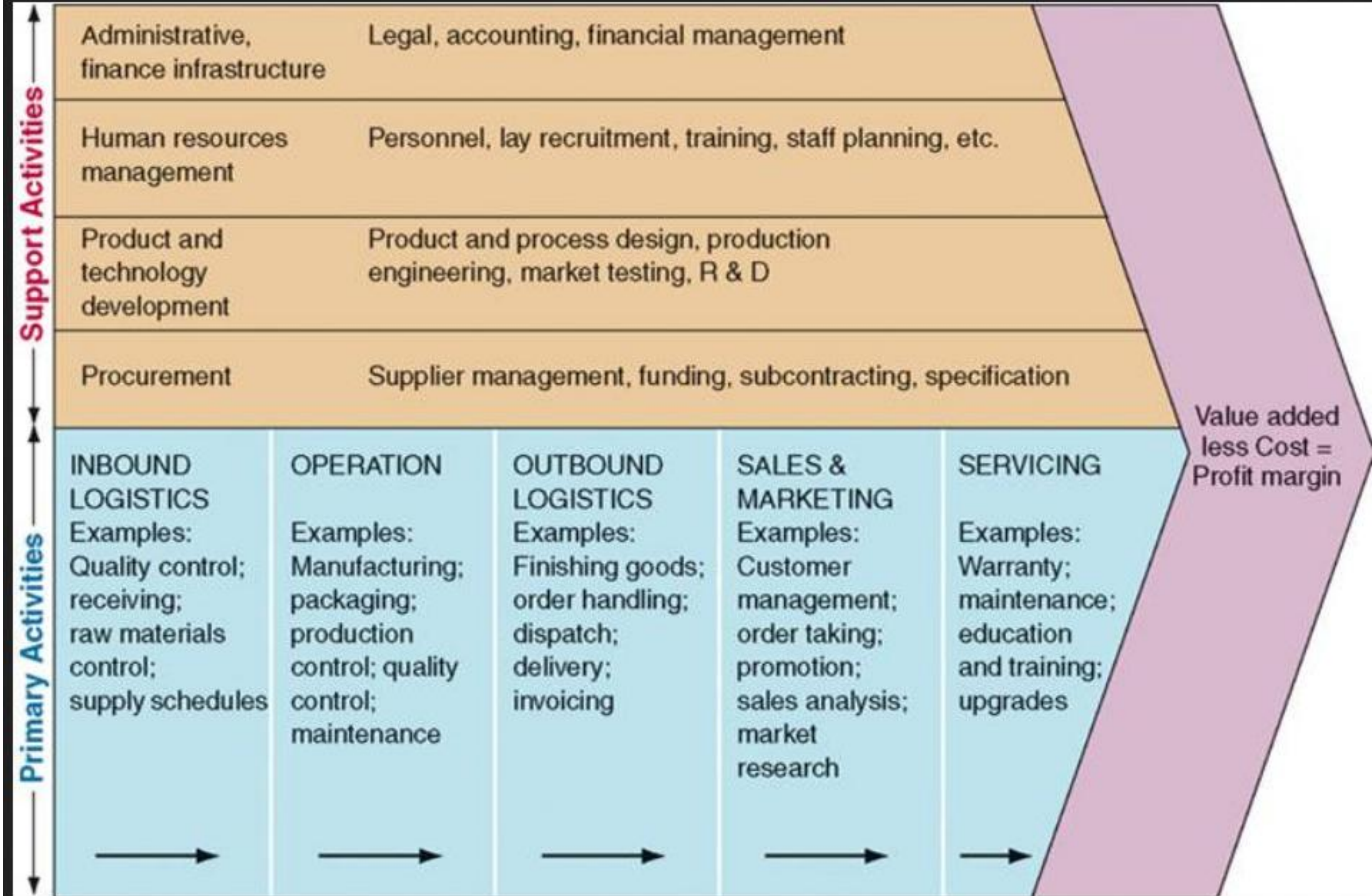
- Internet of Things
- Three IT Waves
- Smart Connected Products
- Communications: Three Forms
- Why now?
- Smart Capabilities
  - Monitoring
  - Control
  - Optimization
  - Autonomy

'Internet of Things'□

- Reflects growing number of smart, connected products
- New opportunities .
  - Internet: mechanism for transmitting information.
- What makes smart, connected products fundamentally different is not the Internet, but the changing nature of the 'things'□
  - That is, expanded capabilities of smart, connected products and their related data creates a new environment
- Competitive transformation taking place now!

First IT Wave: ‘60s and ‘70s

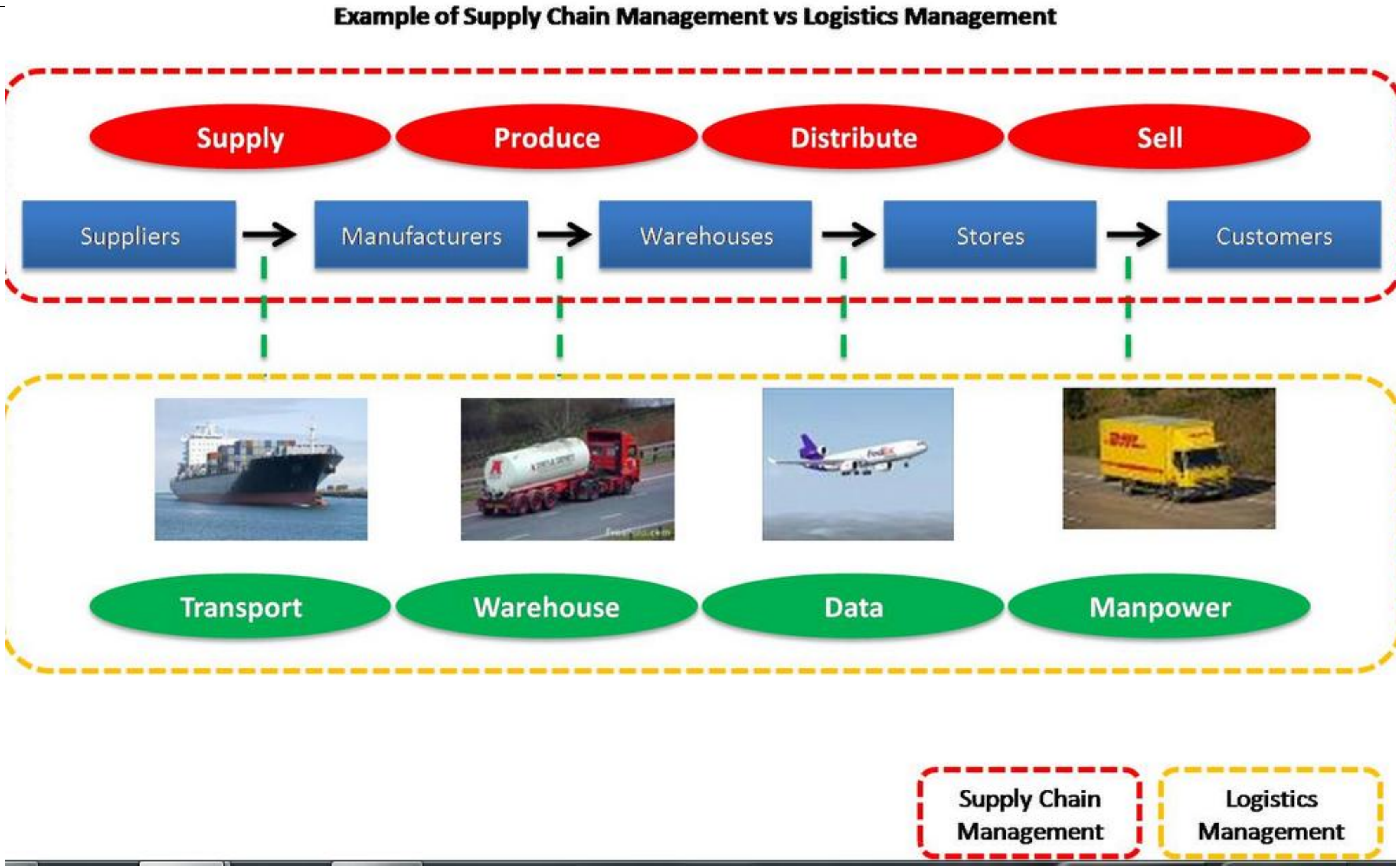
- Automated individual value chain activities
  - Order processing
  - Bill paying
  - Computer-aided design CAD
  - Manufacturing resource planning MRP…
- Productivity of activities dramatically increased
  - Huge amounts of new data captured and analyzed.
- Across companies, processes become standardized.
- Problem becomes: how to capture IT's operational benefits while maintaining distinctive strategies?



IT First Wave: Automated individual activities in the value chain

Second Wave: ‘80s and ‘90s

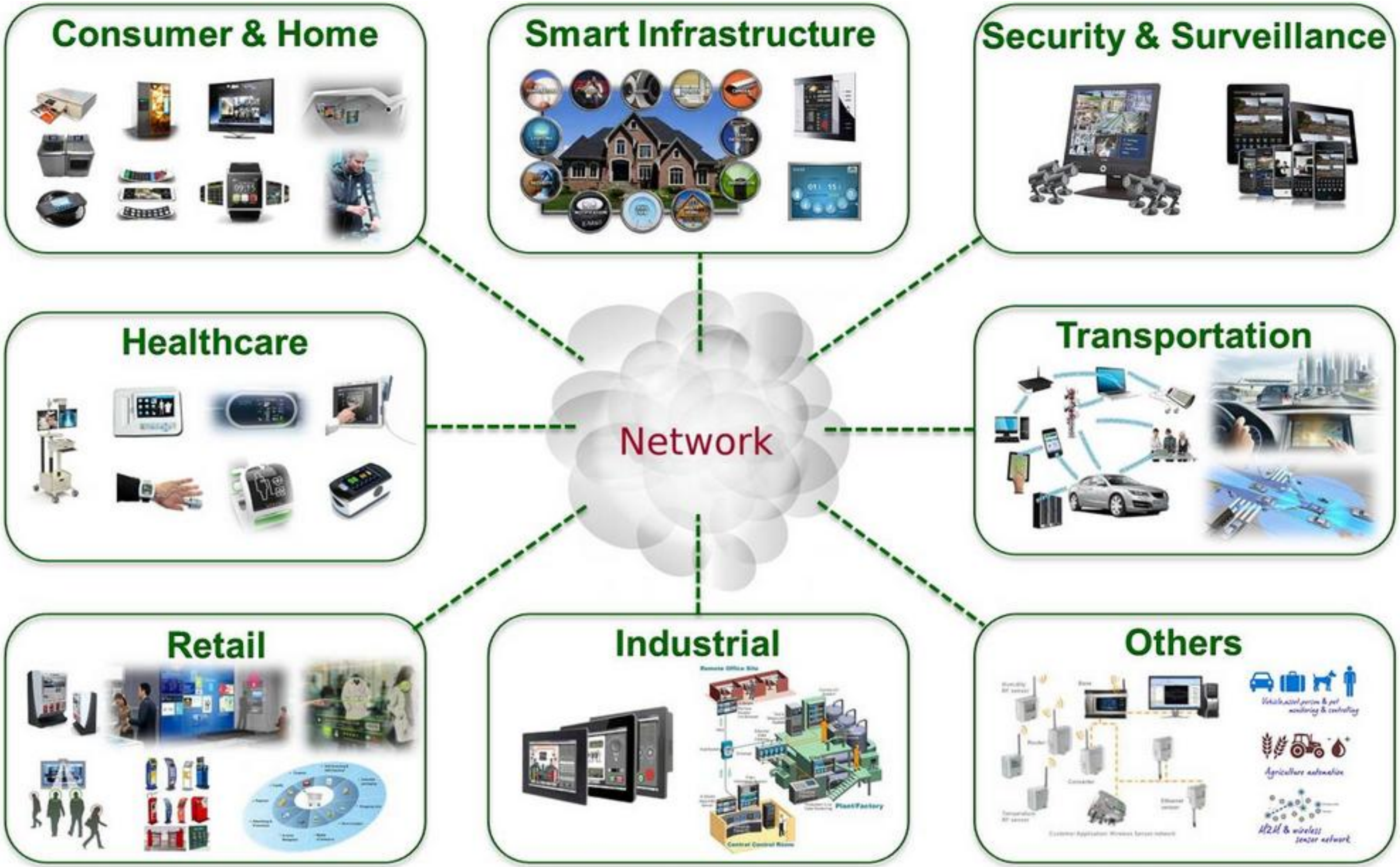
- Rise of the Internet
- Inexpensive/ubiquitous connectivity.
- Enabled coordination and integration across individual activities:
  - Outside suppliers
  - Channels
  - Customers
  - Across geography.
- Allowed firms to closely integrate globally distributed supply chains.



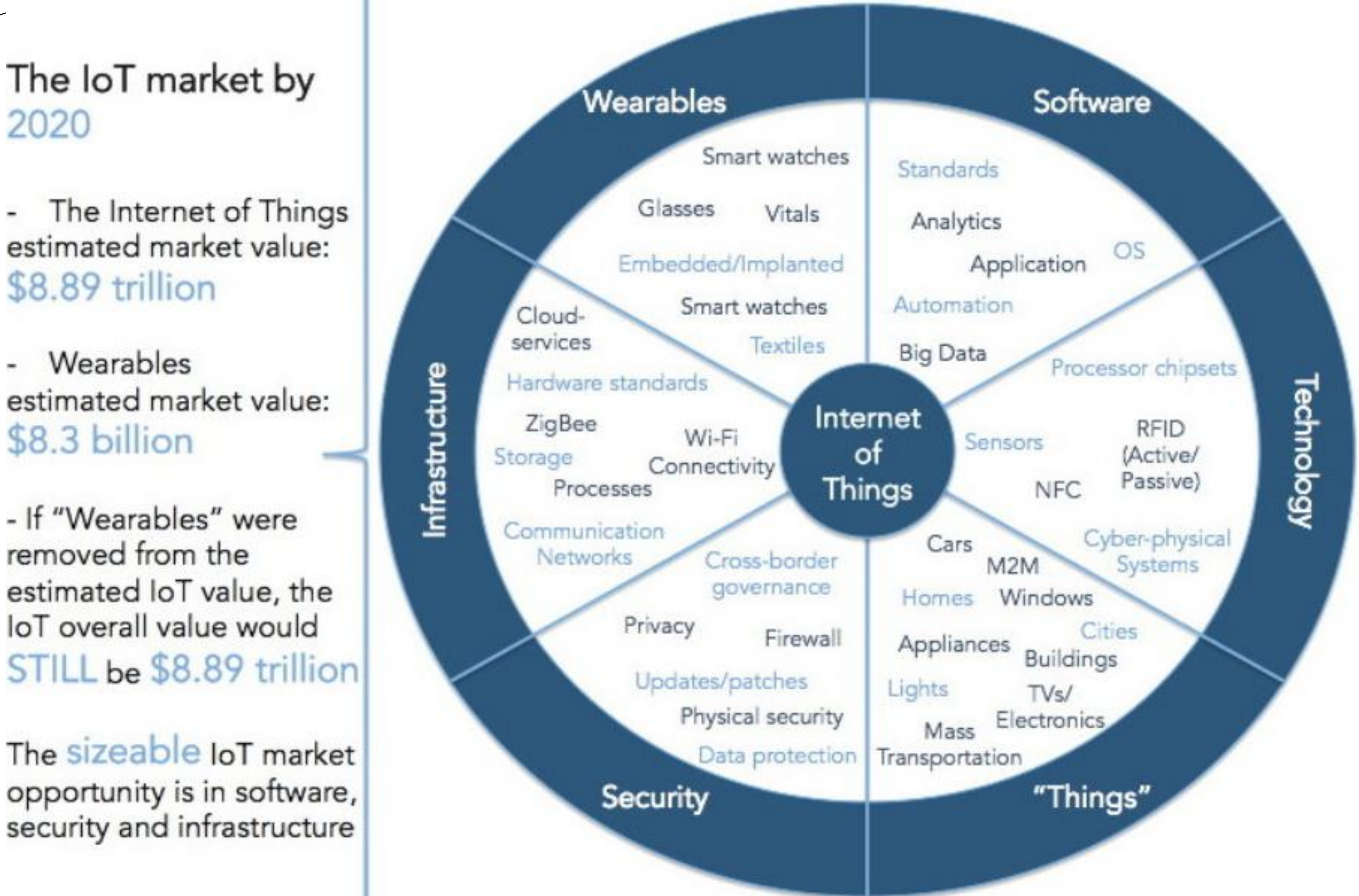
IT Second Wave: Logistics and Supply Chain Management

Third Wave: IT becomes Part of Product

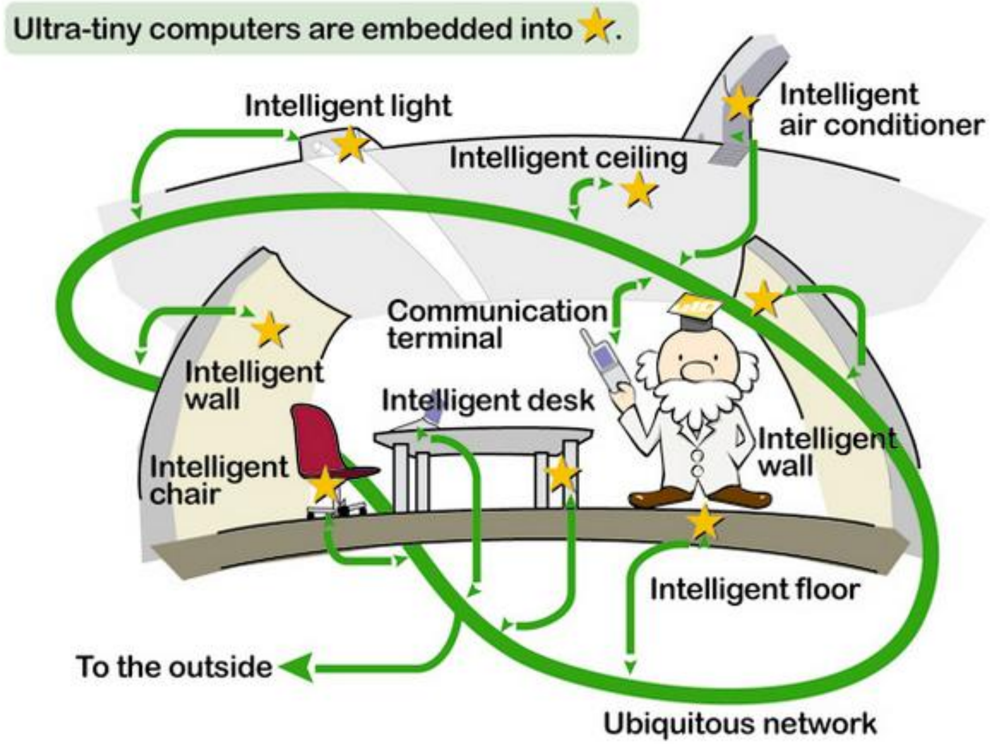
- Products get embedded sensors, processors, software, and connectivity.
- Smart products lead to product clouds that store product data
  - Creates potential for Big Data analysis
- Which leads to dramatic improvements in product functionality and performance.
- Potential to be the biggest wave yet, with even more:
  - Innovation
  - Productivity gains
  - Economic growth.



Third Wave: Internet of Everything



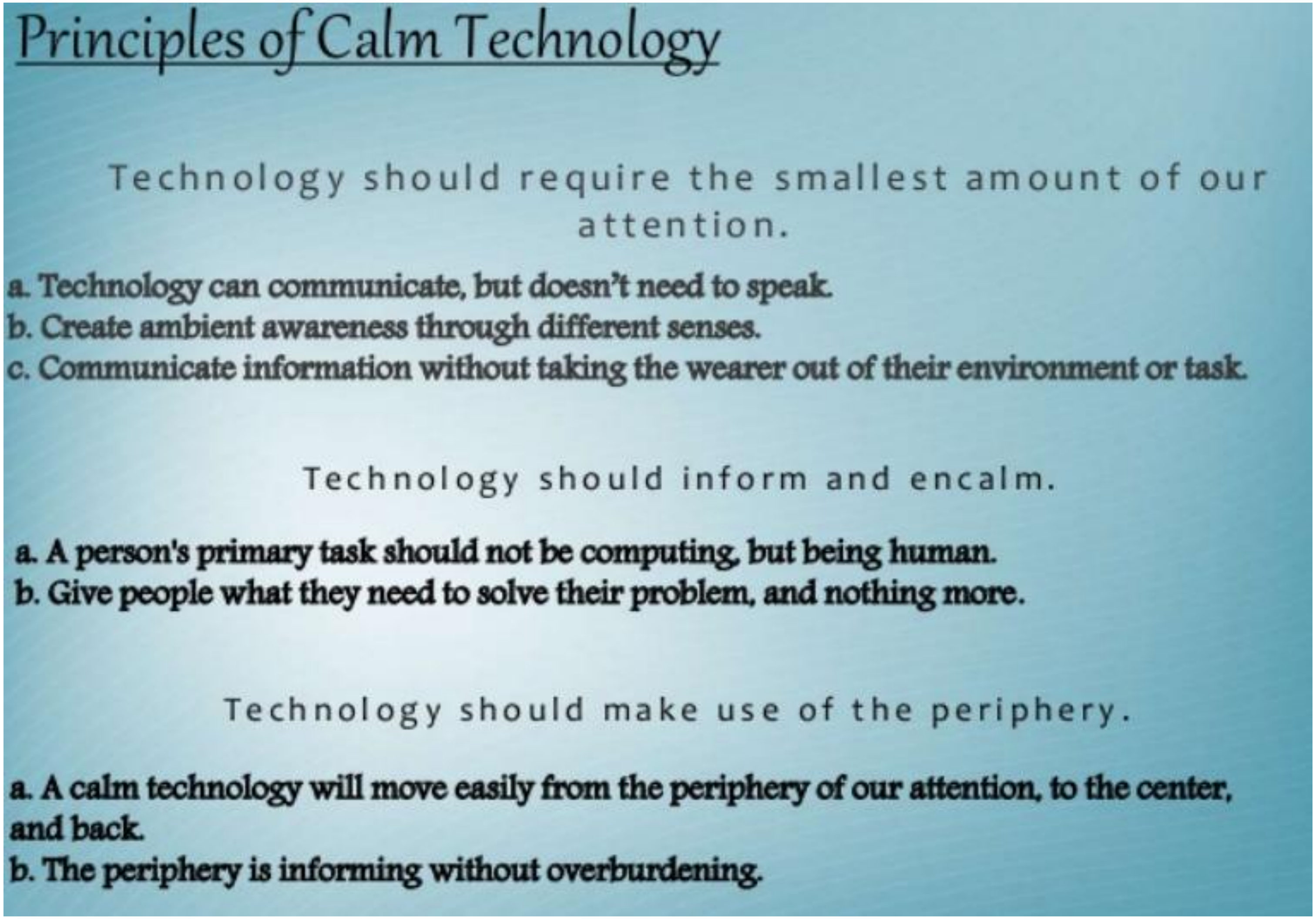
Third Wave: Internet of Everything



Ubiquitous Computing Principles

Ubiquitous computing principles:

- Purpose of computer is to help you do something else.
- Best computer is a quiet, invisible servant.
- The more you can do by intuition the smarter you are…
  - Computer should extend your unconscious.
- Technology should create calm.



"The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it." --Mark Weiser

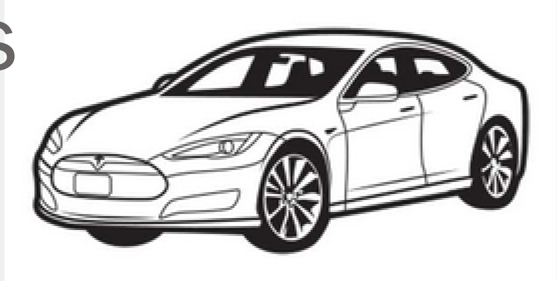
"The Computer for the Twenty-First Century" (Scientific American, 1991, pp. 66–75)

Smart, Connected Products Three Core Components

1. Physical
2. 'Smart' ☐
3. Connectivity

- Physical components comprise the product's mechanical and electrical parts.
- In a car, for example, physical components include engine block, tires, and batteries.

Tesla



A Tesla vehicle in need of repairs can autonomously call for a corrective software download, or, if necessary, send a notification to the customer with an invitation for a valet to pick up the car and deliver it to a Tesla facility.

Smart Components

- Sensors, microprocessors, data storage, controls, software…
  - Typically with embedded operating system and enhanced user interface.
- In a car, smart components include:
  - Engine control unit ECU
  - Antilock braking system
  - Rain-sensing windshields with automated wiper
  - Touch screen displays.
- In many products, software replaces some hardware components or enables a single physical component to perform at a variety of levels.

Connectivity: Three Modes

One-to-one

- Individual product connects to user, manufacturer, or another product through a port or other interface
  - Car with computer based diagnostics.

One-to-many

- Central system continuously or intermittently connected to many products simultaneously.
  - Tesla automobiles connected to a single manufacturer system that monitors performance and accomplishes remote service and upgrades.

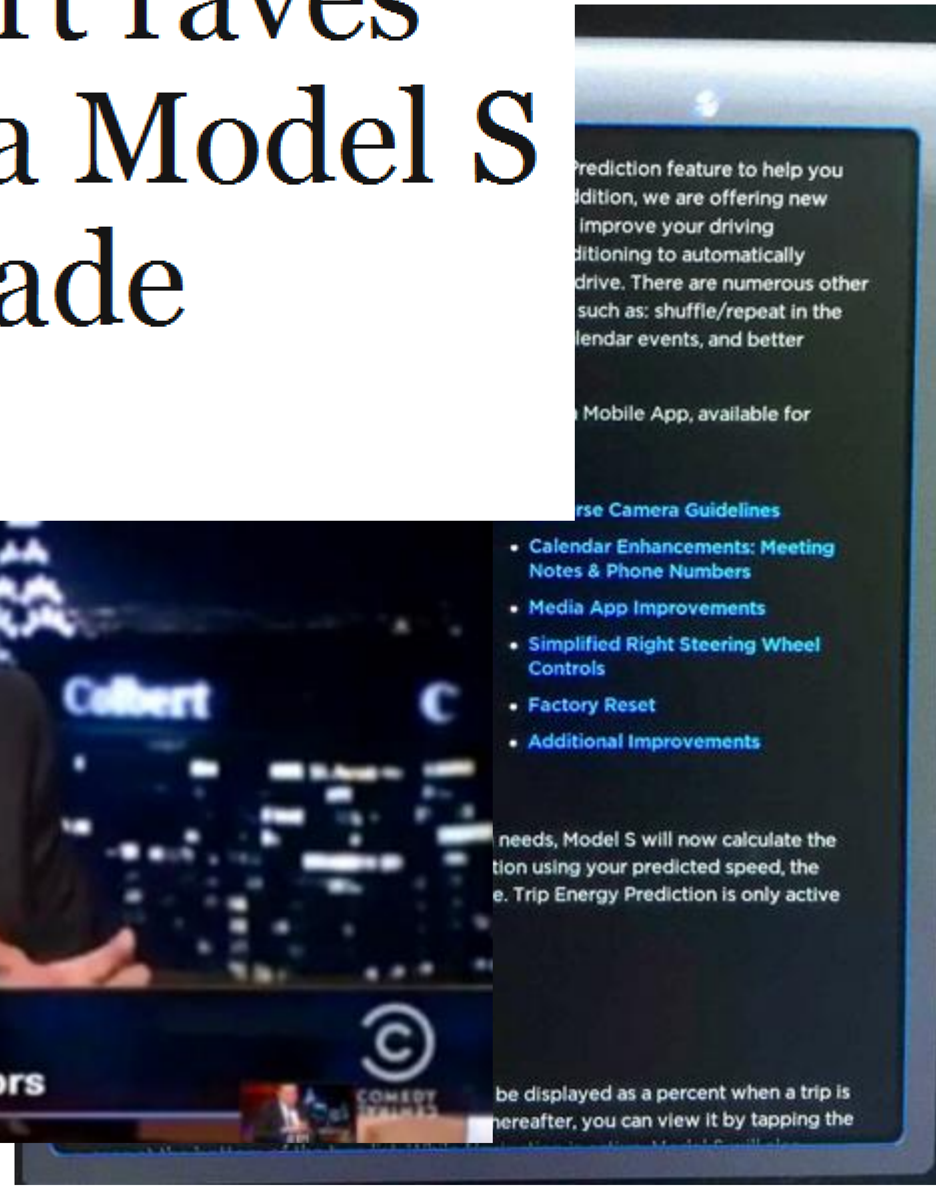
Many-to-many

- Multiple products connect to many other types of products and often also to external data sources.

No longer is a product just a product. Now, it is a product and a product cloud.

Stephen Colbert raves about the Tesla Model S autopilot upgrade

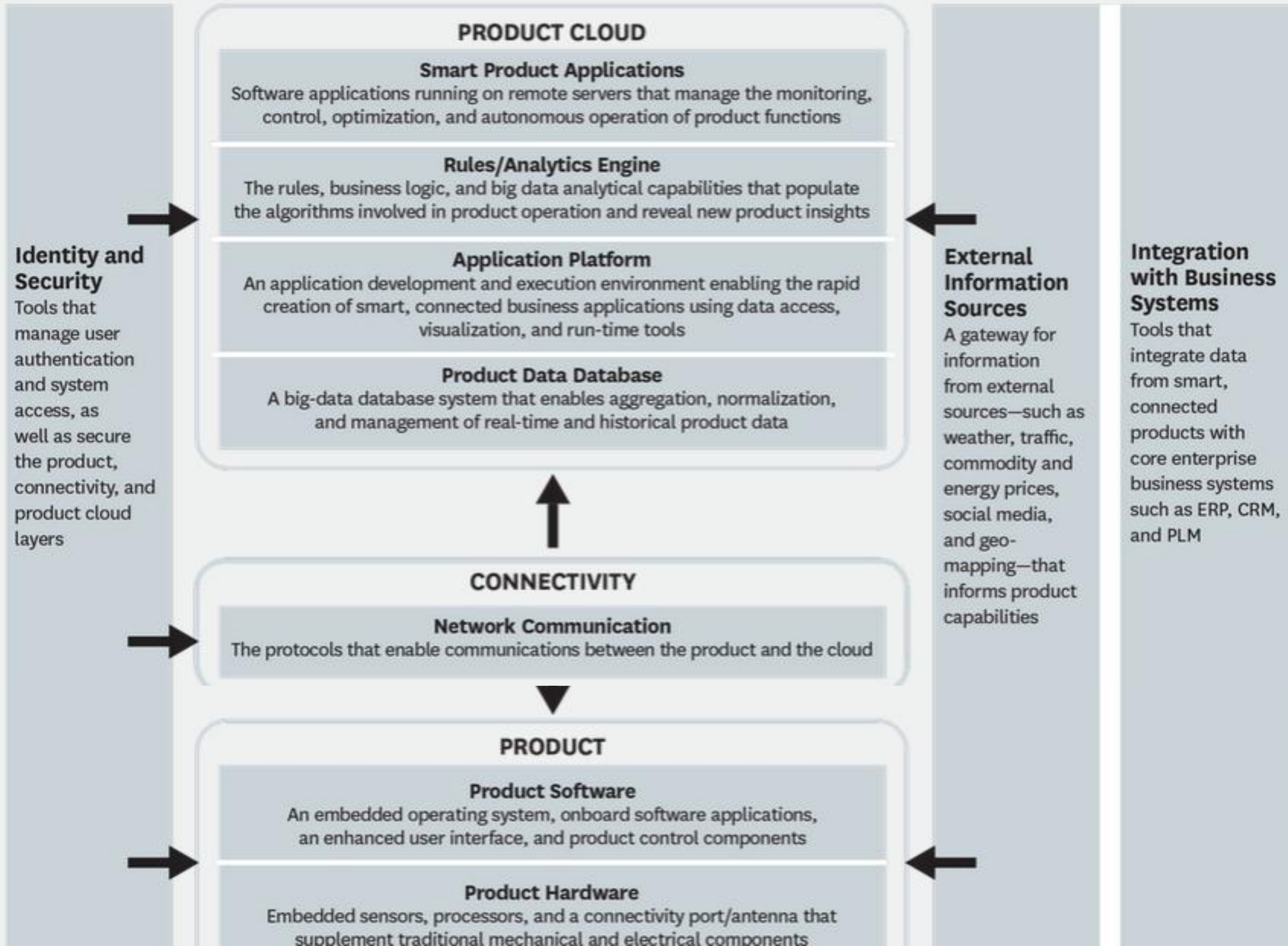
by Michal Addady @FortuneMagazine



https://www.youtube.com/watch?v=9005htLHWuE

The New Technology Stack

Smart, connected products require companies to build and support an entirely new technology infrastructure. This "technology stack" is made up of multiple layers, including new product hardware, embedded software, connectivity, a product cloud consisting of software running on remote servers, a suite of security tools, a gateway for external information sources, and integration with enterprise business systems.



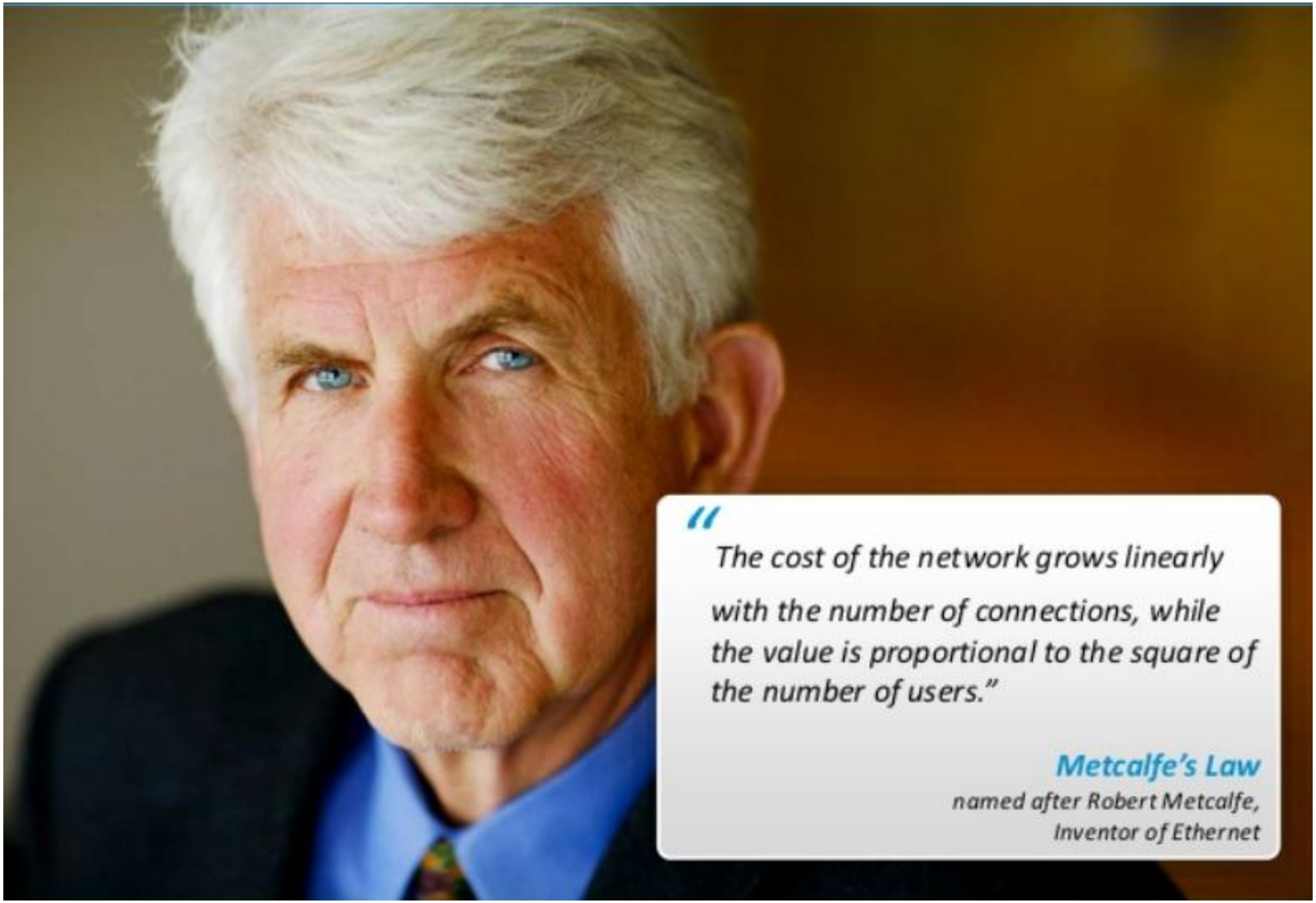
Why Now? (One)

- Moore's Law (Porter's 'breakthroughs'), each year brings:
  - Better performance
  - More miniaturization
  - Less required energy
  - More efficient sensors
  - Better batteries
- Compact, low-cost computer processing power and data storage
  - Computers/controllers part of product
- Cheap connectivity
  - Ubiquitous, low-cost wireless connectivity
- Tools that enable rapid software development

Why Now? (Two)

- Big Data Analytics
  - Examination of large data sets containing a variety of data types to uncover hidden patterns, unknown correlations, market trends, customer preferences and other useful business information.
- IPv6
  - Tillion trillion trillion internet addresses
  - Potentially, better security support
  - Simplified handoffs as devices move across networks
  - Allow devices to request addresses autonomously.

Metcalfe’s Law



Data Collection

- Now, possible to collect, analyze, and share potentially huge amounts of longitudinal data generated inside and outside of products.
  - Never previously possible.
  - Full duplex communications…
- Leads to 'Big Data"…
- Leads to new capabilities including:
  - Monitoring
  - Control
  - Optimization
  - Autonomy

Capabilities of Smart, Connected Products

The capabilities of smart, connected products can be grouped into four areas: monitoring, control, optimization, and autonomy. Each builds on the preceding one; to have control capability, for example, a product must have monitoring capability.

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

Intelligence and Connectivity

- Facilitates new capabilities.
  1. Monitoring
  2. Control
  3. Optimization
  4. Autonomy
- Each capability valuable by its self
  - Also sets stage for next level.
- Potentially, a product can incorporate all four.

Monitoring

- Smart, connected products enable comprehensive monitoring of a product's
  - Condition
  - Operation
  - External environment
- Can alert users to changes in circumstances or performance.
- Also allows companies and customers to track a product's operating characteristics and history
  - Enables a better understand how product is actually used.

Data Gathering Implications

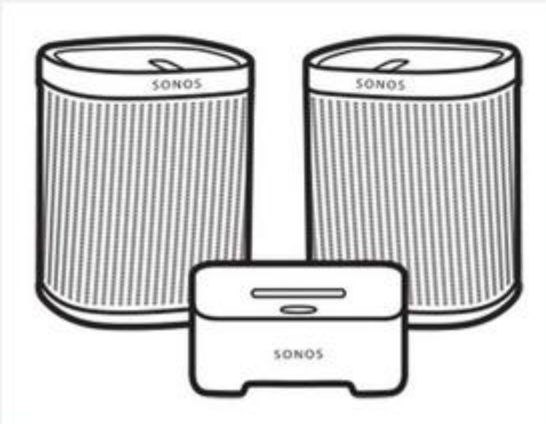
- Design
  - Reduce overengineering
- Market segmentation
  - Analyze usage patterns by customer type
- After-sale service
  - Dispatch right technician with right part
  - Improve first-time fix rate.
- Monitoring data may also reveal:
  - Warranty compliance issues
  - New sales opportunities.
    - Such as the need for additional product capacity because of high utilization.

Control

Through:

- remote commands or
- algorithms built into the device or residing in the product cloud.

Sonos



The company's wireless music systems place the user interface in the cloud, enabling users to control the portable device from a smartphone.

Control Through Embedded Software

- Embedded in product, or in cloud, allows customization of product performance to a degree that previously was not cost effective or often even possible.
- Same technology also enables users to control and personalize their interaction with the product in many new ways.
  - For example, users can adjust their Philips Lighting hue lightbulbs via smartphone:
    - Turn them on and off
    - Program them to blink red if an intruder is detected
    - Dim them slowly at night.

Optimization

Wind Turbine

When smart wind turbines are networked, software can adjust the blades on each one to minimize impact on the efficiency of turbines nearby.

- Flow of monitoring data from smart, connected products, coupled with capacity to control product operation, allows companies to optimize product performance in ways not previously possible.
- Smart, connected products can apply algorithms and analytics to in-use or historical data to dramatically improve:
  - Output
  - Utilization
  - Efficiency.

Real Time Monitoring

- Enables firms to optimize service by performing preventative maintenance when failure is imminent and accomplishing repairs remotely.
  - Reduce downtime and need to dispatch repair personnel.
- Even when on-site repair is required, you can reduce service costs and improve first-time fix rates with advance information concerning:
  - What is broken
  - What parts are needed
  - How to accomplish the fix.
- Diebold, for example, monitors many of its automated teller machines for early signs of trouble.

ATM Example

- Malfunctioning ATM:
  - If possible, repair machine remotely
  - Or deploys technician with a detailed problem diagnosis, a recommended repair process, and, needed parts.
- Diebold’s ATMs can be updated remotely

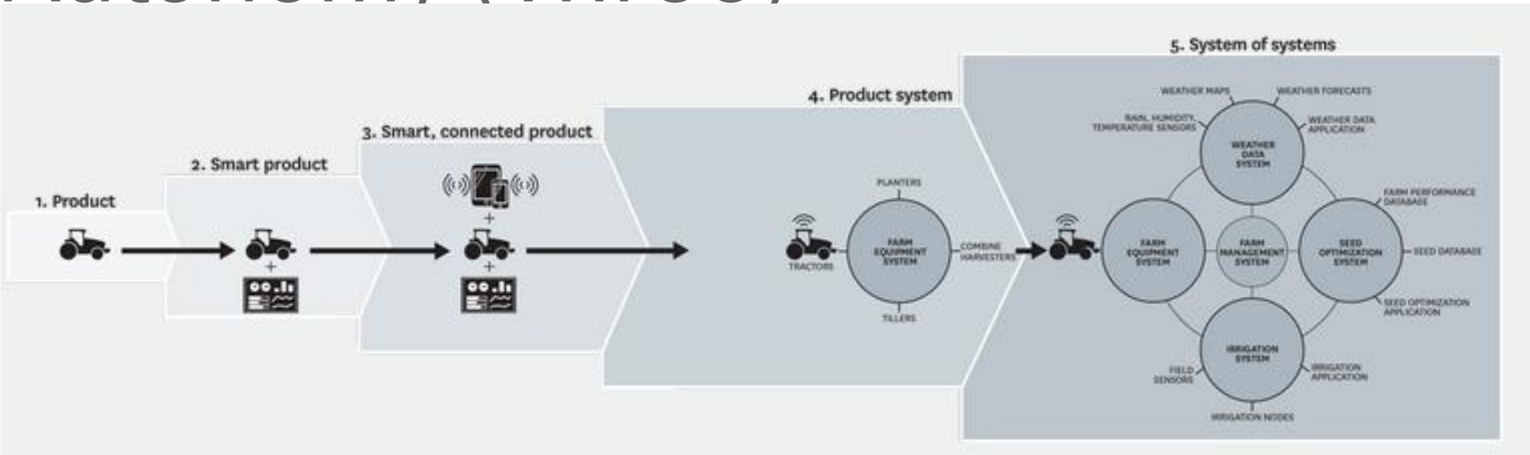
Autonomy

- Monitoring, control, and optimization capabilities combine to allow smart, connected products to achieve a previously unattainable level of autonomy.
  - At the simplest level is autonomous product like that of the iRobot Roomba.
- More-sophisticated products are able to:
  - Learn about their environment
  - Self-diagnose their own service needs
  - 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.

Autonomy (Two)

- Autonomous products can also act in coordination with other products and systems.
  - Value of these capabilities can grow exponentially as more and more products become connected. (Metcafe's Law.)
  - For example, the energy efficiency of the electric grid increases as more smart meters are connected, allowing the utility to gain insight into and respond to demand patterns over time.
- Ultimately, products can function with complete autonomy
  - Applying algorithms that utilize data about their performance and their environment—including the activity of other products in the system—and leveraging their ability to communicate with other products.

Autonomy (Three)



- Human operators merely monitor performance or watch over the fleet or the system, rather than individual units.
  - 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 monitored continuously for performance and faults, and technicians are dispatched underground to deal with issues requiring human intervention.

Questions?

- *Porter continues with "Reshaping Industry Structure"…*