Industry 4.0

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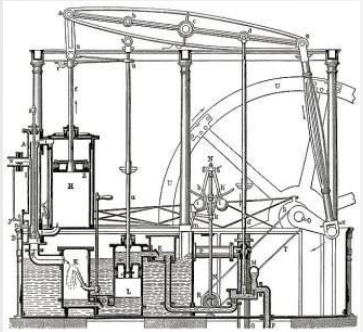
Outline

1. Industry 4.0 Basic Principles
2. Success stories & Best practices
3. Market and vendors
4. Future trends & Research topics

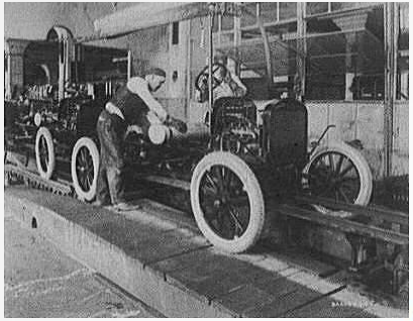
1. Industry 4.0 Basic Principles

Industrial Evolution



1st Industrial Revolution

Introduction of mechanical, production facilities supported by water and steam power

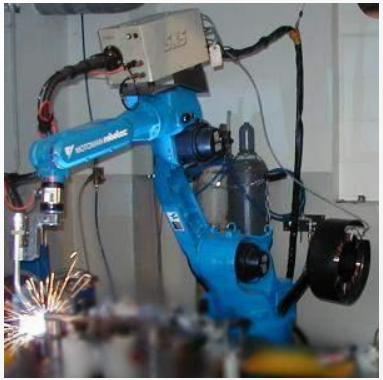


2nd Industrial Revolution

Mass production fuels the 2nd industrial revolution with the help of electrical power

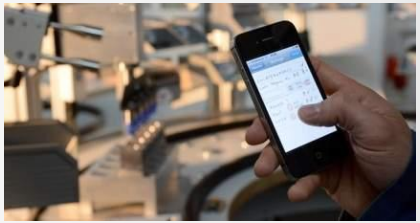
3rd Industrial Revolution

Combining IT and electronics allows for further automation of the production process



4th Industrial Revolution

The connected enterprise leads to the 4th industrial revolution. Connecting production facilities with the internet of things



Source: https://cdn2.slidemodel.com/wp-content/uploads/13049-01-industry-4-3.jpg

The earlier Industrial Revolutions

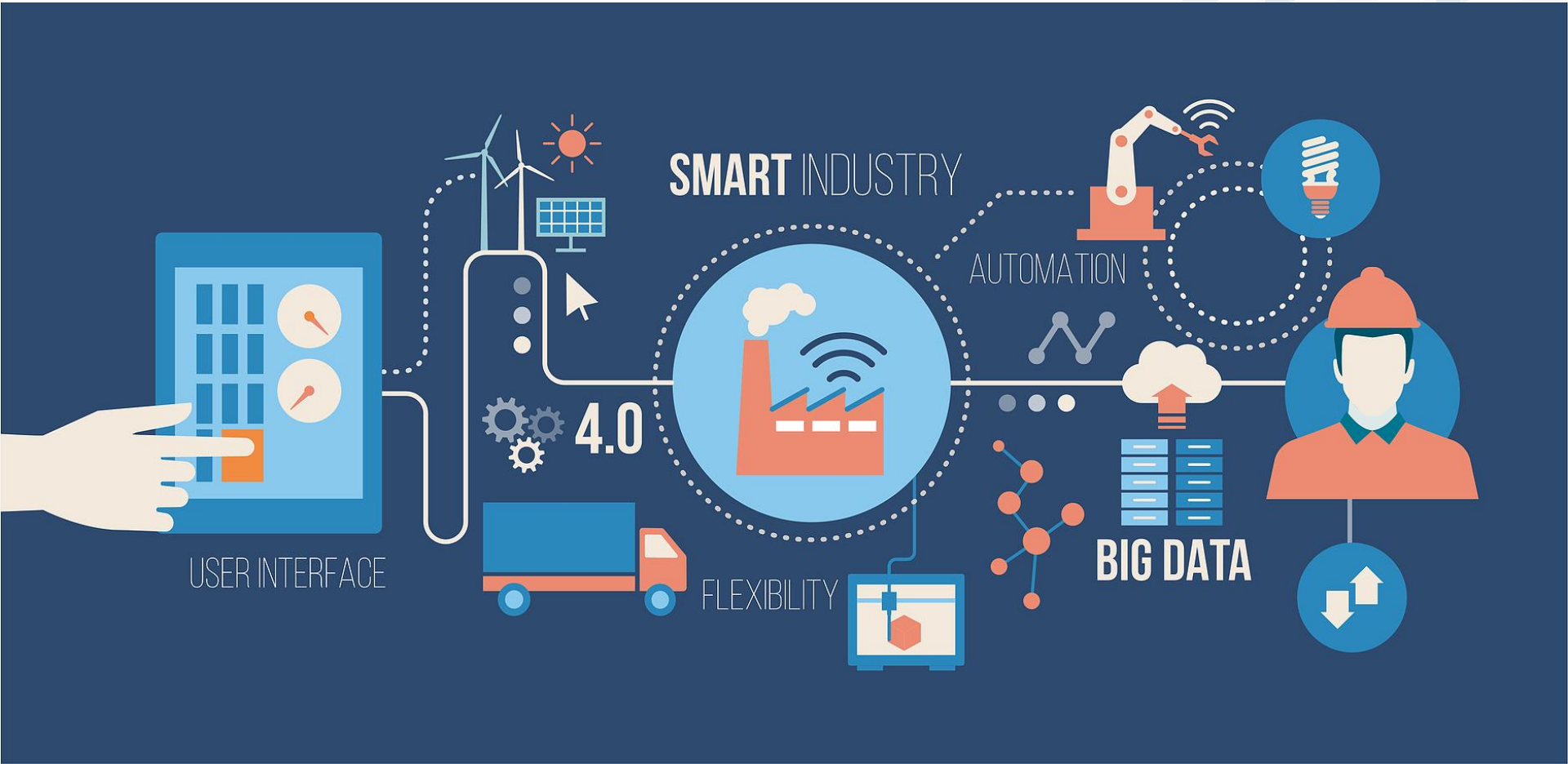
1. 1760 to 1840 - **Mechanical** production; railways and steam engine
2. 1870 to 1940 - **Mass** production; electricity and assembly line
3. 1960 to 2010 - **Computers**; semi conductors, main frame computing, personal devices, internet

The 4th Industrial Revolution: Industry 4.0

1. A **collective term** for technologies and concepts of value chain organization.
2. Vision of the **Smart Factory**: cyber-physical systems, the Internet of Things and the Internet of Services.
    - **Modular** structure
    - **Cyber-physical systems**
        - monitor physical processes
        - create a virtual copy of the physical world
        - make decentralized decisions.
3. Cyber-physical systems & humans **real time** communication

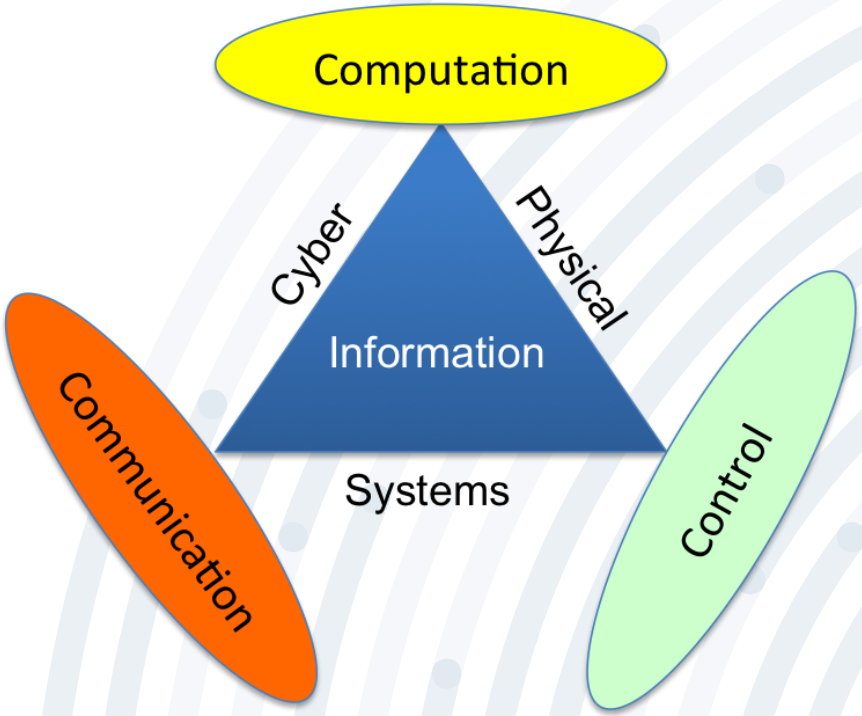
Cyber-physical systems

Source: http://www.imm.dtu.dk/~jbjo/cps.htmll



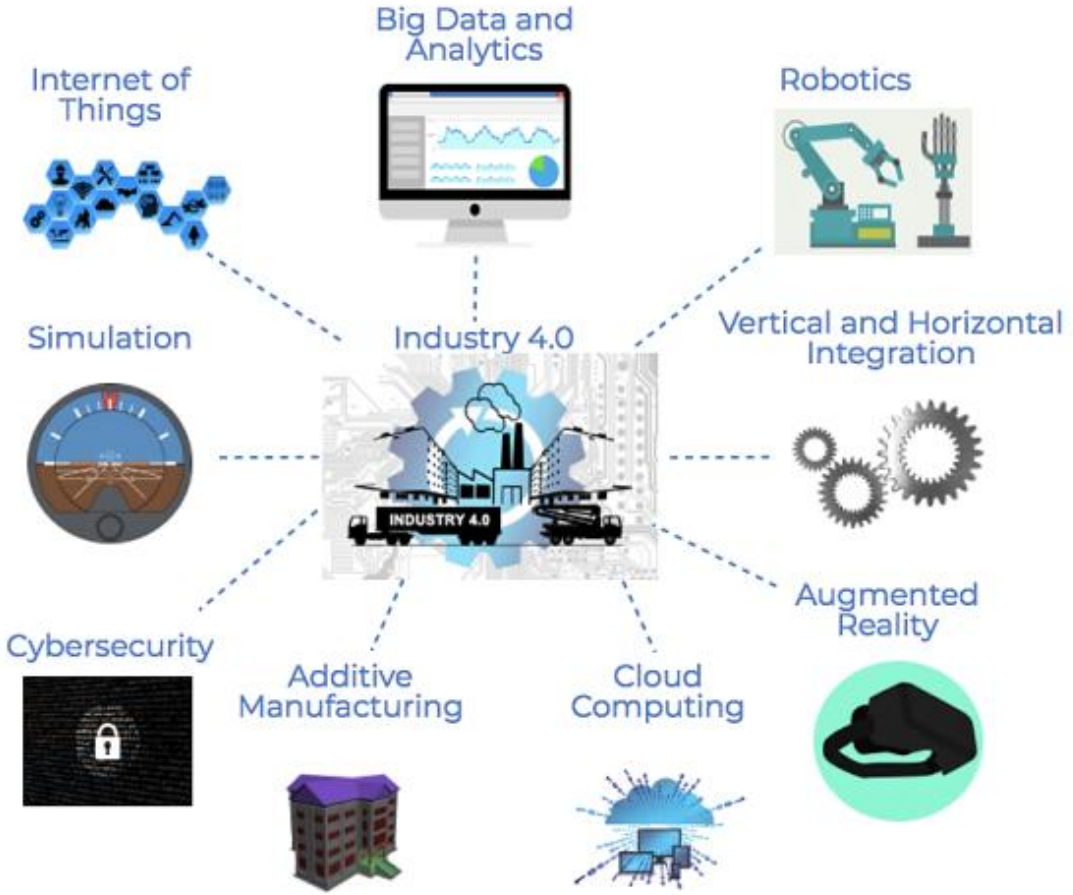
Industry 4.0 Objectives

1. Digital revolution
2. Smaller & powerful sensors
3. Machine Learning
4. Artificial Intelligence (AI)
5. Ubiquitous internet
6. Labour & Energy Cost



Source:
http://www.ece.sunysb.edu/~slin/career/education.html

Industry 4.0 Building Blocks



Source: https://www.linkedin.com/pulse/quality-40-framework-nidhi-sharma

Six Design Principles 1/2

1. **Interoperability**: the ability of cyber-physical systems (i.e. workpiece carriers, assembly stations and products), humans & Smart Factories to connect and communicate with each other via the Internet of Things and the Internet of Services.
2. **Virtualization**: a virtual copy of the Smart Factory which is created by linking sensor data (from monitoring physical processes) with virtual plant models and simulation models
3. **Decentralization**: the ability of cyber-physical systems within Smart Factories to make decisions on their own

Six Design Principles 2/2

4. **Real-Time Capability**: the capability to collect and analyze data and provide the insights immediately
5. **Service Orientation**: offering of services (of cyber-physical systems, humans and Smart Factories) via the Internet of Services
6. **Modularity**: flexible adaptation of Smart Factories for changing requirements of individual modules

Impact in Economy & Business

1. Growth
2. Productivity
3. Employment
4. Labour substitution
5. The nature of Work
6. Customer expectations
7. Data enhanced products
8. Collaborative innovation
9. New operating models

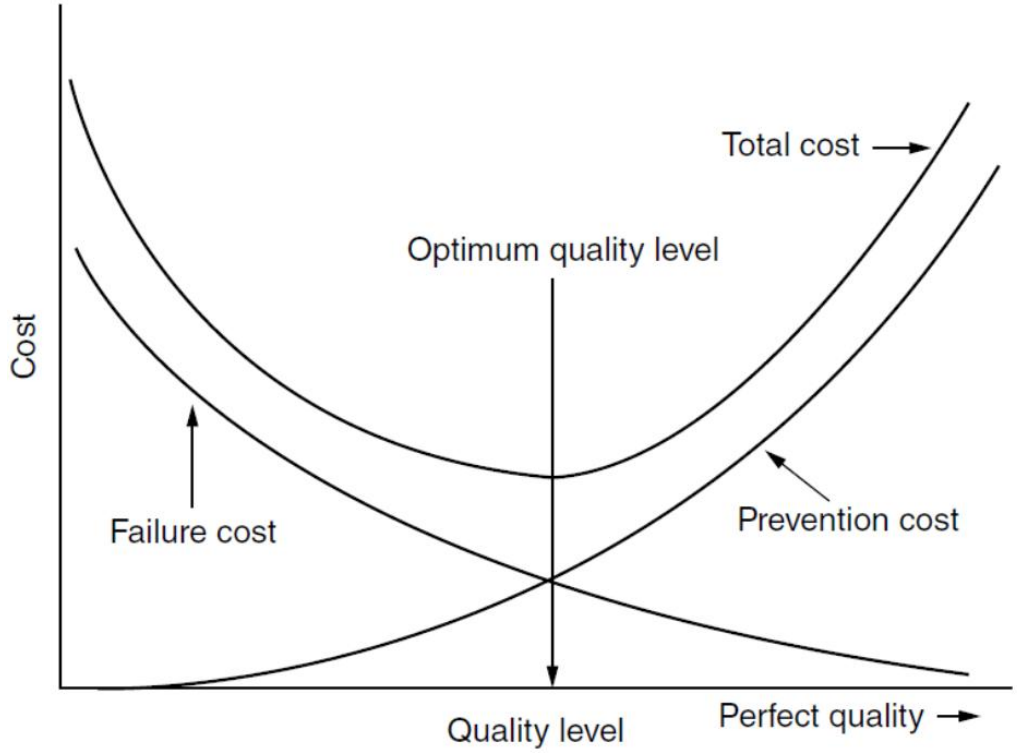
Source: https://restart-project.eu/industry-4-0-impact-education/

Quality with focus on Cost

- Difficult to measure
- Investing in Quality → high return in revenue and profit

Source: https://msie4.ait.ac.th/

Understanding Quality Cost



Source: Juran's Quality Handbook: The Complete Guide to Performance Excellence

2. Success stories & Best practices

Example SIEMENS

- German **manufacturing giant** Siemens is implementing an Industry 4.0 solution in medical engineering.
- Artificial knee and hip joints were **standardized products**, with engineers needing several **days to customize** them for patients.
- **Current software** and steering solutions enable Siemens to **produce** an implant **within a few hours**.

Source: Think Act: INDUSTRY 4.0 The new industrial revolution How Europe will succeed.

Example TRUMPF

- German **toolmaker** Trumpf, an Industry 4.0 supplier and worldwide market leader of laser systems, has put the first **social machines to work**.
- **Each component is "smart"** and knows what work has already been carried out.
- **Production options are automatically optimized**, since the production facility already knows its capacity utilization and communicates with other facilities.

Source: Think Act: INDUSTRY 4.0 The new industrial revolution How Europe will succeed

Example General Electric (GE)

- **Industrial IoT Platform**, the operating system for the Industrial Internet, is powering digital industrial businesses that drive the global economy.
- Connecting industrial equipment, analyzing data, and delivering real-time insights.
- **Industrial IoT Platform-based apps** are unleashing new levels of **performance** of both **GE** and **non-GE** assets.

Source: https://www.ge.com/digital/iiot-platform

3.
Market and vendors

Intel Corporation

THINGS

Smart Factory generating

PBs of data per day Large amounts of data processed at edge

→

Drivers for Edge

Latency, Bandwidth, Security, Availability

EDGE

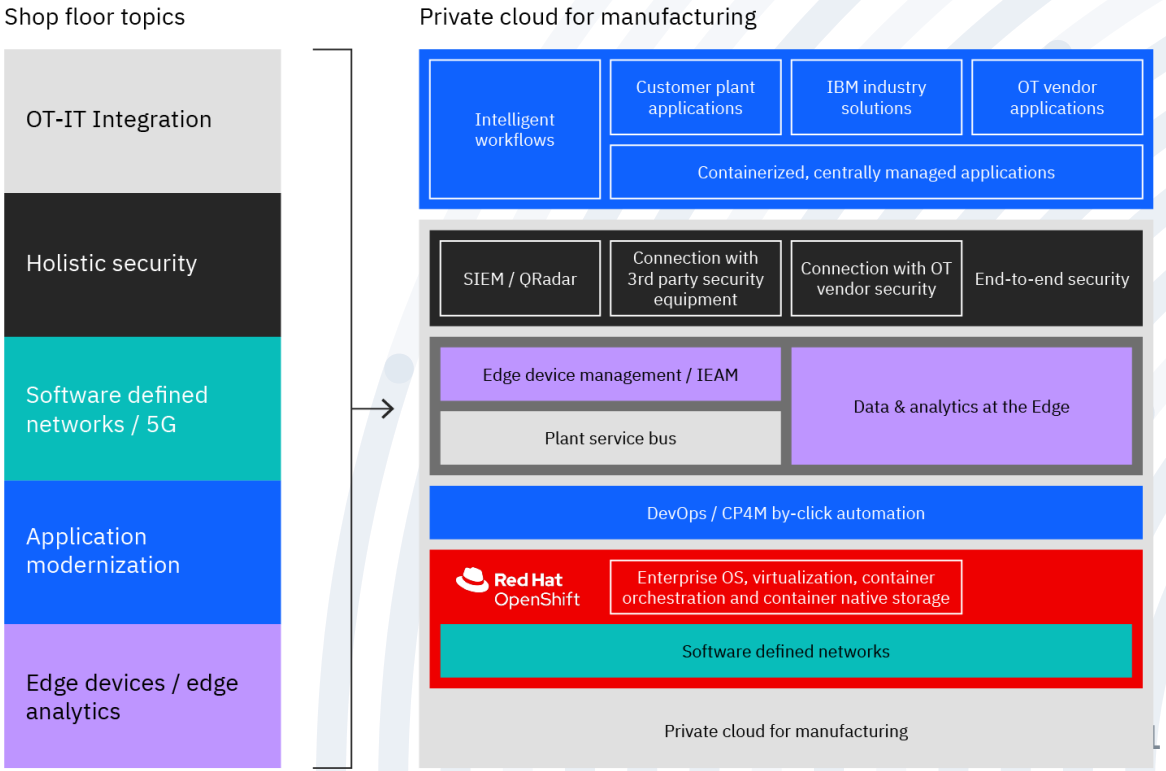
Source: https://www.intel.com

Insights

Big Data Analytics, Predictive Maintenance Monitoring & Orchestration

IBM Corporation

- Transparency, such as track and trace systems
- Online Overall Equipment Effectiveness (OEE)
- Higher throughput, minimizing outages (predictive maintenance, minimizing MTBF and MTTR)
- Product quality (zero errors, rework reduction, and predictive quality)
- Accelerated changeover and line configuration (flexible production, lot size one)
- Process stability and standardization, especially in production IT

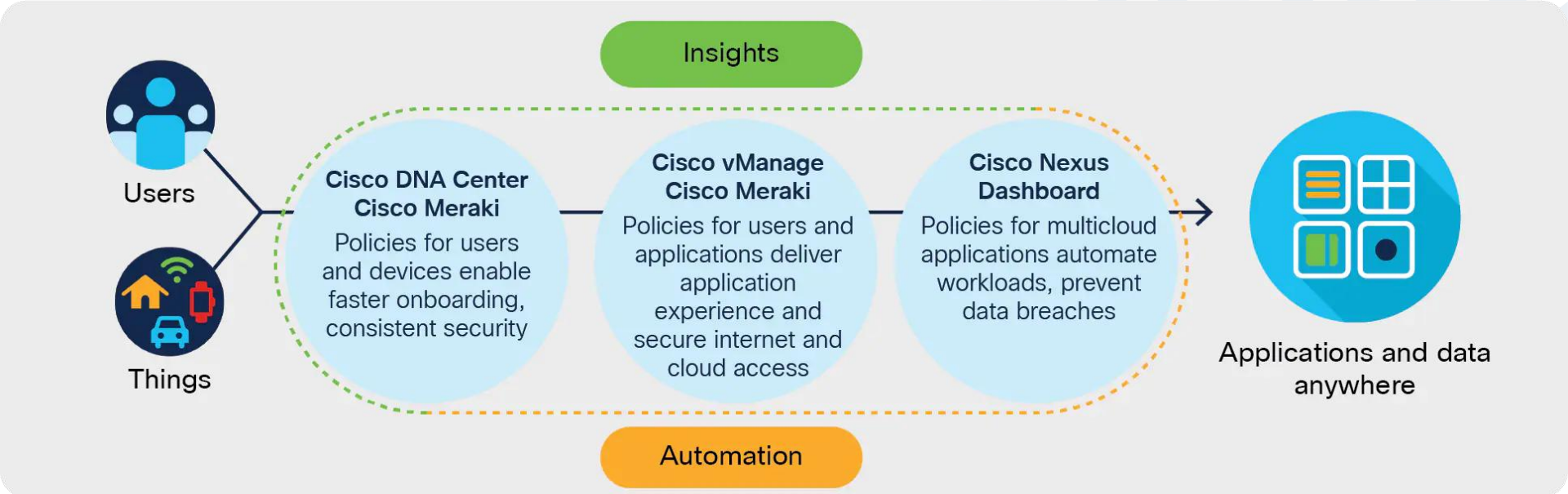


Source: https://www.ibm.com

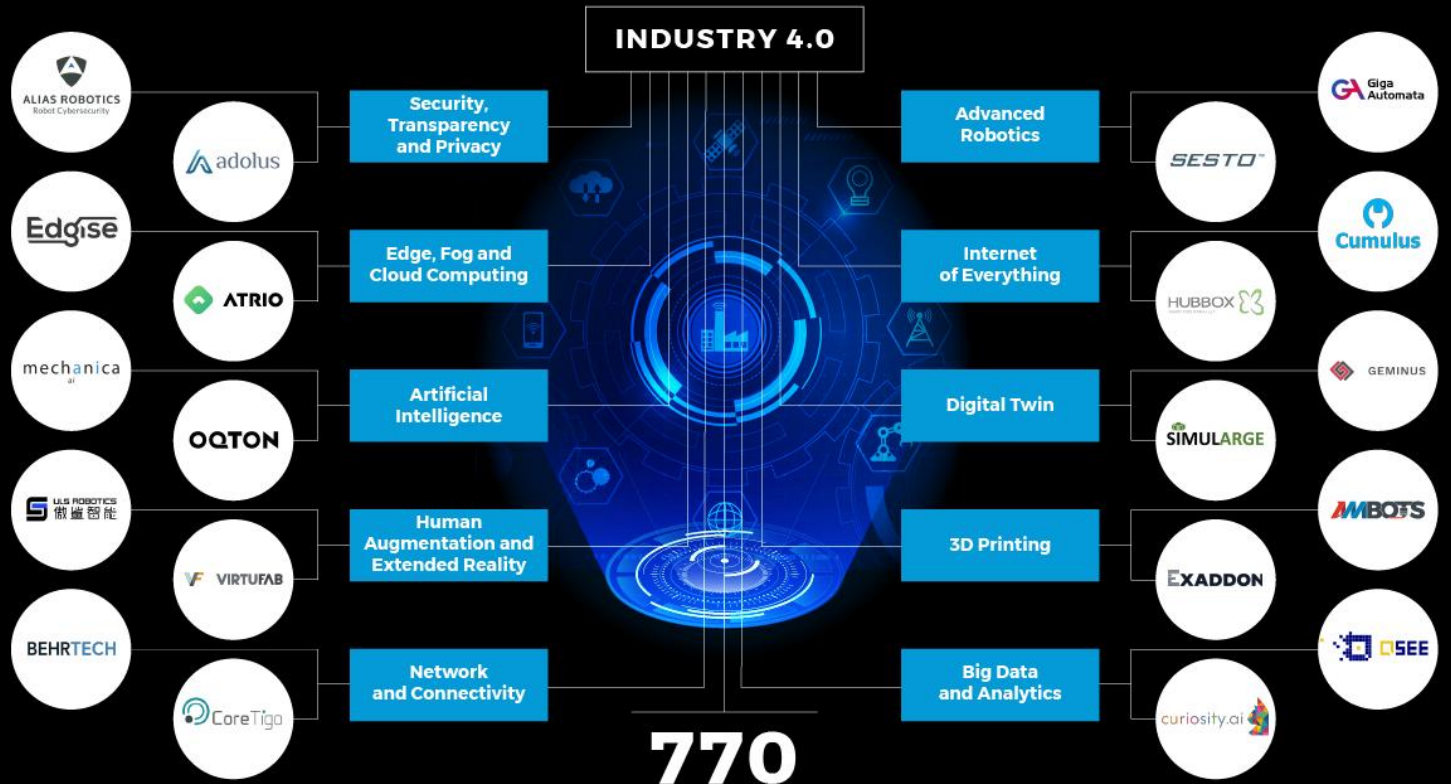
Cisco Systems Inc.

- Insight-based Networking
- Intelligent Network Architecture
- Programmable network devices, open platforms, & an extensive ecosystem

Source: https://www.cisco.com



10 Top Industry 4.0 Trends & Innovations in 2022



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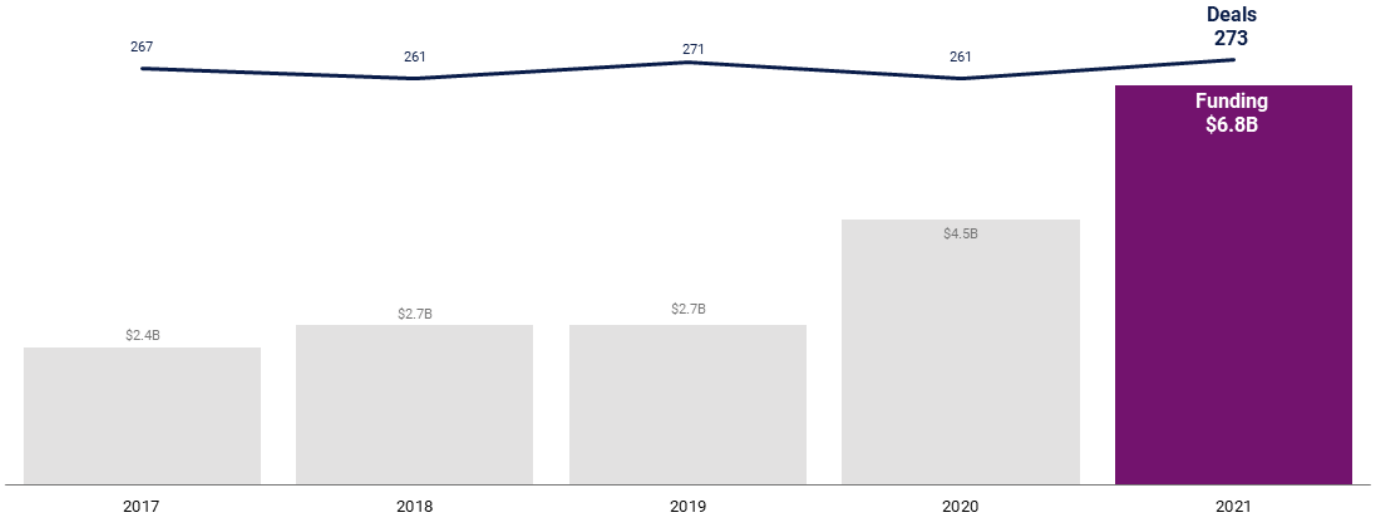
Startups & emerging companies analyzed

4.
Future trends & Research topics

Investment in manufacturing tech companies

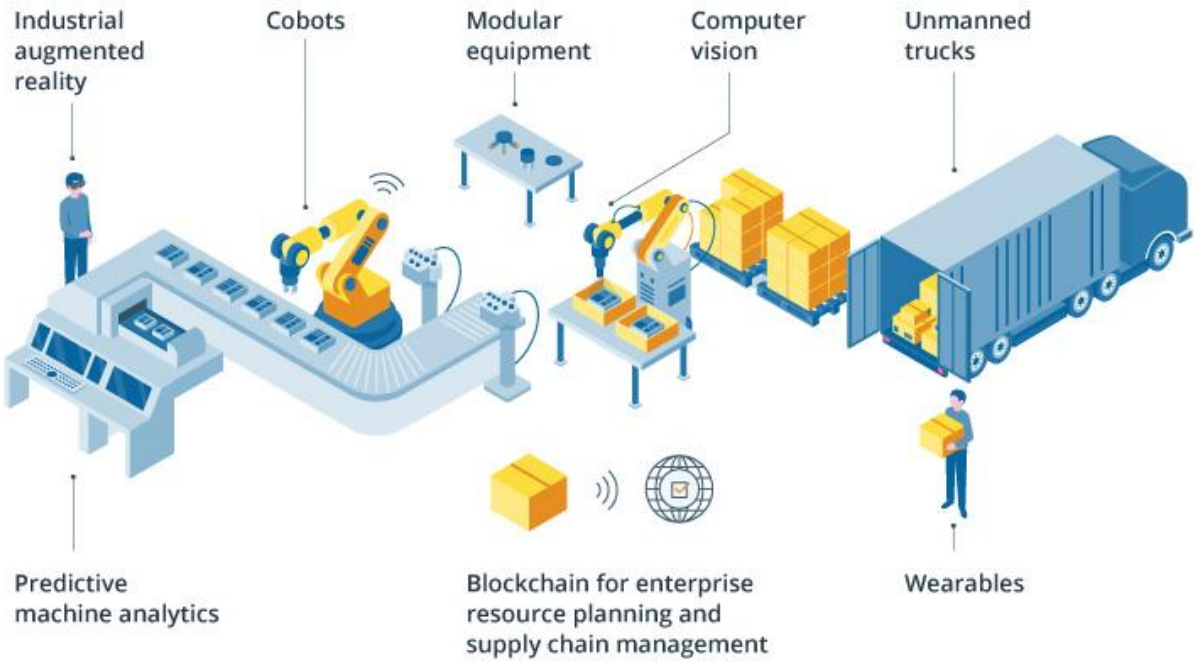
Manufacturing startups see record funding in 2021

Disclosed equity funding & deals



Source:: https://www.cbinsights.com/research/future-factory-manufacturing-tech-trends/#looking

Towards Industry 5.0



Source: CB Insights — How Technology Is Transforming Manufacturing

Future Trends 1/3

- Industrial Internet of Things (IIoT)
  - Interconnected devices are used in manufacturing and industrial settings in order to collect data – data that can then be used to enhance the manufacturing process.
- 5G & edge computing
  - Enabling manufacturers to easily connect their IIoT technology and leverage the data collection and data processing within devices such as smart machines and sensors.
- Predictive maintenance
  - The use of sensor data and artificial intelligence (AI) to detect failure patterns in machinery and components.

Source:
https://www.forbes.com/sites/bernardmarr/2022/01/25/the-10-biggest-future-trends-in-manufacturing/?sh=5eec1ab64d56

Future Trends 2/3

- Digital twins
  - Simulating any physical process or object.
- Extended Reality & Metaverse
  - Enhanced product design, better production planning, augmenting human abilities on assembly lines, and more immersive training.
- Automation and dark factories
  - Fully automated sites where production happens without direct human intervention on site.
- Robots and cobots
  - Collaborative, intelligent robots – or “cobots” – that are specifically designed to work alongside humans

Source: https://www.forbes.com/sites/bernardmarr/2022/01/17/the-10-best-future-trends-in-manufacturing/?sh=5eec1ab64d56

Future Trends 3/3

- 3D printing
  - Localized on-demand production of toolings
- Web 3.0: Blockchain
  - Monitor their supply chains and even automate many of the transactions along their supply chains
- Smarter products
  - Focus on product sustainability, customer demand for intelligent products

Source: https://www.forbes.com/sites/bernardmarr/2022/01/25/the-10-biggest-future-trends-in-manufacturing/?sh=5eec1ab64d56

Research Topics 1/2

- **Trends axes**
  - Industrial Internet of Things (IIoT)
  - Automation and dark factories
  - Web 3.0: Blockchain
  - Extended Reality & Metaverse

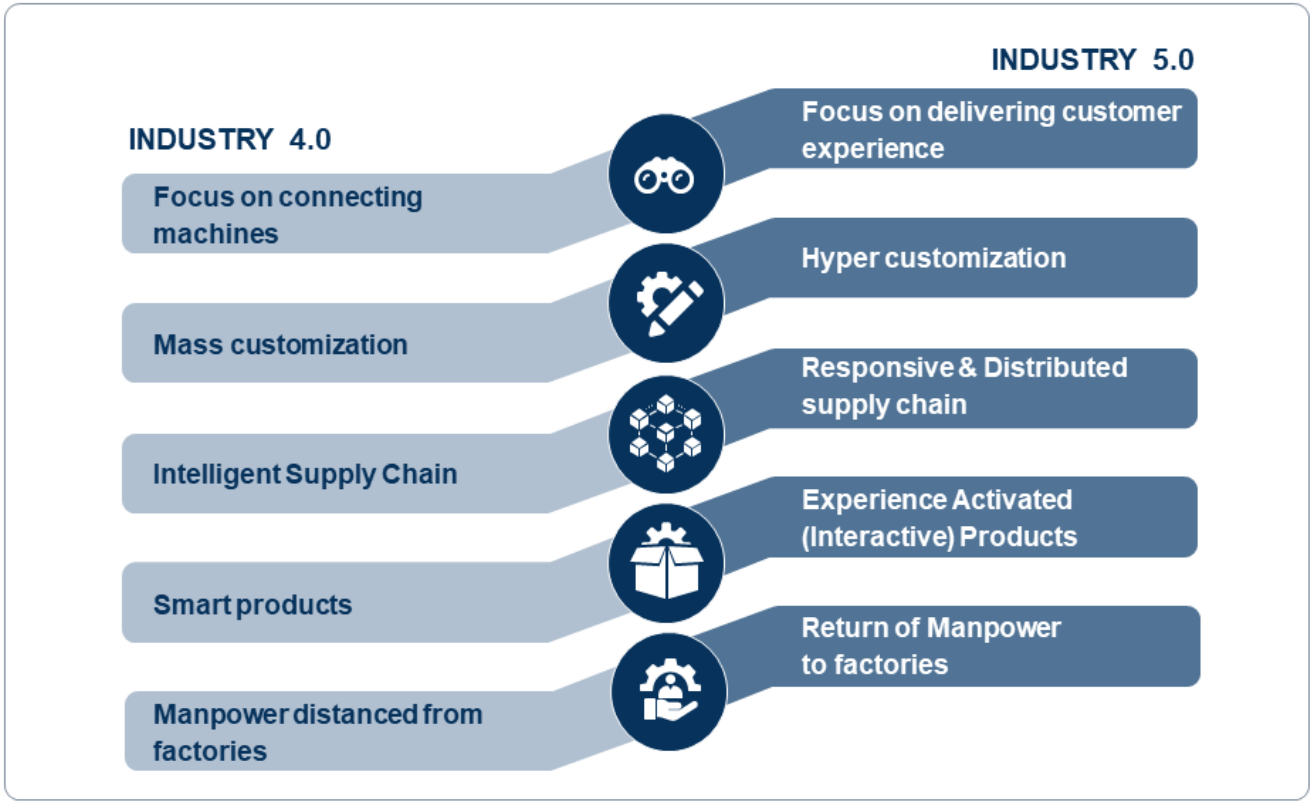
- Huo, Ru, et al. "A Comprehensive Survey on Blockchain in Industrial Internet of Things: Motivations, Research Progresses, and Future Challenges." *IEEE Communications Surveys & Tutorials* (2022).
- Park, Minjae, et al. "A Time-Series Process Event Log Preprocessing Approach for Data-Intensive and Predictive Operationalization of Smart Factories." 2022 *24th International Conference on Advanced Communication Technology (ICACT)*. IEEE, 2022.
- Mazieri, Marcos Rogério, Isabel Cristina Scafuto, and Priscila Rezende da Costa. "Tokenization, blockchain and web 3.0 technologies as research objects in innovation management." *International Journal of Innovation 10.1* (2022): 1-5.
- Xi, Nannan, et al. "The challenges of entering the metaverse: An experiment on the effect of extended reality on workload." *Information Systems Frontiers* (2022): 1-22.

Research Topics 2/2

- **Trends axes**
  - Robots and cobots
  - 3D printing
  - 5G & edge computing
  - Predictive maintenance

- Berx, Nicole, Wilm Decré, and Liliane Pintelon. "Examining the Role of Safety in the Low Adoption Rate of Collaborative Robots." *Procedia CIRP* 106 (2022): 51-57.
- Jandyal, Anketa, et al. "3D printing–A review of processes, materials and applications in industry 4.0." *Sustainable Operations and Computers* 3 (2022): 33-42.
- Coutinho, Rodolfo WL, and Azzedine Boukerche. "Design of Edge Computing for 5G-Enabled Tactile Internet-Based Industrial Applications." *IEEE Communications Magazine* 60.1 (2022): 60-66.
- Cao, Qiushi, et al. "KSPMI: A Knowledge-based System for Predictive Maintenance in Industry 4.0." *Robotics and Computer-Integrated Manufacturing* 74 (2022): 102281.

Towards Industry 5.0



Source: https://www.frost.com/frost-perspectives/industry-5-0-bringing-empowered-humans-back-to-the-shop-floor/

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