RV College of Engineering®

Go, change the world

Elements of Industry 4.0

Category: Emerging Technologies (22EM1C17/27)

Presented by

Department of Mechanical Engineering,

RV College of Engineering

Bangaluru-560059

UNIT- II (10 hours)

Opportunities and Challenges : Lack of resources, Availability of skilled workers, Broadband infrastructure, Policies, Future of Works and Skills in the Industry 4.0 Era

Horizontal and Vertical Integration : End-to-end engineering of the overall value chain, Digital integration platforms, Role of machine sensors, Sensing classification according to measuring variables, Machine-to-Machine communication.

At the very core Industry 4.0 includes the (partial) transfer of autonomy and autonomous decisions to cyber-physical systems and machines, leveraging information systems.

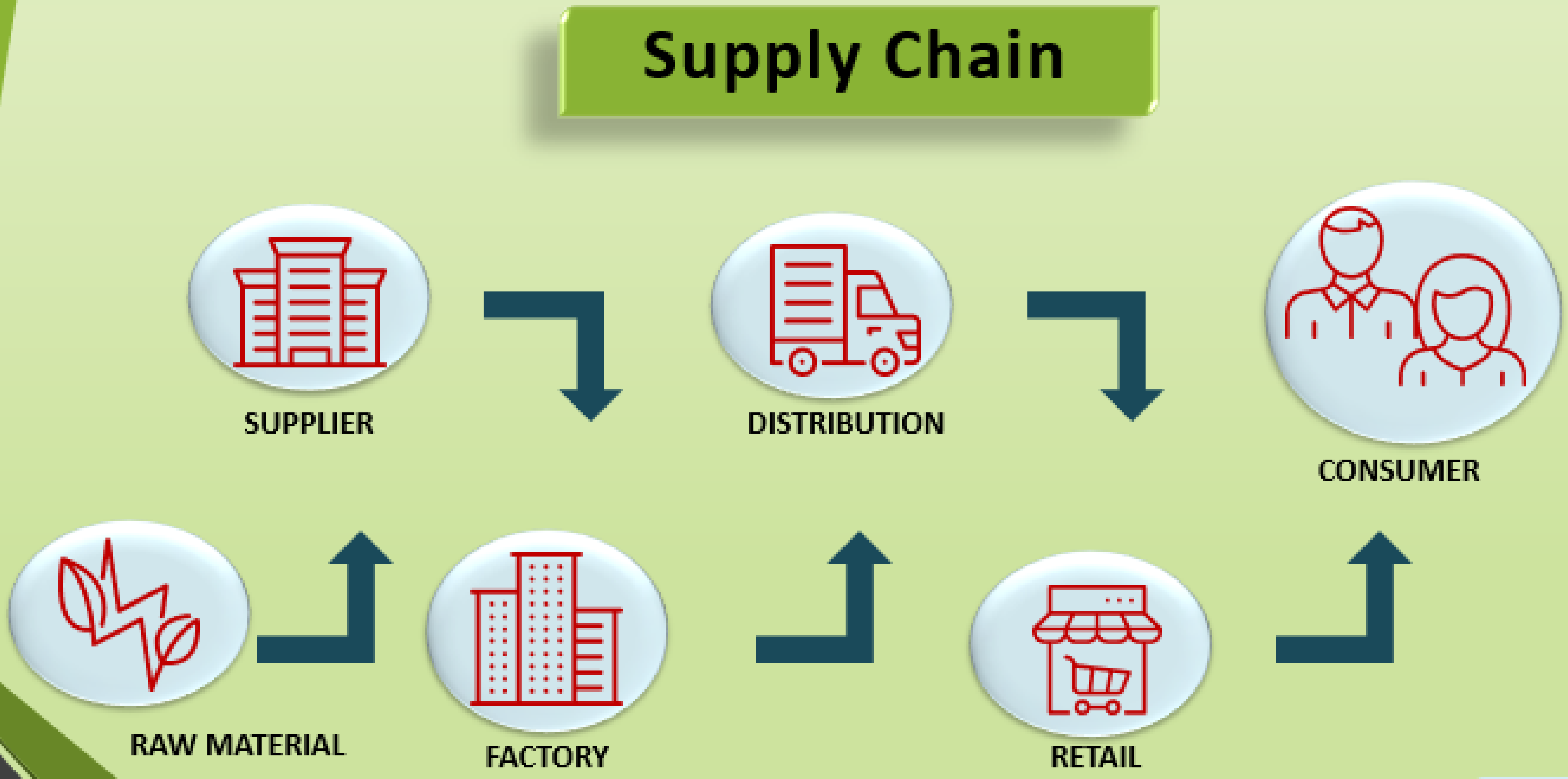
Components of a Value Chain: Primary and Secondary Activities

Vertical Integration

Table 1 Main information systems that can compose vertical integration

Levels	Pyramid components	Role
Level 0 and 1	Instrumentation	Source of the data derived from a measurement of the process. The instrumentation measures a specific process variable and can distribute this information to a PLC. The data generated is used only to monitor process variables (raw data).
Level 2	Supervisory Control and Data Acquisition (SCADA)	System used for data acquisition or process control. Thus, the processes communicate with several devices in real-time. In this context, devices called PLC (Programmable Logic Controller) are generally used. SCADA takes raw data from the PLC and transforms it for use only in the production process (allows limited access to the history of information).
Level 3	Manufacturing Execution System (MES)	A system with functions focused on the execution of production activities. MES establishes a direct link between planning and the shop floor. It generates accurate and real-time information that promotes the optimization of all production stages, from the issuance of an order to the shipment of finished products. The MES has data processed for decision-making (allows access to the history of this information).
Level 4	Enterprise Resource Planning (ERP)	An information system with a unified view of the business, covering all departments and their corresponding functions. It covers product design, operations, logistics, sales and marketing, information storage, material planning, human resources, finance, and project management.
	Product Lifecycle Management (PLM)	Business software manages all data associated with a product during its life cycle phases, including design, manufacture, use, maintenance, recycling, and disposal. It is often referred to as a "single registration system" for product data throughout the product's life cycle.

Horizontal Integration Example



Role of Industry 4.0

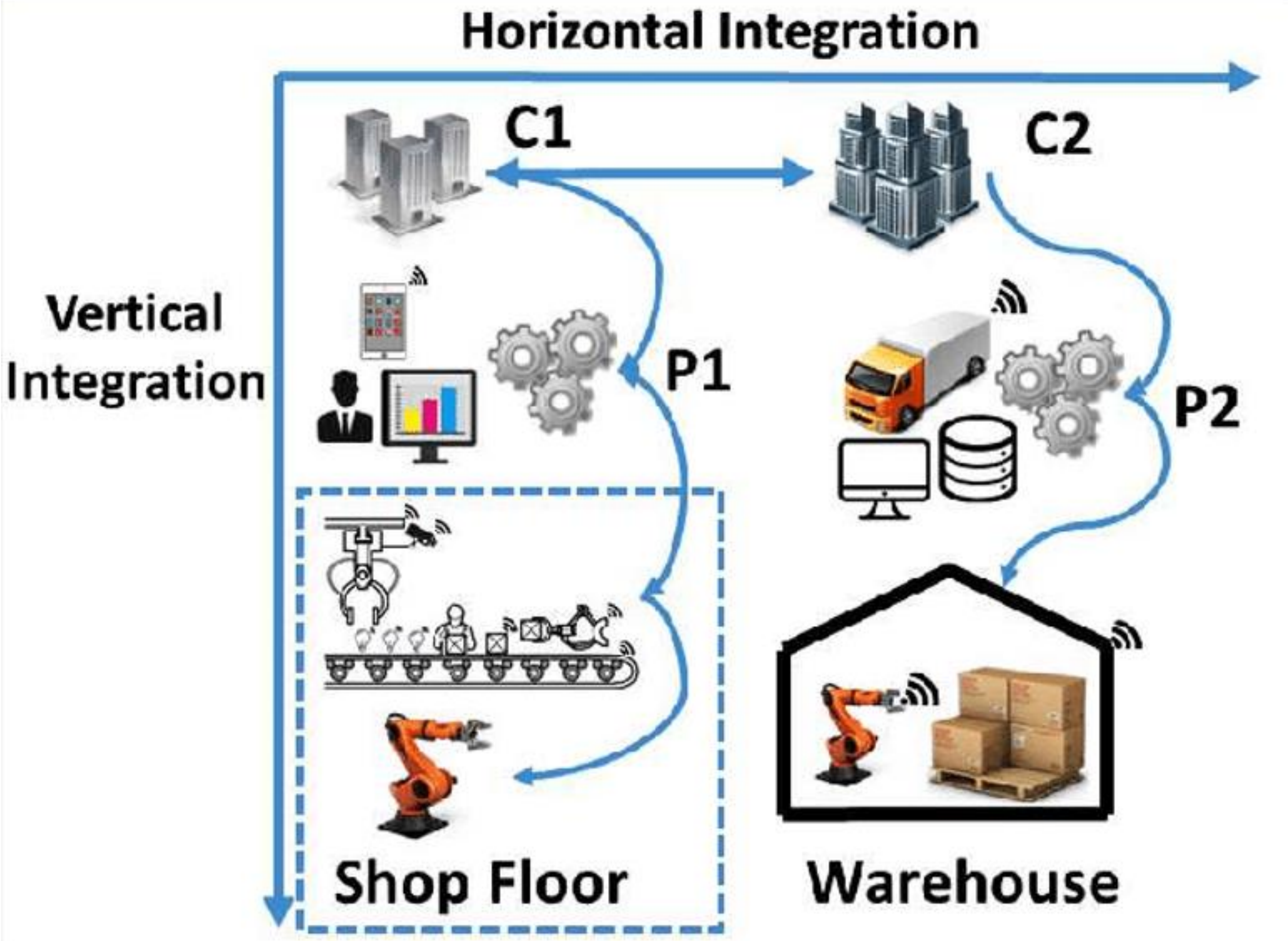
Enabling more direct models of personalized production servicing, as well as customer/consumer interaction *(including gaining real-time data from actual product usage)*

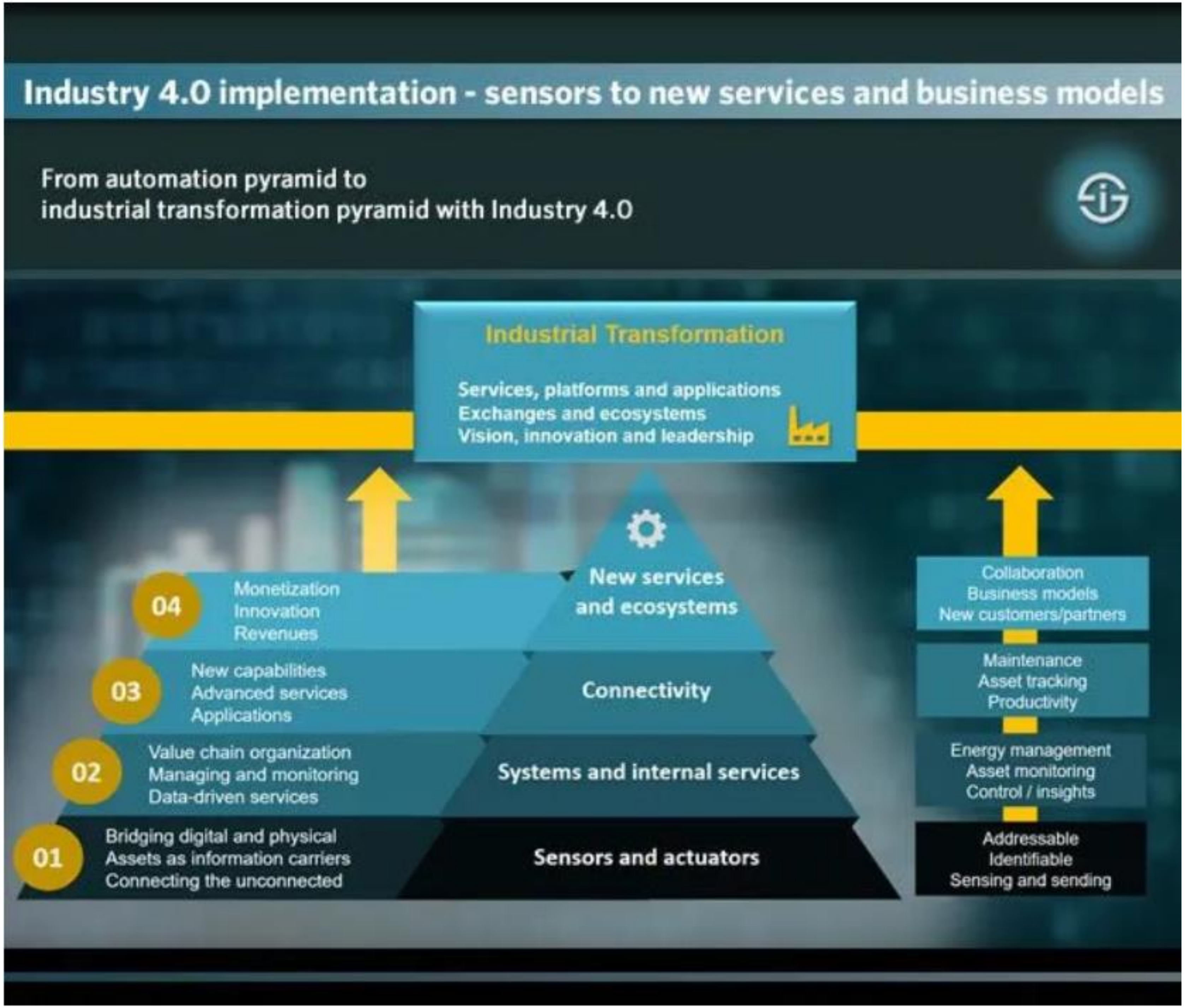
cutting the inefficiencies, irrelevance and costs of intermediaries in a digital supply chain model

in this customer-centric sense of increasingly demanding customers who value speed, *(cost)* efficiencies and value-added innovative services.

Business models and processes:

- **Increase profit**
- **Decrease costs**
- **Enhance customer experience**
- **Optimize customer lifetime value**


Horizontal Integration
C1
C2
Vertical Integration
P1
P2
Shop Floor
Warehouse


Industry 4.0 implementation - sensors to new services and business models
From automation pyramid to
industrial transformation pyramid with Industry 4.0
Industrial Transformation
Services, platforms and applications
Exchanges and ecosystems
Vision, innovation and leadership
04
Monetization
Innovation
Revenues
New services
and ecosystems
03
New capabilities
Advanced services
Applications
Connectivity
02
Value chain organization
Managing and monitoring
Data-driven services
Systems and internal services
01
Bridging digital and physical
Assets as information carriers
Connecting the unconnected
Sensors and actuators
Collaboration
Business models
New customers/partners
Maintenance
Asset tracking
Productivity
Energy management
Asset monitoring
Control / insights
Addressable
Identifiable
Sensing and sending

Industry 4.0

Characteristics

- even more automation than in the third industrial revolution
- bridging of the physical and digital world through cyber-physical systems (CPS)
- a shift from a central industrial control system to one where smart products define the production steps
- personalization/customization of products

The goal is to enable

- autonomous decision-making processes
- monitor assets and processes in real-time
- enable equally real-time connected value creation networks

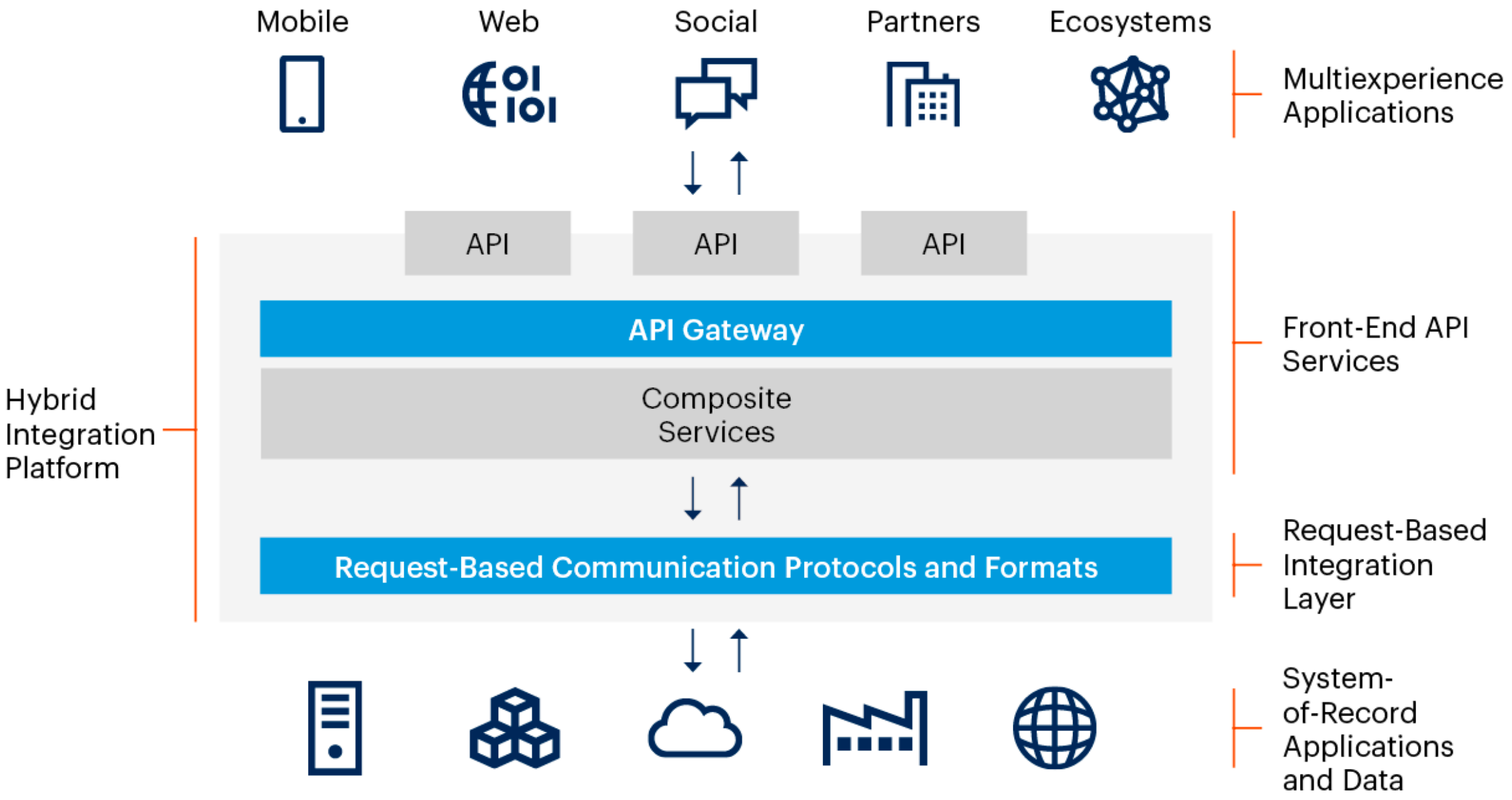
through early involvement of stakeholders, and vertical and horizontal integration.

- ***Systems, Applications, and Products in data processing*** **and it is one of the largest software company in the world.**

- **SAP provides end-to-end solutions for financials, manufacturing, logistics, distribution, etc.**

- **Each SAP module is integrated with other modules.**

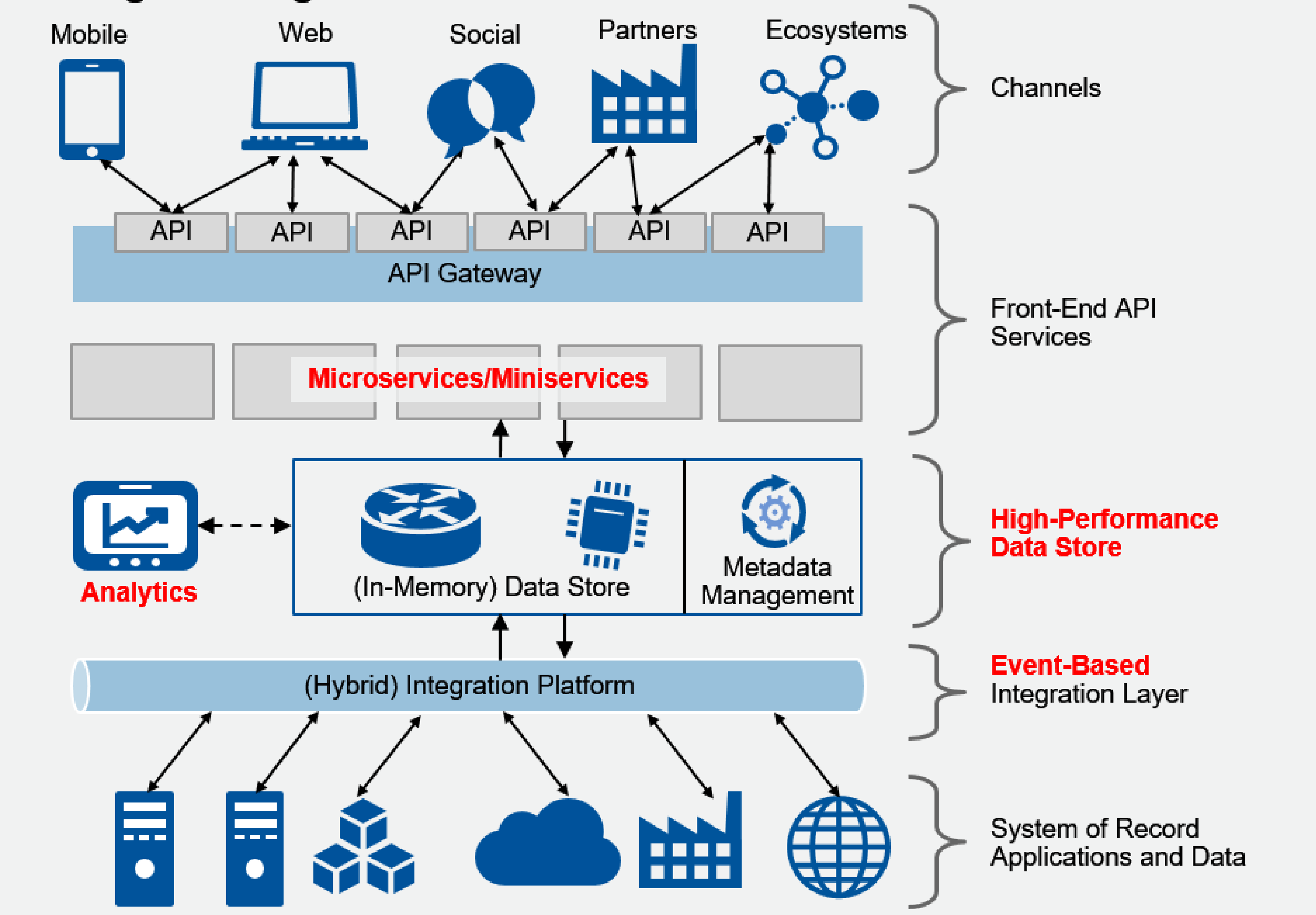
API Services Access Systems of Record via an Integration Layer



Source: Gartner

722630

The Digital Integration Hub Architecture

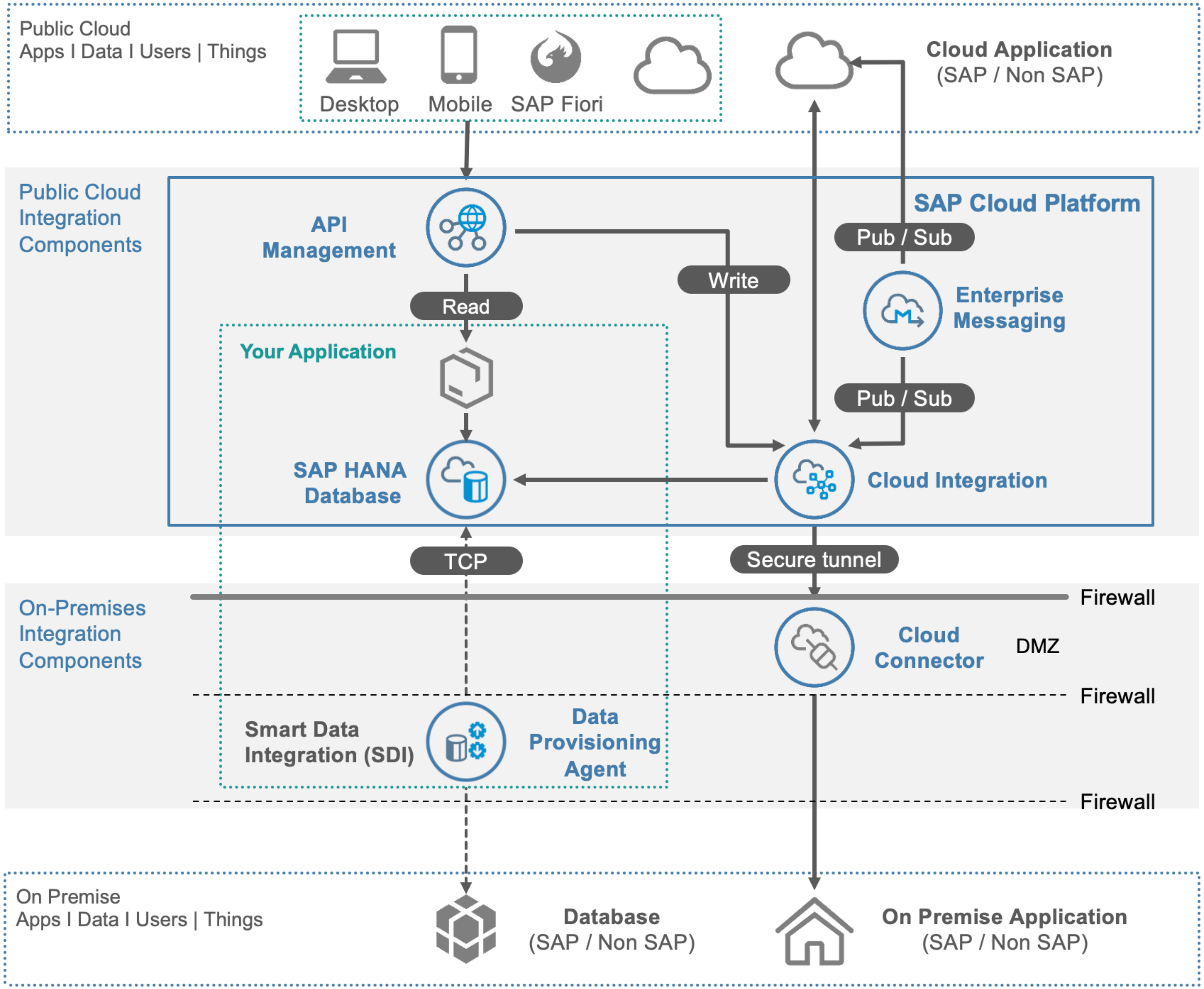


ID: 360082

The important ERP *SAP modules* used by organizations are

1. ***SAP FICO (Financials and Controlling) module,***
2. ***SAP MM (Materials Management) module,***
3. ***SAP SD (Sales & Distribution),***
4. ***SAP HR (Human Resources Management),***
5. ***SAP PP (Production Planning) module,***
6. ***SAP QM (Quality Management) module,***
7. ***SAP Project systems,***
8. **S4 Hana Finance**
9. **S4 Hana Controlling**
10. **ABAP on Hana**
11. **Simple Finance**
12. **Simple Logistics**


CO
Controlling
Asset
Accounting
FI
Financial
Accounting
SD
Sales and
Distribution
HR
Human
Resources
SAP R/3
Client /
Server
ABAP/4
MM
Material
Management
Plant
Maintenance
PP
Production
Planning
PS
Project
Systems
QM
Quality
Management
PM
Production
Planning


Public Cloud
Apps I Data I Users | Things
Desktop
Mobile
SAP Fiori
Cloud Application
(SAP / Non SAP)
Public Cloud
Integration
Components
SAP Cloud Platform
API
Management
Write
Pub / Sub
Enterprise
Messaging
Read
Your Application
Pub / Sub
SAP HANA
Database
Cloud Integration
TCP
Secure tunnel
Firewall
On-Premises
Integration
Components
Cloud
Connector
DMZ
Firewall
Smart Data
Integration (SDI)
Data
Provisioning
Agent
Firewall
On Premise
Apps I Data I Users | Things
Database
(SAP / Non SAP)
On Premise Application
(SAP / Non SAP)

SIGNIFICANCE OF SMART SENSORS FOR INDUSTRY 4.0

Digitalization and Smart Sensor Technology play an increasingly important role in Industry 4.0.

With the advent of both the Internet of Things (IoT) and Industry 4.0, new sensors and their related applications are being introduced every day. By combining smart sensors and IoT, Industry 4.0 is conceived as a bridge between the physical and digital worlds.

- **Smart sensors provide the opportunity to determine failure**
- **increase efficiency and**
- **monitor levels to design a smart factory**

- **The sensors are vital components of Industry 4.0, allowing several transitions such a**
- **changes in positions**
- **Lengths**
- **Heights**
- **external pressures and**
- **dislocations to be measured, analyzed, and processed.**

Different types of sensors

Sensors are categorized by what is being “sensed” or detected like force, pressure, flow, temperature, proximity, smoke, gas, alcohol, etc

Depending on the type of sensor, its output can be a voltage, current, capacitance, resistance, frequency, or another electrical attribute that varies over time.

- **Pressure sensors**

The pressure sensors monitor pipelines and alert supervisors to leaks and inconsistencies that may require maintenance or repairs through a centralized computer system that has real-time tracking. There are countless everyday applications that use these sensors for control and monitoring.

- **Temperature sensors**

There is also a very common use of temperature sensors in various industrial settings. One of the easiest examples of smart sensors that relate to machines is the use of temperature sensors that connect to a piece of industrial equipment or machinery. This device is connected to an IIoT cloud computing platform and can determine whether a machine or piece of equipment overheats to the point of requiring maintenance or shutting off. Often used in the automobile industry, aviation industry, medical sector, computers, cooking appliances, and other daily applications, these sensors are widely used throughout our everyday lives.

- **Level sensors**

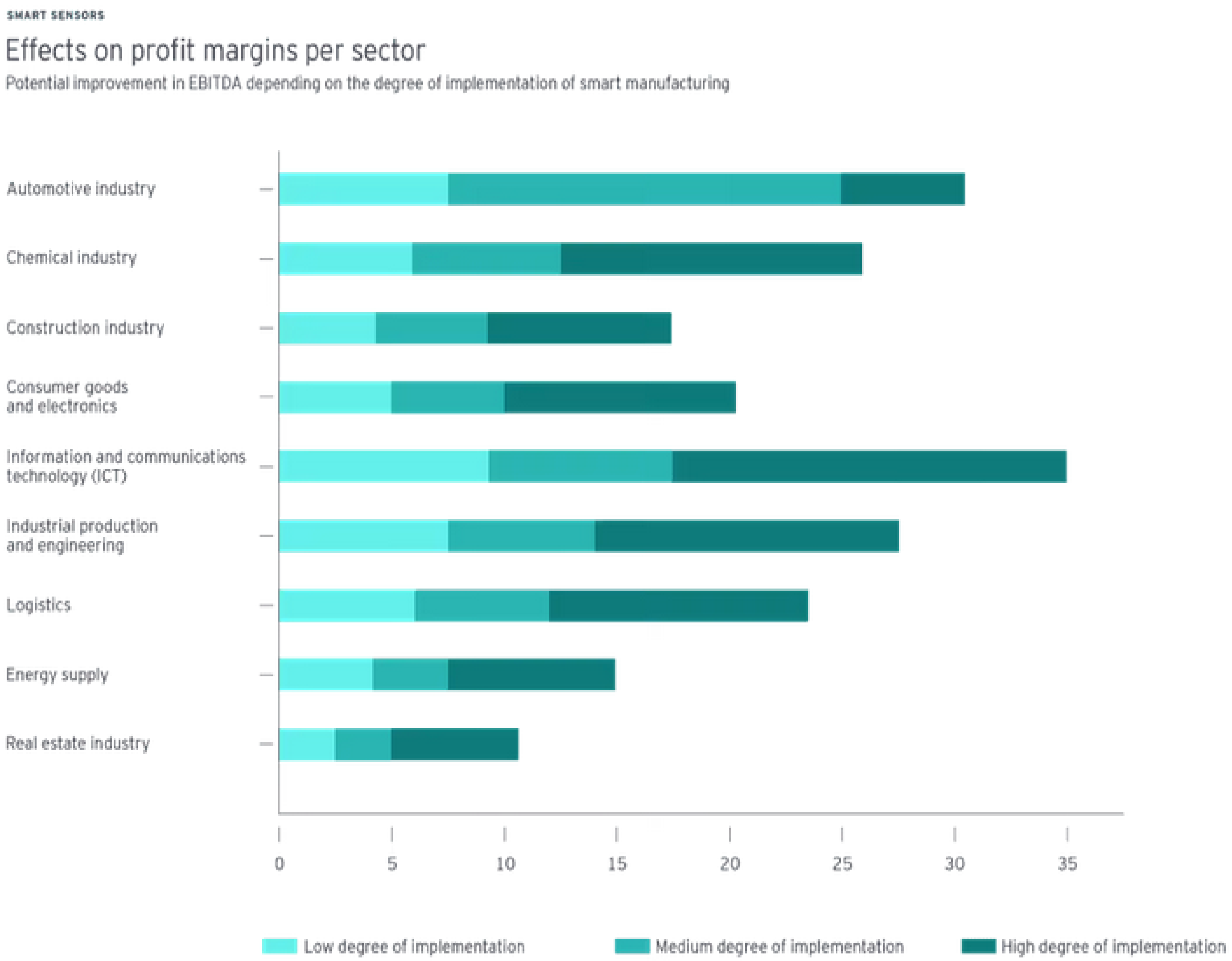
Level sensors provide real-time information to inventory management systems and process control systems about containers, bins, and tanks. There is a wide range of purposes for them, from waste management to irrigation to diesel fuel gauging and many more.

- **Proximity sensors**

One of the most common applications of a proximity sensor can be in a retail outlet. They can be used in retail outlets to detect customer location and track crowd flow. Different retailers use this technology to ping shoppers' smartphones with coupon offers they might find on their periphery.

Smart sensors for Industry 4.0

A detailed analysis of smart sensors in nine industries was conducted by EY. According to the analysis, companies across all industrial sectors benefited from the introduction of sensors even with a low degree of implementation. With the highest level of sensor saturation, profit margins are expected to rise from 11 to 34 percent by 2030 as per EY report.



Major advantages of smart sensors for Industry 4.0

•**Data-driven decisions:** Smart sensors provide historical and real-time data on the operational status of machine components. In addition, they enable plant managers to monitor and diagnose systems remotely, as well as identify and resolve problems before there's any negative impact on the production.

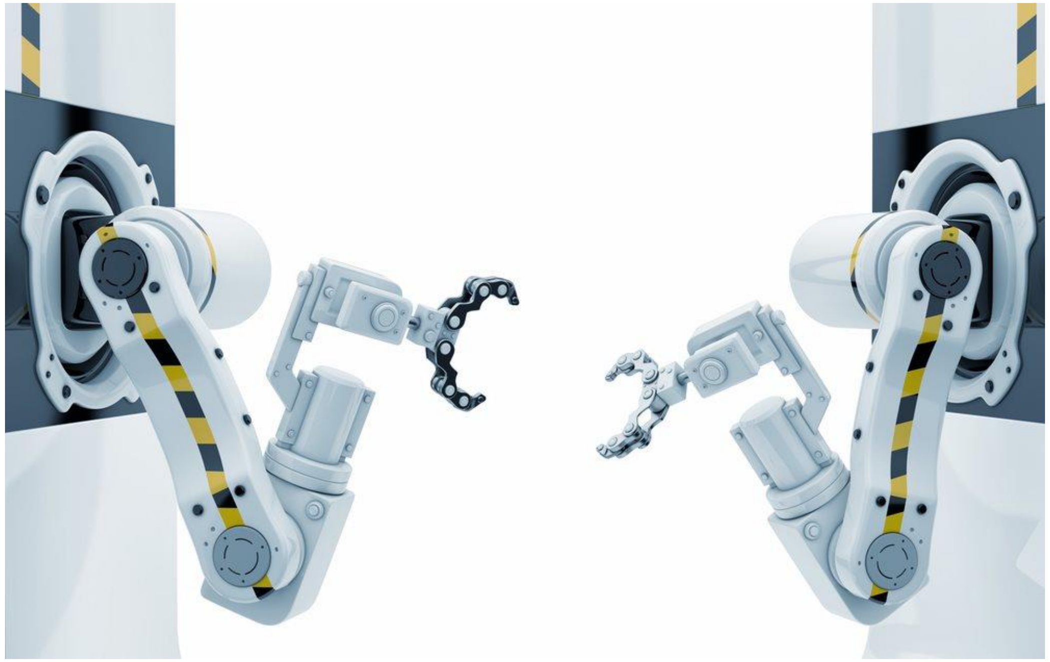
•**Assuring maximum uptime:** Predictive analytics can be used to improve maintenance planning in order to increase the mean time between failures and reduce the cost of unnecessary preventative maintenance.

•**Enhanced productivity:** Interconnectivity enables seamless communication between people, machines, and components, thereby increasing productivity. Additionally, it facilitates increased autonomy and streamlines manual procedures, thereby increasing efficiency.

•**Predictive maintenance:** employs the use of sensors to precisely collect data describing an asset's condition and overall operational state. The data can then be analyzed to predict when failure events will occur.

https://anfieldsensors.com/blog/significance-of-smart-sensors-for-industry-4-0/


COMMUNICATION
VOICE



machine-to-machine (M2M) Communication

Machine-to-machine, or M2M, is a broad label that can be used to describe any technology that enables networked devices to exchange information and perform actions without the manual assistance of humans. Artificial intelligence (AI) and machine learning (ML) facilitate the communication between systems, allowing them to make their own autonomous choices.

M2M technology was first adopted in manufacturing and industrial settings, where other technologies, such as SCADA . M2M has since found applications in other sectors, such as healthcare, business and insurance.
M2M is also the foundation for the internet of things (IoT).

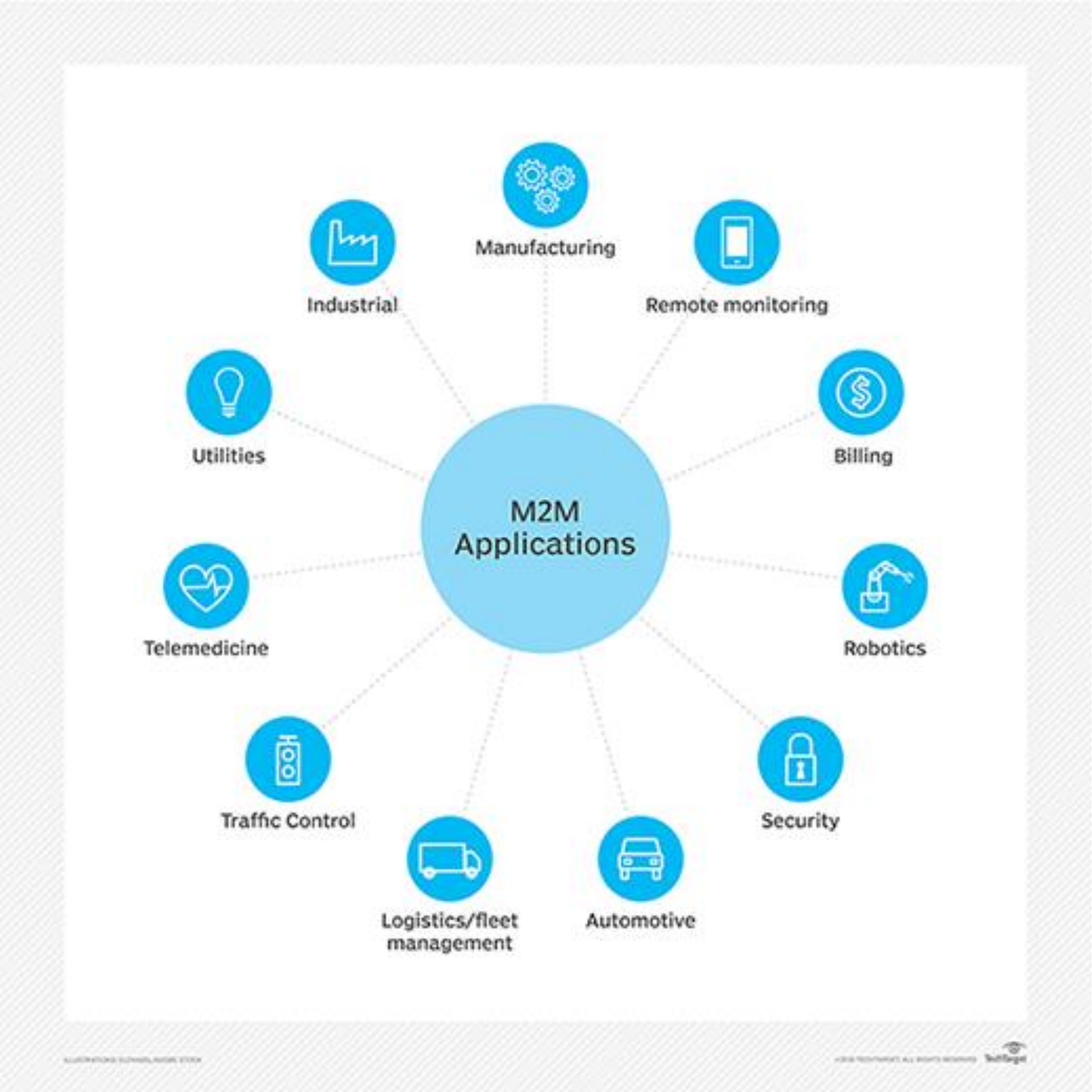
How M2M works

- The main purpose of machine-to-machine technology is to tap into sensor data and transmit it to a network. Unlike SCADA or other remote monitoring tools, M2M systems often use public networks and access methods -- for example, cellular or Ethernet -- to make it more cost-effective.
- The main components of an M2M system include sensors, RFID, a Wi-Fi or cellular communications link, and Autonomic Computing software programmed to help a network device interpret data and make decisions. These M2M applications translate the data, which can trigger preprogrammed, automated actions.
- One of the most well-known types of machine-to-machine communication is telemetry
- The Internet and improved standards for wireless technology have expanded the role of telemetry from pure science, engineering and manufacturing to everyday use in products such as heating units, electric meters and internet-connected devices, such as appliances

Advantages

•reduced costs by minimizing equipment maintenance and downtime
•boosted revenue by revealing new business opportunities for servicing products in the field
•improved customer service by proactively monitoring and servicing equipment before it fails or only when it is needed.

Machine-to-machine communication is often used for remote monitoring. In product restocking, for example, a vending machine can message the distributor's network, or *machine*, when a particular item is running low to send a refill.


Manufacturing
Industrial
Remote monitoring
Utilities
Billing
M2M Applications
Telemedicine
Robotics
Traffic Control
Security
Logistics/fleet management
Automotive

M2M vs. IoT: What's the difference?

M2M	IoT
Machines	Sensors
Hardware-based	Software-based
Vertical applications	Horizontal applications
Deployed in a closed system	Connects to a larger network
Machines communicating with machines	Machines communicating with machines, humans with machines, machines with humans
Uses non-IP protocol	Uses IP protocols
Can use the cloud, but not required to	Uses the cloud
Machines use point-to-point communication, usually embedded in hardware	Devices use IP networks to communicate
Often one-way communication	Back and forth communication
Main purpose is to monitor and control	Multiple applications; multilevel communications
Operates via triggered responses based on an action	Can, but does not have to, operate on triggered responses
Limited integration options, devices must have complementary communication standards	Unlimited integration options, but requires software that manages communications/protocols
Structured data	Structured and unstructured data

Opportunities

Increased Efficiency and Productivity: Industry 4.0 technologies enable automation, real-time data analytics, and optimization, leading to enhanced efficiency and productivity in manufacturing processes. Smart factories and digital technologies can streamline operations, reduce waste, and improve overall output.

Enhanced Flexibility and Customization: With Industry 4.0, organizations can achieve greater flexibility in production, allowing for customized products and shorter lead times. The ability to rapidly reconfigure production systems and respond to changing customer demands provides a competitive advantage.

Data-Driven Decision Making: Industry 4.0 generates vast amounts of data that can be analyzed to gain valuable insights. This data-driven decision making enables organizations to make informed choices, optimize processes, identify bottlenecks, and improve overall performance.

Opportunities

Improved Quality and Predictive Maintenance: By leveraging data analytics and machine learning, organizations can implement predictive maintenance strategies. This helps prevent equipment failures, reduce downtime, and improve product quality by detecting anomalies and addressing them proactively.

Supply Chain Optimization: Industry 4.0 facilitates improved supply chain visibility and coordination. Real-time data sharing and collaboration among suppliers, manufacturers, and customers can optimize inventory management, reduce lead times, and enhance overall supply chain efficiency.

New Business Models and Revenue Streams: Industry 4.0 opens up opportunities for organizations to develop new business models and revenue streams. The integration of digital technologies, such as IoT and AI, enables the provision of value-added services, predictive maintenance contracts, and outcome-based business models.

Challenges

Security and Cybersecurity: With increased connectivity and digitization, there is a corresponding increase in security risks and cyber threats. Protecting critical data, infrastructure, and intellectual property from unauthorized access and cyberattacks is a significant challenge that requires robust security measures and ongoing vigilance.

Workforce Adaptation and Skill Gaps: The implementation of Industry 4.0 technologies often requires a shift in workforce skills and capabilities. Organizations need to invest in training and upskilling employees to ensure they can effectively operate and collaborate with advanced technologies. Addressing the potential job displacement and ensuring a smooth transition for workers is also crucial.

Data Management and Privacy: Handling and managing large volumes of data generated by Industry 4.0 technologies can be complex. Organizations need effective data management strategies to ensure data integrity, privacy, and compliance with regulations such as GDPR. They must also consider ethical considerations regarding data collection, usage, and sharing.

Challenges

Interoperability and Standardization: Integrating different systems, devices, and technologies from various vendors can be challenging due to interoperability issues and a lack of standardized protocols. Establishing common standards and ensuring seamless interoperability is essential for efficient collaboration and data exchange.

Cost and Return on Investment (ROI): Implementing Industry 4.0 technologies often requires significant investments in infrastructure, technology, and workforce training. Organizations need to carefully evaluate the costs and expected returns to justify the investments and ensure a positive ROI over time.

Change Management and Organizational Culture: Embracing Industry 4.0 involves significant changes in processes, workflows, and organizational culture. Managing change, overcoming resistance, and fostering a culture of innovation and continuous improvement are crucial for successful adoption and integration of new technologies.

Lack of Resources

The successful implementation of Industry 4.0 can be influenced by several factors, including the availability of resources, skilled workers, broadband infrastructure, and supportive policies. Here's a brief overview of how these factors can impact the adoption of Industry 4.0:

Lack of Resources: Implementing Industry 4.0 technologies often requires significant investments in infrastructure, equipment, and technology. Organizations need adequate financial resources to acquire and deploy advanced technologies, such as sensors, automation systems, and data analytics platforms. Limited financial resources can pose a barrier to entry for smaller companies or organizations operating in resource-constrained environments.

Availability of Skilled Workers and Broadband Infrastructure

Availability of Skilled Workers: The skills and capabilities of the workforce are crucial for the successful adoption and integration of Industry 4.0 technologies. However, there may be a shortage of workers with the required digital skills and technical expertise to operate and leverage these technologies effectively. Upskilling and reskilling initiatives, collaboration with educational institutions, and targeted training programs can help bridge the skills gap and ensure a competent workforce for Industry 4.0.

Broadband Infrastructure: Industry 4.0 relies heavily on seamless connectivity and data exchange between machines, devices, and systems. Robust and reliable broadband infrastructure is essential for transmitting large volumes of data in real-time. However, the availability and quality of broadband connectivity can vary across regions, especially in rural or underserved areas. Investment in improving broadband infrastructure, including high-speed internet access, is necessary to facilitate the widespread adoption of Industry 4.0 technologies.

Policies and Regulations: Government policies and regulations play a significant role in shaping the adoption and development of Industry 4.0. Clear and supportive policies can encourage investment, innovation, and collaboration in emerging technologies. Governments can establish regulatory frameworks that address concerns such as data privacy, cybersecurity, and ethical use of technologies. Additionally, policies focused on fostering digital skills development, incentivizing research and development, and promoting technology adoption can further accelerate the implementation of Industry 4.0.

Collaboration and Partnerships: Collaboration among different stakeholders, including industry players, educational institutions, research organizations, and government bodies, is crucial for the successful implementation of Industry 4.0. Collaboration can facilitate knowledge sharing, resource pooling, and joint initiatives to address challenges collectively. Public-private partnerships can play a pivotal role in driving Industry 4.0 initiatives and creating an ecosystem conducive to innovation and growth.

The future of work and skills in the Industry 4.0 era is undergoing significant transformation due to the integration of advanced technologies and automation. While Industry 4.0 brings numerous opportunities for organizations, it also necessitates a shift in the skills and capabilities required by the workforce. Here are some key aspects to consider:

Automation and Robotics: With the increasing adoption of automation, robotics, and autonomous systems, certain repetitive and manual tasks will be automated. This requires workers to adapt and acquire skills to operate, program, and maintain these technologies. Collaborative skills that allow humans to work alongside robots and utilize their capabilities effectively will be valuable.

Digital Literacy and Data Analytics: The ability to understand and work with digital technologies is becoming essential in the Industry 4.0 era. Workers need digital literacy skills to navigate through digital interfaces, use software tools, and leverage data analytics platforms. Understanding data analysis, interpretation, and visualization will be crucial for making data-driven decisions.

Cybersecurity and Data Privacy: As digital connectivity increases, cybersecurity and data privacy become critical concerns. Organizations will require workers who are well-versed in cybersecurity practices, risk management, and data protection regulations. Skills related to securing networks, detecting and responding to cyber threats, and ensuring data privacy will be in high demand.

Critical Thinking and Problem-Solving: Industry 4.0 technologies generate vast amounts of data and insights. Workers will need strong critical thinking skills to analyze complex problems, identify patterns, and make informed decisions. Problem-solving skills, creativity, and the ability to adapt to new situations will be valuable assets.

Adaptability and Lifelong Learning: The pace of technological change in Industry 4.0 demands a continuous learning mindset. Workers will need to adapt to new technologies, acquire new skills, and embrace lifelong learning. The ability to quickly learn and upskill in response to evolving industry demands will be crucial for career success.

Collaboration and Communication: As the integration of digital technologies enables increased connectivity and collaboration, effective teamwork and communication skills become vital. Workers will need to collaborate with diverse teams, including human colleagues and intelligent machines. Strong interpersonal and communication skills will be essential to foster collaboration and build productive relationships.

Ethical and Social Awareness: Industry 4.0 technologies raise ethical and social considerations that workers should be aware of. Understanding the implications of technology on society, privacy, bias, and responsible use of AI and automation will become increasingly important. Workers will need to navigate ethical dilemmas and make value-driven decisions.

Entrepreneurial Mindset and Innovation: Industry 4.0 fosters an environment of innovation and entrepreneurship. Workers who can think creatively, identify opportunities for improvement, and embrace an entrepreneurial mindset will thrive. Being adaptable, open to change, and willing to take calculated risks will be valuable traits.