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CITS 5506
The Internet of Things
Lecture 07

Smart Products & their effects on the Industry

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Smart Products – Transforming Businesses

- Conventional Products were composed solely of mechanical and electrical parts in the past.

- But now Products have become complex systems that combine
  - hardware
  - sensors
  - data storage
  - Computing entity
  - software
  - connectivity

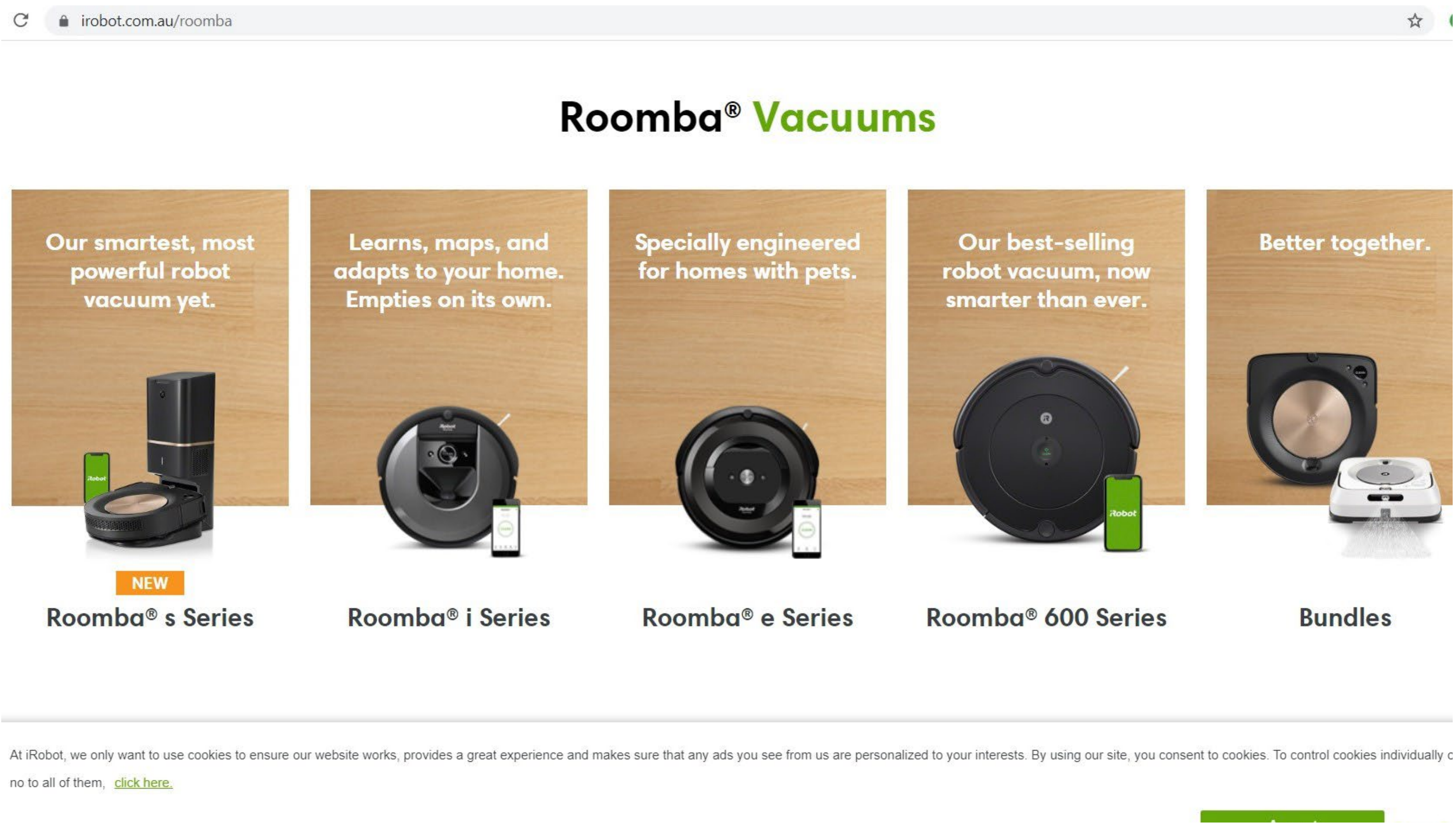
Smart Products – Transforming Businesses

Smart, connected products offer opportunities for

- New functionality
- Far greater reliability
- Much higher product utilization
- Capabilities that cut across and transcend traditional product boundaries.

IoT Applications: Smart Vacuum Cleaner

Robotic Vacuum Cleaners



Spying Vacuum Cleaners

https://7news.com.au/technology/be-very-wary-spying-robot-vacuum-sparks-expert-warning-on-common-household-items-c-12232066

Smart Products – Transforming Businesses

- The changing nature of products is also disrupting value chains, forcing companies to rethink and retool nearly everything they do internally.

- The idea of the value chain is based on the process view of organizations, the idea of seeing a manufacturing (or service) organization as a system, made up of subsystems each with inputs, transformation processes and outputs.

Smart Products – Transforming Businesses

- Inputs, transformation processes, and outputs involve the acquisition and consumption of resources – money, labour, materials, equipment, buildings, land, administration and management. How value chain activities are carried out determines costs and affects profits.

- These new types of products alter industry structure and the nature of competition, exposing companies to new competitive opportunities and threats. They are reshaping industry boundaries and creating entirely new industries.

Smart Products – Transforming Businesses

- Smart, connected products raise a new set of strategic choices related to
  - How value is created and captured
  - How the huge amount of new (and sensitive) data they generate is utilized and managed
  - How relationships with traditional business partners are redefined
  - What role companies should play as industry boundaries are expanded

Smart Products – Transforming Businesses

- What makes smart, connected products fundamentally different is not the internet, but the changing nature of the "things."

- It is the expanded capabilities of smart, connected products and the data they generate that are ushering in a new era of competition.

Smart Products – Transforming Businesses

- Before the advent of modern information technology, products were mechanical and activities in the value chain were performed using manual, paper processes and verbal communication.

- The first wave of IT, during the 1960s and 1970s, automated individual activities in the value chain, from **order processing and bill paying to computer-aided design and manufacturing resource planning**. This resulted in increase in productivity.

Smart Products – Transforming Businesses

- The rise of the internet, with its inexpensive and ubiquitous connectivity, unleashed the second wave of IT-driven transformation in the 1980s and 1990s.

- This enabled **coordination and integration across individual activities; with outside suppliers**, **channels, and customers; and across geography**. It allowed firms, for example, to closely integrate globally distributed supply chains.

Smart Products – Transforming Businesses

- The first two waves gave rise to huge productivity gains and growth across the economy. While the value chain was transformed, however, **products** themselves were largely **unaffected**.

- Now, Information Technology is becoming an integral part of the product itself. Embedded sensors, processors, software, and connectivity in products, data storage and analysis, resulting in improvements in product functionality and performance.

- Massive amounts of new product-usage data enable many of these improvements.

Smart Products – Transforming Businesses

- There will be new and better products.

- In addition, production process will alter by changing product design, marketing, manufacturing, and after-sale service and by creating the need for new activities such as product data analytics and security.

Smart Products

Smart, connected products have three core elements:

- Physical components
- "Smart" components
- Connectivity components

Smart components amplify the capabilities and value of the physical components.

Connectivity amplifies the capabilities and value of the smart components and enables some of them to exist outside the physical product itself.

Smart Products

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

- Smart components comprise the sensors, microprocessors, data storage, controls, software, and typically an embedded operating system and enhanced user interface. In a car, for example, smart components include the engine control unit, antilock braking system, rain-sensing windshields with automated wipers, and touch screen displays.

- In many products, software replaces some hardware components or enables a single physical device to perform at a variety of levels.

Smart Products : Connectivity

- Connectivity components comprise the ports, antennae, and protocols enabling wired or wireless connections with the product.

- Connectivity takes three forms, which can be present together:
  - **One-to-one**: An individual product connects to the user, the manufacturer, or another product through a port or other interface. Example, when a car is hooked up to a diagnostic machine.

Smart Products : Connectivity

- **One-to-many**: A central system is continuously or intermittently connected to many products simultaneously. For example, many Tesla automobiles are 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. An array of types of farm equipment are connected to one another, and to geo-location data, to coordinate and optimize the farm system. For example, automated tillers inject nitrogen fertilizer at precise depths and intervals, and seeders follow, placing corn seeds directly in the fertilized soil.

Smart Products : Connectivity

- Connectivity serves a dual purpose. First, it allows information to be exchanged between the product and its operating environment, its maker, its users, and other products and systems.

- Second, connectivity enables **some functions** of the product to exist **outside** the physical device, in what is known as the product cloud. For example, in Bose's new Wi-Fi system, a smartphone application running in the product cloud streams music to the system from the internet.

- To achieve high levels of functionality, all three types of connectivity (one to one, one to many, many to many) are necessary.

Smart Products

- In the energy sector, ABB's smart grid technology enables utilities to analyze huge amounts of real-time data across a wide range of generating, transforming, and distribution equipment (manufactured by ABB as well as others), such as:
  - Changes in the temperature of transformers and secondary substations.

- This alerts utility control centers to possible overload conditions, allowing adjustments that can prevent blackouts before they occur.

*ABB (ASEA Brown Boveri) Ltd is a Swedish–Swiss multinational corporation headquartered in Zürich, Switzerland, operating mainly in robotics, power, heavy electrical equipment, and automation technology areas.

Smart Products

https://new.abb.com/news/detail/110537/converting-adelaide-metro-into-australias-first-ever-diesel-hybrid-train-fleet

Smart Products

- Smart, connected products are emerging across all manufacturing sectors.

- In heavy machinery, Schindler's PORT (Personnel Occupant Requirement Terminal) Technology reduces elevator wait times by as much as 50% by:
  - Predicting elevator demand patterns
  - Calculating the fastest time to destination
  - Assigning the appropriate elevator to move passengers quickly

Schindler's PORT(Personnel Occupant Requirement Terminal) Technology

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https://www.schindler.com/en/innovations/schindler-port.html

Getting Started | UWA Intranet | https://fpcv.cs.columb... | Computer-Vision-Vide... | WACE ATAR resources | Urdu Thesaurus | Class 10th Math Book ... | Other Bookmarks

Schindler

Elevators | Escalators & Moving walkways | Services | Careers

Schindler PORT

Schindler PORT optimizes traffic flow, alleviates congestion, and reduces elevator wait times while offering personalized service and access control.

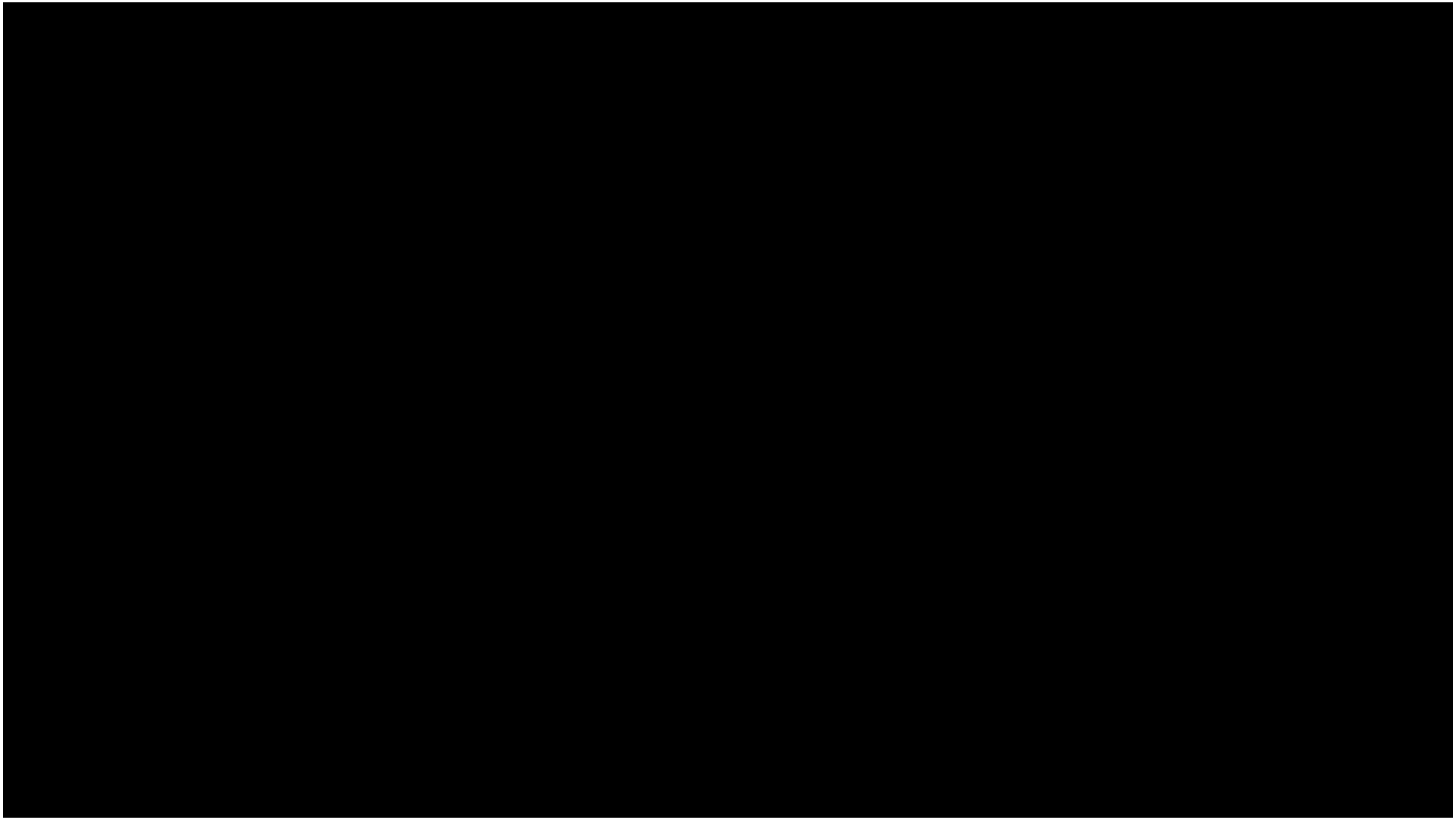
Schindler myPORT

With the Schindler myPORT smartphone app, users gain convenience, security, and comfort with features that can be programmed to verify user identity and summon an elevator based on user needs and preferences.

Destination interface

A destination interface elevator modernization converts conventional controls to destination dispatching, giving you all the benefits of Schindler PORT quickly and easily.

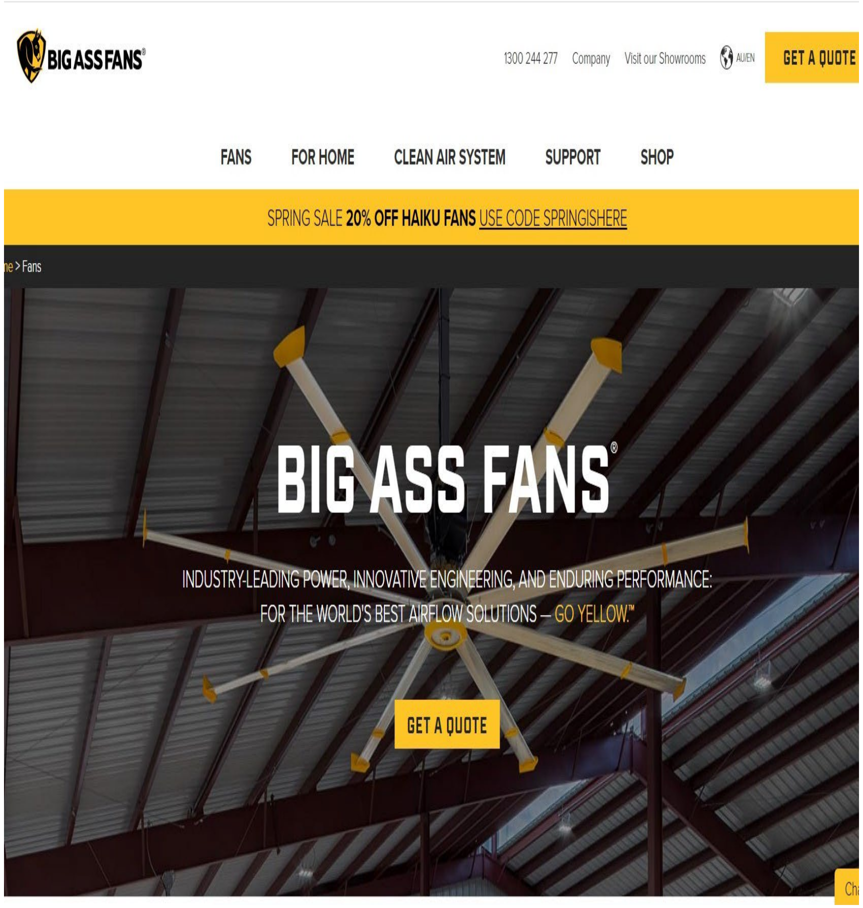
Schindler PORT Technology



Smart Products

In consumer goods, Big Ass ceiling fans sense and engage automatically:

- When a person enters a room
- Regulate speed on the basis of temperature and humidity
- Recognize individual user preferences and adjust accordingly.



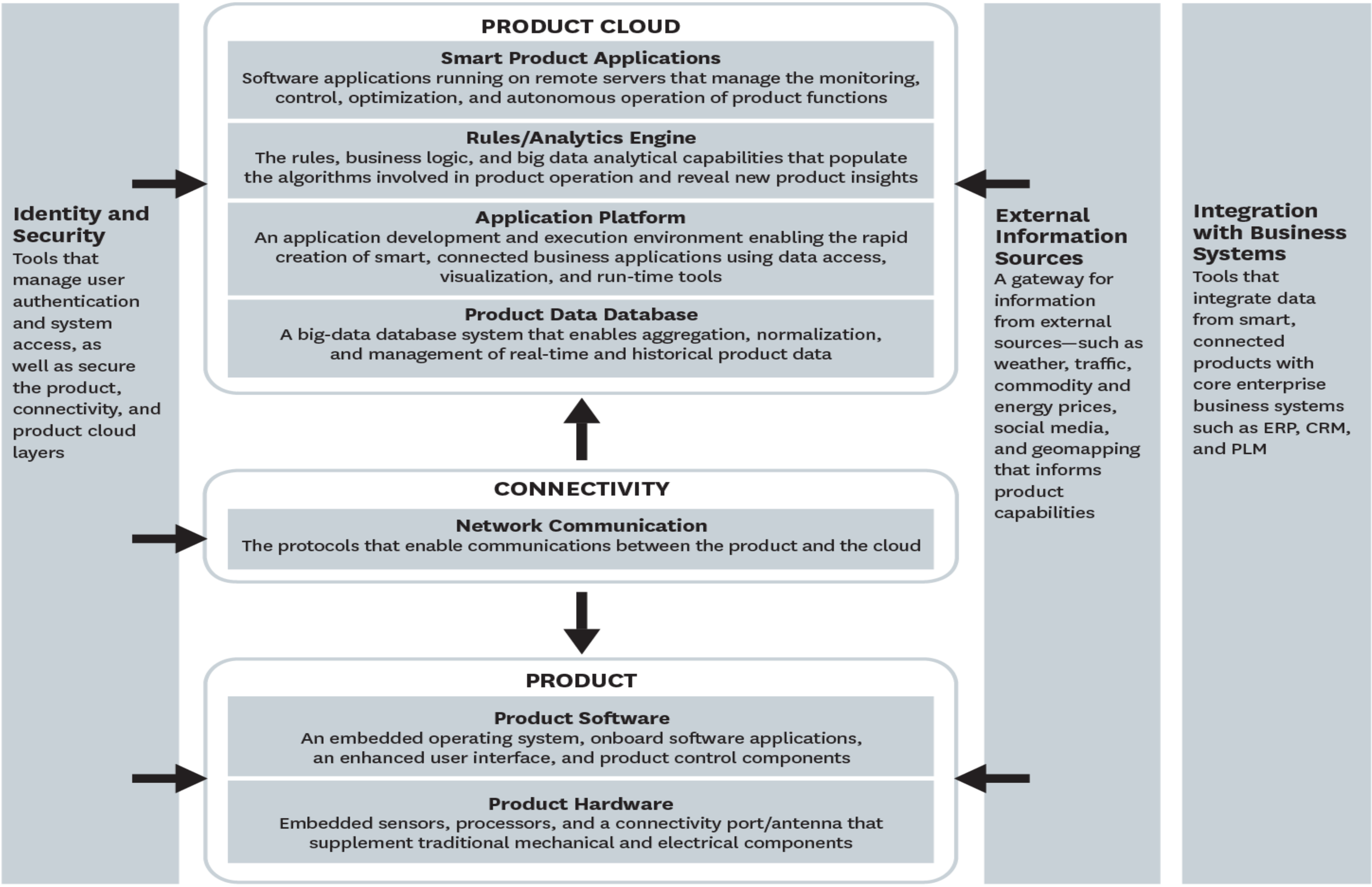
Smart Products : Tech Infrastructure

Smart, connected products require that companies build an entirely new technology infrastructure, consisting of a series of layers known as a “technology stack”.

Smart Products : Tech Infrastructure

This technology stack includes :

- Modified hardware
- Software applications
- Operating system embedded in the product itself
- Network communications to support connectivity
- Product cloud (software running on the manufacturer’s or a third-party server) containing the product-data database
- A platform for building software applications
- An analytics platform
- Smart product applications that are not embedded in the product



PRODUCT CLOUD
Smart Product Applications
Software applications running on remote servers that manage the monitoring, control, optimization, and autonomous operation of product functions
Rules/Analytics Engine
The rules, business logic, and big data analytical capabilities that populate the algorithms involved in product operation and reveal new product insights
Application Platform
An application development and execution environment enabling the rapid creation of smart, connected business applications using data access, visualization, and run-time tools
Product Data Database
A big-data database system that enables aggregation, normalization, and management of real-time and historical product data
CONNECTIVITY
Network Communication
The protocols that enable communications between the product and the cloud
PRODUCT
Product Software
An embedded operating system, onboard software applications, an enhanced user interface, and product control components
Product Hardware
Embedded sensors, processors, and a connectivity port/antenna that supplement traditional mechanical and electrical components
Identity and Security
Tools that manage user authentication and system access, as well as secure the product, connectivity, and product cloud layers
External Information Sources
A gateway for information from external sources—such as weather, traffic, commodity and energy prices, social media, and geomapping that informs product capabilities
Integration with Business Systems
Tools that integrate data from smart, connected products with core enterprise business systems such as ERP, CRM, and PLM

Smart Products : Tech Infrastructure

All the layers are accessed through an identity and security structure, a gateway for accessing external data, and tools that connect the data from smart, connected products to other business systems. For example, ERP(Enterprise resource planning), Product lifecycle management (PLM) and CRM (Customer relationship management) systems.

- **ERP** system track business resources (cash, raw material, production capacity, orders and payroll etc.
- **PLM** is the process of managing the entire life cycle of a product from its inception through the engineering, design, manufacture as well as service and disposal of manufactured products.
- **CRM** manages the company's relationship and interaction with customers and potential customers.

Smart Products : Tech Infrastructure

- IoT enables not only rapid product application development and operation but the collection, analysis, and sharing of the potentially huge amounts of data generated inside and outside the products that has never been available before.

- Building and supporting the technology stack for smart, connected products requires substantial investment and a range of new skills—such as software development, systems engineering, data analytics, and online security expertise—that were rarely found in manufacturing companies in the past.

Smart Products Capabilities Areas

Capabilities of Smart Products

The capabilities of smart, connected products can be grouped into four areas:

- Monitoring
- Control
- Optimization
- Autonomy

Capabilities of Smart Products

Monitoring

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

Control

2. Software embedded in the product or in the product cloud enables:
   - Control of product functions
   - Personalization of the user experience

Optimization

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

Autonomy

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

Monitoring

- Smart, connected products enable the comprehensive monitoring of a product’s condition, operation, and external environment through sensors and external data sources.

- Using data, a product can alert users or others to changes in circumstances or performance.

- Monitoring also allows companies and customers to track a product’s operating characteristics and history and to better understand how the product is actually used.

Monitoring

- The collected data has important implications for design (by reducing over-engineering), market segmentation (through the analysis of usage patterns by customer type), and after-sale service (by allowing the dispatch of the right technician with the right part, thus improving the fix rate).

- Monitoring data may also reveal warranty compliance issues as well as new sales opportunities, such as the need for additional product capacity because of high utilization.

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.

Monitoring

- Monitoring capabilities can span multiple products across distances.

- Joy Global, a leading mining equipment manufacturer, monitors operating conditions, safety parameters, and predictive service indicators for entire fleets of equipment far underground.

- Joy Global also monitors operating parameters across multiple mines in different countries for benchmarking purposes.

Control

- Smart, connected products can be controlled through remote commands or algorithms that are built into the device or reside in the product cloud.

- For example, “if pressure gets too high, shut off the valve” or “when traffic in a parking garage reaches a certain level, turn the overhead lighting on or off, or display the filled capacity”.

Control

- Control through software embedded in the product or the cloud allows the customization of product performance to a degree that previously was not cost effective or often even possible.

- The 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 light bulbs via smartphone, turning them on and off, programming them to blink red if an intruder is detected, or dimming them slowly at night.

- Doorbot (now named as ***Ring,*** *https://ring.com*), a smart, connected doorbell and lock, allows customers to give visitors access to the home remotely after screening them on their smartphones.

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.

- Smart, connected products can apply algorithms and analytics to dramatically improve output, utilization, and efficiency.

Optimization

- In wind turbines, for instance, a local microcontroller can adjust each blade on every revolution to capture maximum wind energy. And each turbine can be adjusted to not only improve its performance but minimize its impact on the efficiency of those nearby.

- Real-time monitoring data on product condition and product control capability enables firms to optimize service by performing preventative maintenance.

- Advance information about what is broken, what parts are needed, how to accomplish the fix reduces the repair costs.

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 operation like that of the iRobot Roomba, a vacuum cleaner that uses sensors and software to scan and clean floors in rooms with different layouts.

- More-sophisticated products are able to learn about their environment, self-diagnose their own service needs, and adapt to users' preferences.

Autonomy

- Autonomy not only can reduce the need for operators but can improve safety in dangerous environments and facilitate operation in remote locations.

- Autonomous products can also act in coordination with other products and systems. 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.

Autonomy

- 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.

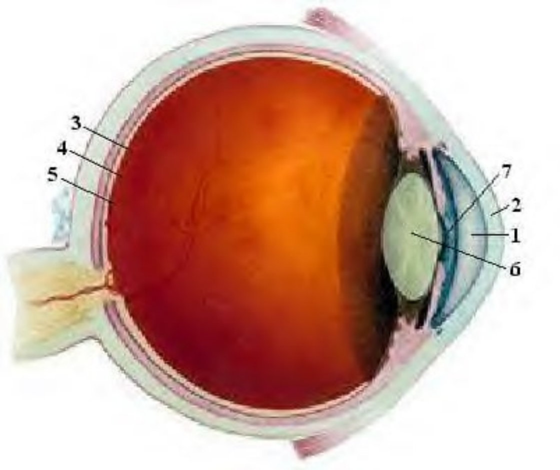
- Example, The Google self-driving car project , Waymo.

Waymo – Formerly Google self-driving car project

Sensors, Sensing Principles and Properties

Lecture Outline

- What is Sensor?
  - Transducer, Sensor, Actuator
- Categorization of Sensors
  - Analog & Digital Sensors
  - Active & Passive Sensors
- Sensor’s Specifications
- Attributes of Sensor
- MEMS
- Sensors Examples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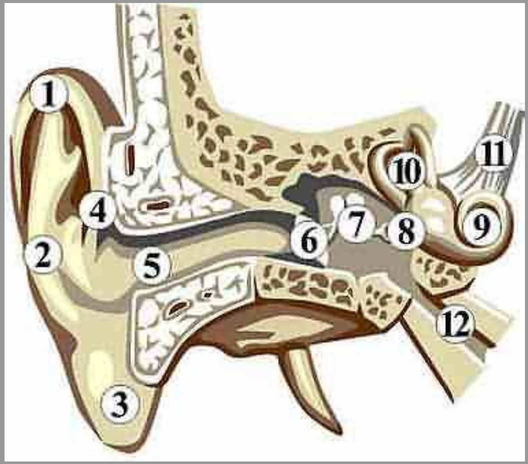
Our 5 Senses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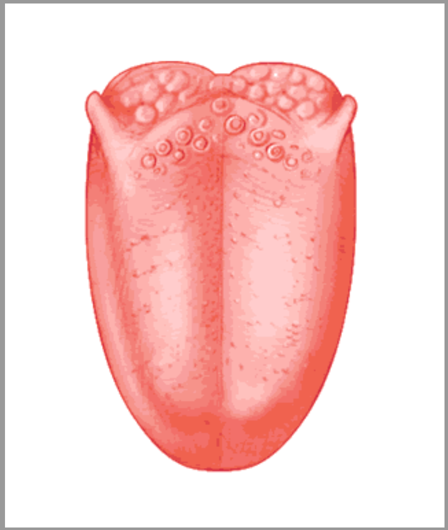

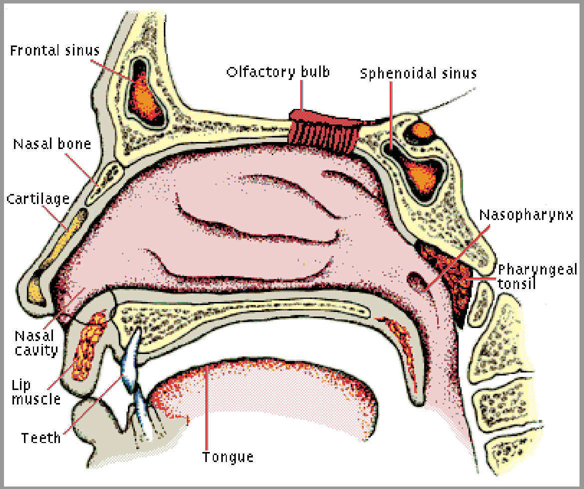
Frontal sinus
Olfactory bulb
Sphenoidal sinus
Nasal bone
Cartilage
Nasopharynx
Pharyngeal tonsil
Nasal cavity
Lip muscle
Teeth
Tongue

Sensor

- A sensor is a device that detects and responds to some type of input from the physical environment.
- The input can be light, heat, motion, moisture, pressure or any number of other environmental phenomena.
- The output is generally a signal that is converted to a human-readable display at the sensor location or transmitted electronically over a network for reading or further processing.

Sensor

A device which provides a usable output in response to a specified measurand.

A sensor acquires a physical quantity and converts it into a signal suitable for processing (e.g. optical, electrical, mechanical).

Nowadays common sensors convert measurement of physical phenomena into an electrical signal

Transducer

Active element of a sensor is called a transducer.

A device which converts one form of energy to another.

Sensors detect by receiving a signal from a transducer, then responding to that signal by converting it into an output that can easily be read and understood.

The output can be analog or digital.

Transducer

A transducer converts one form of energy to another, but does not quantify the conversion, e.g. a light bulb converts electrical energy into light and heat; however, it does not quantify how much light or heat. Similarly, battery converts chemical energy into electrical energy.

If the purpose of a device is to quantify an energy level, it is a sensor.

When input is a physical quantity and output electrical reading → Sensor

When input is electrical and output a physical quantity → Actuator

Sensor

A thermometer senses and converts temperature into a readable output, thus it is a sensor. This output can be direct or indirect.

A mercury thermometer that uses a level of mercury against a fixed scale is a direct output.

A digital thermometer is an indirect output using a thermocouple and then quantification.

Magnetic Sensors

Perhaps one of the first sensors used by man was a compass, which is essentially a magnetic sensor. The compass needle, which is steel, aligns itself with the earth's magnetic field lines and points toward the north.

Terminologies

Transducer is a device which transforms energy from one type to another.

- Typical energy domains are mechanical, electrical, chemical, magnetic, optical and thermal.

Transducer can be further classified into Sensors, which monitors a system and Actuators, which impose an action on the system.