ITRI
Industrial Technology Research Institute

Directions of IoT Technology Development

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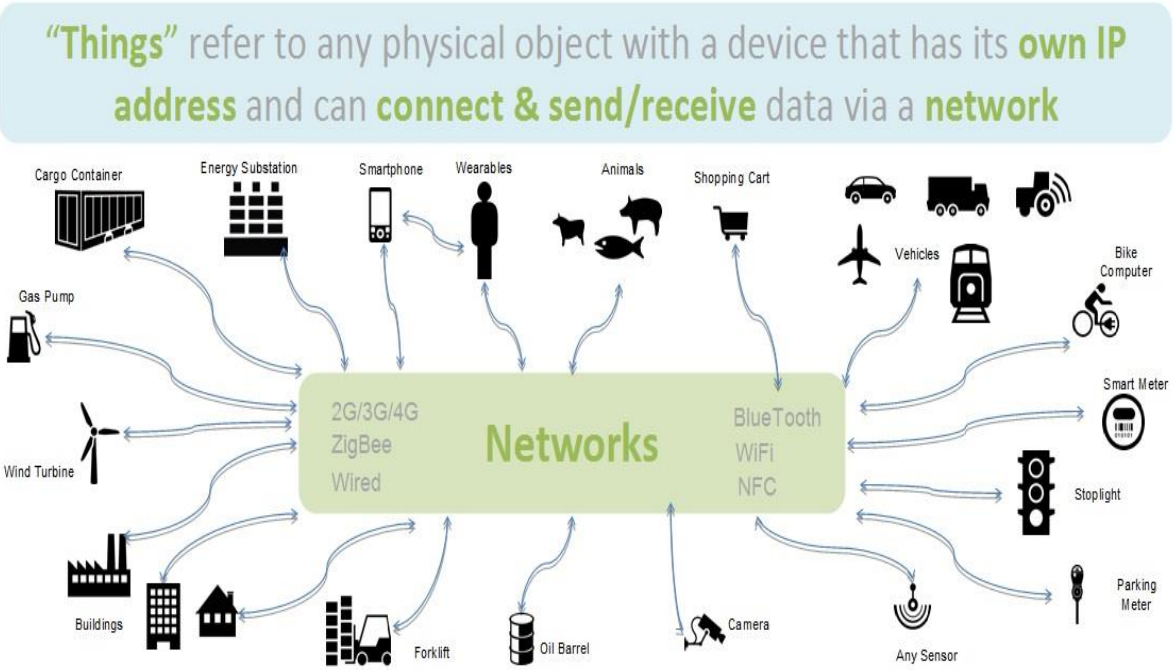
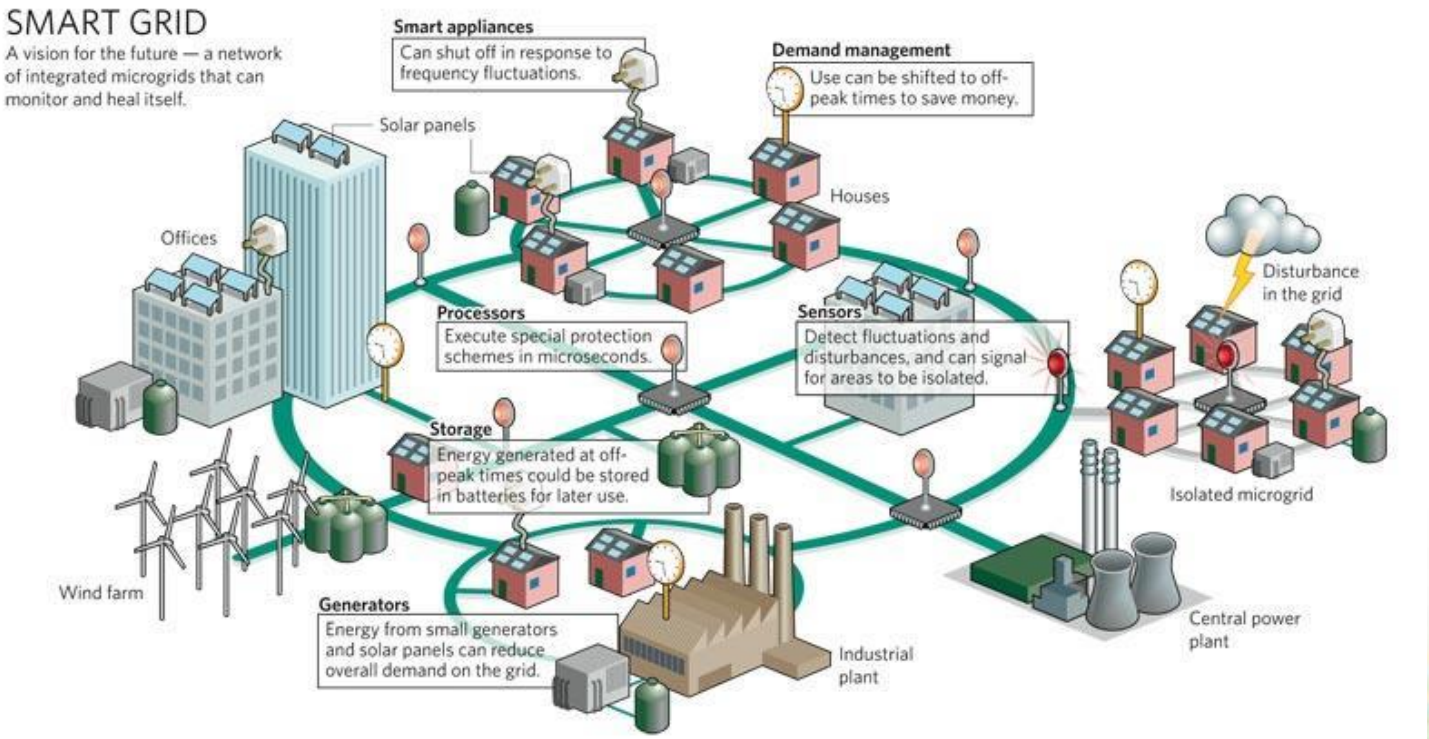
IoT in a Nutshell

- Design pattern
  - Sense
  - Collect
  - Analyze
  - React
- Common practice in communication and computer systems design
  - Feedback control
  - Data-driven
  - Smart X



Example: Smart Grid

- Collect electricity load and usage geography information
- Balance supply and demand by tuning pricing, generation, transmission and distribution



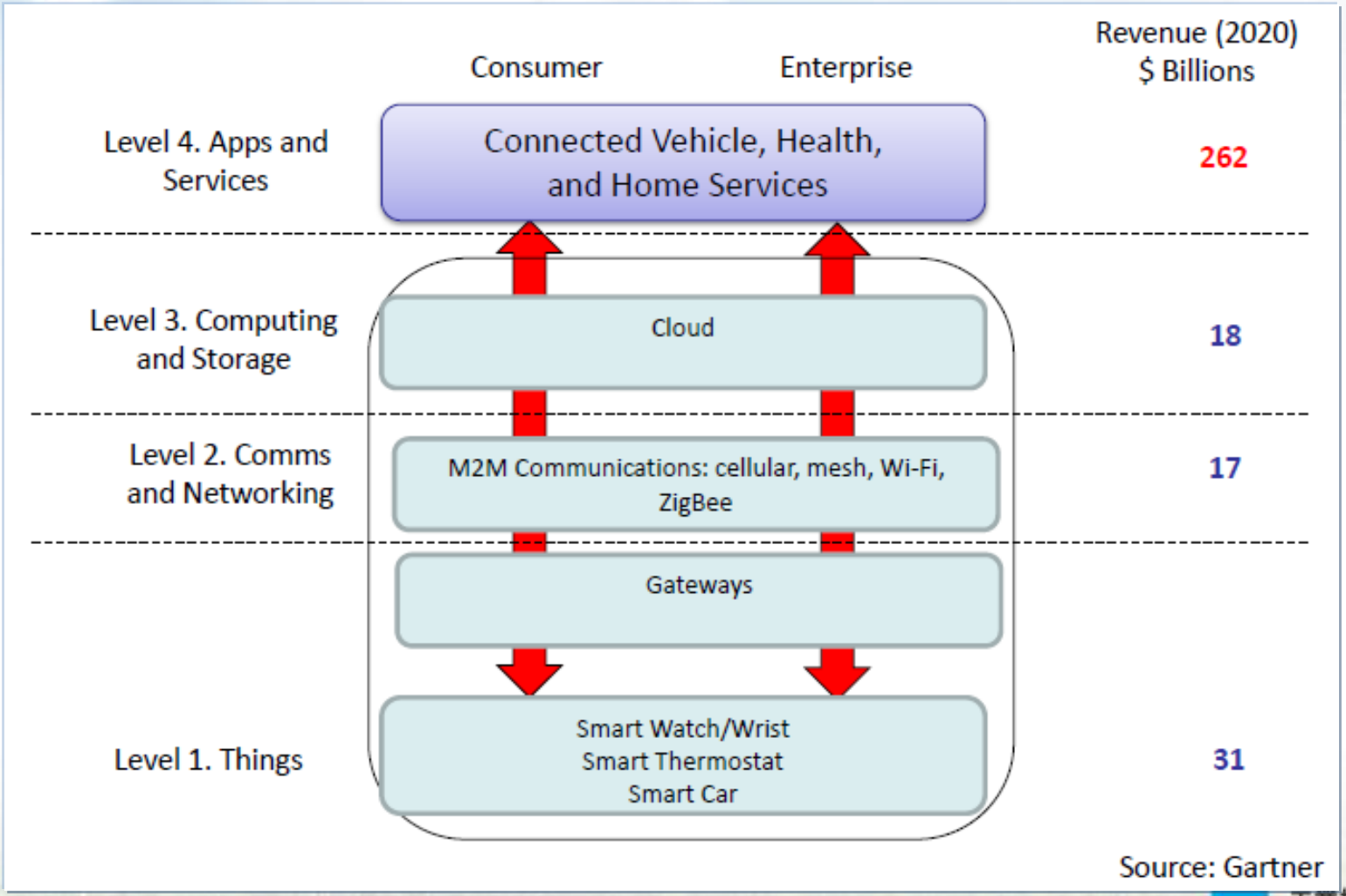
Example: Intelligent Building

- Collect occupancy, weather, temperature and air quality
- Reconfigure heating, ventilation, air conditioning and lighting to minimize energy consumption

So What's New?

- Scale
  - Number of end-point devices in a given IoT application easily exceeds millions
  - "It just works" is a must
  - Examples: wearable for wellness or health management, connected vehicle, environmental monitoring, etc.
- Variety
  - Sensor data measurement, analysis, and reaction are highly domain-specific
  - Domain knowhow-driven customization is key to sustainable deployment or commercial success

IoT Ecosystem



IoT Hardware Opportunities

- IoT device HW is indispensable but not where value is
  - Sensor: vital signs, manufacturing equipment status, structural integrity, etc.
    - Example: Non-invasive blood sugar measurement, food safety sensor
  - Low-power and heterogeneous system design
    - System in a package-based module
  - Sustainable system design: energy harvesting, self-diagnosis, targeted redundancy, etc.
- Large variety and small quantity
  - An infrastructure for rapid prototyping ➔ small-scale manufacturing ➔ mass production

Low-Power Design Techniques

- Ultra-low-voltage circuit: Use as little power as possible when it is turned on
  - How to deal with fabrication process variation
- Normally off computing: Turn things off whenever possible without performance/energy penalty
  - Suspend and resume quickly at fine granularities
  - Use non-volatile register and memory
- Event-driven sensor design: Turn the sensor on only when the sensor value is big enough
  - Sensor input directly turns on the sensor
  - Eliminates the periodic “wake-up and check” loop

Business Opportunities

- Innovative IoT service and business models
  - There is no silver bullet; your guess is as good as mine
  - Order of the day: explore as many alternatives as possible
- Reference platform for IoT device
  - Qualcomm, Marvell, Intel, MediaTek, ITRI and Arduino
- Reference platform for IoT backend service ➔ IoT PaaS (Platform as a service)
  - Goal: enables quick development of the baseline backend service of a new IOT service and easy customization that incorporates domain-specific knowhow

IoT PaaS Requirements

- Overall goal: Zero or small modification required for basic IoT service, but ease of customization for advanced IoT service
  - A matter of man weeks
- Sensor data filtering, ingestion, indexing and storage
  - High-performance sensor database management
- Sensor data analysis and presentation, including Big Data-style data analysis and transformation
  - Domain-specific
  - Anomaly and alert detection and report
- Security, availability and scalability: Cloud Computing
- Manageable
- Testable

ITRI's Cerebro Platform

Cerebro Device Agent

Cerebro Access App

Cerebro IOT Service

Event Query & Presentation Layer

Shallow & Deep Event Data Analysis

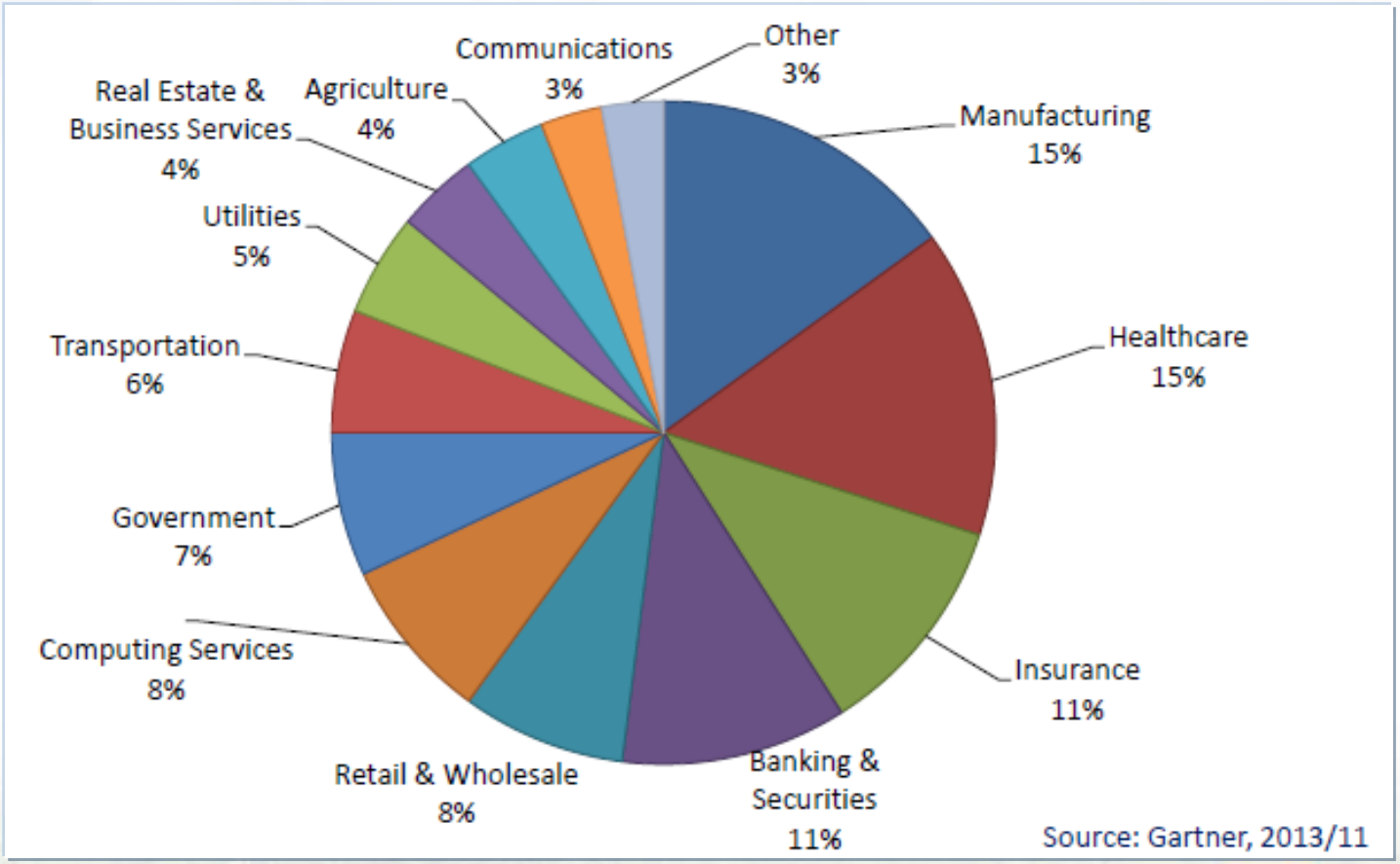
Scalable Event Data Ingestion & Management

Development of Cerebro-based IOT System

- Measure sensor values and output them to the backend service
- Design sensor database schema and their indexes
- Configure filtering rules on device, shallow event analysis rules, and service keys
- Write deep event analysis code running on stored sensor data on the service
- Write an app to access stored sensor data, and results of shallow and deep event analysis
- Test the IOT device and service

IoT Market in 2020

1.9 Trillion USD



Insurance and Banking?

- Name of the game in Insurance industry: precision profiling
  - More precise and comprehensive risk assessment, more accurate and competitive premium
  - Long-term-averaged and sketchy history ➔ Real-time and detailed record, e.g., car insurance based on driving patterns, health insurance based on exercise/diet patterns
- Usage-based Insurance (UBI) or Pay As You Drive (PAYD): Insurance premium is tied with
  - Driving distance (Odometer)
  - Actual roads travelled (GPS)
  - Time of driving
  - Degree of congestion (traffic condition sensor)
  - Driving behavior: speeding, using smartphones while driving, distraction, or drunk driving (OBD-II)

Alibaba's Finance Service

- Every Alibaba loan costs 0.3 yuan (about 5 U.S. cents), roughly 1/1,000 of a traditional loan processing cost. Bad loan percentage is 1.3%, slightly higher than the banking industry's average of around 1%.
  - Secret: E-commerce trading data on Alibaba's platform
- The Ant Group's Sesame credit assessment (芝麻信用分)
  - Credit history: credit borrowing and repayment record
  - E-commerce transaction record
  - Personal and family bill payment record
  - Authenticity and intensity of on-line social interactions
  - Depth and breadth of on-line social connectivity
  - Applications: dating, deposit for hotel reservation, travel visa, etc.

So Where Is the Money?

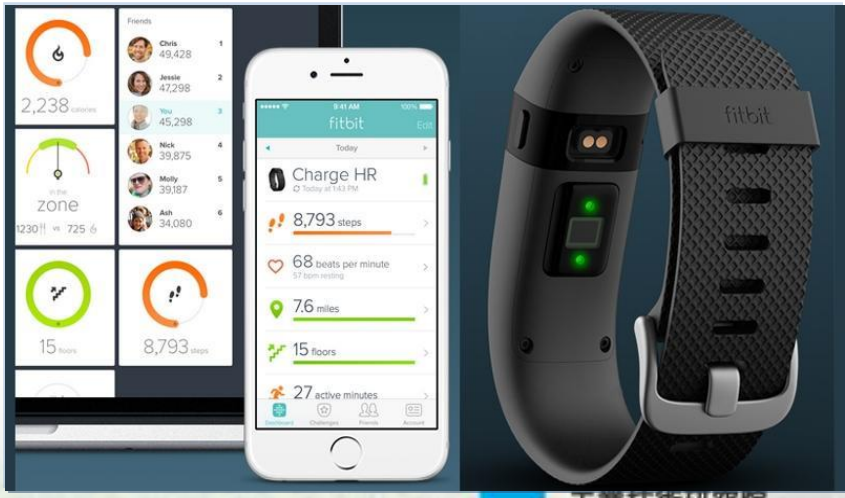
- Nobody has good answers yet
- Consumer vs. Non-consumer
- Wearable vs. Non-wearable
- My picks:
  - Connected vehicle:
    - Autonomous driving
    - E-car battery management
  - Manufacturing automation: Industry 4.0
    - Semiconductor fabrication process as a model
  - Product support and maintenance
    - Machining tool
  - Long-term elderly care: a societal challenge

NEST Labs

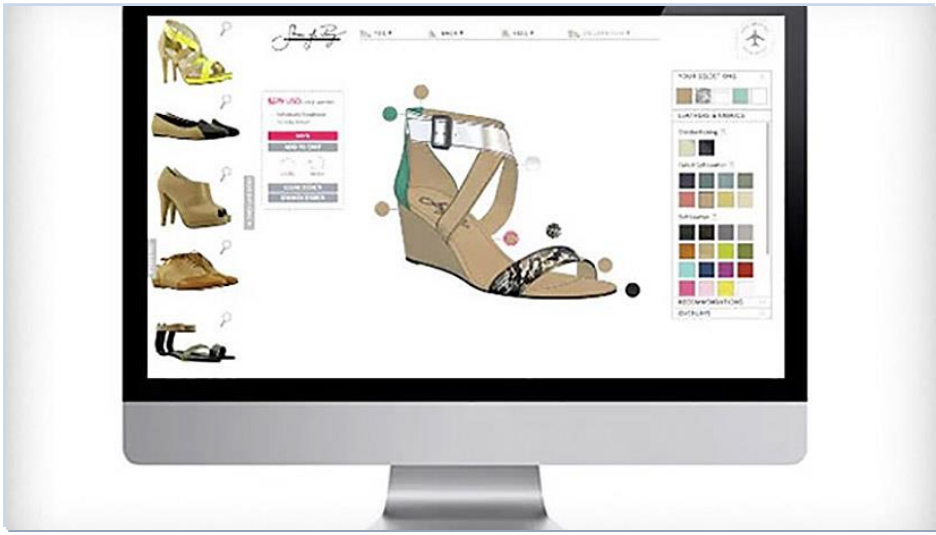
- Nest Learning Thermostat: an electronic, programmable, and self-learning Wi-Fi-enabled thermostat that automatically tunes heating and cooling of homes and businesses to conserve energy
- Controllable by smartphone app
- Home-used thermostat market share second to Honeywell
- Acquired by Google for $3.2B in Jan 2014
- Acquired Dropcam for $550M in July 2014

Fitbit

- An activity tracker in the form of a wireless-enabled wearable device that measures data such as the number of steps walked, quality of sleep, steps climbed, and other personal metrics
- Needs a basestation or PC to upload data
- Smartphone apps for monitoring
- 58% of the activity tracker market
- IPO in May 2015

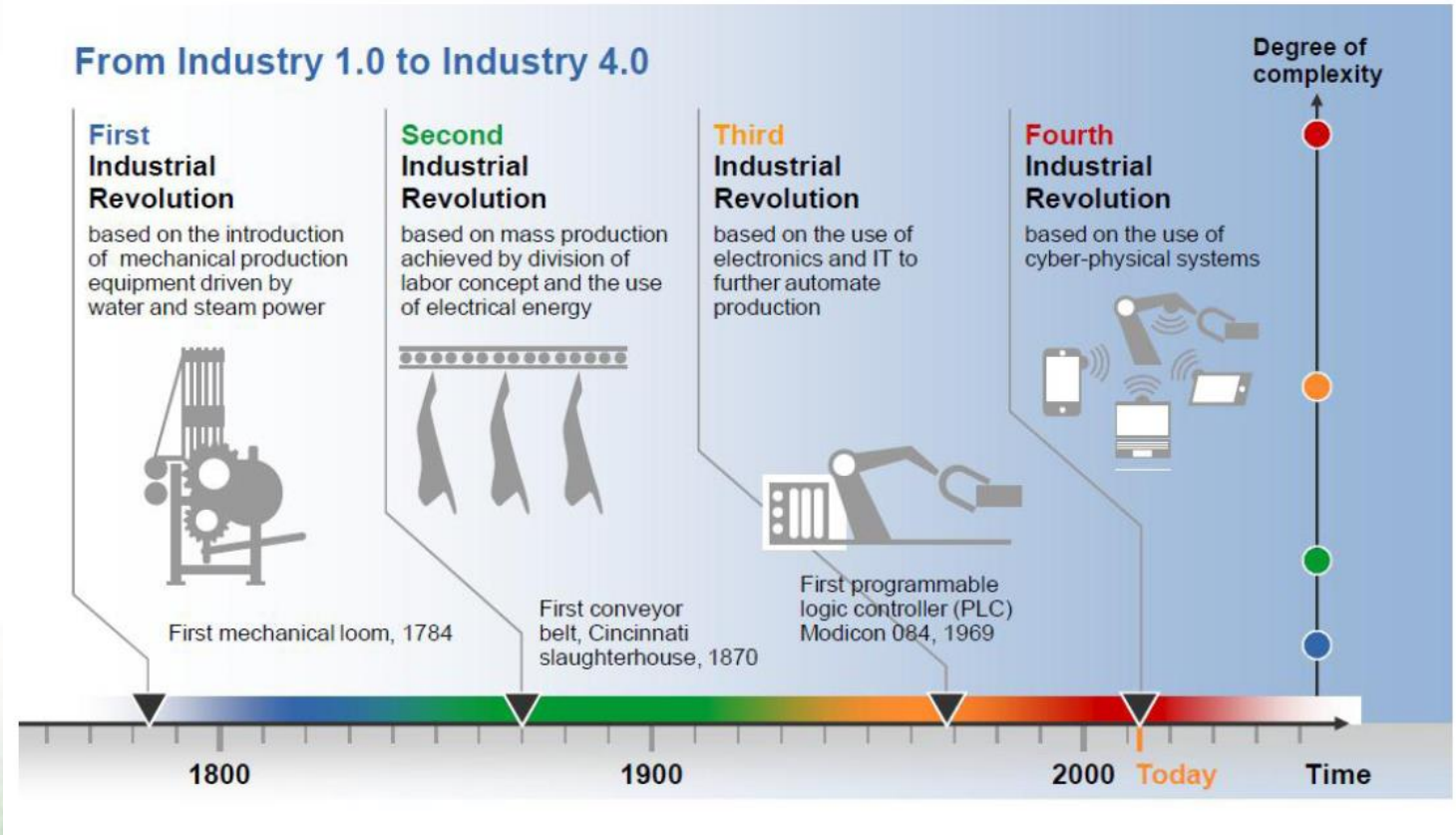


Mass Customization



Industry 4.0

- An industrial IoT: Use of sensor values for work pieces and manufacturing equipment for real-time manufacturing process optimization



Siemens's Smart Plant in Amberg

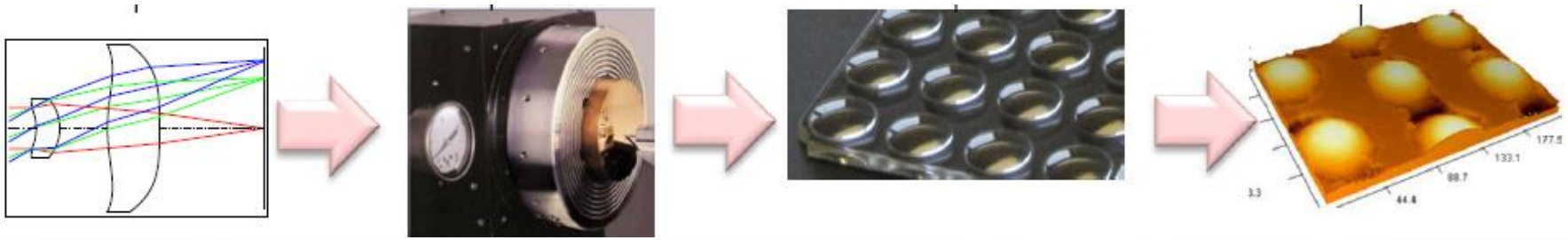
- 950 production lines using 1.6B component combinations coming from 250 suppliers
- 24 hours turn around time with an error rate < 10 ppm
- 7 times improvement in productivity in 20 years

Key Building Blocks of Industry 4.0

- Sensors for manufacturing equipment and work pieces
  - Work piece: Error between “should be” and “turn out to be”
    - Example: All-optical instrumentation (AOI), but other sensors are needed, e.g., how to measure how tightly a screw is twisted
  - Manufacturing equipment: health status and operation condition
- Industrial-grade sensor network and manufacturing information model: OPC UA
- Real-time sensor data analysis and feedback control
  - Model-based: Cyber physical system
  - Statistics-based: Big data

Cyber Physical System

- CAD output ➔ CAM instructions
- Digital simulation model of manufacturing process
- Use measured manufacturing errors to fine-tune manufacturing equipment in real time
- Design ➔ Mold creation ➔ Mold-based fabrication ➔ Error measurement ➔ Mold/Design change ➔….



Advanced Optical Lens Design and Manufacturing

MySpendingBook

- What if we can sense and collect every family's expenditure?
  - A unique open data source in Taiwan enables this
- Service Concept: A personal or family archive of electronic invoices stored in Ministry of Finance
- Free services offered to consumers
  - A permanent record of all expenditure involving electronic invoices
  - Basic analysis tools for spending records
  - Discount notification and e-coupon delivery
  - Platform for precision target marketing
  - Formation of purchase groups for store-initiated and consumer-initiated volume discounts

Summary

- Internet of Things (IoT) and Internet of Everything (IoE) applications are on the rage
  - Wearable device and connected self/home/vehicle
  - Value is in data and service
  - Google/Apple want to own everybody's data
- Current challenge: technologies are largely ready, but profitable service/business models remain elusive
  - Many exploration trials are needed
  - Rapid development of IOT devices and IOT services
    - This is where home-grown IOT PaaS comes into play
  - For Taiwan, B2B may be more promising than B2C

Thank You!

Questions and Comments?

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