UNIT-V

Industry 4.0 laboratories

- A teaching and research lab for industry4.0 Located in the **School Of Management** of Politecnico di Milano. A **tangible physical entity** to carry out research and teaching activities in **a real-like Industry4.0 environment.**
- I4.0 Lab is **dedicated** to the memory of **Marco Garetti**, whose commitment and vision paved the ground for the research activities carried out by the Manufacturing Group

https://www.industry40lab.org/

The industry 4.0 LAB of CeDInt

- The industry 4.0 LAB of CeDInt will provide a research Infrastructure and facilities for the industry of the future including a BatNet network of sensors and actuators over digital manufacturing machines ready as a test bed and research facility on industry 4.0 solutions.
- The BATNet system offers connectivity of objects to the internet. The system connects industrial machinery to thr control and monitoring system and is OpenHW based (BAT-PlaformMiddleware for Industry).
- This Infrastructure is designed to facilitate the test and development of systems and solutions for the Industry 4.0 that require object connection to the internet. More specifically this infrastructure is prepared to test applications and services related to:
  - Energy efficiency on industrial environments
  - Industrial processes control
  - Preventive maintenance processes
- Indoor positioning applied to intelligent storage and logistics
- The Industry 4.0 LAB is designed to support present research in the future industry area. The final objective is to find universal solutions to optimize the industrial processes.
- This infrastructure is already available to the research community both private and public. If you are interested in accessing this facility please fill out this request form.
- *https://www.cedint.upm.es/en/infrastructure/industry-40-lab*

The Smart Production Laboratory: A Learning Factory for Industry 4.0 Concepts

- The manufacturing industry is moving “digital” and the changes required are numerous and extensive.
- This transformation, also known as the 4th industrial revolution or Industry 4.0, created the need of a research platform that could enable practitioners and academia collaboration on new technologies.
- Aalborg University developed a Learning Factory that is a facility equipped with machines, materials and tools established to support research projects.
- This paper presents Aalborg University’s "small Industry 4.0 factory" and its contribution to Industry 4.0 research by creating a platform for developing technologies to satisfy manufacturing requirements and by demonstrating their value in a production environment.
- The Leaning Factory is contributing to research by enabling the development of manufacturing technology. At the same time, it is providing practitioners with a platform for solving industrial problems

Source:“The Smart Production Laboratory: A Learning Factory for Industry 4.0 Concepts”

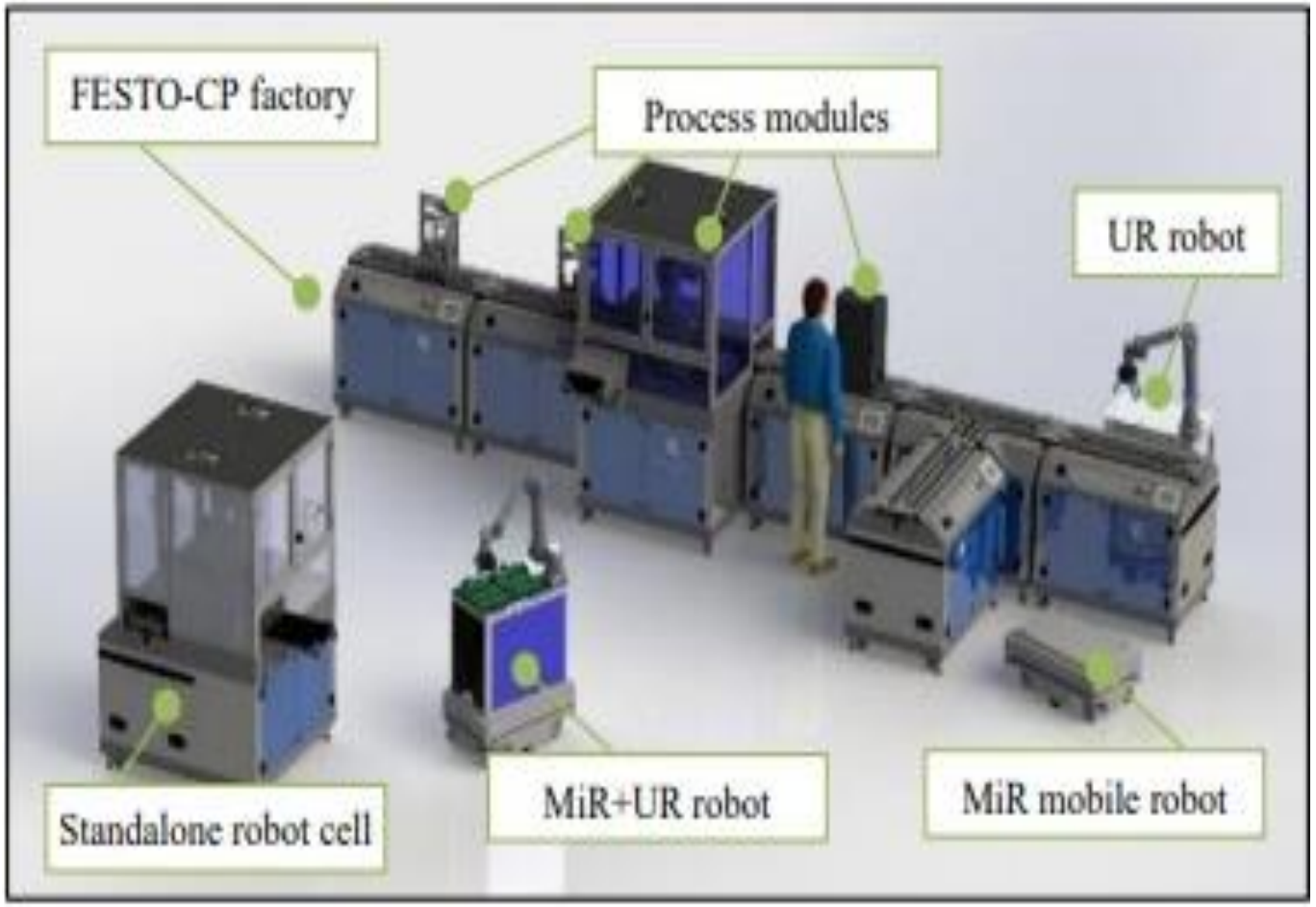
Methodology

- In August 2016 Aalborg University decided to develop a LF in smart manufacturing.
- Applying the design science approach , Aalborg University designed the Smart Production Lab to address needs from the industry and research concerning automation, robotics, and production methods.
- Manufacturing companies were lacking knowledge and capabilities related to I4.0.
- The university main goal was to develop the necessary equipment to operate as an I4.0 factory.
- The descriptive evaluation of the artifact is based on the completion of research projects related to I4.0.

Smart Production Lab description

- FESTOs CP factory , a small modular and expandable factory integrating many relevant I4.0 technologies composed of several standard FESTOCP-factory transportation modules (linear conveyor belts) and one branch module.
- These modules have electrical, pneumatic and mechanical interfaces and can be easily moved since they are on wheels.
- Process modules, like part dispenser, drilling module, inspection module, and assembly module, are mounted on the transportation modules. Process modules are the ones performing the actions on the products and they can be mounted and unmounted from the transportation modules. Our process modules are either from FESTO or were developed in research projects.
- Robots integrated with the production line, like the dedicated robot (KUKA) assembly cell, developed by FESTO as part of CP Factory, the mobile robots (MiR) and collaborative robots (UR-robots).
- The latter two can also be combined (see figure) for example to automate the packaging of the finished parts.
- The standalone robot cell (SCARA robot from Adept) performs various tasks, like production of subcomponents for the FESTOs CP factory.

Overview of the Smart Production Lab



References

- *https://www.hta-it.com/blog/lab-4.0-features-and-prospectives.html*
- *https://www.fhstp.ac.at/en/campus/studios-and-laboratories/industry-4-0-lab*
- *https://www.future-science.com/doi/10.2144/btn-2019-0061*
- *https://www.wichita.edu/academics/engineering/ime/_centers_and_labs/Industry40_Lab.php*
- *https://www.sdu.dk/en/forskning/i40lab*
- *https://www.researchgate.net/publication/322683341_The_Smart_Production_Laboratory_A_Learning_Factory_for_Industry_40_Concepts*

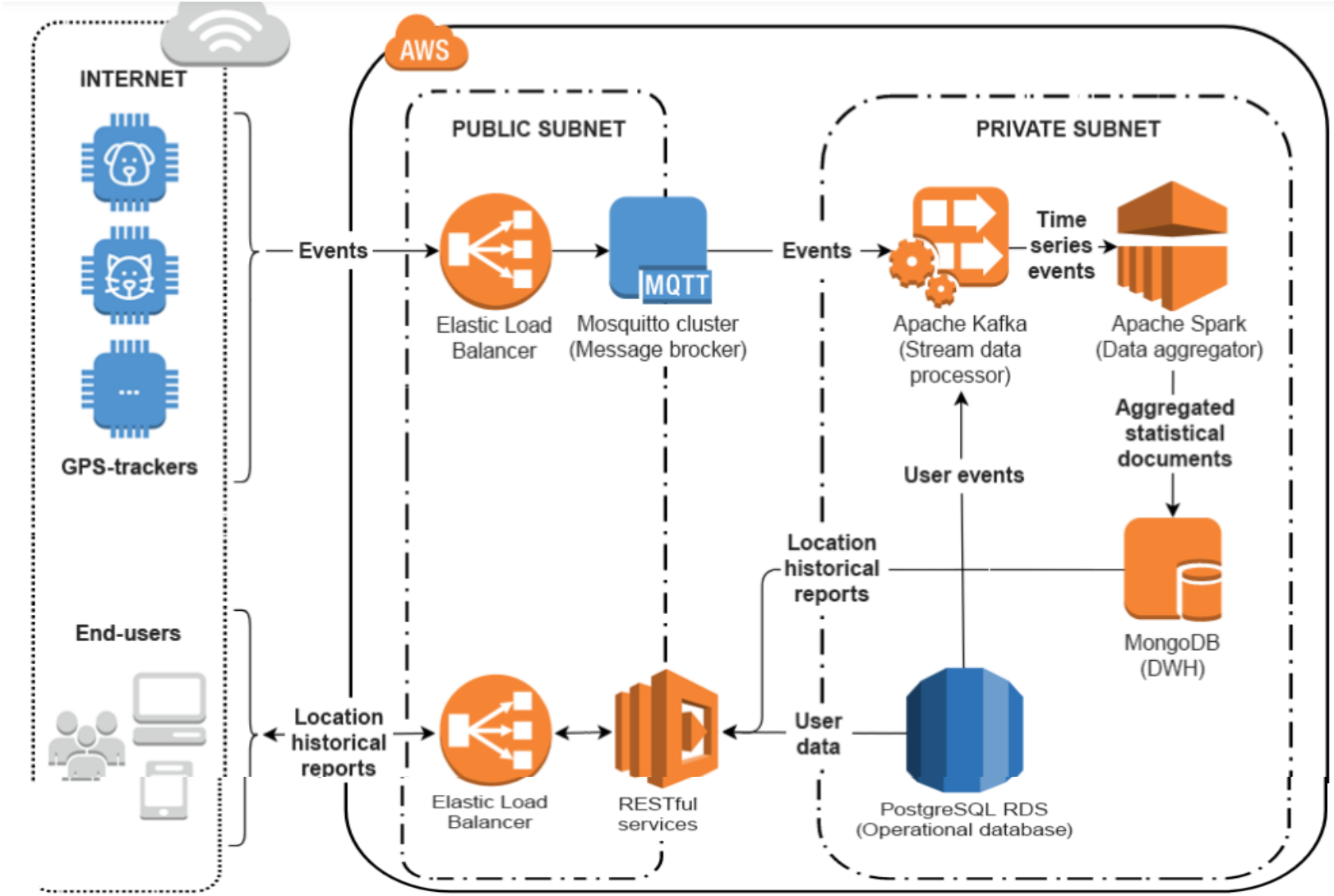
DEVELOPMENT OF A BIG DATA SOLUTION FOR IOT PET TRACKERS

CHALLENGE

- The Customer wanted a big data solution that would allow the users to be always up-to-date about their pets' locations, receive real-time notifications about critical events, as well as access the reports on their pet's presence.
- The solution was to enable media content transfer (audio, video and photos) so that pet owners could speak to their pets or see where their pets were at a particular moment.
- As the Customer expected that the number of users would be constantly growing, the solution was to be easily scalable to store and process an increasing amount of data.

Source:https://www.scnsoft.com/case-studies/big-data-solution-for-iot-pet-trackers

SOLUTION


INTERNET
GPS-trackers
End-users
AWS
PUBLIC SUBNET
PRIVATE SUBNET
Events
Elastic Load Balancer
MQTT
Mosquitto cluster (Message brocker)
Events
Apache Kafka (Stream data processor)
Time series events
Apache Spark (Data aggregator)
Aggregated statistical documents
MongoDB (DWH)
User events
Location historical reports
Location historical reports
Elastic Load Balancer
RESTful services
User data
PostgreSQL RDS (Operational database)

How the solution works

- Multiple GPS-trackers transmit real-time data about pet location, as well as about events (e.g., low battery, leaving a safe territory, etc.) to **the message broker** using the **MQTT protocol**. The protocol was chosen because it helps to ensure a device-friendly interface and save mobile phone battery life.
- A **stream data processor** based on Apache Kafka streams data from multiple MQTT topics, processes it in real time and checks data quality. Its component, Kafka Streams, makes push-notifications possible and ensures a safe data transfer.
- A **data aggregator** implemented on Apache Spark processes data in memory, aggregates it by hour, day, week and month and transfers to **a data warehouse.** For the latter, ScienceSoft's team suggested MongoDB technology because it allows storing the time series events as a single document (by hour, by day, by week). Besides, its document-oriented design allows in-place updates that lead to a major performance win.
- **Operational database** on PostgreSQL RDS stores users' profiles, accounts and configuration data.
- **RESTful services** separate user interface from the data storage, as well as ensure reliability, scalability and independency from the platform type or a programming language.

RESULTS

- The Customer received an easily scalable big data solution that allows processing 30,000+ events per second from 1 million devices.
- As a result, the users can track their pet’s location in real time, as well as send and receive photos, videos and voice messages.
- If a critical event happens (e.g., a pet crossed a geo fence set by the pet owner or the pet’s wearable tracker turned “out of communication,” etc.), the user receives push-notifications. Pet owners can also access hourly, weekly or monthly reports set automatically, or manually tune the reporting period, if needed.

DEVELOPMENT OF AN IOT SOLUTION FOR CONSTRUCTION HEALTH MONITORING

CHALLENGE

- In order to provide a continuous and efficient technical control and thus increased security of constructions and complex engineering objects, the Customer decided to develop a smart construction monitoring system for collecting and processing data through sensors installed on the key elements of a building.
- The solution was designed to automate regular data collection and processing.

SOLUTION

- ScienceSoft's IoT development team designed and developed a smart solution to collect sensor data and aggregate it on a central server for processing and further calculations of a building's state. Data processing and averaging make it possible to boost system performance and reduce data volumes.
- The user-friendly interface presents the data from connected through intuitive color coding – the green, yellow and red lights indicate the state of a building. Additionally, the system allows a flexible configuration of threshold values to regulate the transition from one status to another.
- To aggregate the data – suppose, for calculating a construction deformation, ScienceSoft developed a system of virtual sensors collecting information from several physical sensors. It allows users to monitor specific parameters which can be used only in the aggregate.

RESULTS

- The Customer received an easy-to-use IoT solution to monitor the state of a construction in real time. The tool automatically notifies the operator about a sensor failure or a construction defect and can be integrated with external systems.

References

- https://www.iotcentral.io/blog/10-case-studies-for-the-industrial-internet-of-things
- https://new.siemens.com/in/en/company/topic-areas/digital-enterprise.html?gclid=CjwKCAjwy42FBhB2EiwAJY0yQoMkGNufW6uzju1Bvk_RS0J_9Jj9epdUFgB4GrG0TeWyYmVFk479wxoCIfAQAvD_BwE#Technologies

Why are Case studies necessary?

- Case studies provide in-depth knowledge and clarity of concepts regarding the research topic.
- Case study
  - enables a researcher to closely examine the data
  - within a specific context
  - follows certain procedures
  - provides quantitative and qualitative analysis of the data
- Case studies explore and investigate real-life phenomenon through detailed analysis of related events.
- Generally, in a case study, a small geographical area or a very limited number of individuals, are selected as the subject matter

➢ Points to ponder … (for all case studies)

- Transformation of existing processes for Industry 4.0 adoption
- Assessment of existing processes
- Target objectives
- Transformation project management … setting objectives, schedule, budget
- Sensors, actuators, networks, interoperability
- automated fault detection & maintenance
- feedback control
- analysis of data (real time & non-real time)
- reduction of health hazards of workers
- improvement in overall efficiency

UAVs in Industries

UAVs are Connected to IoT

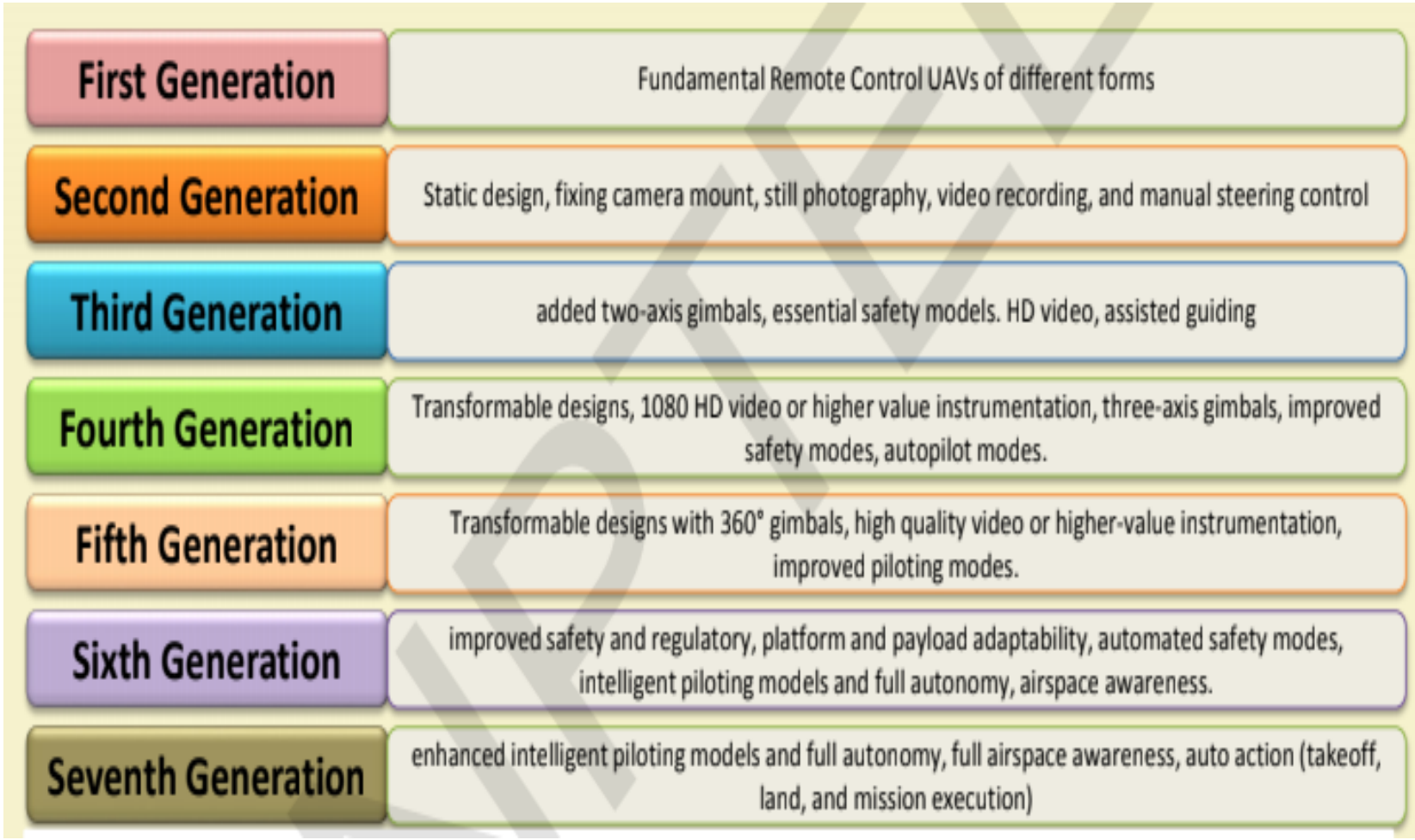
- Deployable to various locations
- Capable of conveying adaptable payloads
- Measure the required data from different locations
- Re-programmable

➢ UAVs in Industries

- UAVs gather integration of the measurements using IoT sensors
- UAVs have an end-to-end connection via wireless, from user to controller
- Communicates directly to an industrial control system such as the SCADA
- UAVs are capable of taking aerial imagery, visual imagery, thermal imagery and also radio-frequency imagery of factory stations and substations.

Source: Why Drones Are the Future of the Internet of Things, Skylogic Research Drone Analyst

UAVs Technology Generations



Application Fields

Application in Agriculture

Increase effective yields:

- Precisely estimate the field characteristics

Save time:

- Help farmers in scouting their crops

Optimized inputs:

- Optimize use of seed, fertilizer, water

Crop health monitoring:

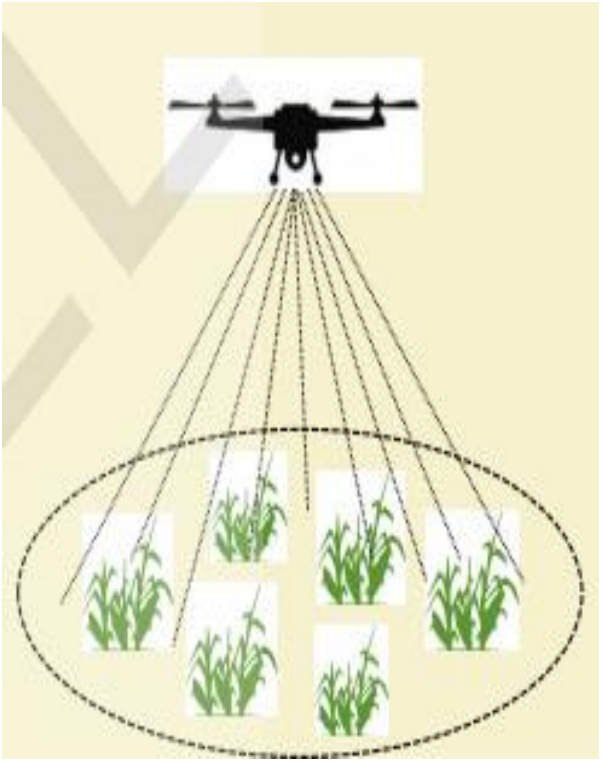
- Fertilization dispersal to different areas as per needed
- Monitor crop stress factors (like over fertilization or drought)

Other information:

- Find the field borders for flight pattern
- Soil quality, plant counting, plots size

Low-cost camera platform :

- Integrated software covers maximum areas of growing yields
- Take effective images by planning their flight path
- High quality and high precision real time images



Source: Use cases: The many IoT applications of drones, RCR Wireless News

Application in Construction Sites

Survey:

- Quick survey of required job areas
- Build maps

Monitoring job sites:

- Monitor progress, works, and safety standards

Inspecting structures:

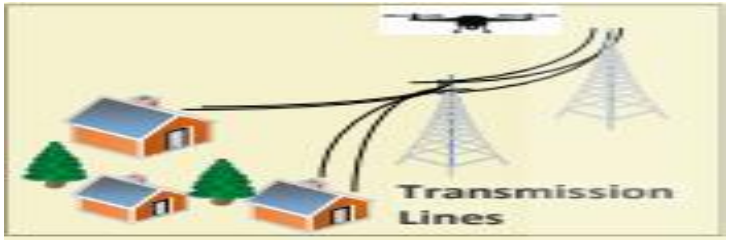
- Take continuous complex readings instead of lots of workers and heavy softwares
- Inspect infrastructures and constructing roadways and forest roads
- Showing clients progress:

  Show clients work progress when they are far away from job sites
- Require less time, save energy and money
- Monitor shoreline erosion

Source: Use cases: The many IoT applications of drones, RCR Wireless News

Energy Management

- Inspections without climbing power poles
- No need to get close to dangerous wires
- Observe miles of transmission lines in a single flight
- Damage from storms
- Inspect large boiler at power plants
- Monitor solar panels of the farms
- Inspect of wind turbines
- Inspect bridges, dams



Application in Mining

- Regular surface survey for optimized blast design
- Identify misfire and wall damage
- Manage stockpiles
- Helps in grading control
- Site exploration
- Safety and surveillance

Source: Top 5 Industrial Applications For Drones, OpTo Blog

Application in Delivery and Healthcare

- Delivery of medicines, vaccines,defibrillators, snake bite serum
- Delivery to the hospitals and remote areas
- Transport blood samples to laboratories for testing crucial diseases
- Research is being done on drones with manipulator arms that can help the senior population

Application in Entertainment

➢Cheaper and exciting:

- UAV-based light displays are cheaper and more exciting than traditional firework display
- Entertains as a flying light show
- Controlled by single computer that consumes manpower
- Reusable

➢ Film industries for capturing frames in a cost effective way

Source: Drones as Entertainment: what's ahead for this emerging application?, Unmanned Systems source

Application in Oil and Gas

- Data collection:
- Collect videos and thermal imagery of oil and gas fields, fed to the industry for analyze
- Pipeline monitoring:
- Detect leakage of oil and gas pipelines
- Oil spill detection and damage assessment
- Construction planning:
- Information gathered by elevation mapping, watershed analysis
- Reduce manpower requirement and increase safety:
- No need of industrial mountaineering with risk and high cost
- Monitoring work progress
- Tracking asset usage

Application in Warehousing and Inventory

- Scans a huge number of items in a warehouse
- Check the missing items
- Monitor full inventory in a day

Shipping and Delivery

- Shipping and delivery by drone in different companies
- Save manpower and resources
- Save time by avoiding unnecessary road traffic

Source: 10 stunning applications of drone technology, Allerin

Application in Forestry

- Forestry survey:
- Show information about the forest species including the humans around the forest
- Precision forestry and canopy mapping:
- Measurement of canopy height, density and volume estimation
- Wildland fires tracking
- Protecting endangered species
- Save time, manpower and resources
- Forest management:
- Manage forest plantations and evenly distribute seedlings sprinkling fertilizer
- Control forest density
- 3D mapping of carbon storage in the forest:

Measure the carbon storage in biomass by remote sensing

- Resist deforestation and increase security

Challenges for Industrial IoT (IIoT)

- Connectivity Outage Challenge
- Delivering Value to The Customer
- Data Storage
- Security
- Analytics Challenges
- Energy Efficiency
- Real-Time Performance
- Coexistence and Interoperability
- Security and Privacy

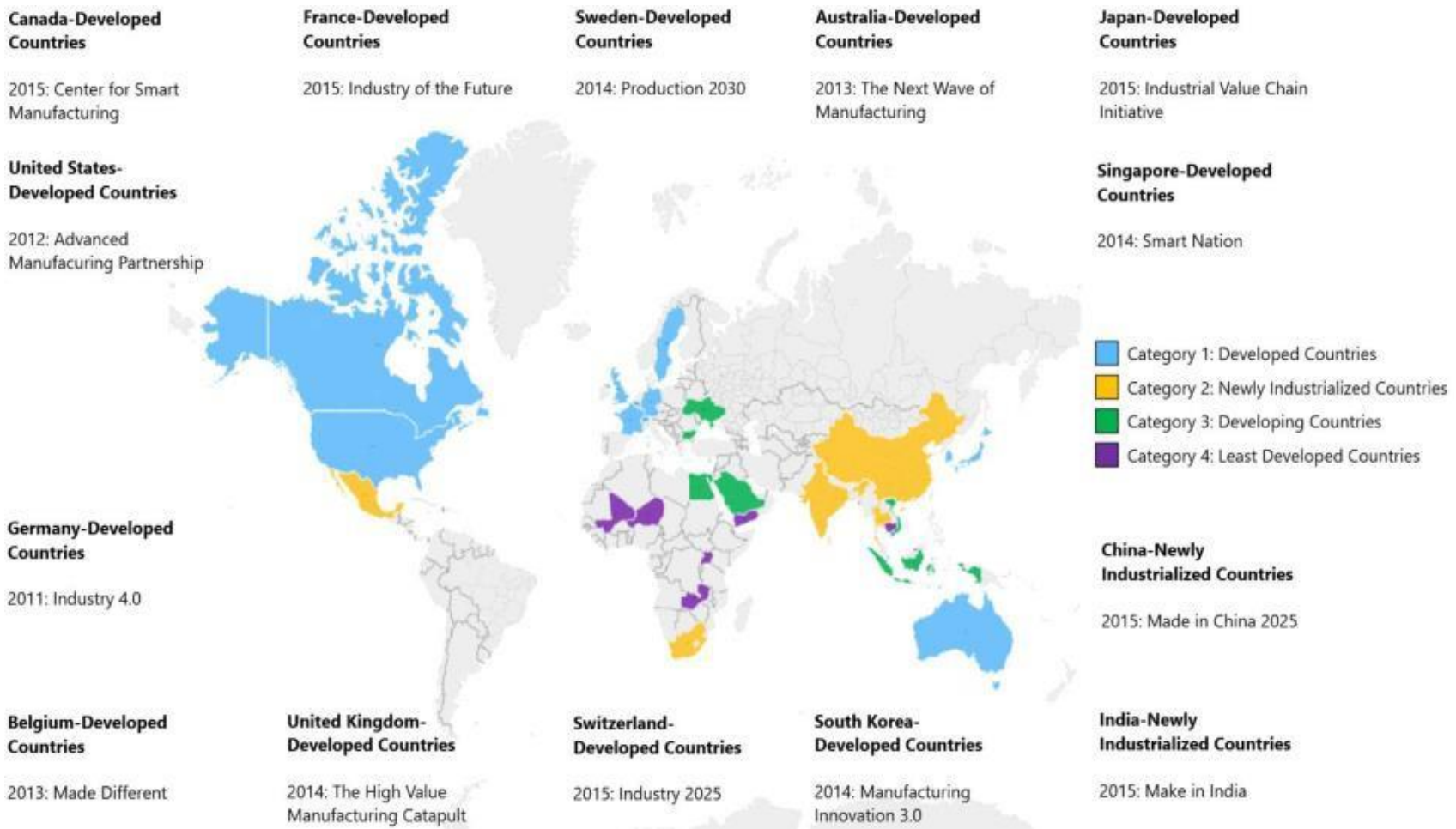
https://www.business2community.com/tech-gadgets/top-5-challenges-for-industrial-iot-iiot-implementation-02144024

Opportunities of Industry 4.0

- In Germany, Industry 4.0 was born in the direction of developing a collaboration of all stakeholders. Now, a new phase has started that aims to overcome national borders and establish new international collaborations, especially at the European level.
- Industry 4.0 provides opportunities for a country to develop economically and provide its citizens with a better income and lifestyle. Nevertheless, some countries are more equal than others when it comes to equality of opportunity with Industry 4.0.

Source:https://www.intechopen.com/books/digital-transformation-in-smart-manufacturing/fourth-industrial-revolution-current-practices-challenges-and-opportunities

Main initiatives for Industry 4.0



(source: IL sole 24 Ore magazine)

Developed Countries

- Without doubt, Industry 4.0 offers great opportunities in economic gains, more reliable and smart production, sustainable manufacturing systems, technology innovation, and many other areas to most developed countries. Based on the four factors used in our study, these countries are most prepared to benefit from
- Industry 4.0. They have accumulated tremendous competitive advantages in the knowledge economy, innovation, and smart manufacturing.
- **Least-Developed Countries**
- These could Clean energy and a sustainable development mode are among the most exciting topics in Industry 4.0; both of which provide opportunities for the poorest countries around the world. For example, these countries' ample solar energy and wind power may supplant an unreliable centralized grid infrastructure, if one exists at all, benefiting local residents. Nevertheless, least- developed countries may need help to capitalize on these opportunities.

Industry 4.0: Challenges and Opportunities in Different Countries
by Keng Siau, Yingrui Xi, and Cui Zou

INDUSTRY 4.0: SKILLS FOR THE FUTURE OF WORK

https://www.global-imi.com/blog/industry-4-0-skills-for-the-future-of-work

INDUSTRY 4.0: SKILLS FOR THE FUTURE OF WORK

- From automation and big data to artificial intelligence (AI) and robotics, the technologies ramping up the next great Industrial Revolution are here.
- The question is, do your employees have the skills and strengths required by Industry 4.0's workplace?
- All these new technologies will not be maximized and optimized by an organization if their employees do not develop the skills needed to utilize them.

https://www.global-imi.com/blog/industry-4-0-skills-for-the-future-of-work

- **Tech and talent: a skills mismatch:**There are four reasons for this skills gap, as enumerated by HR consulting firm Randstad:

- **The rise of automation.** According to The Future of Jobs Report by the World Economic Forum, automation will disrupt 85 million jobs by 2025. Automation in the workplace will enable employees to take on more strategic and high-level roles—provided they have the skills to assume them.
- **New technologies mean new skills.** All these new technologies such as AI, data analytics, blockchain, and robotics require corresponding skills—all of which are new and in short supply.
- **Emerging roles**. As technologies become more advanced, new roles will develop to supervise, program, and troubleshoot machines. According to the World Economic Forum, 97 million new roles may emerge that are more adapted to "the new division of labor between humans, machines, and algorithms".
- **The development of more technologies.** Because we cannot predict what new technologies will be developed, we can't foresee what skills those technologies will require.

- **Bridging the gap:**

- As technology changes the business landscape, companies are in danger of not having the skills to operate effectively in this new era of digital transformation.
- What can organizations do to ensure that employees are not left behind as we meet the future of work?

- **A change in mindset:**
  Companies need to shift their strategy from recruiting and retaining top performers to identifying emerging roles and preparing their employees for them. The good news is there has been a five-fold increase in employers providing online learning opportunities to their staff. And despite the global economic downturn, 66% of employers surveyed by the World Economic Forum expect a return on their investment in upskilling and retraining their employees within one year.
- **A winning combination: technical and transferable skills**
  Together with technical expertise, transferable skills that enhance one's ability to solve problems, work independently, and collaborate with others are required for the workplace of the future.

https://www.global-imi.com/blog/industry-4-0-skills-for-the-future-of-work

What Impact Will the Fourth Industrial Revolution Have on the Future of Work?

- The 4th Industrial Revolution is largely driven by four specific technological developments: high-speed mobile Internet, AI and automation, the use of big data analytics, and cloud technology. Of these four technologies, AI and automation are expected to have the most significant impact on employment figures within the global workforce.
- A recent study released by McKinsey Global Institute reports that roughly one-fifth of the global workforce will be impacted by the adoption of AI and automation, with the most significant impact in developed nations like the UK, German and US. By 2022, 50% of companies believe that automation will decrease their numbers of full-time staff and by 2030, robots will replace 800 million workers across the world.
- While these figures may sound depressing, it may also simply represent a change within the workforce and displaced employees could, with the right skills, take on more beneficial roles. The World Economic Forum reports that 38% of businesses believe AI and automation technology will allow employees to carry-out new productivity-enhancing jobs while over 25% of companies think automation will result in the emergence of new roles.

https://www.changerecruitmentgroup.com/knowledge-centre/how-will-the-fourth-industrial-revolution-impact-the-future-of-work

strategies for competing in an Industry world

- https://www.sciencedirect.com/science/article/abs/pii/002463018990057 5
- https://www.ukessays.com/essays/economics/competing-in-globalizing-markets-economics-essay.php

Refer these journals for information