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Industry 4.0: Cybersecurity

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What is Cybersecurity?

- In computing, security consists of
  - Cybersecurity
  - Physical security

- Protection of internet-connected systems from cyber-attacks is known as cybersecurity.

Source: Techtarget.com: Cybersecurity

What is Cybersecurity?

- This protection involves protection of
  - hardware
  - software
  - data
- Enterprises use cybersecurity and physical security simultaneously against unofficial access to data centres.

Source: Techtarget.com: Cybersecurity

Protect against what?

- Unofficial change in the data
- Unofficial deletion of the data
- Uncertified access

Source: Techtarget.com: Cybersecurity

Components of Cybersecurity

- Application Security
- Information Security
- Network Security
- Operational Security
- End-user Education

Source: Techtarget.com: Cybersecurity

Elements of cybersecurity(Contd.)

- Application security
  - It ensures the protection of applications from outer threats.
  - Some software, hardware and procedural methods are used for protection.
  - Some actions are needed to certify application security; these actions are known as countermeasures. There are two types of countermeasures.
    - Software countermeasure: application firewall
    - Hardware countermeasure: router/proxy

Source: Techtarget.com: Cybersecurity

Elements of cybersecurity(Contd.)

- Information Security
  - Information security is recognized as a subset of cybersecurity.
  - A set of strategies is known as information security, which handles some tools and policies. These policies filter the threats.
  - These strategies help maintain the availability, integrity and confidentiality of business data.

Source: Techtarget.com: Cybersecurity

Elements of cybersecurity(Contd.)

- Network Security
  - Network security is a process by which we take physical and software actions for protecting the network architecture.
  - It provides protection from unofficial access, improper use, fault, deletion, demolition.
  - Create a protective platform for users and computers.
  - It combines multiple layers of defences at the edge and in the network.

Source: Cisco: Security

Elements of cybersecurity(Contd.)

- Operational Security
  - Operational security (OPSEC) is an analytical action which categorizes information benefits.
  - For protection of these information benefits, it regulates the control.
  - Protection is an important factor in business perspectives; because of this OPSEC operations are commonly used in business actions.

Source: Cisco: Security

Elements of cybersecurity(Contd.)

- End-User education
  - End-users are the biggest security risk for an industry. They are the first to compromise the security.
  - Employees do not have all information about all the attacker, hence they can easily open the doors for the attackers.
  - As cybercrimes are increasing, it will be more important for industry to educate their employees about cyber-attacks.

Source: Cisco: Security

Types of Cybersecurity threats

- Ransom-ware
  - It provides a facility to the attacker in which the attacker locks the user’s computer files by using an encryption and demand some money to unlock them.
  - Example: Locky
- Malware
  - A computer program which is used to disturb the computer user, such as computer viruses, spyware etc.
  - Example: Trojan Horse

Source: Techtarget.com: Cybersecurity

Types of Cybersecurity threats(Contd.)

- Social Engineering
  - This attack involves human interaction to mislead users.
  - It breaks security policy to get critical information, which is typically secured.
  - Example : Watering hole and Pretexting.
- Phishing
  - Phishing is in the form of false information. These information are basically false emails which have been sent through recognizable sources.
  - The aim is to get critical data, such as login information or credit card information.
  - Example: Google docs Phishing and Dropbox Phishing.

Source: Techtarget.com: Cybersecurity

Industrial Internet (II)

- Internet of things, computers and people, machines all together make Industrial Internet.
- It enables industrial intelligent actions to use advanced data analytic tools for gettable business results.
- Autonomous cars, intelligent rail-road systems are applications of industrial internet.

Source: i-scoop.eu : Cybersecurity-IIoT

Why IIoT Security Standards is required?

- Industries will need to use diverse systems and equipment but everything will be integrated on smart factory floor.
- Legacy systems must be brought under implementation.
- Every weak line in the chain puts whole factory at risk.
- Leaving security at the hands of individual IIoT implementers is dangerous.

Source: i-scoop.eu : Cybersecurity-IIoT

Cybersecurity Requirements

CIA Triad

- C-Confidentiality
- I-Integrity
- A-Availability

IIoT requirements

- Reliability
- Safety

Source: Techtarget.com: Cybersecurity

CIA Triad

- C-Confidentiality
  - Confidentiality stops unauthorized disclosure of Information.
- I-Integrity
  - Integrity ensures that data cannot be changed in any unauthroized manner.
- A-Availability
  - Availability guarantees that information must be available only to the authorized user.

Source: Techtarget.com: Cybersecurity

Cybersecurity: Challenge in IIoT

- Cybersecurity has a major role in digital economy and it certainly is a big challenge in IIoT as well.
- In current digital transformation, capabilities such as manufacturing, logistics, shipping, healthcare and industries, which comes under the industrial internet, data breaches can occur, which increases different kinds of cybercrimes and cyber threats.

Source: Cybersecurity for industry 4.0: Thames

Cybersecurity for Industry 4.0

- Traditional cybersecurity mechanisms have the characteristics- confidentiality, authenticity, integrity, non-repudiation and access-control.
- These methods provide safety in network and computer attacks.
- The **new internet security** deals with **other attacks** which are capacious and very fast.
- Some methods are required for Industry 4.0 systems which enables automatic detection to cyber-attacks.

Source: Cybersecurity for industry 4.0: Thames

Cyberattack Detection: Methodologies and Algorithms

- Computational Intelligence systems (CIS)
  - An algorithm is required for CIS which combines and filters the data. This data is created by different types of events in a cyber domain.
  - Cyber-attack recognition systems deal with extensive volume of big dimensional data along with uniform advancing attack features.
  - CIS have become reasonable preferences to build new categorization algorithms for detection systems.

Source: Cybersecurity for industry 4.0: Thames

Software-Defined Cloud Manufacturing Architecture (SDCMA)

- There are mainly three parts of SDCMA
  - Software Plane
  - Hardware Plane
  - Ensemble Intelligence Framework (EIF).
- Software plane consists of control elements (CE).
- CE are used as data tap points, since they have deep observation into the communications and activities.

Source: Cybersecurity for industry 4.0: Thames

SDCMA(Contd.)

- In SDCMA, the streaming data is supplied to EIF by CE.
- Sensed data is detected by EIF.
- EIF is also responsible for detecting abnormality.

Source: Cybersecurity for industry 4.0: Thames

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Thank You!!

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Basics of Industrial IoT: Introduction

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Introduction

- Industrial Internet of Things (IIoT) can be considered as a branch of Internet of Things (IoT)
- IIoT is the application of IoT in manufacturing and other industrial processes with the aim to <u>enhance the working condition</u>, <u>increase machine life</u> and <u>optimize operational efficiency</u>.

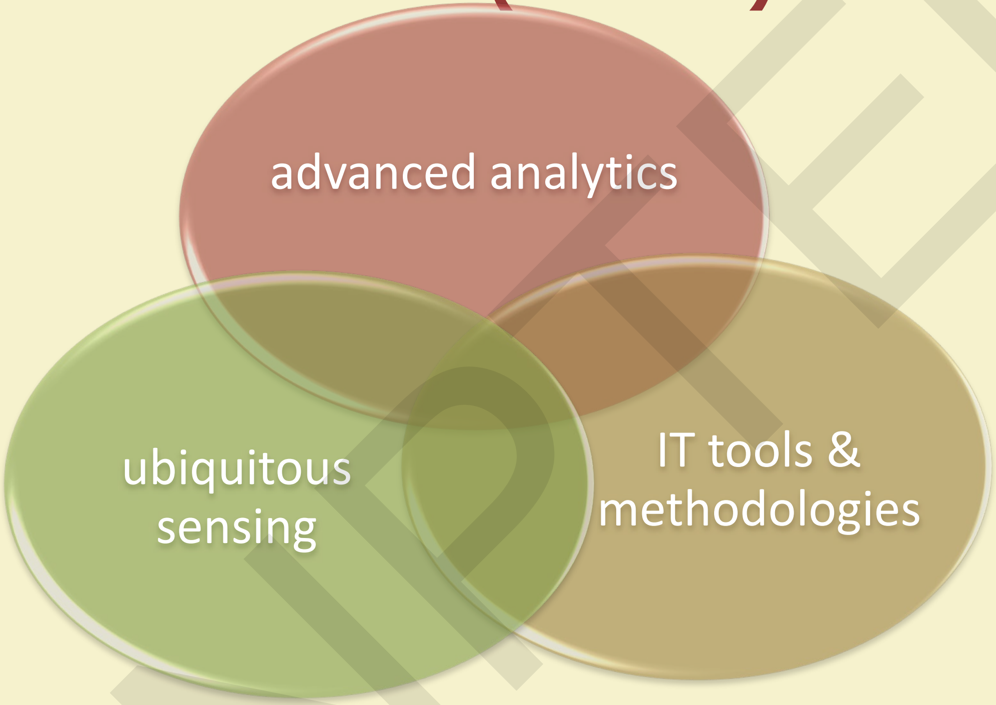
Source: "The Industrial Internet of Things (IIoT)"

IIoT vs Automation

- There are three key differences between IIoT and Automation which have been deployed in industries for decades.
- They are:
  - ubiquitous sensing
  - advanced analytics, and
  - IT tools and methodologies

Source: "Industrial Internet of Things, A high-level architecture discussion"

IIoT vs Automation (contd.)



Concept taken from: "Industrial Internet of Things, A high-level architecture discussion"

Ubiquitous Sensing

- In traditional automation, sensors and actuators are used to <u>control</u> critical elements (industrial machines, etc).
- In IIoT, sensors and actuators are used almost everywhere to <u>control, enhance and optimize</u> various functions.
  - E.g. To monitor machine health, to track various operations, emergency system etc.
- Ubiquitous Sensing enables Advanced Analytics

Source: "Industrial Internet of Things, A high-level architecture discussion"

Advanced Analytics

- The various data from array of deployed sensors and actuators can be exploited and extracted to decipher latent meanings using varieties of advanced analytic tools and algorithms.
- In IIoT, data much more and varied compared to traditional Automation.
- In IIoT, advanced analytics helps to enhance the working condition, increase machine life and optimize operational efficiency etc.

Source: “Industrial Internet of Things, A high-level architecture discussion”

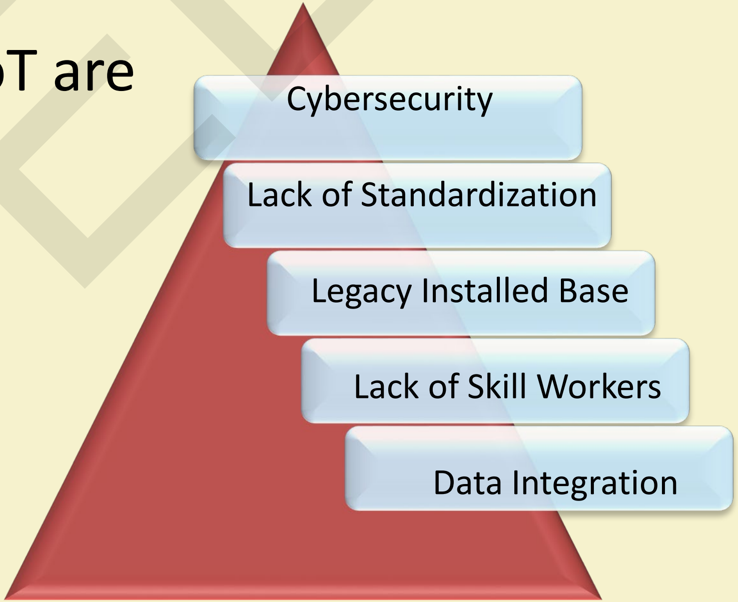
IT methodologies

- IIoT modifies the traditional automation techniques by exploiting IT technology.
- This modification gives three main benefits:
  - Availability of talent pool
  - Standardization
  - Accessibility of already available IT hardware and software solutions

Source: "Industrial Internet of Things, A high-level architecture discussion"

Challenges in IIoT

- The challenges in deployment of IIoT are
  - Data integration challenges
  - Cybersecurity
  - Lack of standardization
  - Legacy installations
  - Lack of skills



Source: “Industrial Internet of Things, A high-level architecture discussion”

Data integration challenges

- Big data volume
  - Complex and different varieties of data from different sensors and actuators
  - Frequency of data generated by multiple devices
- Data integration is one of the main challenges
- Understanding the generated data for analysis and application in business is not an easy task

Source: "Industrial Internet of Things, A high-level architecture discussion"

Cybersecurity

- Cybersecurity is one of the most essential elements of IIoT, because in IIoT all the devices are interconnected and these connected devices interact with the real world
- The two most important security concerns of IIoT are -
  - information security
  - data privacy protection

Source: “Industrial Internet of Things, A high-level architecture discussion”

Cybersecurity

- Examples:
  - Healthcare Industries: Data integrity is highly essential in healthcare industries
  - Food Industries : Information that can harm the reputation of the company should be made confidential
  - Power Grid: Collapse of a power grip can give huge impact
  - National Transportation: National Transportation is like the veins of the nation. Making them secure is very crucial

Source: “Industrial Internet of Things, A high-level architecture discussion”

Lack of Standardization

- Large automation supplier firms do not encourage open standardization, as it will reduce the customer's reliance on them
- Small automation supplier firms lacks the capability to incentivize this huge step

Source: "Industrial Internet of Things, A high-level architecture discussion"

Lack of Standardization

- Lack of standardization leads to different issues related to :
  - Device interoperability
  - Semantic interoperability (data semantics)
  - Security and privacy etc.

Source: "Industrial Internet of Things, A high-level architecture discussion"

Legacy Installations

- Technology evolves fast
- Coexistence of the fast evolving technology with legacy equipment is a huge complication

Source: "Industrial Internet of Things, A high-level architecture discussion"

Lack of skills

- Limitation of workers with IIoT related skills, like data integration etc. because
  - The technologies associated with IIoT are new
  - Workers should have vast and diverse knowledge

Source: "Industrial Internet of Things, A high-level architecture discussion"

Applications of IIoT

- The key application areas of IIoT are -
  - Healthcare industry
  - Mining industry
  - Manufacturing industry
  - Transportation & logistics
  - Firefighting

Source: "Industry 4.0: the industrial internet of things"

Healthcare industry

- Availability of the information and reputations of doctors helps the patients to choose the right doctor
- Connectivity of healthcare devices to the internet helps in location each devices and also knows the status of the connected devices and the patients monitor by them
- Availability of healthcare data helps in advance healthcare researches

Source: "Industry 4.0: the industrial internet of things"

Mining industry

- Sensor networks comprise of
  - different gas sensors for detecting oxygen, combustible gas like methane, poisonous gases etc.
  - strata monitoring device, rock mass deformation device to detect the internal structural condition of the mine
  - RFID tags for tracking miners
  - Wi-Fi and other wireless networking module

Source: “The Industrial Internet of Things (IIoT): the business guide to Industrial IoT”

Mining industry (contd.)

- These will benefit in
  - early disaster warning
  - working condition of the miners
  - locating and monitoring miners
  - Safety and increasing efficiency

Source: "The Industrial Internet of Things (IIoT): the business guide to Industrial IoT"

Manufacturing industry

- The interconnection and integration of devices, equipment, workforce, supply chain, work platform comprises smart manufacturing
- This provides
  - reduction in operational costs
  - efficiency of the worker
  - Improved safety at the workplace
  - resource optimization and waste reduction
  - end-to-end automation.

Source: “Industry 4.0: the industrial internet of things”

Transportation & logistics

- Easy monitoring of equipment, engines, tracks using the connected devices, deployed sensors, GPS etc.
- Analysis of data from devices will provide the information related to
  - maintenance
  - status and performance
  - optimum scheduling

Source: “Industry 4.0: the industrial internet of things”

Transportation & logistics (contd.)

- Optimum scheduling will
  - provide good customer services by reducing cancellation and delays
  - reduce fuel consumption
- Proper maintenance of the equipment will
  - provide better safety to both the on boarded passengers and machines
  - reduce maintenance expenses

Source: “Industry 4.0: the industrial internet of things”

Firefighting

- Sensor networks with RFID tags are deployed, which helps in
  - real-time monitoring
  - early warning of disaster
  - fast and automatic diagnosis
  - This makes the emergency rescue more effective.

Source: “Industry 4.0: the industrial internet of things”

Benefits of IIoT

- Improves connectivity among devices
- Improves operational efficiency
- Improves productivity
- Optimizes asset utilization
- Creates new jobs and business opportunities
- Reduces operation time

Source: "The Industrial Internet of Things (IIoT): the business guide to Industrial IoT"

Benefits (contd.)

- Remote diagnosis
- Cost effective
- Boost worker safety
- In depth knowledge of customer demand

Source: "The Industrial Internet of Things (IIoT): the business guide to Industrial IoT"

Conclusion

- IIoT has many promising features, but at the same time it has many barriers.
- It does not mean its future is bleak, but it is better to deploy it in the areas, where the hindrances are less

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Thank You!!

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Basics of Industrial IoT: Industrial Internet System

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Introduction

- The digital industrial company, General Electric (GE), coined the term Industrial Internet.
- Industrial Internet is not exactly the same as Industrial Internet of Things (IIoTs), but they are often used interchangeably.
- GE is also a founding member of Industrial Internet Consortium (IIC), which is also a huge contributor in shaping IIoTs

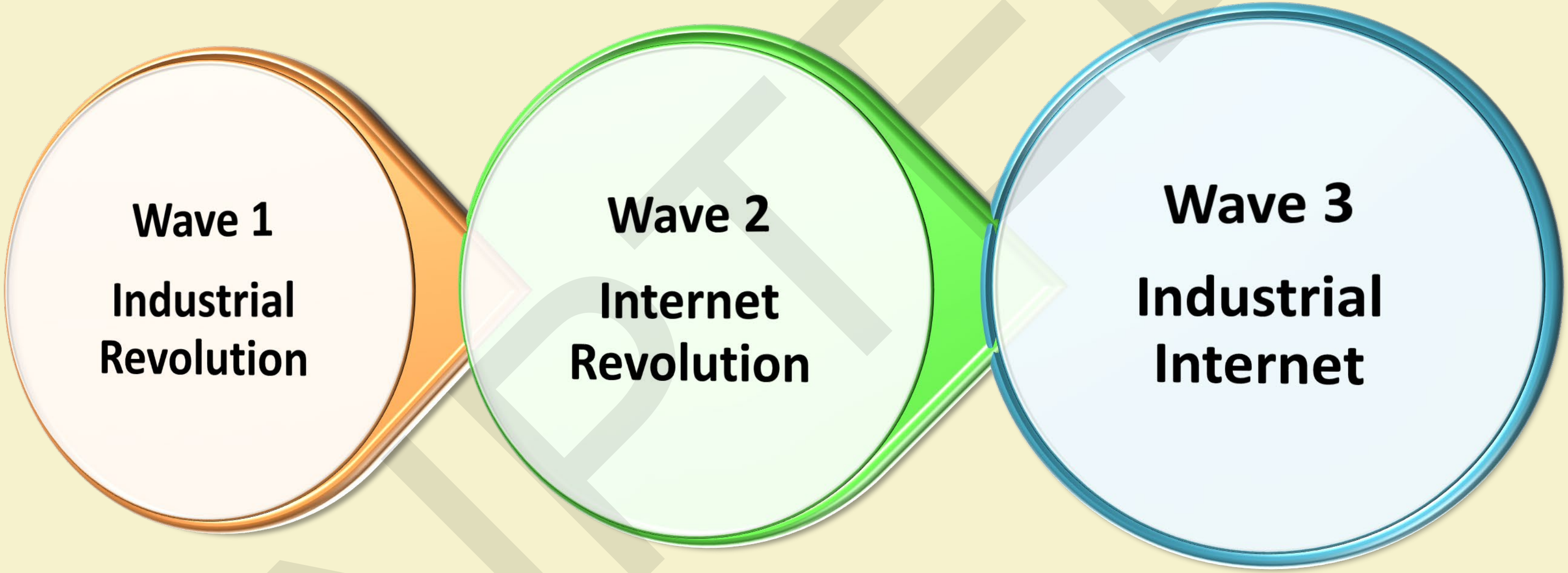
Source: "The Industrial Internet and the Industrial Internet of Things"

Three Waves of Innovation

- According to GE, there are three waves in industrial level
  - The First Wave or The Industrial Revolution
  - The Second Wave or The Internet Revolution
  - The Third Wave or The Industrial Internet

Source: "Industrial Internet: Pushing the Boundaries of Minds and Machines", GE

Three Waves of Innovation



Concept taken from: “Industrial Internet: Pushing the Boundaries of Minds and Machines”, GE

The Industrial Revolution

- The Industrial Revolution lasted for around 150 years which began in 1750 and ended in 1900
- It had two stages.
- <u>Commercialization and the mass production of steam engines</u> marked the beginning of the First Stage. It was started in the middle of eighteenth century.

Source: "Industrial Internet: Pushing the Boundaries of Minds and Machines", GE

The Industrial Revolution (contd.)

- The Second Stage started in 1870 with the invention of internal combustion engines and electricity
- The Second Stage is more powerful
  - Electricity brings new types of communications
  - Combustion Engines brings new forms of transportation systems

Source: “Industrial Internet: Pushing the Boundaries of Minds and Machines”, GE

Drawbacks of Industrial Revolution

- Even though Industrial Revolution brought significant leap in the economy and society, it had some negative effects
  - The waste products harmed the environment
  - Bad working environment
  - Inefficient

Source: "Industrial Internet: Pushing the Boundaries of Minds and Machines", GE

The Internet Revolution

- The Internet Revolution started around 1950 and lasted for around 50 years
- It was started with a government sponsored experimentation on computer networks
- It became more eminent with the emergence World Wide Web
- Computing capacity had also increased
- Rapid information exchange over large geographical distance was made possible

Source: “Industrial Internet: Pushing the Boundaries of Minds and Machines”, GE

The Industrial Internet

- Integration of Internet-based technologies to industries
- Currently we are under Third Wave or The Industrial Internet
- Third Wave has not reached its peak
- According to GE, Industrial Internet can be defined as "the association of the global industrial system with low-cost sensing, interconnectivity through internet, high-level computing and analytics"

Source: "Industrial Internet: Pushing the Boundaries of Minds and Machines", GE

The Industrial Internet (contd.)

- It has three key elements
  - Intelligent machines
  - Advanced analytics
  - People at work

Source: “Industrial Internet: Pushing the Boundaries of Minds and Machines”, GE

Three Key Elements

Intelligent Machines

- Connects different devices located at different places
- The devices are controlled through sensors and actuators using advance IT software

Advanced Analytics

- Huge amount of data are generated from device
- Data are input to the advance predictive algorithms

People at Work

- People are interconnected
- Regardless of their location, they can monitor the machines, to provide more flexible and quality services

Concept taken from: “Industrial Internet: Pushing the Boundaries of Minds and Machines”, GE

Intelligent machines

- Different kinds of machines located at different locations can be interconnected
- These machines can be monitored using advanced sensors and actuators using related software

Source: “Industrial Internet: Pushing the Boundaries of Minds and Machines”, GE

Advanced analytics

- The huge data generated from different kinds of machines and sensors, advance analytic and prediction techniques make possible in shaping a whole new era of automation and intelligent machines.

Source: “Industrial Internet: Pushing the Boundaries of Minds and Machines”, GE

People at work

- Through web and mobile interfaces, everybody can connect with one another regardless of their location.
- A doctor can interact with his patient virtually, a worker can control a machine from anywhere etc.
- This makes the system more intelligent, maintenance and operations become easier, safety and the quality of services also enhances at the same time.

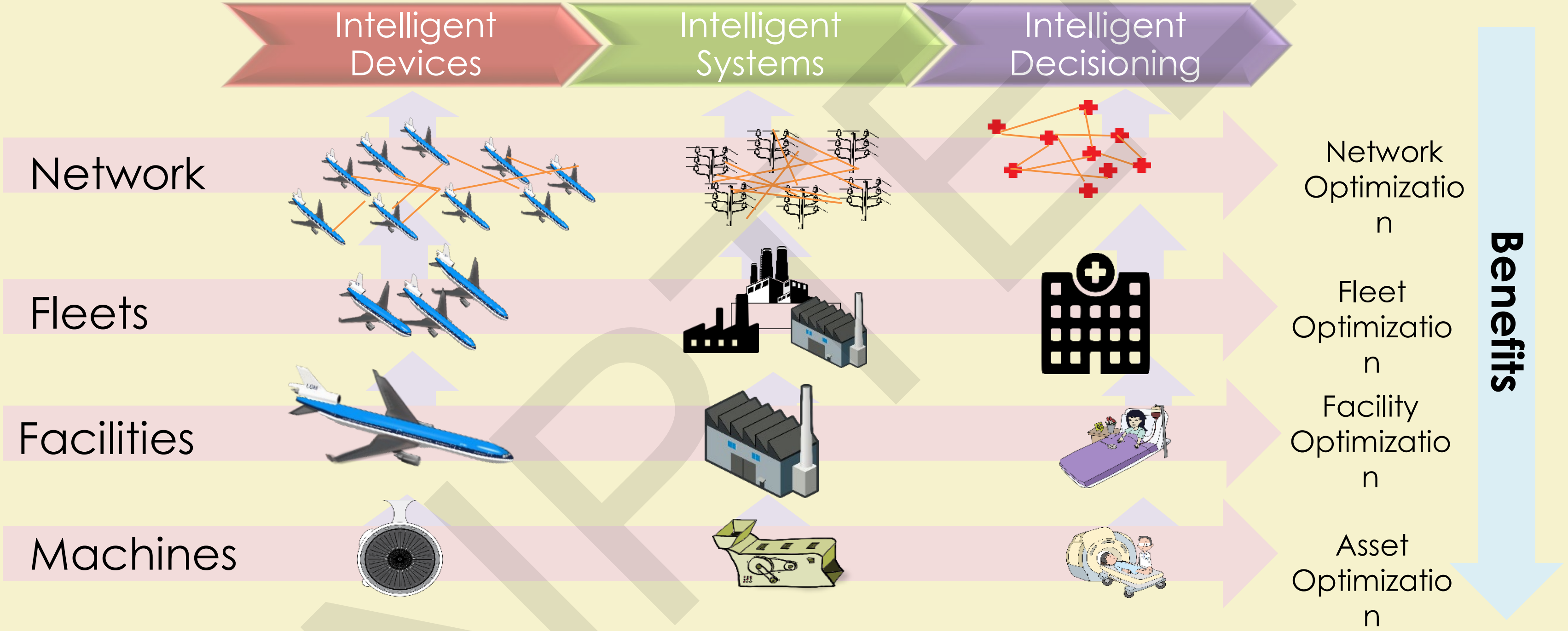
Source: “Industrial Internet: Pushing the Boundaries of Minds and Machines”, GE

Applications

- Commercial Aviation
- Rail Transportation
- Power Production
- Oil and Gas Sectors
- Healthcare

Source: “Industrial Internet: Pushing the Boundaries of Minds and Machines”, GE

Applications of Industrial internet



Concept taken from: “Industrial Internet: Pushing the Boundaries of Minds and Machines”, GE

Commercial Aviation

- The Industrial Internet can benefit commercial aviation industries by improving both <u>airline operations</u> and <u>asset management</u>
- Airline operation
  - Reducing fuel consumption
  - Effective management of crews, flight scheduling, minimizing delays and cancellations of flight

Source: "Industrial Internet: Pushing the Boundaries of Minds and Machines", GE

Commercial Aviation (contd.)

- Asset Management
  - Proper maintenance of engines and other parts
  - Timely repairing

Source: “Industrial Internet: Pushing the Boundaries of Minds and Machines”, GE

Rail Transportation

- Real-time analysis and application of <u>predictive algorithms</u> will help
  - in reducing the maintenance cost
  - in preventing engine breakdown
- Availability of software will help in providing a <u>real-time</u> overview of the entire system to operators. Therefore,
  - the rail operator can monitor the trains and make optimal decisions
  - optimal train scheduling

Source: “Industrial Internet: Pushing the Boundaries of Minds and Machines”, GE

Power Production

- In power industries, outage is a huge problem because locating a broken power line or equipment is not an easy task
- With the help of industrial internet, everything will be connected to internet. Therefore
  - status updates and performance related data will be easily available
  - analysis of the incoming data will provide new insights relating to potential problems which may occur in future
  - cost of field inspection before repairing will be reduced

Source: "Industrial Internet: Pushing the Boundaries of Minds and Machines", GE

Oil and Gas Sectors

- Industrial Internet
  - reduces fuel consumption
  - enhances production
    - tracking events inside well, simulation of inside well, improve production flow
  - reduces costs
    - real-time monitoring and alert system for safety and optimization
- Predictive analysis of the incoming data from different devices helps in understanding the behavior of the underground reservoir

Source: "Industrial Internet: Pushing the Boundaries of Minds and Machines", GE

Healthcare

- Industrial Internet enables safe and efficient operations.
  - availability of the information and reputations of doctors helps the patients to choose the right doctor
  - connectivity of healthcare devices to the internet helps in location each devices and also know the status of the connected devices and the patients monitor by them
  - availability of healthcare data helps in advance healthcare researches

Source: “Industrial Internet: Pushing the Boundaries of Minds and Machines”, GE

Advantages of Industrial Internet

- One percent fuel savings (in 15 years)
  - Commercial Aviation Industries will save $30 billion
  - Gas and Power segment of Power plants will save $66 billion
- One percent reduction in system inefficiency in
  - Healthcare sector will save $63 billion
  - Freight transportation through world rail network will save $27 billion
- One percent reduction in capital expenditure during exploration and development in Oil and Gas industries will save $90 billion
- The emergence of cloud-based system will replace the isolated systems

Source: "Industrial Internet: Pushing the Boundaries of Minds and Machines", GE

Advantages of Industrial Internet

Industry	Segment	Type of Savings	Estimated Value (Over 15 Years)
Aviation	Commercial	One percent in fuel Saving	$30 Billion
Power	Gas-Fire Generation	One percent in fuel Saving	$66 Billion
Health	System Wide	One percent reduction in system inefficiency	$63 Billion
Oil	Freight	One percent reduction in system inefficiency	$27 Billion
Rail & Gas	Development and Exploration	One percent reduction in capital expenditure	$90 Billion

Source: “Industrial Internet: Pushing the Boundaries of Minds and Machines”, GE

Catalysts

- Innovations in terms of
  - Equipment
  - Advance analytics
  - System platform
  - Business processes
- Infrastructure
- Cybersecurity management

Source: "Industrial Internet: Pushing the Boundaries of Minds and Machines", GE

Catalysts (contd.)

- Talent Development
  - Next Generation Engineering
  - Data Scientists
  - User Interface Experts

Source: “Industrial Internet: Pushing the Boundaries of Minds and Machines”, GE

Conclusion

- Industrial Internet has many benefits and promises across the globe
- But it needs a little innovation, capital, and platform

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Thank You!!

Basics of IIoT:

Industrial Sensing & Actuation

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Introduction

- **IoT** deployment in **Industry** (IIoT)
- **Sensor**: Primary source of IIoT data, Big analog/digital data
- **Intelligence** of IoT is developed based on sensor data
- **Actuator**: Follow control decision

Need of Sensing for Industry

- Higher degree of automation
- Raise Productivity
- Improve Quality
- Better Safety
- Reduced Downtime

Requirements for Industrial Standard

- Reliable Sensing
- Low cost sensing and actuation
- Perpetual sensor and actuation network connectivity

Industrial Sensing

Conventional Sensing

- Involved in feedback automation of a process in industrial control system
- Based on sensing (feedback), further action is taken as per the application requirements

Industrial sensing (Contd.)

Contemporary Sensing

- Sensors connected to the Internet
- Can sense
  - Product lifetime
  - Loop efficiency
  - Safety
  - Reliability

Smart Sensor

" Sensor with small memory and standardized physical connection to enable communication with the processor and data network "

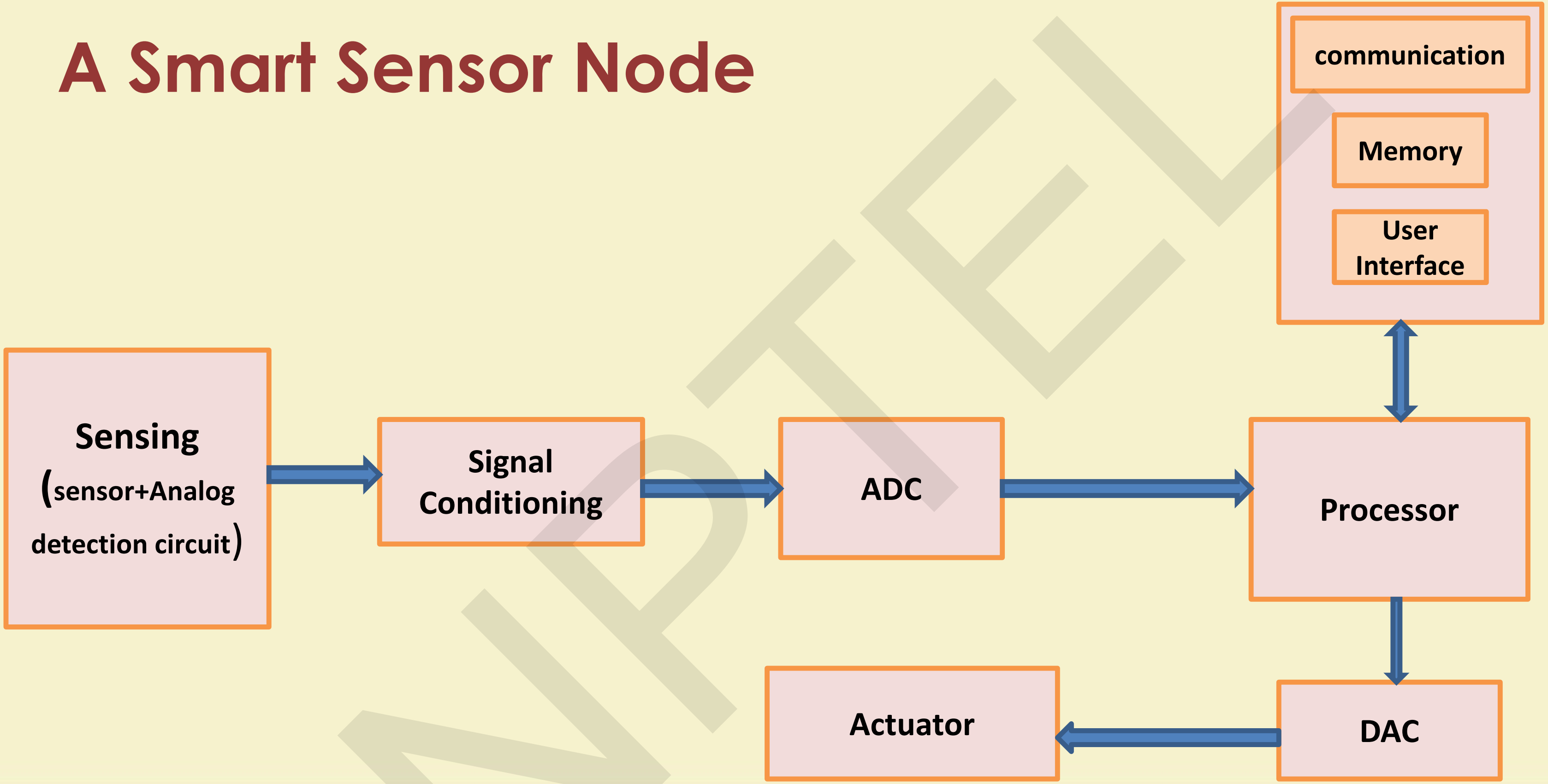
-defined by IEEE 1451 standard

Configurations involved in Smart Sensors

- Multiparameter Sensing Unit
- Analog Detection Circuit
- Digital Signal Conditioning Unit
- Interfacing Unit to bus

Source: T. Islam, S. C. Mukhopadhyay and N. K. Suryadevara, "Smart Sensors and Internet of Things: A Postgraduate Paper," in *IEEE Sensors Journal*, vol. 17, no. 3, pp. 577-584, 1 Feb.1, 2017

A Smart Sensor Node



Smart Sensor Functions

- Smart sensors can perform multiple functions
  - **Multisensing:** It can sense multiple parameters (temperature, pressure, light, humidity etc) at a single sensor node, which may help in the deciding factors in production unit of an industry
  - **Communicate data:** Communicating vital information like measured, callibration and compensation data to the Central control unit
  - **A/D or D/A Conversion:** The Analog data needs digital conversion to apply several signal processing methods for having reliable and accurate data

Smart Sensor Function (Contd.)

- **Self-Decision Making:** It can self-monitor its operation and changes in the ambience by taking proper decision for required compensation by itself or by alerting human for required action
- **Reduced Cost** : Cost continues to reduce as investment is recovered by reduced downtime in industries

Illustrating Sensing in Milk Packaging Unit

- Install sensor in line with the outlet tap
- Sensor contain impellers inside
- Impeller spins when milk moves
- Sends electrical signal to the control unit
- Controller interprets amount of liquid flow and stops when threshold is reached

Accessing Sensors & Actuators

- **Supporting OS** Zephyr , Ubuntu , Opensuse , Ublinux , Archlinux , Androidthing

- **Programming Language** C , C++ , Java , Python , Lua

Intel IoT Device Library used by sensors

MRAA	UPM
• Low-level skeleton library for communication in GNU/Linux platform • Not hardware specific • Better level of abstraction	• High level APIs for easier connectivity to sensors • Easier to control • Supporting industrial grade sensor

Source: " mraa 1.9.0" , Intel

Utility in Industrial Sub-Units

- Measurements
- Production
- Product Inspection
- Packaging & Shipping

Industrial Sensor Calibration

- It is the method adopted to improve the performance of the sensing system by readjusting and removing the error in the measured response of the sensor compared to the actual response
- Industrial grade sensors use highly complex signal processing algorithm and onboard circuitry to take care of calibration.

Industrial Sensor Calibration (Contd.)

- Calibrate in system to be used
- Standard references
- Proper calibration methods
- Re-calibration

Examples of Industrial sensors

- **Navigation industry** (Track sensors: GPS)
  - Spot significant places
  - Tracking real time object
  - Analyze traffics
  - Scanning at check post
  - Predict driver Destination

Examples of Industrial sensors (contd.)

- **Agriculture Industry** (Smart sensors)
  - Soil and water sensor, Weather tracking, RFID technology, Optical sensors
  - For accurate use of fertilizers and determining crop health; Crop sensors
  - Best time to plant crop
  - Remote monitoring
  - Agbots; To automate agricultural processes

Examples of Industrial sensors (contd.)

- **Health Care Industry**
  - Implantable sensors, MEMS ,biosensors, nano sensors
  - Smart pills
    - Pills sends alert message to other members when swallowed
    - Camera pills for imaging
  - Smart bed
    - Use sensors that prevent fall of the patient and sends report about the patient’s movement

Examples of Industrial sensors (contd.)

- **Retail Industry**
  - RFID tracking chip
  - Tracking location of shipment made possible with GPS and IoT
  - Sensors on shopping cart and product to avoid theft

Sensors Technology Manufacturers

DTS

BOSCH

Honeywell

adafruit

MASSA

ΩOMEGA

µS MICRO-SENSOR

PLC: Industrial Applications

- Programmable Logic Controller (PLC) is
  - special computer device used in industrial automation systems
  - special-purpose digital computer in industries.
- Architecture of PLC
  - **CPU module:** consists of central processor and memory.
    - Central processor-performs the computations and processes data
    - Memory –stores the programs and data
  - **Power supply module:** supplies power to the entire circuitry
  - **I/O module:** connects the sensors and actuators.

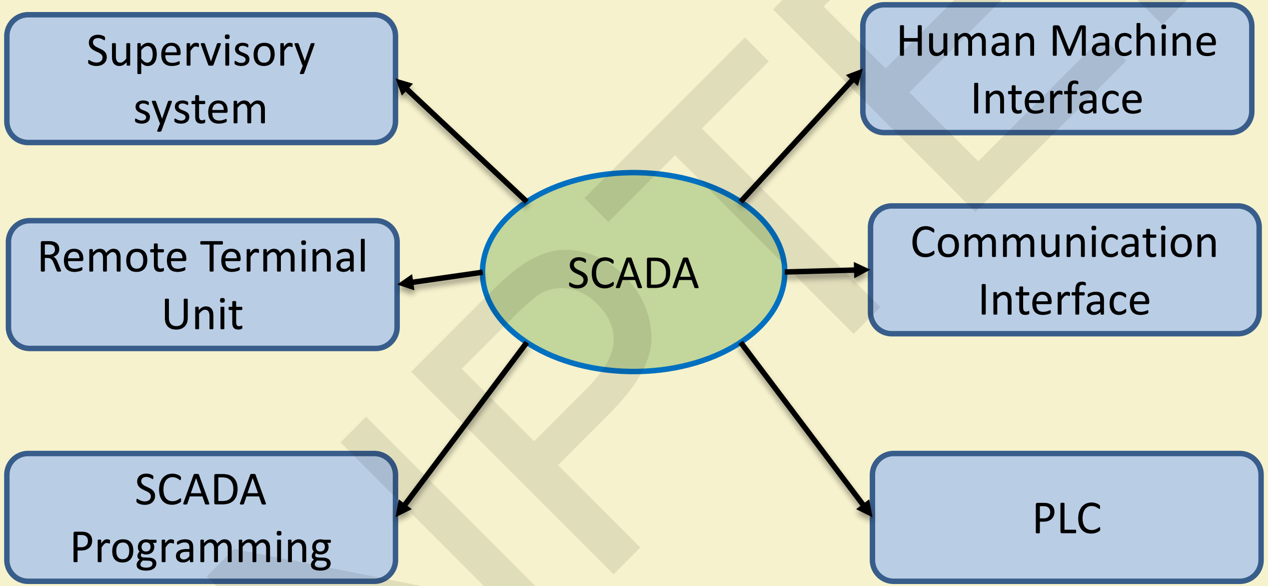
Source: edgefx.in

SCADA: Industrial Applications

- Supervisory control and data acquisition (SCADA) is
  - an **industrial control system**
  - process, monitor, and analyze data at the same time
  - used to collect data from remote sites and transmit data to a central site.
  - applicable for process, oil, power generation, energy, water and waste control, and manufacturing industries.

Source: edgefx.in

SCADA: Industrial Applications (contd.)



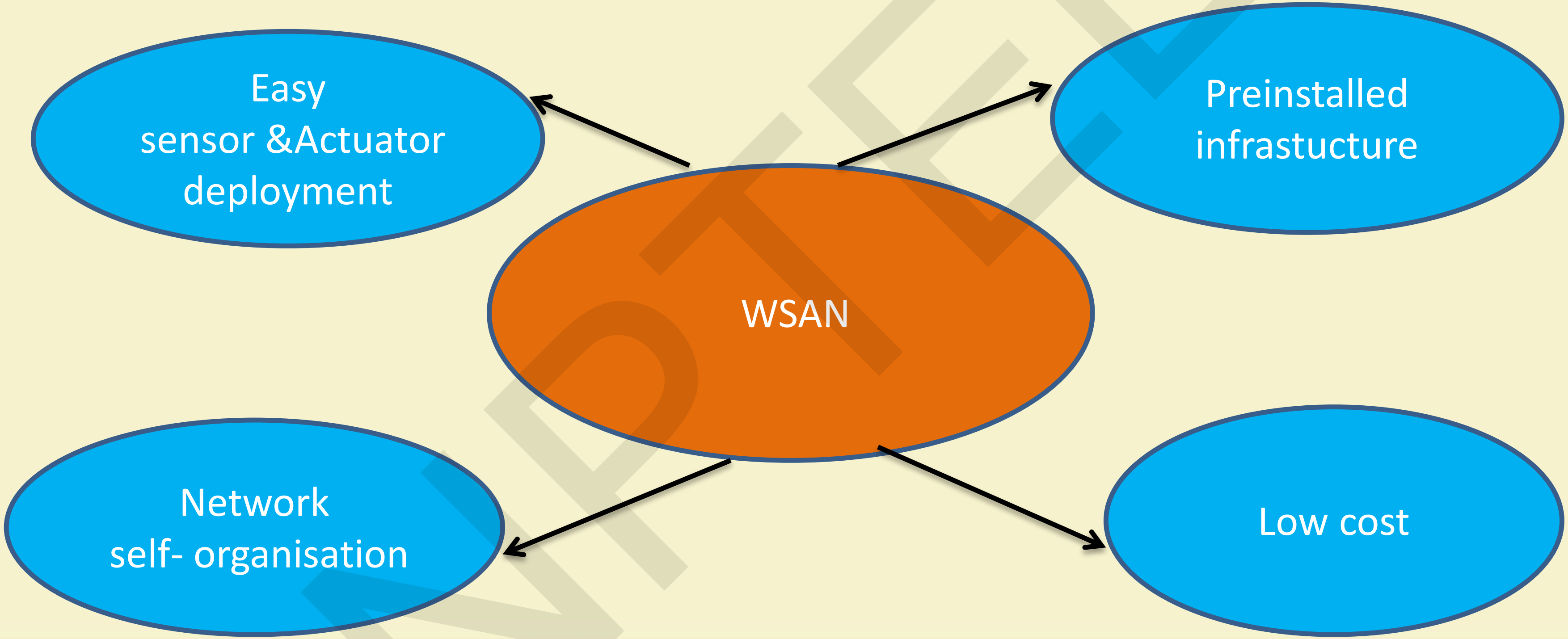
Source: edgefx.in

Industrial control with WSANs

- Industrial Monitoring and control are made easier with WSANs (Wireless Sensing & Actuation Network)
- "Integration of sensors and actuators with wireless network protocol, Real time task scheduling and control law form a WSAN"
  - HVAC control system in industries employ wireless sensor in order to measure temperature
  - Actuation depends on the controllers treatment on the sensors measurement
  - In HVAC control system Actuator can be an wireless air conditioner

Source: Distributed Collaborative Control for Industrial Automation With Wireless Sensor and Actuator Networks, *IEEE Transactions on Industrial Electronics*

WSANs Advantages



Electro-hydrostatic Actuation System

- A Substitute to traditional hydraulic and elecromechanical actuators
- Combined advantage of electric and hydraulic actuators
- High force capability
- High energy efficiency
- Decentralized Actuation

Source: Electrohydraustatic Actuation System , MOOG

Electro-pneumatic systems

- Precise flow control
- Advanced communication
- Better diagnostics
- Ultra high resolution
- Combine advantage of Electric and Pneumatic actuators

Source: Industrial pneumatic actuators ,Bray commertial

Actuators Technology Manufacturers

MOOG

SKF

KNR

FUYU

SPAT

SIRIUS ELECTRIC

ZABER

ECKART

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[8] Source: Industrial pneumatic actuators ,Bray commertial. OnlineURL:http://www.greenheck.com/media/pdf/submittals/Bray9293Series_submittal.pdf

Thank You!!

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Basics of Industrial IoT: Industrial Processes – Part 1

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Timeline of Industrial Revolution

Industry 1.0: Mechanization

(~ 1770-1820)

Industry 2.0: Mass Production

(~ 1870-1950)

Industry 3.0: Computer & Automation

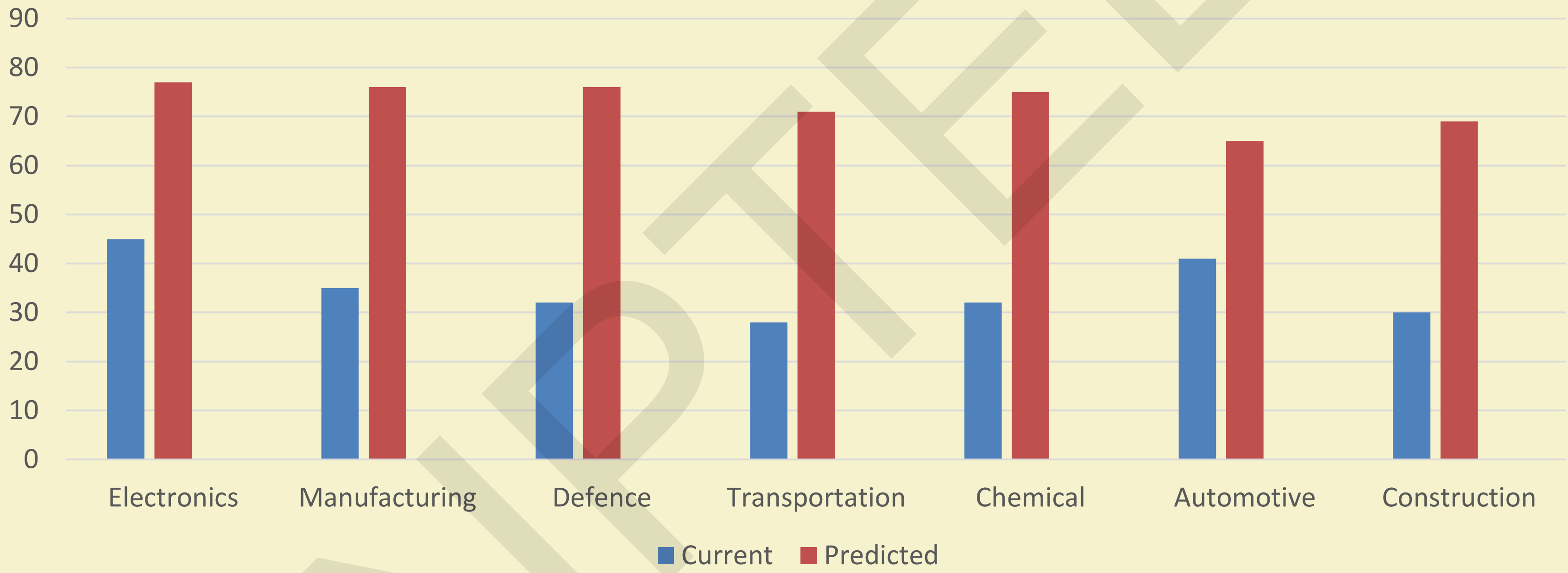
(~ 1950-2000)

Industry 4.0: Intelligent Things

(~ 2000-)

Source: "Industry 4.0 and Maintenance", Norsk Forening for Vedlikehold (NFV)

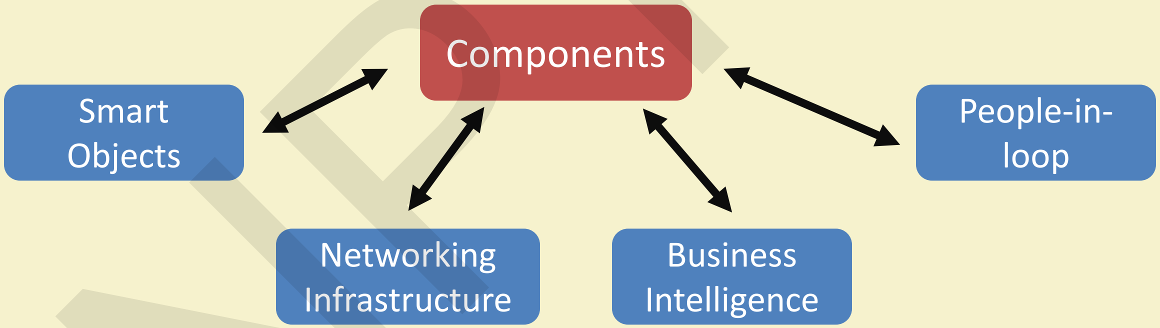
Predicted Growth in Industrial Sectors



Source: "Industry 4.0: Building the Digital Enterprise", PwC, *Global Industry 4.0 Survey*, 2016.

Industrial Internet of Things (IIoT)

- Network of objects (“things”) embedded with computation and communication facilities to achieve industrial jobs by exchanging information among themselves



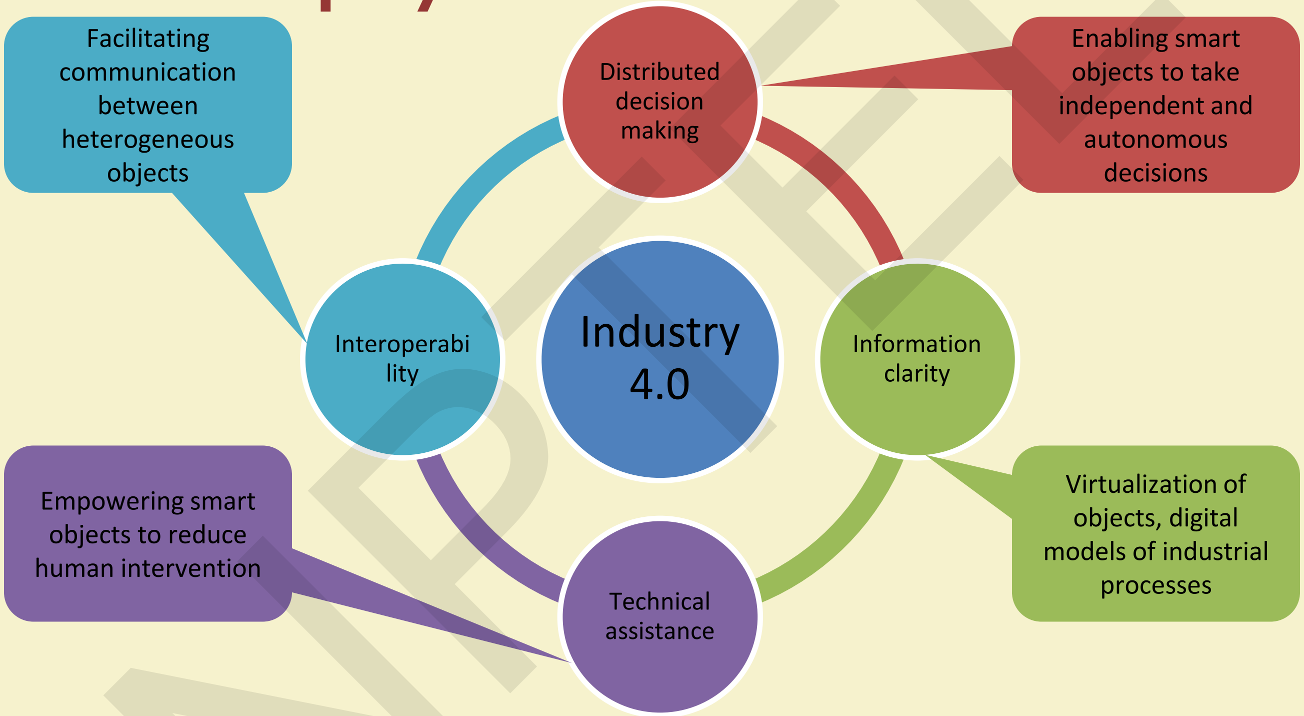
Source: Xu et al., 2014

Challenges for Industrial Processes in Industry 4.0

Dynamic market conditions	• High risk market • Target for lowering cost
Constrained workforce	• Lack of skilled workforce • Ageing society
Supply chain management	• Higher flexibility & convenience expected • Media influence
Resource utilization	• Efficient utilization of available resources • Increased cleanliness and lower waste footprint
Product management	• Increased product types • Lower product lifecycle expected

Source: “Industry 4.0”, Wikipedia

Design Philosophy: IIoT for Industrial Processes



Source: “Industry 4.0”, Wikipedia

Expected Features of Industrial Processes with Industry 4.0

Source: “Industry 4.0”, Wikipedia; "Industry 4.0: the fourth industrial revolution – guide to Industrie 4.0", i-Scoop

Futuristic Industrial Plant

Customized application demands

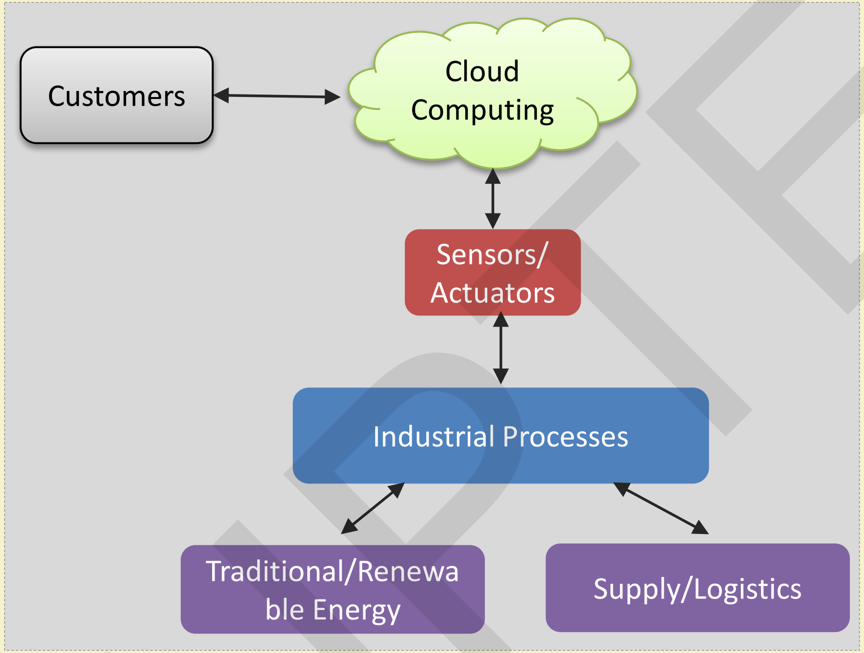


Figure: Components of Futuristic Industrial Plant in Industry 4.0

Source: Aazam et al., 2018.

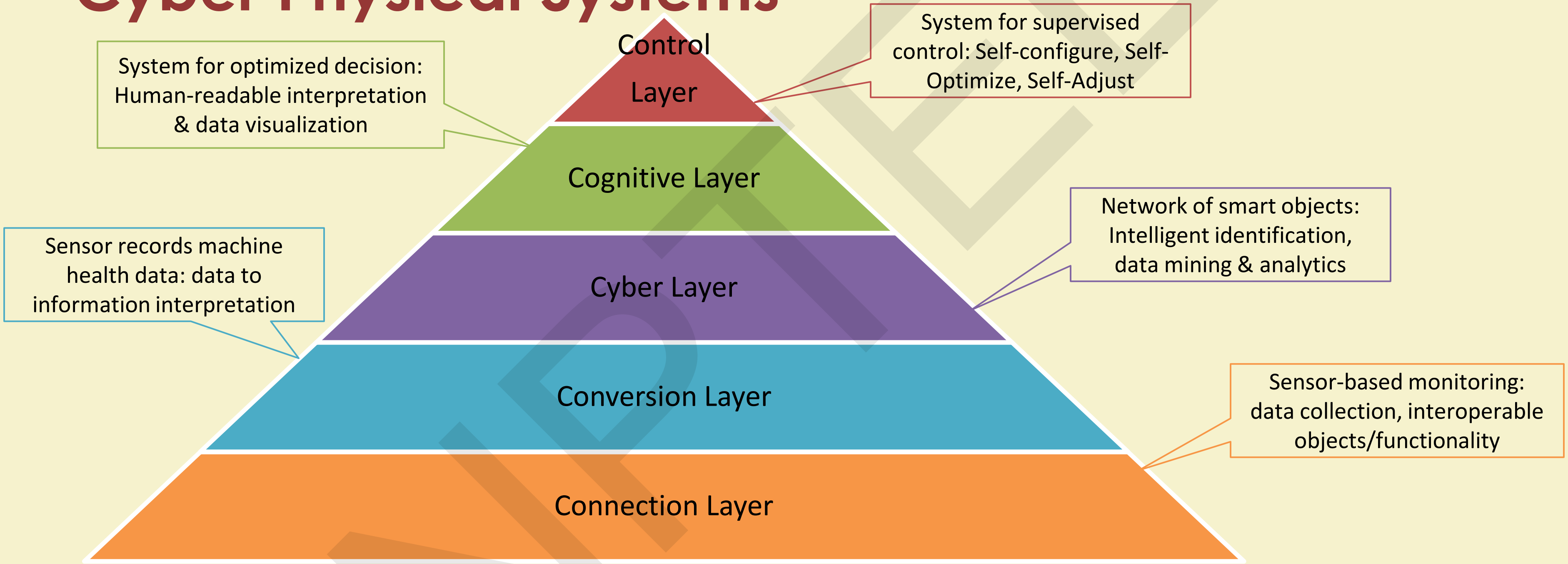
Cloud-based advanced analytics, cyber security

Smart 'things' tasked with sensing, actuation, computation, communication, and decision making

Different industrial processes – 3D printing, manufacturing, automation

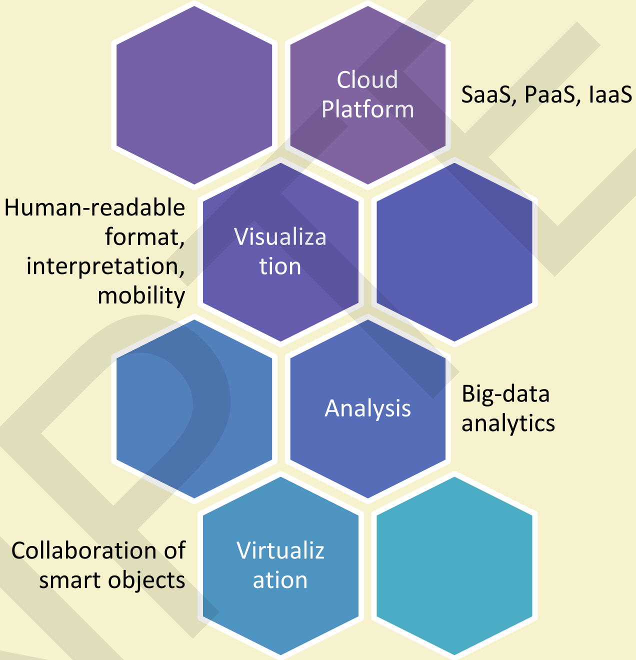
Industrial resources, supply chain management

Futuristic Industrial Plant: 5C Architecture for Cyber Physical Systems



Source: Lee et al., 2015; Aazam et al., 2018.

Industrial Processes Enablers



Source: Aazam et al., 2018.

Industrial Process 4.0: Operation Efficiency

- Benefits
  - Improved resource utilization
  - Increased productivity
  - Cost reduction

Smart Water Management by *Thames Water*
- Sensor-based equipment status monitoring
- Failure detection
- Critical condition monitoring
- Dynamic response to critical conditions

Oil & Gas Industry Maintenance by *Apache*
- Sensor-based leak detection in pipe lines
- Failure detection in pumps
- Production monitoring
- Predictive analysis of loss

Source: Thames Water, "Draft Water Resources Management Plan 2019"
MapR Technologies, "Big Data and Apache Hadoop for the Oil and Gas Industry"

Industrial Process 4.0: Product Innovation

- Benefits
  - Service-oriented deployment
  - Data monetization
  - Pay-per-use

Augmented Maintenance by *Volkswagen*
- Sensors collect data from automotive
- Augmented Reality-based app provide visual interpretation of on-board problem
- Problem analysis & diagnosis

Source: Volkswagen AG

Industrial Process 4.0: Enhanced Ecosystem

- Benefits
  - Connected ecosystem
  - Innovative product lines
  - Dynamic marketplace
  - Pay-per-outcome

Increased Renewable Energy Production by *General Electric*
- Controlled power generation by using weather forecast
- Sensor-controlled maintenance
- Lower operation cost by analyzing collected data

Increased reliability in aircraft engines by *Rolls-Royce*
- Sensor-based remote analytics tools
- Predictive maintenance
- TotalCare program increases the engine reliability

Source: GE Renewable Energy; Rolls-Royce plc

Industrial Process 4.0: Autonomous Pull Economy

- Benefits
  - End-to-end automation facility
  - Updated demand information
  - Low waste generation
  - Better resource optimization

Factory Maintenance by *General Electric*
- *Predix* platform for Cloud-as-a-Service
- Pay-per-use pricing model
- Secure and compatible environment
- Analytical services helps in service optimization

Source: General Electric Inc.

Smart Factory of Future

- *Application areas*
  - Facility management
  - Connected factory
  - Inventory management
  - Production line management
  - Process safety and security
  - Service quality control
  - Supply chain optimization
  - Packaging management

Source: "8 Uses, Applications, and Benefits of Industrial IoT in Manufacturing", New Generation Applications Pvt Ltd,

Smart Factory of Future (contd.)

Facility Management

- Sensor-equipped manufacturing facility
- Provision for condition-based monitoring
- Machinery health monitoring
- Optimization & remote functional control
- Higher efficiency, lower cost & energy expense

Connected Factory

- Connected components of factory – machinery, engineers, and manufacturers
- Enables automation and optimization
- Remote control and management
- Ease of command and control
- Facilitate identification of Key Result Areas (KRAs)

Source: "8 Uses, Applications, and Benefits of Industrial IoT in Manufacturing", New Generation Applications Pvt Ltd,

Smart Factory of Future (contd.)

Inventory management

- Tracking of items by monitoring events in supply chain
- Global inter-connectivity facilitates real-time updates
- Higher visibility & transparency
- Realistic and fail-safe estimate for customers
- Supply optimization & cost reduction

Production line management

- End-to-end production line management with sensors
- Ease of process re-adjustment facility
- Detailed understanding of production delay & failures
- Process flow analytics

Source: "8 Uses, Applications, and Benefits of Industrial IoT in Manufacturing", New Generation Applications Pvt Ltd,

Smart Factory of Future (contd.)

Process safety and security

- Safe & secure working environment
- Complete record & analytics on accidents, injuries & causes
- Optimized financial planning & insurance schemes
- Ensured precautions for safe environments

Service quality control

- End-to-end product cycle monitoring
- Provision to ensure quality for raw materials, factory environment
- Waste management
- Multi-level product quality check
- Enabling feedbacks from customers
- Holistic analytics

Source: "8 Uses, Applications, and Benefits of Industrial IoT in Manufacturing", New Generation Applications Pvt Ltd,

Smart Factory of Future (contd.)

Supply chain optimization

- Real-time monitoring of supply chain elements in multiple dimensions
- Ease & transparency for related personnel
- Identification of inter-block dependency

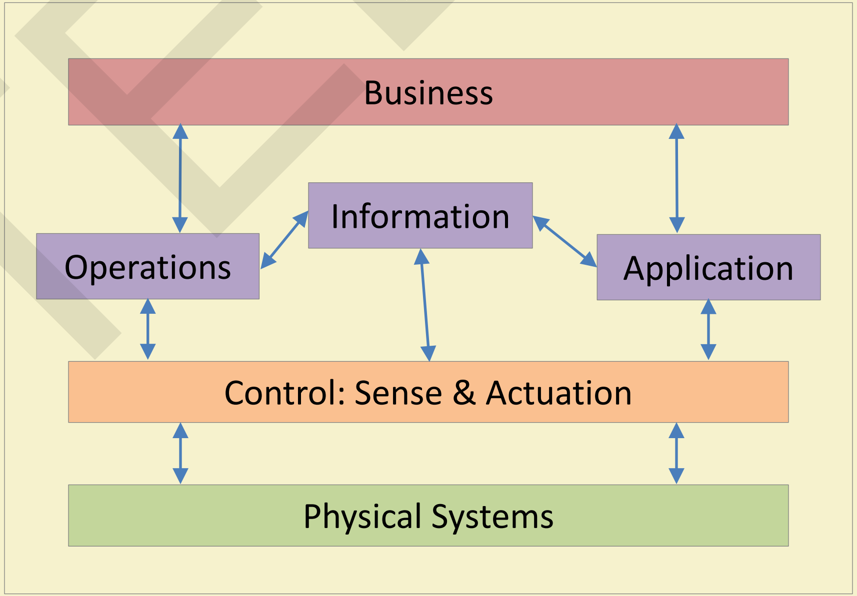
Packaging management

- Sensor-based packaging facility
- Real-time monitoring
- Detailed analytics on customers usage patterns
- Multi-point trace enables package condition monitoring
- Continued customer satisfaction & reduced cost

Source: "8 Uses, Applications, and Benefits of Industrial IoT in Manufacturing", New Generation Applications Pvt Ltd,

Functional Viewpoint of Industrial Processes

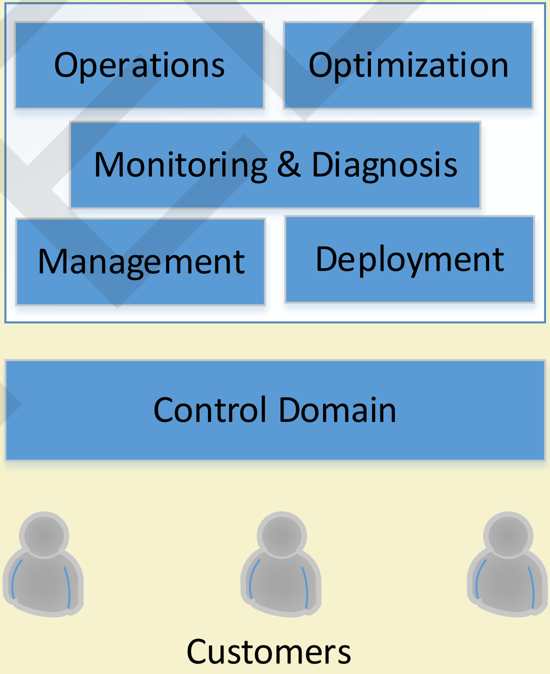
- Highlights the stakeholder's concerns regarding the industrial processes
- Flexible & applicable to various types of industrial processes
- Importance to specific domain varies across industries



Source: A. Gilchrist, "Industry 4.0 - The Industrial Internet of Things", APress

Operational Domain of Industrial Processes

- Cross-environment interconnected control system
- Intra and Inter factory communication
- Distributed analysis & learning



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Thank You!!