PBR VISVODAYA INSTITUTE OF TECHNOLOGY AND SCIENCE

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

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INDUSTRIAL IOT

EEE - IV. B. Tech SEM – I

by

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UNIT-II

INDUSTRIAL INTERNET OF THINGS (IIOT)

UNIT-II SYLLABUS

INDUSTRIAL INTERNET OF THINGS

Introduction, Industrial Internet Systems, Industrial sensing, Industrial Processes. Business Models and Reference Architecture of IIoT: Definition of a business model, Business models of IIoT.

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.

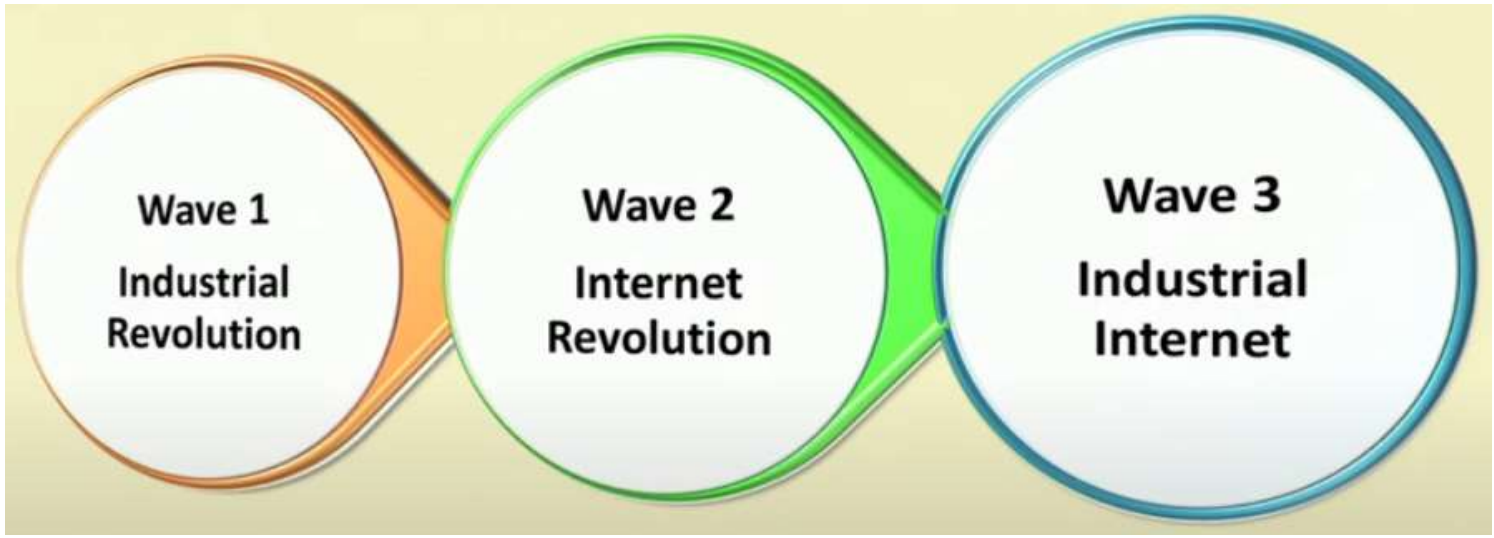
- GE is also a founding member of Industrial Internet Consortium (IIC), which is also a huge contributor in shaping IIoTs.

- So, General Electric along with few other members founded the industrial internet consortium IIC and this consortium is the body, which is largely the main player for shaping up this industrial internet for the future.

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



The Industrial Revolution

- The Industrial Revolution lasted for around 150 years which began in 1750 and ended in 1900

- It had two stages.

- Commercialization and the mass production of steam engines marked the beginning of the First Stage. It was started in the middle of eighteenth century.

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

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

The Internet Revolution

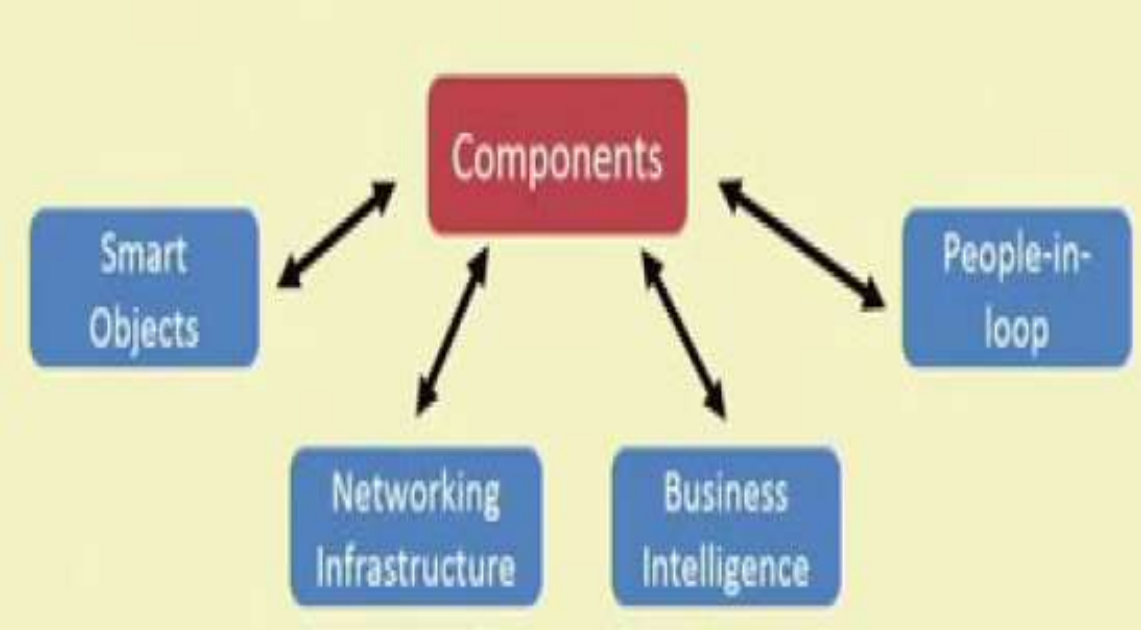
- The Internet Revolution started around 1950 & lasted for around 50 years.
- It was started with a government sponsored experimentation on computer networks
- It became more eminent with the emergence World Wide Web
- Computing capacity had also increased
- Rapid information exchange over large geographical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

Industrial Internet Systems:

The Industrial Internet is the Integration of Internet-based technologies to industries (or) Network of objects ("things") embedded with computation and communication facilities to achieve industrial jobs by exchanging information themselves.

- 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''

➢ It has 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

- 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.

- 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.

Appilcations of Industrial Internet:

Different applications of the industrial internet are commercial aviation, rail transportation, power production, oil and gas sectors, and healthcare.

- Commercial aviation,
- Rail transportation,
- Power production,
- Oil and Gas sectors,
- Healthcare.

Commercial aviation:

- The Industrial Internet can benefit commercial aviation industries by improving both airline operations and asset management
- Airline operation
  - Reducing fuel consumption
  - Effective management of crews, flight scheduling, minimizing delays and cancellations of flight
- Asset management
  - Proper maintance of engines and other parts
  - Timely repairing

Rail Transportation:

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

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

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.

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

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

Industrial sensing:

Sensing is very important and then comes issues of connectivity, communication, analytics, and so on. So, there are different sensors, when we talked about the introductory issues of different sensors and sensing.

The sensors that are used in the industries are typically the ones, which have higher performance, are much more accurate, and are able to perform for longer durations of time. So, they are high grade, better performing, highly and normally scalable, and can work for longer durations of time.

Sensors need to be deployed in the industrial scenarios typically are going to collect lot of analog data, digital data and not only lot of data, but data, which are big in nature.

The data that are collected by the sensors will have to powered with; will have to be powered with intelligence. So, this data will have to be processed, to process in order to get information and knowledge out of the data from this processing.

Need of Sensing in Industry:

- Higher degree of automation
- Raise productivity
- Improve Quality
- Better Safety
- Reduce Downtime

Requirements for Industrial standard

- Reliable sensing
- Low cost sensing
- Perpetual sensing network connectivity

Types of Industrial Sensing

1. 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

2. Contemporary sensing:

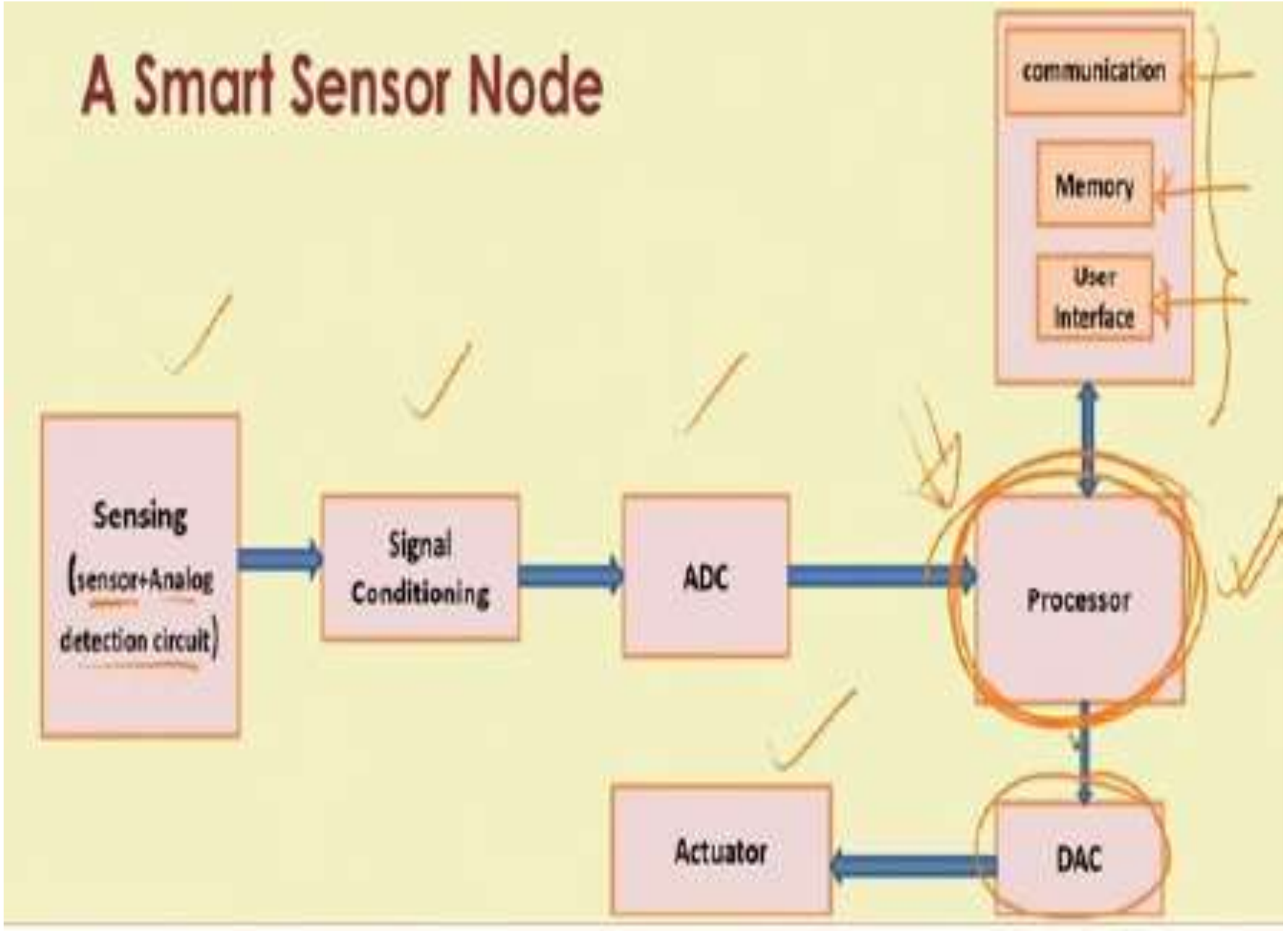
- Sensors connected to the internet
- can sense
  - Product lifetime
  - Loop efficiency
  - Safety
  - Reliability

Smart Sensor:

As per the IEEE 1451 standard, the smart sensor is defend as the "Sensor with small sensor and standardized physical connection to enable communication with the processor and data network".

Configurations involved in smart sensors:

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


A Smart Sensor Node
communication
Memory
User Interface
Sensing (sensor+Analog detection circuit)
Signal Conditioning
ADC
Processor
Actuator
DAC

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.

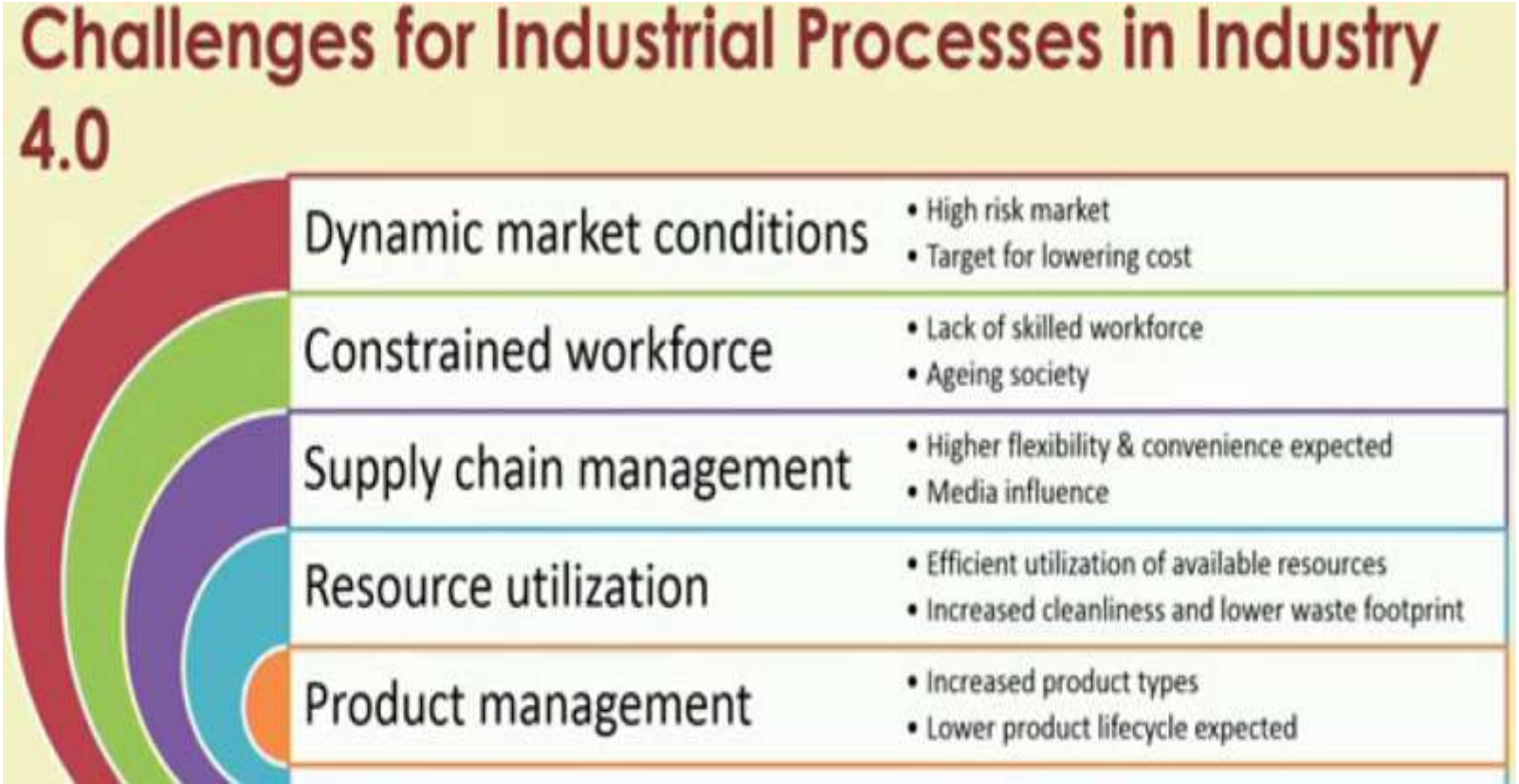
- **A/D or D/A Conversion:** The Analog data needs digital conversion to apply several signal processing methods for having reliable and accurate data.

- **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.

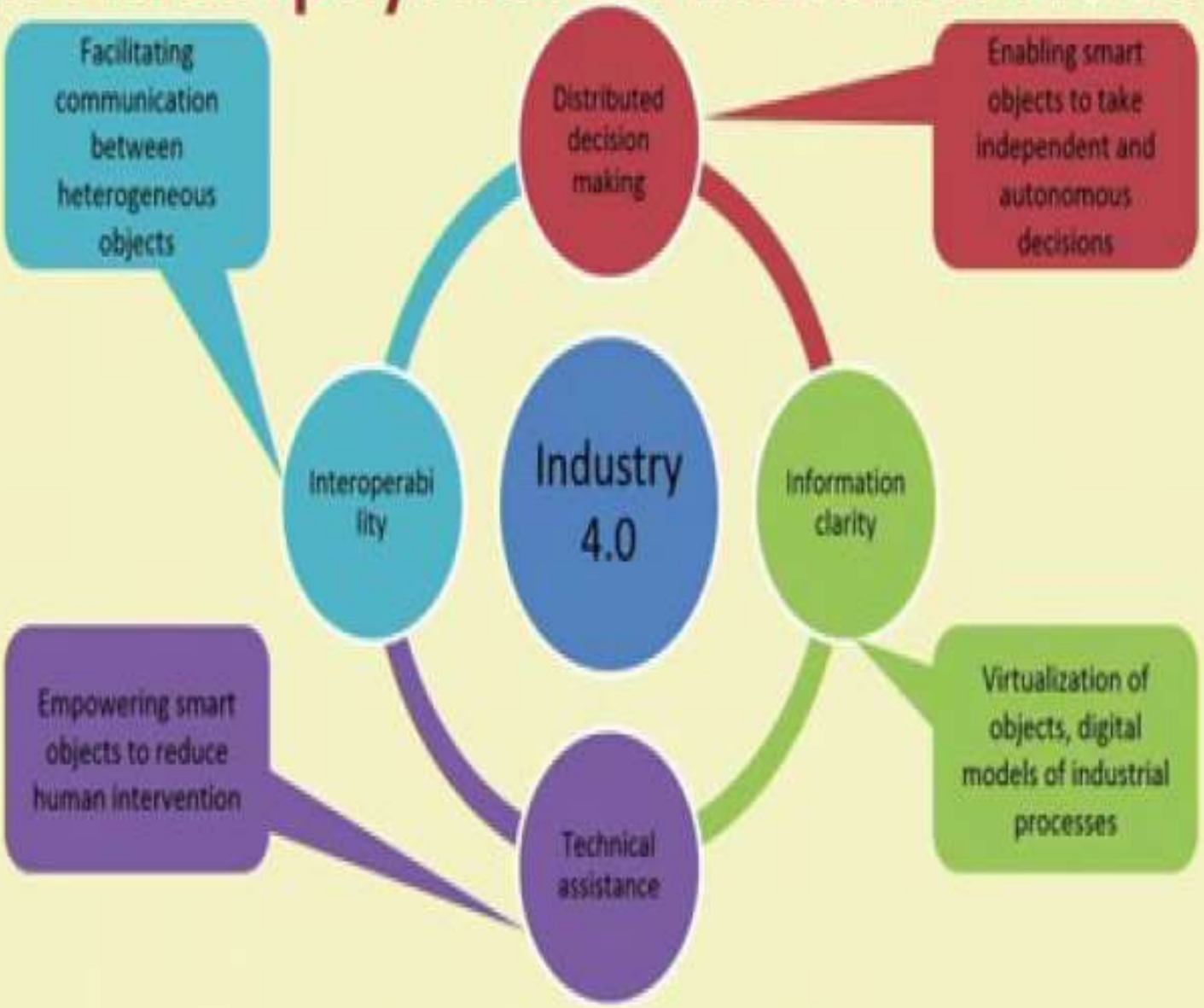
- **Reduced Cost:** Cost continues to reduce as investment is recovered by reduced downtime in industries.

Industrial Processes:

The Industry 4.0, if you are talking about incorporation of IIoT in the Industry 4.0 ecosystem, there are different challenges that are going to be faced for industrial processes. So, basically adoption of IIoT for improving industrial processes, different challenges are going to be faced. So, these are some of these different challenges categorized in different ways.



Design Philosophy: IIoT for Industrial Processes

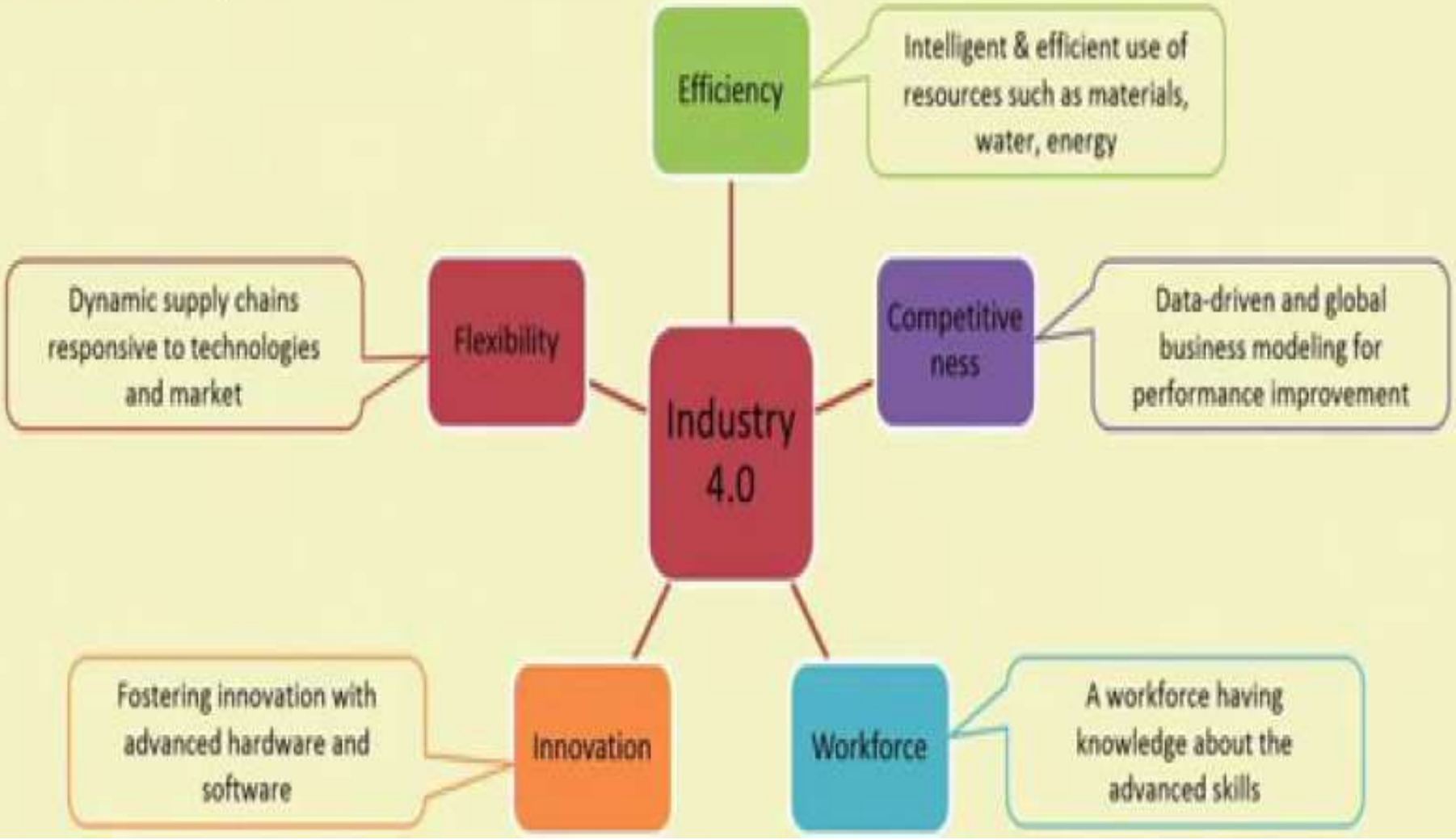


Interoperability is about facilitating communication between heterogeneous objects facilitating communication between heterogeneous objects, heterogeneous machinery running different, different, because these are now smart objects. In the IIoT world we are talking about smart machinery and smart objects. These are all heterogeneous. And now you want to have communication between them, and that is what is the objective of Industry 4.0.

The second thing is **distributed decision making**, because these different machineries the physical objects and so on. They are now interconnected in the Industry 4.0; they are all interconnected. So, distributed decision making will have to be done. So, each of these different machines will locally perform certain decisions themselves, certain analytics will be performed in them individually plus together also they will have to do something, for the holistic good.

So, the third one is **information clarity**, where we are talking about the visualization of the objects. So, basically all these different objects, the digital models of these different objects, the data that are procured from these objects, these will have to be visualize, the data visualization aspect of it for information clarity. This is what is the third component of the design philosophy. And the fourth one is the technical assistance. And here we are talking about empowering smart objects to reduce human intervention. And this kind of technical assistance will also have to be incorporated into the design philosophy of IIoT for industrial processes.

Expected Features of Industrial Processes with Industry 4.0



Efficiency means like, we are talking about intelligent machinery, performing things efficiently. So, basically, even if you are talking about resources, efficient utilization of energy, efficient utilization of water, or other resources, and other materials that are used.

Competitiveness: In the Industrial IoT era is that everything is going to be data driven, data are going to come from all these distributed machineries. And this is not going to be just local within a particular industry, but across different industry, and also you can scale it up to the global level.

Work force. Here we are going to talk about is skilled workforce, which will have advanced skills in all these domains of IIoT, and that knowledge has to be built up.

Innovation: So, in overall what is going to happen is through the incorporation of hardware, software, and the connected behavior between these different objects. You are going to foster innovation, and improve upon the efficiency.

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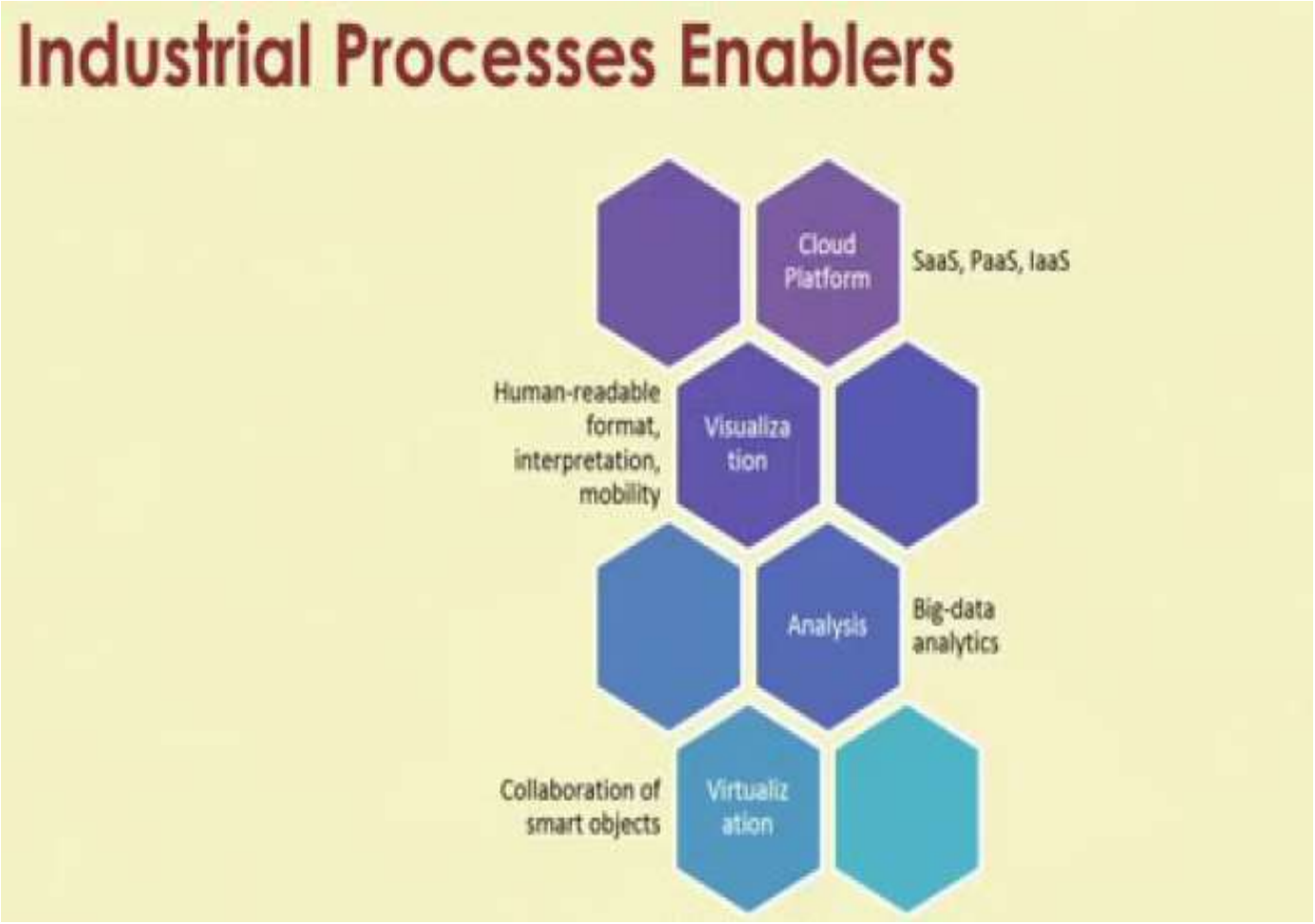
Flexibility this is also a prime feature of the incorporation of IIoT for improving upon industrial processes. This is flexibility about having dynamic supply chains, which are responsive to technologies, responsive to market changes, and so on.



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

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

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

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

Business Models and Reference Architecture of IIoT:

What is a Business Model?

"A business model describes the rationale of how an organization creates, delivers, and captures value"…….[Business Model Generation]

- It is the embodiment of the organizational and financial architecture of a business

- Description of how a business intends to operate and earn profits in a specific marketplace

Building Blocks of a Business Model

- Value Proposition:
  - Products or services that create value for a customer segment
  - Values may be:
    - Quantitative
      - Price, product or service performance, post-purchase cost reduction
    - Qualitative
      - Design, customization, customer experience, brand
- Market Segment:
  - Different groups of customers or end-user organizations that the business enterprise aims to serve
  - There are different types of customer segments:

    - Mass market (e.g., consumer electronics markets)
    - Niche market (, e.g., car part manufacturers depend heavily on purchases from major automobile manufacturers)

- Segmented (e.g., Micro Precision Systems serves three different Customer Segments- the watch industry, the medical industry, and the industrial automation sector)

- Diversified (e.g., Amazon, the online retail business enterprise, diversified its business by selling "cloud computing" services)

- Multi-sided markets (e.g. credit card company, for example, needs a large base of credit card holders and a large base of merchants who accept those credit cards)

- Value Chain Structure
  - The key resources and activities that a business requires to create value proposition
  - Resources:
    - Can be Physical, Intellectual, Human, Financial
    - Key resources can be owned or leased by the company or acquired from key partners.
  - Activities:
    - Production, Problem solving, Platform/Network

Revenue Generation and Margins:

- The revenue that is generated from each customer segment in a business
- Two different types of Revenue Streams -Transaction revenues and Recurring revenues
- Ways to generate revenue - Asset sales, Subscription fees, Usage fee, Leasing/Renting, Licensing, Brokerage, Advertising
- Two types of pricing - Fixed and Dynamic

Position in Value Network

- Value proposition also depends on the network of suppliers and partners
- Partnerships and alliances created to -
  - Optimize business models
  - Reduce risks
  - Acquire resources

- Competitive Strategy
  - Strategy of a particular company to gain competitive advantage over its competitors in the market
  - Three generic competing strategies:
    - Cost leadership
    - Differentiation by bringing something unique to customers
    - Focus on a small market segment or a niche rather than the mass market

Need for New Business Models for IoT

- Advent of lot has resulted in the following:
  - Increased business opportunities
  - Efficient processes
  - Enhanced asset utilization
  - Increased productivity
- Business challenges in IoT:
  - Diversity of objects
  - Immaturity of innovation
  - Unstructured business ecosystems
- IoT business models must address these requirements:
  - Extend scope beyond the company level to ecosystem level
  - Support design/visualization of complex value streams within the stakeholder network
  - Explicitly consider the value proposition for all key stakeholders (e.g., users, customers, and partners)
  - Consider data as an asset within and beyond the actual opportunity

Types of Business Models for lot

1. Subscription Model
2. Outcome-Based Model
3. Asset-Sharing Model
4. IoT-as-a-Service
5. Others:
   - ➢IoT Products as a Proxy to Sell Another Product
   - ➢IoT Products as a Vehicle to Monetize Data

1. Subscription Model

- Data generated by lot devices is "consumable, measurable and repeatable"
- It is capable of generating "recurring" revenue
- Using this model:
  - Instead of a one-time charge, customers are offered a regular subscription
  - Here, a fee is charged for periodic usage

Subscription Model: Advantages

- Provides predictable, recurring revenue
- The product can be monetized by providing paid upgrades or by implementing a "freemium" model
- Businesses are able to foster active relationships with customers due to repeated post-subscription interaction
- Businesses are able to learn more about their customers and are able to provide services specific to their requirements

Subscription Model: Challenges

- Customer management
- Automatic invoicing
- Subscription plan management
- Requirement of skilled labor and organizational structure
- Requirement of regular updates

2. Outcome-Based Model

- Businesses deliver to the customers the outcome/benefits that the product/service provides - "Pay-per-outcome“

- Customer is relieved from the responsibilities of ownership, and maintenance

- It brings together the businesses and their customers to monetize the solutions

Outcome-Based Model: Advantages

- Increased profit margin
- Reduced negotiation cycle
- Higher customer satisfaction
- Reduced risks
- Better alignment of the value proposition of the vendor and consumer.

Outcome-Based Model: Challenges

- Requirement of new infrastructure, policies and processes
- Price standardization
- Safe and reliable outcome delivery
- Lack of proven business models

3. Asset-Sharing Model

- Businesses virtually consolidate and share their IoT-enabled assets among multiple customers or with other business entities in exchange of revenue
- Revenue is charged based on time or nature of usage
- Aim is to minimize downtime and maximize utilization of the assets
- Can be used for Smart Energy

Asset-Sharing Model: Advantages

- Increased profit margin
- Reduced prize for customers
- Ease of scaling of business
- Reduced wastage of resources

Asset-Sharing Model: Challenges

- Security of products/services
- Mutual arrangements among business entities
- Asset configuration
- Device synchronization and synergies

4. IoT-as-a-Service

- Businesses provide loT-enabled products on lease to customers and earn revenue
- Products can be anything - software, hardware, information/data, results obtained from analysis of data, etc
- Revenue based on volume and quality
- Generates recurring revenue
- Example: Sensor-as-a-Service

IoT-as-a-Service: Advantages

- Reduced licensing costs
- Increased revenue from planned upgrades
- Better aligned value propositions
- Efficient operations and preventive maintenance by vendors
- Better customer relations

IoT-as-a-Service: Challenges

- Product Compatibility
- Maintaining data accuracy
- Security of date

5. Other Models

- IoT Products as a Proxy to Sell Another Product
  - IoT products are sold at cost price or at loss to sell other products
  - For example, lot devices keep track of status of products and perform actions accordingly
  - Used by manufacturers to sell products which require refills.

- IoT Products as a Vehicle to Monetize Data
  - IoT-enabled products collect data from users while providing services
  - This data is sold by businesses to third party businesses to earn revenue
  - As per requirement, data is processed and aggregated
  - Customers must be made aware beforehand about the usage of their data and privacy policies

Business Opportunities in IIoT:

- Entrepreneurship theory:
  - Asset-driven opportunities
  - Service innovations that aid manufacturing
  - Service-driven opportunities targeted at end-users
  - Information infrastructure ownership
- Transaction cost theory:
  - Non-ownership contracts
  - Performance contracts
- Components of IIoT Business Models:
  - Value proposition
  - Value capturing mechanism
  - Value network
  - Value communication

IIoT Business Models: Types

- IIoT business models can be divided into following categories:

1. Cloud-based Business Model
2. Service-Oriented Business Model
3. Process-Oriented Business Model

1. Cloud-Based Business Model

- Cloud-based BMs have manifold offerings
  - Processing power
  - Data storage
  - Virtualization of the operating system online
- Infrastructure-as-a-Service (IaaS) model
  - Aim at providing required hardware and software online in the cloud

- Platform-as-a-Service (PaaS) model
  - Open towards external parties
  - Provide development-oriented platforms
  - Facilitate the development of applications
  - Facilitate the integration of applications into existing solutions

- Software-as-a-Service (SaaS) model
  - Offer online capable and customized applications

- Partner network
  - Risk reduction
  - Scalability
  - Shared usage of resource

- Value configuration
  - Development of cloud services and applications
  - Establishment of partner network

- Core competencies
  - IT resources
  - Software and hardware infrastructure
  - Technical knowhow

- Relationships
  - Community networks (with customers, infrastructure providers)
  - Forums (e.g., websites)

- Value proposition
  - Processing power
  - Data storage
  - Virtualization of the operating system
  - Development oriented platforms
  - Integration of applications
  - Applications

- Distribution channels
  - On demand

- Target customers
  - Educational institutions
  - Startups
  - Independent software vendors
  - Small and medium-sized enterprises

- Cost structure
  - Cost reduction
  - Initial costs for installation
  - Service costs

- Revenue model
  - Pay-per-use
  - Subscription fees
  - Advertisement

2. Service-Oriented Business Model

- Offers
  - Primarily utilization
  - Analysis of data
  - Aggregation of data

- Example:
  - Medical environment

- Offered to a mass market on demand through infrastructures and platforms established by Cloud-based BMs

- Provides to customers
  - Self-service interface
  - Automated services
- Target customers
  - Mass market

- Partner network
  - Community
  - Infrastructure providers
  - Platform developers

- Distribution channels
  - Platforms
  - On demand

- Value configuration

  Maintenance and further development of
  - Platforms
  - Infrastructures
  - Applications

- Relationships
  - Self-service interface
  - Automated services

- Value proposition
  - Utilization of data
  - Analysis of data
  - Aggregation of data

- Core competencies
  - Platforms
  - Data analysis methods
  - Data

- Cost Structure
  - Initial establishment costs
  - Variable instead of fixed costs

- Revenue Model
  - Collected data
  - Direct and indirect monetization of data

3. Process Oriented Business Model

- Process optimization resulting in
  - Reduced downtimes
  - increased machine availability

- Optimize processes within a company and across company borders

- Optimize data analyzed by service-oriented BMs

- Results in reduced downtimes due to the eliminated delivery times

- Value configuration
  - Master complex production processes
  - Various production technologies

- Core competencies
  - Platforms
  - Data

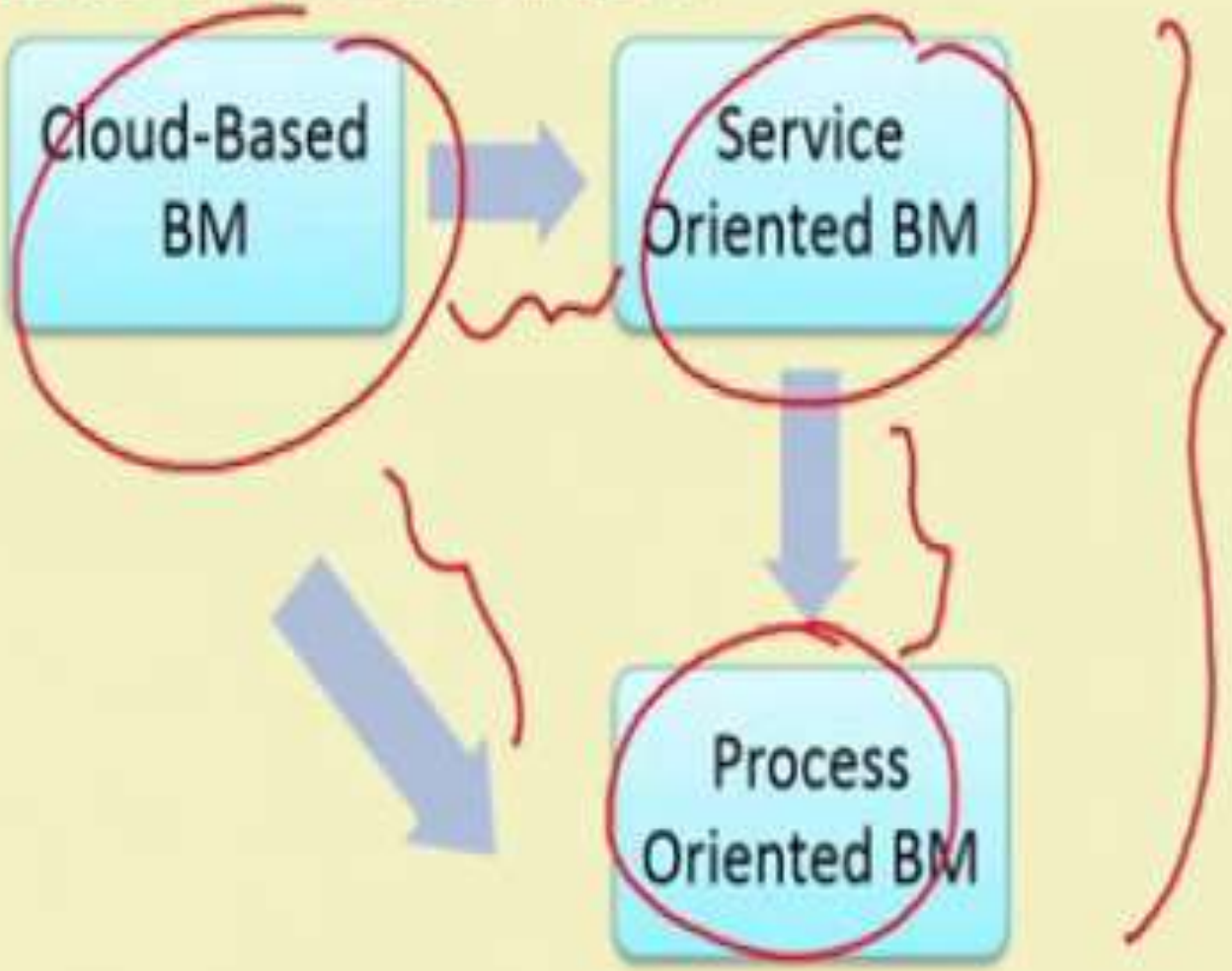
- Value proposition
  - Reduced downtimes
  - Increased machine availability

- Target customers
  - Machine and plant engineering industry

- Cost Structure
  - Initial establishment costs

- Revenue Model
  - License
  - Higher prices possible

IIoT Business Model: Flow



- Cloud-based BMs aim at providing an infrastructure

- Companies operating a Service-oriented BM employ Cloud-based BMs to gather data and information
  - Analyze and sell as a service

- Analyzed and prepared data help companies with a Process-oriented BM to optimize process flows

IIoT Business Model: Challenges

- >Security and data privacy
  - Physical and virtual worlds combine at a large scale
- Need security frameworks for entire cyber physical stack
  - Device-level authentication and application security
  - System-wide
    - ✓Assurance
    - ✓Resiliency
    - ✓Incidence response models

Thank you

Thanks!

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