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20EC004 Industrial IoT Applications

Department: CSE, CSD & IT
Batch/Year: 2023 -2024/ IV/IIIYear

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CONTENTS

1. Course Objectives

1. Course Objectives

- To introduce how IoT has become a game changer in the new economy where the
- customers are looking for integrated value.
- To get insights over architecture and protocols of IIoT
- To know the various sensors and interfacing used in IIoT.
- To bring the IoT perspective in thinking and building solutions.
- To introduce the tools and techniques that enable IoT solution and Securityaspects.

2. Pre Requisites

2. Pre Requisites

- Know basics about sensors for this subject
- Knowledge on Industry 4.0

3. Syllabus

3. Syllabus

20EC004:Industrial IoT Applications L T P C : 3 0 0 3

UNIT I INTRODUCTION

Introduction to IOT, What is IIOT? IOT Vs. IIOT, History of IIOT, Components of IIOT –Sensors,Interface, Networks, People Process, Hype cycle, IOT Market, Trends; future Real life examples,Key terms IOT Platform, Interfaces, API, clouds, Data Management Analytics, Mining Manipulation;Role of IIOT in Manufacturing Processes, Use of IIOT in plant maintenance practices, Sustainability through Business excellence tools Challenges, Benefits in implementing IIOT

UNIT II ARCHITECTURE AND PROTOCOLS

Overview of IOT components; Various Architectures of IOT and IIOT, Advantages &disadvantages,Industrial Internet - Reference Architecture; IIOT System components: Sensors, Gateways, Routers,Modem, Cloud brokers, servers and its integration, WSN, WSN network design for IOT; Need for protocols, Wi-Fi, Zigbee, Bacnet, IIOT protocols COAP, MQTT, 6LoWPAN, LWM2M, AMPQ.

UNIT III SENSORS AND INTERFACING

Introduction to sensors, Transducers, Classification, Roles of sensors in IIOT , Various types of sensors ,Design of sensors, sensor architecture, special requirements for IIOT sensors, Role of actuators, types of actuators. Hardwire the sensors with different protocols such as HART, MODBUS-Serial,Parallel,Ethernet, BACNet , Current, M2M

UNIT IV CLOUD, SECURITY AND GOVERNANCE

IIOT cloud platforms: Overview of cots cloud platforms, predix, thingworks, azure,. Data analytics, cloud services, Business models: Saas, Paas, Iaas; Introduction to web security, Conventional web technology and relationship with IIOT, Vulnerabilities of IoT, IoT security tomography and layered attacker model,Identity establishment, Access control, Message integrity; Management aspects of cyber security

UNIT V IOT ANALYTICS AND APPLICATIONS

IOT Analytics : Role of Analytics in IOT, Data visualization Techniques, Statistical Methods; IOT Applications : Smart Metering, e-Health Body Area Networks, City Automation, Automotive Applications, Plant Automation, Real life examples of IIOT in Manufacturing Sector

4. Course outcomes

4. Course outcomes

Upon completion of the course, students will be able to

- CO1: Describe IOT, IIOT (K4)
- CO2: Understand various IoT Layers and their relative importance (K2)
- CO3: Interpret the requirements of IIOT sensors and understand the role of actuators.(K2)
- CO4: Study various IoT platforms and Security(K4)
- CO5: Realize the importance of Data Analytics in IoT(K4)
- CO6: Design various applications using IIoT in manufacturing sector.(K5)

5. CO- PO/PSO Mapping

5. CO- PO/PSO Mapping

CO	HKL	PROGRAM OUTCOMES												PSO		
		K3	K4	K5	K5	K3,K4,K5	A3	A2	A3	A3	A3	A3	A2	PSO1	PSO2	PSO3
		PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12			
C203.1	K3	3	2	1										3	3	3
C203.2	K3	3	2	1										3	3	3
C203.3	K3	3	2	1										3	3	3
C203.4	K3	3	2	1										3	3	3
C203.5	K3	3	2	1										3	3	3
C203.6	K2	2	1	-										2	2	2

6. Lecture Plan

6. Lecture Plan

S.No	Topic	No. of Periods	Proposed date	Actual Lecture Date	pertaining CO	Taxonomy level	Mode of Delivery
			UNIT I INTRODUCTION				
1	Introduction to IOT, plant maintenance practices, Sustainability through Business excellence tools Challenges, Benefits in implementing IIOT	1	07.08.2023		CO1	K4	Lecture
2	What is IIOT? IOT Vs. IIOT,	1	09.08.2023		CO1	K4	Lecture
3	History of IIOT, Components of IIOT -	1	10.08.2023		CO1	K1	Class Discussion
4	Sensors,Interface, Networks, People Process,	1	11.08.2023		CO1	K2	Lecture
5	Hype cycle, IOT Market, Trends;	1	12.08.2023		CO1	K2	Lecture
6	future Real life examples,	1	14.08.2023		CO1	K2	Lecture
7	Key terms – IOT Platform, Interfaces,	1	16.08.2023		CO1	K2	Lecture
8	API, clouds, Data Management Analytics, Mining Manipulation; Role of IIOT in Manufacturing Processes,	1	17.08.2023		CO1	K3	Lecture
9	Use of IIOT in plant maintenance practices, Sustainability through Business excellence tools Challenges, Benefits in implementing IIOT	1	18.08.2023		CO1	K2	Lecture

S.No	Topic	No. of Periods	Proposed date	Actual Lecture Date	pertaining CO	Taxonomy level	Mode of Delivery
UNIT II ARCHITECTURE AND PROTOCOLS							
10	Overview of IOT components; Various Architectures of IOT and IIOT,	1	19.08.2023		CO2	K1	Lecture
11	Advantages &disadvantages, Industrial Internet -	1	22.08.2023		CO2	K3	Lecture
13	Reference Architecture;	1	23.08.2023		CO2	K3	Lecture
14	IIOT System components: Sensors, Gateways, Routers, Modem,	1	24.08.2023		CO2	K2	Lecture
15	Cloud brokers, servers and its integration, WSN, WSN network design for IOT;	1	25.08.2023		CO2	K1	Lecture
16	Need for protocols,	2	26.08.2023		CO2	K3	Lecture
17	Wi-Fi, Zigbee, Bacnet, IIOT protocols	1	28.08.2023		CO2	K2	Case Study
18	COAP, MQTT,	1	29.08.2023		CO2	K3	Lecture
UNIT III LEVELS OF TESTING							
19	Introduction to sensors, Transducers,	1	01.09.2023		CO3	K1	Lecture
20	Classification, Roles of sensors in IIOT ,	1	02.09.2023		CO3	K3	Lecture
21	Various types of sensors , Design of sensors,	1	04.09.2023		CO3	K3	Lecture
22	sensor architecture, special requirements for IIOT sensors,	1	05.09.2023		CO3	K1	Lecture
23	Role of actuators, types of actuators.	1	07.09.2023		CO3	K1	Lecture

S.No	Topic	No. of Periods	Proposed date	Actual Lecture Date	pertaining CO	Taxonomy level	Mode of Delivery
24	Hardwire the sensors with different protocols such as HART,	1	08.09.2023		CO3	K1	Lecture
25	MODBUS-Serial,	1	19.09.2023		CO3	K2	Lecture
26	Parallel, Ethernet,	1	20.09.2023		CO3	K2	Lecture
27	BACNet , Current, M2M	1	21.09.2023		CO3	K2	Individual Project
UNIT IV TEST MANAGEMENT							
28	IIOT cloud platforms: Overview of cots cloud platforms,	1	22.09.2023		CO4	K1	Lecture
29	predix, thingworks, azure,. Data analytics, cloud services,	1	26.09.2023		CO4	K1	Lecture
30	Business models: Saas, Paas, Iaas; I	1	27.09.2023		CO4	K2	Lecture
31	Introduction to web security,	1	29.09.2023		CO5	K2	Lecture
32	Conventional web technology and relationship with IIOT,	1	29.09.2023		CO6	K2	Lecture
33	Vulnerabilities of IoT, IoT	1	30.09.2023		CO6	K1	Lecture
34	security tomography and layered attacker model,	1	03.10.2023		CO6	K1	Lecture
35	Identity establishment, Access control,	1	04.10.2023		CO6	K1	Lecture
36	Message integrity; Management aspects of cyber security	1	05.10.2023		CO6	K1	Lecture

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S.No	Topic	No. of Periods	Proposed date	Actual Lecture Date	pertaining CO	Taxonomy level	Mode of Delivery
			UNIT V TEST AUTOMATION				
37	Analytics : Role of Analytics in IOT, Data visualization Techniques,	1	06.10.2023		CO6	K1	Lecture
38	Statistical Methods; IOT Applications :	1	09.10.2023		CO6	K1	Lecture
39	Smart Metering,	1	10.10.2023		CO6	K3	Lecture
40	e-Health Body Area Networks, C	1	11.10.2023		CO6	K2	Lecture
41	ity Automation,	1	12.10.2023		CO6	K2	Lecture
42	Automotive Applications,	1	13.10.2023		CO6	K3	Lecture
43	Plant Automation,	1	14.10.2023		CO6	K3	Lecture
44	Real life examples of IIOT in Manufacturing Sector	1	16.10.2023		CO6	K3	Lecture
45	Real life examples of IIOT in Manufacturing Sector	1	17.10.2023		CO6	K3	Lecture

7. Lecture Notes

UNIT I -INTRODUCTION

Introduction to IOT

The Internet of Things (IoT) describes the network of physical objects—"things"—that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the internet. These devices range from ordinary household objects to sophisticated industrial tools. With more than 7 billion connected IoT devices today, experts are expecting this number to grow to 10 billion by 2020 and 22 billion by 2025. Oracle has a network of device partners.

Why is Internet of Things (IoT) so important?

Over the past few years, IoT has become one of the most important technologies of the 21st century. Now that we can connect everyday objects—kitchen appliances, cars, thermostats, baby monitors—to the internet via embedded devices, seamless communication is possible between people, processes, and things.

By means of low-cost computing, the cloud, big data, analytics, and mobile technologies, physical things can share and collect data with minimal human intervention. In this hyperconnected world, digital systems can record, monitor, and adjust each interaction between connected things. The physical world meets the digital world—and they cooperate.

What technologies have made IoT possible?

While the idea of IoT has been in existence for a long time, a collection of recent advances in a number of different technologies has made it practical.

Access to low-cost, low-power sensor technology. Affordable and reliable sensors are making IoT technology possible for more manufacturers.

Connectivity. A host of network protocols for the internet has made it easy to connect sensors to the cloud and to other "things" for efficient data transfer.

Cloud computing platforms. The increase in the availability of cloud platforms enables both businesses and consumers to access the infrastructure they need to scale up without actually having to manage it all.

Machine learning and analytics. With advances in machine learning and analytics, along with access to varied and vast amounts of data stored in the cloud, businesses can gather insights faster and more easily. The emergence of these allied technologies continues to push the boundaries of IoT and the data produced by IoT also feeds these technologies.

Conversational artificial intelligence (AI). Advances in neural networks have brought natural-language processing (NLP) to IoT devices (such as digital personal assistants Alexa, Cortana, and Siri) and made them appealing, affordable, and viable for home use.

IoT stands for the Internet of Things.It is a network of physical objects or "things" embedded with sensors, software, and connectivity capabilities.These objects can collect and exchange data over the internet.IoT includes everyday devices like smart appliances, wearables, industrial machinery, and more.

Key components of IoT are devices, connectivity, data processing, cloud computing, and data analytics.IoT devices use sensors to collect data from the environment (e.g., temperature, motion, humidity).The collected data is transmitted through various connectivity options like Wi-Fi, Bluetooth, cellular networks, etc.

Cloud computing platforms process and store the data, providing scalable storage and computational resources. Data analytics and artificial intelligence help derive meaningful insights from the collected data.

IoT has applications in smart homes, healthcare, industrial automation, agriculture, transportation, and smart cities.Challenges in IoT include data security, privacy concerns, interoperability, and cybersecurity.

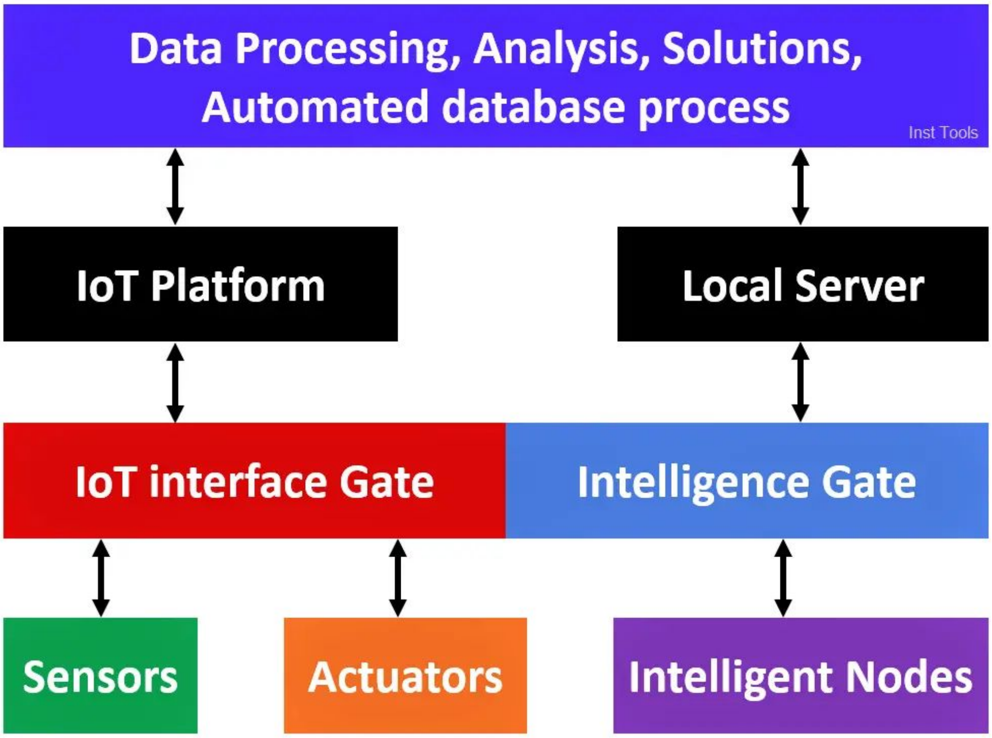
What is IIoT?

IIoT is a network of intelligent devices connected to form systems that monitor, collect, exchange and analyze data. Each industrial IoT ecosystem consists of the following:

- Connected devices that can sense, communicate and store information about themselves.
- Public and private data communications infrastructure.
- Analytics and applications that generate business information from raw data.
- Storage for the data that's generated by the IIoT devices.
- People.

These edge devices and intelligent assets transmit information directly to the data communications infrastructure, where it's converted into actionable information on how a certain piece of machinery is operating. This information can be used for predictive maintenance, as well as to optimize business processes.

IIoT Infrastructure



IIoT Infrastructure

IIoT is a network of smart devices connected to **systems of systems** that monitor, control, collect, exchange and analyze the data.

In other words, the Internet of things is a network of physical objects or things that collect and exchange data to monitor and control industrial processes.

Importance of Industrial Internet of Things (IIoT)

The industrial internet of things (IIoT) is concerned with the effective utilization of smart sensors, transmitters, and actuators to increase industrial production and manufacturing processes.

IIOT uses the ability of smart machines and real-time analytics used to utilize the data that "dumb old machines" have produced in industrial establishments for years.

This information can be used for predictive maintenance as well as to modify to achieve maximum efficiency in business processes.

The philosophy that guides and also drives the industrial internet of things (IIoT) is that smart machines are better than human beings at capturing and analyzing data in real-time.

IOT Vs. IIOT

IoT and IIoT have many technologies in common, including cloud platforms, sensors, connectivity, machine-to-machine communications and data analytics, they are used for different purposes. IoT applications connect devices across multiple verticals, including agriculture, healthcare, enterprise, consumer and utilities, as well as government and cities.

S.No.	IIOT	IOT
1.	It focuses on industrial applications such as manufacturing, power plants, oil & gas, etc.	It focuses on general applications ranging from wearables to robots & machines.
2.	It uses critical equipment & devices connected over a network which will cause a life-threatening or other emergency situations on failure therefore uses more sensitive and precise sensors.	Its implementation starts with small scale level so there is no need to worry about life-threatening situations.
3.	It deals with large scale networks.	It deals with small scale networks.
4.	It can be programmed remotely i.e., offers remote on-site programming.	It offers easy off-site programming.
5.	It handles data ranging from medium to high.	It handles very high volume of data.
6.	It requires robust security to protect the data.	It requires identity and privacy.
7.	It needs stringent requirements.	It needs moderate requirements.
8.	It having very long life cycle.	It having short product life cycle.
9.	It has high- reliability.	It is less reliable.

History of IIOT

1960s: The origins of IIoT can be traced back to the development of Supervisory Control and Data Acquisition (SCADA) systems, which enabled remote monitoring and control of industrial processes.

- 1970s: Programmable Logic Controllers (PLCs) were introduced, replacing manual control systems with digital automation, laying the foundation for more interconnected industrial systems.

- 1990s: The concept of "Machine-to-Machine" (M2M) communication emerged, enabling devices to communicate and exchange data without human intervention.

- Late 1990s: The rise of internet connectivity and adoption of standard communication protocols like TCP/IP opened new possibilities for connecting industrial devices and systems.

- Early 2000s: Wireless communication technologies like Wi-Fi and cellular networks gained prominence, making it easier to deploy connected devices in industrial environments.

- 2008: The term "Industrial Internet" was coined by General Electric (GE), highlighting the convergence of industrial machines, data analytics, and the internet.

- 2010s: The IIoT ecosystem saw rapid growth with advancements in sensor technology, cloud computing, big data analytics, and edge computing, enabling more sophisticated data processing and real-time decision-making.

- 2011: The Industrial Internet Consortium (IIC) was founded to promote the adoption of IIoT technologies and develop standards for interoperability and security.

- 2015: The German government launched "Industrie 4.0," a strategic initiative to digitize and transform industrial production, emphasizing the role of IIoT in smart manufacturing.
- 2018: The Industrial Internet Consortium and the OpenFog Consortium merged to form the OpenFog Consortium, fostering collaboration and standardization efforts in fog computing for IIoT.

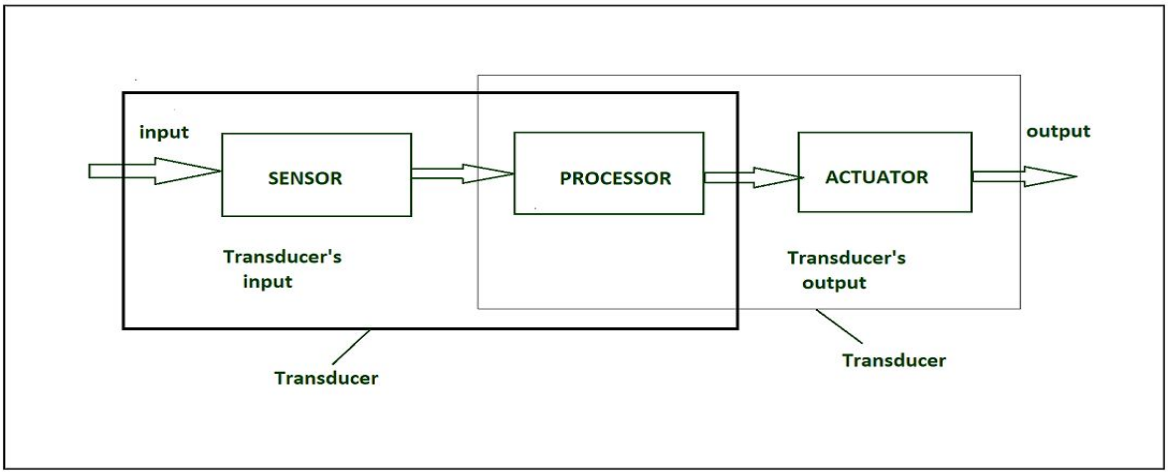
- 2020s: IIoT continued to evolve, with increased focus on edge computing, AI-driven analytics, and 5G connectivity, enabling even more advanced industrial applications and services.

Components of IIOT

The Industrial Internet of Things (IIoT) is a subset of the broader Internet of Things (IoT) that specifically focuses on connecting industrial devices, machines, and systems to the internet. IIoT enables data collection, analysis, and automation in various industrial sectors, leading to increased efficiency, productivity, and optimization of processes. The components of IIoT typically include:

Sensors are used for sensing things and devices etc.A device that provides a usable output in response to a specified measurement.

The sensor attains a physical parameter and converts it into a signal suitable for processing (e.g. electrical, mechanical, optical) the characteristics of any device or material to detect the presence of a particular physical quantity. The output of the sensor is a signal which is converted to a human-readable form like changes in characteristics, changes in resistance, capacitance, impedance, etc.



Transducer :

- A transducer converts a signal from one physical structure to another.
- It converts one type of energy into another type.
- It might be used as actuator in various systems.

Interface

An interface in the context of the Internet of Things (IoT) refers to the mechanism or medium through which IoT devices and systems communicate with each other and with humans. It enables the exchange of data, commands, and information between various components of the IoT ecosystem.

Interfaces play a crucial role in IoT as they allow different devices, sensors, and applications to interact seamlessly, facilitating data sharing and enabling smart functionalities. There are several types of interfaces used in IoT:

1. Machine-to-Machine (M2M) Interface: This type of interface enables direct communication between IoT devices without human intervention. Devices can share data, commands, and responses in real-time, making them capable of autonomous decision-making.
2. Human-Machine Interface (HMI): The HMI allows humans to interact with IoT devices and systems. It includes user interfaces such as mobile apps, web applications, voice assistants, touchscreens, and other interfaces that enable users to control and monitor IoT devices.
3. Application Programming Interface (API): APIs are sets of rules and protocols that allow different software applications to communicate with each other. In IoT, APIs facilitate the integration of various applications and services, enabling interoperability and data exchange.
4. Network Protocols: IoT devices communicate over various network protocols, such as Wi-Fi, Bluetooth, Zigbee, LoRaWAN, MQTT, CoAP, etc. These protocols define how data is transmitted, received, and interpreted by devices in the network.
5. Cloud Interfaces: Many IoT solutions use cloud platforms to store and process data. Cloud interfaces enable IoT devices to connect to cloud services and securely transfer data to and from the cloud.
6. Gateways: Gateways act as intermediaries between IoT devices and cloud services. They collect data from local devices, process it, and send relevant information to the cloud or other connected devices. Gateways often have multiple interfaces to communicate with various devices.

Networks:

The communication infrastructure connecting IoT devices to each other and to cloud platforms. They provide the communication infrastructure that connects IoT devices to each other and to cloud platforms or other central servers. The choice of network plays a crucial role in determining the efficiency, reliability, and security of data transmission in an IoT system. Here are some key types of networks commonly used in IoT:

1. Local Area Network (LAN): LANs are used to connect IoT devices within a limited geographical area, such as a home, office, or factory. Common LAN technologies used in IoT include Wi-Fi and Ethernet. Wi-Fi is widely used for consumer IoT devices due to its convenience and ubiquity.

2. Wide Area Network (WAN): WANs cover larger geographical areas and enable long-range communication. Cellular networks, such as 4G LTE and 5G, are popular WAN technologies for IoT, especially for applications requiring mobility or widespread coverage.

3. Low-Power Wide Area Network (LPWAN): LPWAN technologies are designed to enable long-range communication while conserving energy, making them ideal for battery-powered IoT devices that need to operate for extended periods. Examples of LPWAN technologies include LoRaWAN and NB-IoT.

4. Bluetooth: Bluetooth is commonly used for short-range communication between IoT devices and smartphones or other devices acting as a gateway to the internet. Bluetooth Low Energy (BLE) is especially popular in IoT applications due to its low power consumption.

5. Zigbee: Zigbee is a low-power, wireless communication protocol designed for IoT devices, particularly in home automation and industrial applications. It allows for low-latency, mesh networking, and supports a large number of devices in a network.

6. MQTT (Message Queuing Telemetry Transport): MQTT is a lightweight messaging protocol used for communication between IoT devices and cloud-based applications. It is known for its low overhead and efficient data transmission.

7. CoAP (Constrained Application Protocol): CoAP is another lightweight protocol designed for resource-constrained devices and networks, making it suitable for IoT applications.

People and Process

The human aspect of IIoT, involving the roles of operators, data analysts, and decision-makers in utilizing IIoT insights to optimize processes.

Hype Cycle

The stages of expectation and disillusionment that new technologies typically go through before reaching widespread adoption and maturity.

IoT Market and Trends:

- The IoT market has witnessed exponential growth in recent years, with various industries adopting IoT solutions for improved efficiency and data-driven decision-making.
- The rising trend of edge computing enables real-time data processing and analysis, reducing latency and dependence on cloud infrastructure.
- AI and machine learning are being integrated into IoT systems to enhance predictive analytics and automate decision-making processes.
- The need for robust cybersecurity solutions to protect against cyber threats is becoming increasingly crucial as IoT adoption expands.
- As IoT technologies mature, more industries are exploring the benefits of incorporating IoT into their operations, leading to further market growth and innovation.

Future Real life examples

- Smart Homes: Developing smart homes has caused a revolution in designing residential homes. The smart home products would save energy, time and money. A Smart Home would enable the owner to control house hold jobs at the house even from a remote location. For example, switching on the air conditioner or heaters minutes before reaching home, switching on / off the lights, controlling the washing machine, etc. Although such smart homes have been implemented but the cost of establishing such homes is still a major restriction that limits its usage .
- **Wearable Device:** Wearable devices include wrist watches or glasses that are installed with sensors and software which collect and analyze data. Companies like Google and Samsung have invested heavily in building such devices. These devices broadly cover fitness, health and entertainment requirements. A major challenge for developing such systems are that it should be light weight, small in size and should have very low power consumption
- **Traffic Monitoring:** Vehicles should be capable of optimizing its operation, fuel consumption, pollution control, maintenance and comfort of passengers. A breakthrough will be achieved if such smart traffic could be developed as it would drastically reduce road accident causalities. By installing sensors and using web applications, citizens can also find free available parking slots across the city.
- **Industrial Internet :** Industrial Internet is the new buzz in the industrial sector, also termed as Industrial Internet of Things (IloT). It is empowering industrial engineering with sensors, software and big data analytics to create brilliant machines. IIoT holds great potential for quality control and sustainability. Applications for tracking goods, real time information exchange about inventory among suppliers and retailers and automated delivery will increase the supply chain efficiency.
- **Smart city:** Smart City is another buzzword gaining immense interest from the public. Smart surveillance, automated transportation, smarter energy management systems, water distribution, urban security and environmental monitoring all are examples of internet of things applications for smart cities. It will solve major problems faced by the people living in cities like pollution, traffic congestion and shortage of energy supplies etc. Products like cellular communication enabled Smart trash will send alerts to municipal services when a bin needs to be emptied .

Agriculture : Agriculture With the continuous increase in world's population, demand for food supply is extremely raised. Governments are helping farmers to use advanced techniques and research to increase food production. Smart farming is one of the fastest growing field in IoT. Farmers are using meaningful insights from the data to yield better return on investment. Sensing for soil moisture and nutrients, controlling water usage for plant growth and determining custom fertilizer are some simple uses of IoT .

Healthcare: Healthcare The concept of connected healthcare system and smart medical devices bears enormous potential not just for companies, but also for the well-being of people in general. Research shows IoT in healthcare will be massive in coming years. IoT in healthcare is aimed at empowering people to live healthier life by wearing connected devices. The collected data will help in personalized analysis of an individual's health and provide tailor made strategies to combat illness.

Key terms – IOT Platform, Interfaces, API, clouds, Data Management Analytics, Mining Manipulation

IOT Platform

An IoT platform is an application or service that provides built-in tools and capabilities to connect every "thing" in an IoT ecosystem. By providing functions including device lifecycle management, device communication, data analytics, integration, and application enablement.

An IoT platform harmonizes the many moving parts that contribute to your IoT system. An IoT platform is the foundation for building IoT solutions that deliver value to your business, your customers, your customers' end users, and your partners. By enabling you to maintain visibility, security and control over connected assets, IoT platforms enable you to start and scale IoT projects efficiently so you can launch customer-centric services and remain competitive in an evolving market environment

Uses an IoT platform

An IoT platform is critical to building an IoT ecosystem, it simplifies IoT, making it more secure, regardless of where you are on your IoT journey to build smart, connected products.

IoT is a complex ecosystem that spans a network of devices and software applications touching multiple parts of the physical and digital landscapes. It is rare for an organization to maintain in-house expertise across all the relevant domains to build a complete set of IoT capabilities. As a result, in the "buy versus build" debate over IoT capabilities, most enterprises see value in buying an IoT platform to provide an out-of-the-box set of key capabilities, on top of which the business can build differentiating logic and applications.

An effective platform enables you to rapidly connect and manage existing assets while creating and supporting new, differentiated services. It helps get your IoT projects off the ground quickly, and removes the technical complexity from IoT projects, enabling you to focus on real business outcomes.

As IoT-enabled services become an increasingly important part of how organizations serve their customers, delivering IoT at scale can be a challenge. The approach that works for an initial proof-of-concept connecting a handful of machines may not scale properly—for example, it's common for system management to become a drain on innovation, or to find that costs spiral out of control with thousands of deployments.

Additionally, IoT solutions are a service, not a project or a product. They don't have a defined start and end date, but rather a lifecycle that needs to be managed. IoT solutions built without the right IoT platform means developers may be forced to shift from building new products to supporting, maintaining and updating existing products. In doing so, IoT maintenance become a cost center—leading to inevitable tradeoffs between sustaining what you have and building new innovative products.

With these factors in mind, the fastest, most sustainable path to IoT innovation is not to buy or to build—it's to buy and build. Buying a flexible IoT platform delivers the foundation for innovation and differentiation. Ready-to-use solutions help you achieve strategic business outcomes fast, while intuitive tools enable you to easily build your own services on top. You get a solid, reliable, scalable IoT platform as the foundation, with the ability to drive innovation and differentiation.

Figure 1: An IoT platform provides a means to control your various applications and IoT devices, as well as manage the process of collecting, analyzing and storing the data you generate

IoT platform capabilities

At a basic level, IoT platforms should allow you to connect and manage your devices with ease, offer application enablement and integration tools, and analyze your IoT data for actionable insights.

IoT connectivity

Connection is at the heart of IoT: devices are connected using protocols to share information and enable new insights. An IoT platform provides out-of-the-box connectivity to many device types and protocols.

For devices that do not support standard IoT protocols, an IoT platform is especially valuable if it offers a software development kit (SDK) to integrate devices with the rest of your ecosystem. Leading IoT platforms enable connectivity and integration using publicly documented APIs.

IoT device lifecycle management

An IoT platform allows you to manage the lifecycle of IoT devices and sensors—from planning and onboarding, monitoring and maintenance, through to retirement—remotely from a centralized location. Robust device lifecycle management processes are often neglected in early-stage IoT projects, when the focus is on building and launching a solution, but they are fundamental to scale a rollout and maintain reliable performance.

Enterprise IoT users need to update and communicate with devices efficiently in a controlled, secured and phased way. One example of this is the bulk registration of devices. Another is updating software and firmware to maintain performance, uptime and security. An IoT platform should allow you to access and monitor critical information easily, such as system resource information, alarms and errors, cellular signal strength or GPS location.

Scalable IoT data management

IoT data is the source of insights. An IoT platform handles data logging, storing, and processing, and manages data transactions. IoT data comes from many devices and locations, and spans many data types. IoT platforms can orchestrate action based on real-time data, and coordinate the long-term storage and analysis of large data sets to power analytics.

IoT integration

An IoT platform needs to be much more than a passive destination for data from IoT sensors. IoT needs integration to fill its promise, as integrating IoT data with other systems builds value exponentially by helping you use insights from IoT in your existing systems and processes to make better business decisions.

IoT platforms can offer powerful and intuitive routes to IoT integration. You can integrate device data with enterprise apps, cloud apps, big data apps, data lakes and third-party ecosystems and automate actions, workflows and processes across your operational technology (OT) and information technology (IT) assets—ideally, without coding.

IoT application development

Building and maintaining IoT applications involves technical expertise, time and resources. An IoT platform with application enablement features can help remove the resource technical hurdles to building and deploying applications.

Many businesses see value in enabling their IoT users to develop custom applications with an application builder—or by extending the platform's default applications to meet their specific business needs and requirements.

From amending existing applications according to customer needs to effectively scaling successful applications, an IoT application enablement platform provides users with self-service, low-code/no-code tools for developing, deploying, operating and extending custom IoT applications.

IoT data analytics

The value of IoT is not in the fleet of devices and sensors an organization is monitoring, but in the accurate and relevant data derived from these IoT devices and sensors. And the value of that data comes from analytics.

IoT analytics, which encompasses historical analytics, real-time analytics and predictive analytics, applies context to IoT data to reveal useful information, so you can make accurate, real-time decisions that deliver value.

An IoT platform with powerful analytic capabilities enables you to access this key data and discover insights. You can create dashboards that pull together data, so you have a single view of the status of all devices and how your project's performing.

An IoT platform with self-service analytics puts key data into the hands of many. The more widely accessible your insights, the greater their value across the entire enterprise.

IoT platforms: from cloud to edge

Many IoT platforms run in the cloud to take advantage of speed, scale, lower costs and access from around the world. For organizations that run remote assets, it is also important to many customers for an IoT platform to support edge computing.

IoT edge computing puts data processing closer to the sensors, rather than sending a full stream of data to the cloud. It is an advantage for organizations that have sensors and devices in places with limited connectivity, produce too much data to send to the cloud cost-effectively, or need millisecond response times from analytics.

IoT edge computing exists on a spectrum. On one end, thin edge is defined by an architecture where data from devices are collected and transmitted for centralized processing. It is a lightweight and modular approach that provides new or current devices with an easy, rapid way to connect to established systems. Thin edge is often used for applications that rely on low-powered, resource-constrained sensors.

Thick edge is on the other end of the spectrum. In a thick edge architecture, processing is more decentralized and occurs closer to data collection. Consider the processing that occurs in an autonomous vehicle. Instead of sending sensor data to be processed on a distant server, which would lead to latencies too high to safely respond to sudden changes on the road, a vehicle's systems process data directly onboard for autonomous navigation.

To take advantage of IoT edge computing, an IoT platform should enable you to develop solutions once, and deploy anywhere: on any cloud, at the edge, or on-premises.

How does an IoT platform work?

An IoT platform works by supporting the connectivity and communication between all the components in your IoT ecosystem through one application. It connects your devices and sensors—from registering one new device to bulk connecting thousands of devices. It allows you to remotely manage your devices and device groups, for example, by updating device firmware and software.

An IoT platform then facilitates data transmission and applies analytics to the collected data. It allows you to access IoT device data at both a granular and high-level view.

Finally, an IoT platform integrates this device data with other business applications and systems of record, so you can generate insights and make impactful decisions.

1. Connect

Connect, view and group IoT devices and assets in bulk over networks. Manage and monitor your devices.

2. Analyze

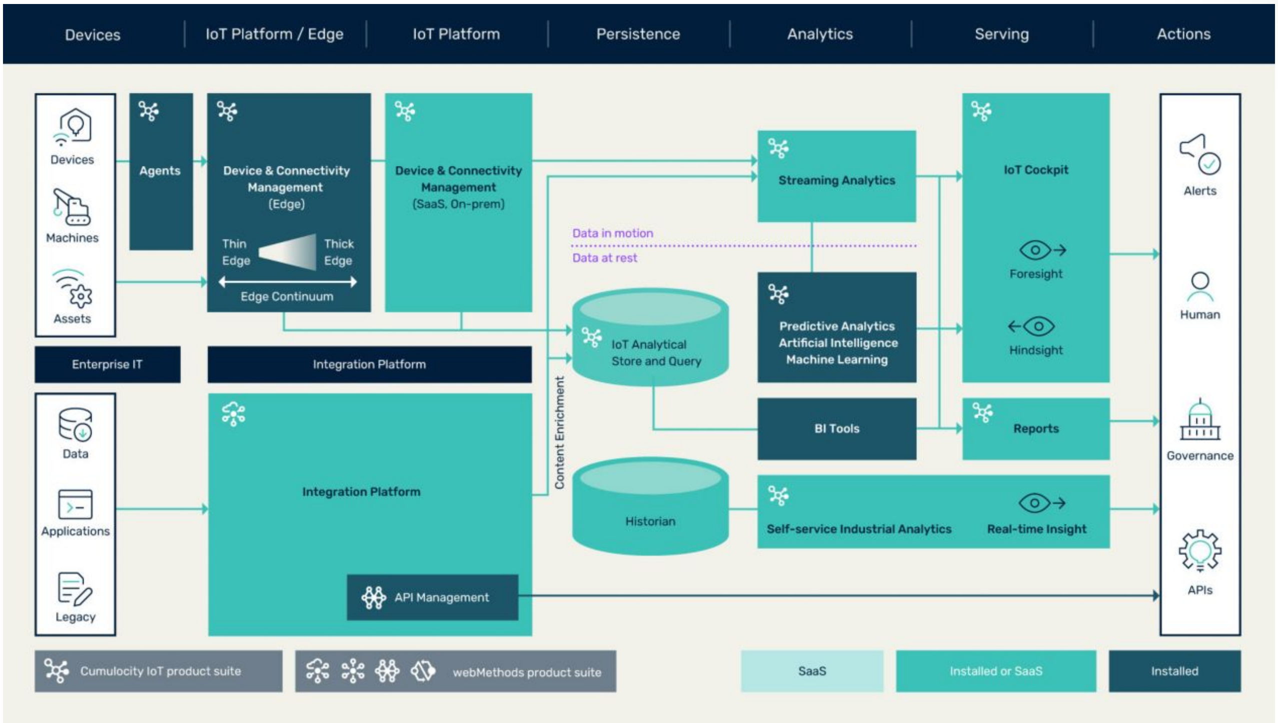
Exponentially increase your insights with powerful analytics. Monitor conditions and generate real-time analytics.

3. Integrate

Integrate device data with enterprise apps, cloud apps, big data apps, data lakes and third-party ecosystems. Assemble integration flows easily and start automated actions based on IoT events.

4. Act

React immediately to conditions or situations. Turn device data into actions. Enable increasing levels of automation for more efficient, reliable, sustainable operations.



How to choose an IoT platform

Technicality: Does the platform remove technical complexity from IoT projects? Or does it require outsized investments of time and resources to stand up and maintain?

Scalability: Does the platform scale effectively when many devices are connected? Can it scale to streamline management of many devices across their life cycle?

Flexibility: Does the platform enable you run on the hardware or cloud provider of your choice? Does it allow you to experiment with new concepts and business models?

Extensibility: Does the platform empower you to easily build your own differentiating services?

Simplicity: Does the platform enable you to run with a consistent architecture from the edge to cloud and on-premises?

Universality: Does the platform enable every stakeholder in your organization—including development teams, equipment operators, and business leads—to build solutions, define rules, create dashboards, and manage other aspects of the platform?

Security: Is the platform certified with the highest grade for security?

Cost and ROI: Will the platform reduce IoT operational costs, help grow your revenue and promise substantial ROI?

Speed: Will the platform help you create pilot projects efficiently to test and learn how to build new capabilities and services?

Visibility: Will analytics be accessible to a wide range of people in your organization?

Support: Will you have access to professional services and experts who can help support your IoT journey and empower your team to succeed?

IoT platform advantages

Software AG's Cumulocity IoT platform is an IoT platform that simplifies things for you with self-services tools and a configuration-driven approach. It's designed to give you complete business visibility and control of all the remote assets in your organization on a resilient platform you can trust.

The Cumulocity IoT platform helps you do more with IoT for faster business results and sustained innovation. It delivers enterprise grade IoT with unrivalled reliability, security and performance.

Read on, and see what our truly connected customers are able to achieve with Cumulocity IoT.

IoT platform supports new business models

"As-a-service" business models help you stay closer to customers and gain a competitive advantage by creating new products and differentiating services that can provide resilient, recurring revenue.

However, making the shift to new business models and transitioning to service-based relationships can be a challenge.

An IoT platform provides businesses with data they need to transition with confidence. It helps organizations build bridges with their customers through recurring services for remote monitoring, more smart field services, and performance management, all to improve the customer experience.

The most forward-looking are building Equipment-as-a-Service (EaaS) models that package products and services in an integrated offering.

IoT platform scalability

Because IoT-enabled services are becoming an increasingly important part of serving customers, an IoT platform that can help support your scalability is incredibly beneficial. IoT projects often start out small but then grow quickly when the first successes materialize. An IoT platform should be able to start as a proof-of-concept and then use the same platform and interfaces to expand to multiple sites, devices and data points. And a platform where costs scale efficiently, even as deployments scale exponentially, is even better.

Cumulocity IoT model scales pricing in line with deployments, allowing you to experiment with new concepts and business models without significant up-front investments.

IoT platform security

An IoT security solution is an absolute essential to doing business in today's connected world. Without security, your business is vulnerable to hacks and data security breaches. Private information can become public and exploited, threatening the well-being and reputation of your company, your customers and business partners.

That's why security is built into the Cumulocity IoT software development process, woven into every line of code.

An IoT platform can make managing the security of your IoT assets much easier. Our IoT security platform delivers carrier-grade features, such as secure multi-tenancy, scalability, high availability and encryption—making it secure for virtually any IoT use case.

IoT platform cost savings

An IoT platform saves organizations substantial development costs to build IoT-capabilities in-house. And further down the line, an effective IoT platform allows organizations to grow revenue with value-added capabilities to deliver IoT services.

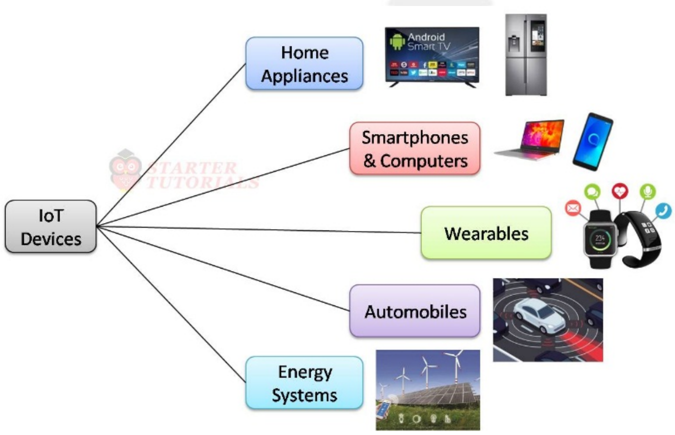
In addition, you'll keep saving money with Cumulocity IoT's advanced capabilities, such as predictive maintenance and remote monitoring—for example, by avoiding costs associated with maintenance repairs or unplanned downtime.

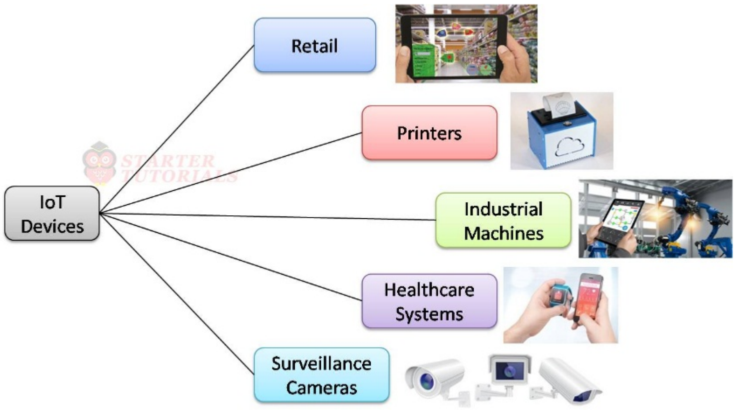
IoT platforms enable sustainability

An IoT platform supports sustainability by connecting the physical world. With knowledge—knowledge of how equipment is performing, where assets are located, and the resources your organization is consuming—comes the ability to drive smarter actions, smarter production, and smarter consumption.

Monitoring capabilities help you to evaluate energy consumption and understand the realities of your environmental footprint. With IoT, you can monitor energy use and emissions from the granular to the global, finding new ways to reduce your carbon intensity. Gain insights on equipment use, supporting improved maintenance to extend the equipment's lifespan. Manage and reduce waste more efficiently. Track the location of materials and understand how products can be designed to support a circular economy.

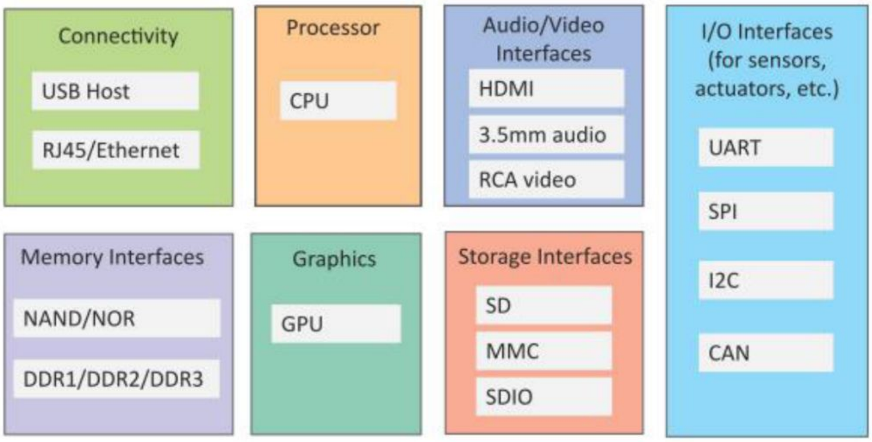
- Printers
- Industrial machines
- Healthcare: smart watch, smart healthcare, etc.
- Surveillance: smart cameras, smart trackers, etc.





An IoT device may consist of several interfaces for connections to other devices, both wired and wireless.

- I/O interfaces for sensors
- Interfaces for Internet connectivity
- Memory and storage interfaces
- Audio/video interfaces.



IOT API

IoT devices offer many benefits as they are connected to the internet. This means they collect data and can communicate with other computers and applications. APIs, or applications programming interfaces, are what make it possible to communicate with a connected device, based on a set of rules.

APIs are critical in IoT, both to communicate with the device and to leverage the information from the device, but there is a lot to understand. In this post, we'll dive into:

What is an IoT API?

The term API (application programming interface) is the tool software developers use to gather and transfer data from one application or computer to another. Or in other words, APIs enable developers to programmatically interact with software components both inside and outside of their own code.

In IoT specifically, APIs are used to gather and transfer data from the connected device to an application or computer. They are also used to instruct a connected device to take a particular action. Because connected devices can be anywhere in the world, having an API makes it possible to remotely access a device and make the data useful.

An API is a way to enable users to programmatically access information about their devices and make decisions or take actions based on it. There are an endless number of ways they can work together in IoT. A few examples include:

- Managing a fleet: Everything from activating devices to billing and reporting are all done via the API.
- Preventing fraud: Leveraging the API enables users to create alerts if a device is moved or if a SIM card was stolen. We've also seen users configure SMS limits to prevent high data charges if a device is stolen.

While the Hologram Dashboard surfaces all of this information and capabilities, users will leverage the Hologram API to either bring data into their own tools or leverage it as part of their application for their customers. APIs are powerful tools that take the data created at the device level and make it usable.

What is an API endpoint and why is it important?

An API endpoint is the source which you want to get the data from. In more technical terms, it's an API call. The most obvious API endpoint in IoT is at the device level, gathering data from the connected device. This collects data usage, connectivity status, and any other additional data an IoT application is intending to collect.

Beyond the device endpoint, there are many other useful endpoints within an IoT deployment. For example, a team may use the API to collect data as it relates to billing, making finance reporting programmatic.

Main types of IoT APIs

There are four common types of APIs: Public, Partner, Internal and Composite.

Public APIs

Public APIs, also known as Open APIs, are available to the public with no restrictions. This enables developers outside of an organization to access data to enhance their own application

. Single sign on, using your email or social media account, is made possible through Public APIs, bringing in the email provider or social platform code into your application.

Partner APIs

Partner APIs can be leveraged by a client or partner of an application. These APIs require users to sign in and authenticate with an API key to access the API. The Hologram API is an example of a Partner API, allowing customers to communicate directly with their connected devices and bring data back to their applications.

Internal APIs

APIs used by a company to build and manage their applications are internal or private APIs. This ensures that only those working on a product have access to make changes to a product or to the sensitive data on a platform.

Composite APIs

Composite APIs batch several API requests into a single API call. This reduces the number of trips to a server. By grouping a chain of API calls into one API, a client can make one API request that includes a chain of calls and end with one response.

Types of API architectures and delivery formats

While we discussed the different types of APIs, there are also different approaches in how data is transferred over a network using API calls. REST and SOAP are leading architectures, but offer different benefits to users. JSON and XML are the formats in which the data is delivered.

SOAP API

SOAP (Simple Object Access Protocol) is a protocol specification for exchanging data between two endpoints. SOAP is mostly used for applications that require a high level of security – like payments.

REST API

REST, also known as a RESTful API (Representational State Transfer), is an architectural style for building client-server applications. REST supports high-performing and reliable communication at scale, independent of the technology used. It is a more lightweight architecture than SOAP.

JSON and XML

JSON and XML are two of the formats in which data is delivered. SOAP relies exclusively on XML while REST allows XML, JSON, HTML, and plain text. JSON is a lightweight, human-readable format that can be used with any programming language. Most public web services use REST APIs with JSON.

networking resources) can easily handle thousands of devices and process their data across large systems

- **Flexibility:** cloud IoT provides a high level of flexibility, as it allows devices to be added or removed as-needed, without having to reconfigure the entire system
- **Maintenance:** in cloud IoT, the maintenance of servers and networking equipment is handled by the cloud service provider (CSP). While in other types of IoT architectures, maintenance may be the responsibility of the end user
- **Cost:** cloud IoT can be more cost-effective over the long-term, as users only pay for the resources they actually consume, and users do not have to invest upfront in their own expensive compute, storage, and networking infrastructure

How Does Cloud IoT Work?

Cloud IoT connects IoT devices – which collect and transmit data – to cloud-based servers via communication protocols such as MQTT and HTTP and over wired and wireless networks. These IoT devices can be managed and controlled remotely and integrated with other cloud services.

IoT data is sourced from anywhere and everywhere, including sensors, actuators, operating systems, mobile devices, standalone applications, and analytic systems. By involving the cloud, vast amounts of IoT data can be stored and processed in a central location.

Scalable Storage

Cloud IoT platforms provide scalable object storage services, such as Amazon Simple Storage Service (Amazon S3), that allow organizations to easily increase or decrease their data storage requirements. This type of flexibility is beneficial for IoT applications, as they often generate large volumes of unstructured data and must be able to store this information without sacrificing device performance.

Device Connectivity

Cloud-based IoT platforms offer straightforward, reliable, and secure connectivity at-scale between physical IoT devices and cloud services. In turn, an organization can connect thousands or millions of IoT devices to the cloud, without the need to provision or manage the requisite servers and networking equipment.

Analytics and Reporting

Cloud-based IoT platforms are equipped with powerful analytics capabilities – *in combination with computing resources* – that enable organizations to gain real-time insights into the large datasets that IoT devices produce. Through sophisticated algorithms, such as predictive modeling, statistical analysis, and machine learning (ML), IoT device data can be used to improve efficiency and make better, information-driven decisions.

Additionally, IoT device data can be combined with other relevant data stored in the cloud to extract meaningful insights for organizations. Furthermore, built-in data reporting features offered by cloud services allow organizations to create useful reports based on collected IoT data.

Identity and Access Management (IAM)

Security for the data generated by IoT devices can be protected in the cloud using Identity and Access Management (IAM), which is an authentication and authorization service. IAM enables organizations to grant or deny access to services and resources in the cloud for large numbers of users with different access needs.

With so much IoT data being sent to the cloud, the granularity of IAM controls allows organizations to comply with security and regulations that are relevant for storing and accessing sensitive information.

IOT- Data Management Analytics

The Industrial IoT refers to the billions of industrial devices - factory machines to aircraft engines - filled with sensors. Sensors interact, collect data locally, store data, and exchange data via wireless sensor networks or Wi-Fi. The advent of miniaturized, low-cost smart objects, like sensors and broadband wireless networks, now means that each IoT sensor, even the smallest connected devices, can be connected to the network. And given the level of current digital intelligence that allows them to be monitored and controlled, as well as share their status and communicate with other devices

. Furthermore, all this IoT device data can be collected and analyzed to improve the efficiency of business processes. The endgame IoT platforms leads to better control over the business and more straightforward ways to find new revenue streams.

The IoT Data Management: Strategies and Solutions

Industrial IoT analytics is important because of its potential for faster and more efficient decision-making. The changes that IoT data analytics and data management can bring are a part of the overall digital transformation that many business entities are working on. By providing highly detailed real-time data, IoT data analytics and data management in IoT can help business entities better understand their business processes and, by analyzing the data coming from sensors, can make their operations more efficient and even unlock new revenue streams. The Industrial Internet of Things can also give businesses an insight into the wider supply chain, allowing companies to coordinate and improve efficiency.

Here are the essential components of a complete IoT data management and analytics solution that both manufacturers and business people should know about:

- **Preparing machine-readable data:** receives, structures, sorts, filters, transforms, modern IoT data management and analytics, groups, analyses, and broadcasts data obtained from "things" - big and small - regardless of whether they come from a fitness bracelet or SDH network monitoring equipment. It prevents "descriptive analytics." Depending on the type of this data,

they can either be redirected to applications for which they are of the most significant value or directly processed by operators of the platform and vertical solutions built on its basis.

- **Data normalization** is a crucial part of the IoT data management strategy. The optimal IoT data analytics system is developed with individual analytical modules without any idea of the physical meaning of the data they will process. Instead, device drivers abstract the received values based on the characteristics of communication protocols. This information is then fed into a single data model, where it is scaled and transformed for consistency. After that, the data can freely move between any platform modules.
- **Big data:** The flow of information in the IoT can be overwhelming. Hundreds of thousands of transactions within data management in IoT, every second at the moment, is "the peak load" for a large financial institution, while for an oil refinery, processing this amount of metrics is a typical work situation. All this IoT data requires an optimized framework to achieve similar amounts of data processing on a single server and much better performance when using a cluster of servers connected through the distributed infrastructure (so-called "fog computing" data management framework.)

- **Domain-specific languages:** Successful IoT data management implies a specific IoT architecture. The optimal architecture should implement query, expression, and process (as well as some others) languages explicitly designed for the "natural" understanding of the normalized data circulating in the system. In addition, the built-in development environment and debugger greatly simplify data processing, without which it is currently challenging to imagine a corporate-level monitoring and control system.
- **Machine Learning:** Discovering relationships between real-time data, historical data, and recently collected data is a critical feature of successful IoT platforms. More than 20 algorithms and hundreds of parameters will satisfy any data analyst's expectations. In addition, the visual process editor allows you to set up, train, evaluate and manage models according to the given logic, while incremental training and the ability to stream data complete the picture.
- **Real-time analytics:** Systems that are particularly good at analyzing time series are the most common data type in IoT. This allows you to detect anomalies, predict the behavior of graphs and classify time series, regardless of the physical meaning of the information and the number of metrics in the data array. In addition, support for working with streams provides seamless processing of large amounts of information that will never fit in memory.
- **Event Management:** The capabilities of the event monitoring and processing module include filtering, sorting, aggregation, de-duplication, masking, correlation, validation, enrichment, and root cause search. Most analytic modules support event activation and can be triggered by events received from external IoT sources or user-created object and process models.
- **Dashboards for data analytics:** From the visual part of the IoT platform, as a rule, nothing more is expected than counters, maps, tables, and graphs. Modern IoT data management and analytics can compete with the best representatives of business intelligence systems in creating statistical, analytical, and data mining interfaces. You can drill down on accumulated data, discover new relationships, and find ways to save energy consumption or equipment downtime.
- **Focus on results:** Although the platform does not bring anything to your business, it allows you to focus on generating profits instead of solving infrastructure problems. The development and deployment of a modern IoT data management and analytics-based solution in a customer's infrastructure usually take only a few months. At the same time, the actual economic effect is visible already in the first weeks of implementation
- **Digital Twins:** The object and process modeling engine allows you to create digital twins of physical assets and services. Models use business rules to make decisions when important events occur automatically. Each model can be attached to devices, data sources, or other models lower in the digital enterprise hierarchy.

Challenges of Implementing Predictive Analytics in IoT

As world statistics show, about 80% of analytical projects in this direction remain unsuccessful and are not being exploited. This may be due to both technological risks and organizational problems. In addition, various barriers hinder the successful implementation of predictive analytics. The most important of them, according to the experience of Factory5, can be divided into three groups:

1. Data. The model's performance critically depends on the availability and quality of the data obtained. At the same time, no data is needed, but suitable according to specific criteria.

2. Business processes. It is essential to understand who is doing what when the "red light" lights up. And the results should influence maintenance and repair processes.

3. Expertise. It is needed both when creating and interpreting the model - "bare mathematics" does not work well. Often vendors have their own closed and universal algorithms to cover the maximum possible range of equipment. The system for each sensor compares the actual value with the calculated one at the current time. Then the diagnostic rules analyze the value of the total deviation and the contribution of each sensor's variation. Forecasting is usually limited. This is also due to the specifics of the models. For example, the value of an individual sensor can be predicted for a short period.

Why are IoT Data Management and Analytics Important?

Collecting, storing, and visualizing raw data is just the beginning of any significant IoT project. The economic effect is achieved by management decisions to optimize existing processes and bring new products and services to the market for end customers. Technically, the above is achieved by aggregating, processing, and in-depth analyzing data received from devices. However, for each significant solution, these operations will be unique - optimizing the storage space of harvested crops is fundamentally different from orchestrating transactional data in smart grids or managing a forklift fleet. Analytic capabilities range from simple emergency alerts to advanced data processing with machine learning modules to detect anomalies and predict events such as turbine failure. Years of presence in the market and thousands of projects implemented by our partners in all vertical markets have allowed us to ensure that the platform has the necessary set of tools for each case.

Potential of IoT Device Management

IoT solutions require automated zero-touch device control at the scale of millions of things. Therefore, predictive analysis and proactive maintenance are critical success factors. In addition, IoT Device Management should automatically classify devices into states that depend on the context of use. If not, they are ineffective solutions for lame ducks. (c) Kurt Peterhans.

IoT device management is a process that helps business entities manage their network infrastructure and endpoints remotely. With the implementation of the IoT Device Management Solution, decision-makers can monitor the performance and health of devices on their network and remotely configure and update them.

Customer experience gives them better visibility into the status of their devices. The IoT space is rapidly evolving and has incredible potential to impact digital life. In the meantime, effective IoT device management is fundamental to any successful IoT solution - provision, authenticate, configure, control, monitor, and maintain IoT devices at scale. IoT solution incorporates future-ready modules and functionalities for successfully deploying, monitoring, and managing IoT devices for any vertical.

IoT device management refers to the combination of access control, quality of service, and data security systems for IoT devices. This is a critical feature for any IoT management and analysis system. Several features are commonly included in IoT device management solutions, such as:

- Identity and Access Management: This helps ensure that only authorized users can access device data.
- Quality of Service: This ensures that devices can perform optimally and provide the required level of service.
- Data Security: This helps protect valuable data from unauthorized access.

IoT Data Management vs. Traditional Database Management Systems

Today, business entities need a solution that can provide efficient, unified management of diverse data at a single level. IoT data management and analytics systems are built on top of management platforms. They can include traditional databases, data lakes and warehouses, big data management systems, analytics, and more.

All these components interact, forming a single platform for working with data. It provides IoT data management and analytics tools used in enterprise applications and analysis tools and algorithms for processing this data. Although modern tools make it possible to automate many management tasks, most database deployments are so large and complex that the intervention of a database administrator is still necessary. This increases the likelihood of errors. Reducing the need for manual IoT data management and analytics is one of the main goals of the new IoT technology for data management, the autonomous database.

Cloud platforms provide an opportunity to quickly scale the number of resources used without extra costs, thus growing in popularity among business users. In addition, some of these platforms are cloud services, providing additional cost savings for business entities.

Big Data Management

The term big data should be taken literally: it means a large, tremendous amount of data. However, big data is diverse and collected faster than traditional data. For example, imagine how much data a social network like Facebook generates daily. The quantity, variety, and speed of such data are of particular value to businesses. However, managing big data is also tricky. The volume of data coming from disparate sources (cameras, social networks, audio recordings, IoT devices) is constantly increasing, inevitably leading to the emergence of big data management and analytics systems. These systems have three main areas of application:

- Big data integration - working with data of different types (from batch to streaming) and converting them for subsequent use;
- Big data management - efficient, reliable, and secure storage of data in a lake or data warehouse, as well as its processing (often using an object storage system);
- Big data analytics - extract new, actionable insights using analytics tools, including graph analytics, and build models with machine learning and ai-powered visualizations.

Business entities are using big data to improve and accelerate product development, proactive maintenance, customer experience, security, operational efficiency, and more. As big data grows, new opportunities open up for us.

Data Privacy and Data Governance Principles

The GDPR, a regulation, has guided the collection, unification, and use of personal data in the EU since May 2018. To protect data, it regulates seven critical principles for managing and processing personal data.

According to these principles, when initiating data access, or working with data, legality, integrity, transparency, accuracy, integrity, confidentiality, compliance with restrictions, and storage requirements, must be ensured, among other things.

The GDPR and similar laws, such as the California Consumer Privacy Act (CCPA), are changing how we manage data. These requirements have shaped data protection standards that give individuals control over their data and its use. In practice, this means that consumers become the data owners and can sue if business entities collect data about them without informed consent, fail to maintain adequate controls over how data is used and hosted, or fail to comply with data deletion or portability requirements.

What is IoT data management and analytics? Practical recommendations

Data management: To successfully manage the challenges of data management, you need a comprehensive, well-thought-out set of best practices. Which recommendation to choose depends on the type of data and the industry, but the following practical recommendations will help you deal with some of the most significant challenges facing businesses today.

Challenges for IoT Data Management and Analytics

Today's data management and analytics challenges are driven primarily by the exponential growth of data and the accelerating pace of business. Business entities have access to more diverse data, which is processed faster and in more significant volumes. This creates a need for effective management tools. Here is a list of some of the toughest challenges business entities face today.

Lack of analytical presentation of data Business entities collects and store data from an increasing number of diverse sources: sensors, smart devices, social networks, and video cameras. But all this data will be useless if the company does not know what it is, where it is stored, and how to use it. In addition, IoT data management and analytics solutions require scale and performance to generate meaningful insights at the right time.

Difficulty maintaining performance levels of IoT data management and analytics systems. Business entities are increasingly collecting, storing, and using data. And to maintain peak response rates throughout the data layer (which continues to expand), you need to constantly monitor the queries the database responds to and adjust indexes as queries change. Yet, with all this, efficiency should not decrease.

valuable in itself - the company needs to process it. Data transformation can take too much time and effort. However, the experts insist on using the data form convenient for analysis so that the data doesn't lose value over time.

The constant need for efficient data storage Today, when data management and analytics issues have become especially relevant, business entities store information in several systems, including data warehouses and unstructured data lakes, where any data in any format can be placed in one repository. As a result, data scientists need to quickly and effortlessly convert data from one source format to another, presenting it the way it is and creating models suitable for virtually any type of analysis.

The need to continually optimize IT agility and costs The availability of cloud-based IoT data management and analytics systems allows business entities to choose whether to store and analyze data on-premise, in the cloud or through a hybrid combination of these options. To maximize IT agility and reduce costs, IT professionals must assess the similarity between on-premises and cloud environments.

IOT Mining Manipulation

Mining is an emerging industry. Before declaring results, mining industries use a variety of technologies and big data in between the procedures. How is IoT affecting the mining industry? What are its advantages and limitations in the mining industry? Which industry has implied IoT in its mining process? We will learn about the entire concept step by step.

IoT and mining

IoT expands for the Internet of Things. The internet of things may be defined as expanding connectivity of the internet on physical devices such as laptops, mobiles, and tablets. The physical devices include the daily devices available nearby.

What are the uses of IoT?

IoT is quite useful in the following ways.

1. It gives devices a soul or life.
2. When hardware is embedded with the internet, the devices are able to interact with each other.
3. IoT enables devices to be remotely monitored and controlled.
4. IoT helps in achieving cost and productivity optimization.
5. IoT improves the safety measures and develops the need for artificial intelligence.

IoT in the mining industry

IoT is often referred to as the backbone of the mining industry. IoT is useful for the mining industry in one or many ways. Mining industry often requires rapid innovations, technologies, automation, digitization and electrification.

The internet of things or IoT is providing the mining sector these facilities. From cost optimization to quick decision making, different advantages and uses of IoT in the mining industry is mentioned under the next title.

IoT helps in implementing artificial intelligence in the mines, thus, makes them more efficient and able. AI further enhances the power of IoT solutions as a way of streamlined operators. It helps in reducing the final costs and also improves the safety and quality level of the mining industry. AI and IoT together help the mining industries to improve their metal extracting process, they make the process more accurate and thus, less waste generating.

What is the need of IoT in the mining industry?

- IoT is required in the mining industry for the following three reasons.
- To improve the performance and productivity and eliminate the unnecessary costs.
- To anticipate machinery failures, this is known as the industrial internet of things.
- Various types of machinery and the plants are covering their machinery with smarter, cheaper and smaller internet connected sensors.

Advantages of IoT in the mining industry

The IoT is also called the backbone of the mining industry. With its advent the entire process of mining has become easier and cheaper. Here is the list of top few advantages of IoT in mining industries:

1. **Robotics advances for mining**

Having the self-standing products i.e., working of vehicle and equipment together, the more data is collected, which improves the accuracy rates. IoT allows mining companies to find the latest technologies, inventions, development trends, new innovations and how to stay top in the market. This makes the job easier and gives a lot of experience in the market and how to run it and how to deal with the various problems that come in between.

2. **Analytical maintenance**

Having an integrated network and monitoring every aspect of operation becomes very easy and it leads to greater safety and productivity. It includes a variation of various vital pieces of equipment and also projecting when repair is required.

3. **Energy and cost benefits**

Investment in the industrial internet of things reduces the use of energy and it also maintains the cost of the mining industries. They also have a transparent system where each part is monitored, and it allows a more efficient process. This continues to grow, and the cost spent on the workers also reduces and it allows the industry to become more profitable.

4. **Time saving**

When we develop and maintain the mine site IoT helps. The data is collected before the digging takes place for mining, it ensures that the process is managed correctly, and it also has less risk. Some of the mining industries use driverless vehicles and they are experimenting with autonomous drilling systems which are operated by machines themselves and there is no human use in this process. In this process the time clock is set according to the extraction process that takes place in the shorter time.

5. **IoT improving safety**

IoT is improving safety measures, various types of difficulty or danger comes during the extraction process, the condition of land is also an important aspect in the mining process. Technologies manage some of the risk and it prevents the collapse of unstable shafts. For example, the sensors pick up the real time data and predict whether there are issues or not.

6. **Cost optimization**

IoT helps in optimizing the costs of raw and finished products.

7. **Increased Productivity**

Implying IoT in the mining process also enhances the productivity level of the mining industry.

Drawbacks of IoT in the mining industry

With so many uses mentioned above, IoT has certain limitations in the mining industry. Following are the drawbacks of IoT in mining industry:

1. **Security and privacy**

   To keep the gathered data which is transmitted by the Iot devices safely is very challenging as they evolve and expand in use. Cybersecurity is very important and it is a priority for the mining companies. IoT devices aren't always included in the strategy. These devices must be protected from physical tampering, internet-based attacks, hardware-based attacks. Data privacy is an important concern for the mining companies because IoT devices are used in the more sensitive industries such as finance and healthcare. Various types of information privacy laws are coming globally which are very important and beneficial for the mining industries.

2. **Technical complexity**

   It might seem like IoT devices are performing simple tasks such as counting the entry swipes at a secure door , there's a lot of complex technologies involved in creating them. If they are providing important data to another workflow or system, then they could negatively affect everything which is connected to it.

3. **Requires regular electrification**

   Most of the devices depend on continuous power or internet connectivity to function properly. When either of them goes down then the device also goes down and anything which is connected to it. Nowadays these devices are very important and if they go down then a lot of things will halt.

4. **Integration**

   Currently there's no consensus regarding the protocols of industrial internet of things and their standards so the devices produced by the different manufacturers might work or not with the existing technologies. Each type requires a different type of configuration and hardware connection and makes it hard to deploy efficiently.

5. **Time consuming**

   Industrial internet of things is very time consuming; they need a lot of time investment and also money investment. There are a number of devices to be purchased and the staff also have to configure them and have to install all of them and other integrate them into a network and support calls to the manufacturer for help. If they all are going into the single location, businesses can make up that investment quickly.

Role of IIOT in Manufacturing Processes

Here are some ways the IoT helps streamline the production process:

1. It enables manufacturers to collect data from various machines and equipment in the factory, allowing them to identify trends and areas for improvement.
2. It offers critical metrics and allows monitoring of production status in real time. This enables easy replication of the production processes, automated auditing and timely resolution of production-related problems.
3. It connects machines and equipment wirelessly to the internet, which allows manufacturers to remotely monitor and control them, reducing downtime and increasing efficiency.
4. IoT-enabled machines can communicate with each other, allowing for a more coordinated and streamlined production process.
5. IoT can help manufacturers fix problems before they occur, reducing unplanned downtime and increasing productivity.

Predictive maintenance is a proactive approach that helps manufacturers avoid equipment failures and downtime. The IoT is increasingly important in predictive maintenance for manufacturing. Connecting devices and machines to the internet allows data to be collected and analyzed in real time to identify potential issues before they cause disruptions.

IoT-enabled predictive maintenance sensors can help improve the efficiency and safety of manufacturing operations and reduce the cost of poor quality (COPQ). These wireless predictive maintenance sensors calculate the vibrations of machines, surrounding temperature, acceleration, displacement and sound frequencies to detect if the machines operate under normal conditions.

Because these sensors can take precise temperature measurements, including extremely low and high temperatures, they are ideal for measuring the temperatures of industrial boilers, liquids and food storage units. This type of IoT-enabled sensor finds application in:

1. Vibration measurement of compressors, motors, robotic equipment, transport vehicles and conveyors.
2. Machine health monitoring.
3. Future fail detection.
4. By predicting downtime, IoT sensors enable manufacturers to take corrective action in time to prevent disruption in the manufacturing process.
5. In addition, wireless industrial sensors optimize safety by helping predict if a machine is about to explode or is reaching a dangerous working condition.

Optimizing Quality Control

Effective quality management involves monitoring a vast array of process and machine parameters influencing product quality. Many manufacturing facilities product quality and process reliability depend on optimal humidity, air quality and temperature control.

There are several reasons why humidity control is so important in manufacturing. High humidity can cause:

1. Material degradation.
2. Increased energy consumption.
3. Microbiological growth.
4. Inaccuracy of testing equipment.
5. Product drying issues.

In the past, quality assurance in manufacturing was a manual process that was often error-prone. With the advent of the IoT, manufacturers can now track quality parameters such as humidity, temperature, pressure and particulate matter with greater accuracy.
IoT sensors help collect data that can determine which products match quality standards and must be inspected more closely. This is especially important for manufacturers that meet quality standards such as ISO and GMP.

Facilitating Warehouse Management

Logistics is the management of materials, products and equipment. Because of changing demands, rising costs and increasing complexity, logistics has become one of the most critical elements in manufacturing today.

As a result, companies are investing millions of dollars in improving their capabilities. But these investments are not always successful because they often fail to anticipate or address their particular industry's unique challenges.

Overall, several areas stand out as the biggest challenges in logistics:

- Complexity: The sheer volume of products and services that need to be shipped can make it difficult to manage and control.
- Speed: The speed at which orders can be processed and delivered can also pose a problem. Increasingly complex production processes, growing supply chain complexity, and globalization translate to faster

delivery times, shorter lead times and shorter distance traveled by the carrier.

- Cost: As shipping costs continue to rise due to increased fuel prices, it becomes increasingly important for companies to minimize their transportation costs wherever possible.
- Capacity: Some of the biggest warehouse management challenges for the manufacturing industry are warehouse capacity, inefficient warehouse layout, managing inventory levels and tracking the movement of goods.

Use of IIOT in plant maintenance practices, Sustainability through Business excellence tools Challenges

Plant maintenance has often been a source of untimely, expensive and unplanned equipment downtime. Preventive maintenance, managed by a computerized maintenance management system, has been a much better alternative to reactive, "breakdown" maintenance, but has not always been the cure to failures and production downtime. A solution that's on the horizon, which promises to combat the high cost of plant maintenance, is predictive maintenance, a radically new form of maintenance that is enabled through implementation of the Industrial Internet of Things (IIoT) systems at manufacturing facilities.

From Preventive to Predictive Maintenance

There are many differences of opinion in the manufacturing industry with regard to the value of the Industrial Internet of Things. The on-going debate on the value of IIoT has frequently reduced the problem to corporate buy-in and capital investment, yet often overlooks its usefulness in the area of plant maintenance, which can amount to about 20% of operating expenses and between 4% to 7% percent of gross revenues for large organizations, according to the consulting firm Accenture. Without a doubt preventive maintenance has improved equipment life cycles and controlled the rising slope of capital costs. But the value of IIoT is multi-faceted; in the context of plant maintenance, it has the ability to take maintenance to a new level — well beyond a preventive style of regularly scheduled maintenance to an innovative, condition-based maintenance that is predictive in nature.

This move to predictive maintenance is expected to occur in the very near future as thousands of machine-based sensors feed data to industrial control systems in order to provide real-time information about both operational status and rule-based equipment conditions. Predictive maintenance is expected to significantly reduce unplanned downtime and eliminate many instances of catastrophic failures - those untimely accidents waiting to happen that kill productivity targets. But the promise of predictive maintenance can only be realized with the full scale adoption of the IIoT. Featuring more complex hardware and software as well as many I/O sensor networks, the IIoT poses a wholly new set of implementation challenges.

Reactive to predictive

Technology development is expanding the tools available to increase the effectiveness of maintenance to dramatically improved uptime and equipment availability. *Reactive maintenance,* which waits for machines and other equipment to break down and then fixes them, is a costly method, affecting production efficiency and manufacturing quality. This practice also has a big impact on increased life-cycle costs, often shortening the useful life of equipment.

Preventive maintenance based on calendar time improves equipment effectiveness. However, lacking a link between equipment use and wear, this method has not proven to be reliable, and it requires a significant commitment of labor resources. Much of the work and materials are overkill. Condition-based maintenance using real-time monitoring to constantly assess the condition of assets can dramatically improve availability and limit downtime. The big next step in maintenance is enabled by IoT technology and cloud computing. Companies identify and correlate patterns in variables that, taken as a whole, affect equipment performance to determine actions that can prevent failures. The application of predictive methods can significantly improve maintenance strategy and the ability to anticipate performance issues and mitigate them before they impact operations and cause unscheduled downtime.

Exploiting asset data

More and more intelligence is built into sensors on equipment every day. Automation systems linked to these intelligent sensors deliver insights into real-time performance data. With the application of Internet of Things technology, these terabytes of data turn into actionable information. The opportunity is for a much clearer fact-based understanding of asset performance and efficiencies to lower maintenance costs, improve production uptime (lower downtime), improve product quality, improve production yield, reduce unplanned downtime, and optimize maintenance labor resources. This data can also be used to justify replacement of existing equipment and verify performance of new production processes and recently installed equipment.

Newer and easier-to-use analytic modeling software is becoming available due to the demands of customers whose appetites are whetted by compelling results and who drive the need for more and more insight into their business operations. Analytic models are bringing high-hanging fruit in reach; maintenance and operational improvement directly affects the bottom line, and that is why large enterprises are so interested in leveraging these technologies.

Exploring potential worth

Data from automation and monitoring systems, leveraged with analytics, monitoring, and reporting, creates the basis for a real-time maintenance program. The potential impact of employing predictive maintenance is significant, as illustrated by a Nucleus Research analysis of potential improvements:

- Reduction of annual unplanned downtime: 60-90 percent
- Reduction of excess capacity required to compensate for unplanned downtime: up to 90 percent
- Scrap or rework reduction: up to 50 percent

- Asset life extension improving lifetime return on assets: 5-15 percent

Identify and prioritize needs

- A valuable analysis is to identify and prioritize your situation considering three factors relative to analytic use cases.
- Operational and organizational readiness: Are you ready, or do people need more information and training?
- Business and strategy alignment: Is this in line with your company's goals and objectives?
- Risk and return value: For your operations, what is the economic potential?

The Challenges of Implementing IIoT

Security, interoperability and connectivity are often cited as the three major obstacles to implementing IIoT. A lack of security for critical infrastructure is a risk to operational performance. A lack of standardized protocols for industrial networks can pose significant limitations on how to get gear from different vendors "talking" to one another. Since industrial processes operate in real time, the need for time sensitive, low latency and high reliability networks that connect massive wireless I/O to the controller is another important challenge that cannot be underestimated.

Beyond the considerations of data security, interoperability and connectivity is the I/O itself. One fact of life (and wireless sensor network maintenance) is that the life expectancy of sensors is uneven. As machine-level devices, IIoT sensors endure a significant amount of environmental exposure and stress that isn't experienced by data processing equipment housed or co-located in an environmentally controlled data center. And sensor networks used in the IIoT will be huge - 20,000 to 50,000 at large facilities.

The maintenance of such a large I/O would likely be unmanageable without making communication down to the sensor visible - a critical need for the success of the IIoT. This is why the IO-Link standard is so important to implementing the IIoT and achieving the holy grail of

Maintaining a Large I/O Demands Sensor Communication

Maintaining a large I/O starts with making communication down to the sensor visible. This is one of the goals behind the IO-Link International Standard (IEC 61131-9). What is IO-Link? In brief, it is the first I/O technology for communicating with sensors and actuators to be adopted as an international standard (IEC 61131-9). Technically speaking, it is a fieldbus and vendor-independent communication standard. Since IO-Link compliant devices can provide information about their status, they can be deployed to help reduce downtime because they can notify plant operators of faulty components in real time. As a result, the frequency of sudden failures can be drastically reduced.

IO-Link allows consistent communication between sensors/actuators and the controller by providing access to all process data, diagnostic data, and device information so corrective maintenance as well as the scheduling of preventive maintenance can be optimized. IO-Link can minimize the risks of catastrophic failures and reduce the efforts needed for troubleshooting equipment problems.

Omron's IO-Link compliant products can make sensor process and diagnostic data, as well as device information visible in order to help reduce maintenance downtimes, eliminate frequent and sudden failures, and improve the efficiency of production changeovers.

With IO-Link, the last yard between the sensor/actuator to the fieldbus or controller becomes communication-enabled. The parameters for the actuators and sensors can be stored in the controller and automatically transferred when the unit is replaced. It allows the detection of wiring cable disconnections and errors. IO-Link can also help improve system commissioning and changeover efficiency by checking identifications in batches. This is especially useful when I/O checks for any of the thousands of sensors installed on a production line must be performed.

IO Link Helps Realize the Promise of IIOT

The importance of the IIoT to the continued success of the manufacturing industry is no longer in the experimental arena. The majority

IIoT technology. But the broad scale adoption of IIoT and the benefits it promises to offer - from predictive maintenance to high productivity and ROI - will depend on the engineering of a coordinated set of solutions, of which, IO-Link compliant devices will play a key role at the sensor/actuator level.

Benefits in implementing IIOT

These are 8 of the biggest benefits of adopting a fully connected IIoT manufacturing operation.

Increased efficiency

The biggest benefit of IIoT is that it gives manufacturers the ability to automate, and therefore optimize their operating efficiency. Robotics and automated machinery can work more efficiently and accurately, boosting productivity and helping manufacturers streamline their functions. Additionally, physical machinery can be connected to software via sensors that monitor performance on a constant basis. This enables manufacturers to have better insights into the operational performance of individual pieces of equipment as well as entire fleets.

IIoT-enabled data systems empower manufacturers to improve operating efficiencies by:

- Bypassing manual tasks and functions and implementing automated, digital ones
- Making data-driven decisions regarding all manufacturing functions
- Monitoring performance from anywhere - on the manufacturing floor or from thousands of miles away

Shorter Time to Market

Greater operational efficiencies also allow for a faster and more efficient manufacturing process. Industrial IoT solutions enable direct communication from network components to employees, which:

- Enables faster decision-making in reaction to market fluctuations
- Provides greater insights into supply chain operation and improves response time to disruptions

• Identifies inefficiencies in the product cycle time, allowing for better optimization in different lines

Reduced Errors

Industrial IoT empowers manufacturers to digitize nearly every part of their business. By reducing manual process and entries, manufacturers are able to reduce the biggest risk associated with manual labor - human error.

This goes beyond just operational and manufacturing errors. IIoT solutions also can reduce the risk of cyber and data breaches caused by human error. According to the World Economic Forum's Global Risks Report, 95% of cybersecurity threats have been traced back to human error. AI and machine learning-enabled programs and machinery can do much of the required computing themselves, eliminating the potential for someone to make a simple mistake and put the manufacturer's data at risk.

Predictive Maintenance

Nothing negatively impacts a manufacturing operation more than machine downtime. Experts estimate that the average manufacturer experiences 800 hours of equipment downtime a year, which adds up to an industry-wide cost of $50 billion a year in unplanned expenses. What could be causing such drastic issues that manufacturers cannot operate? The answer is simple — lack of proper and predictive maintenance.

When maintenance in the manufacturing world is reactive rather than proactive, manufacturers are stuck trying to identify what the issue is, how it can be repaired, and what it will cost. With predictive maintenance powered by industrial IoT solutions, all of those issues are alleviated.

When machinery performance and function are monitored consistently, manufacturers can create a baseline. This baseline and the corresponding data empowers companies with the information they need to see any issue before it occurs. They can then schedule maintenance prior to downtime, which benefits them in that they:

- Have the parts required for the job
- Know the cost of the project beforehand, and can budget for it
- Move production to another area of the facility, so the product quotas are unaffected
- Ensure that machinery is operating at maximum efficiency

Improved Safety:

All of the data and sensors required of a fully functioning IIoT manufacturing operation are also helping to bolster workplace safety. "Smart manufacturing" is turning into "smart security" when all of the IIoT sensors work together to monitor workplace and employee safety.

Integrated safety systems are protecting workers on the floor, on the line, and in distribution. If an accident occurs, everyone in the facility can be alerted, operations can cease, and company leadership can intervene and make sure the accident and incident is resolved. This incident can also generate valuable data that can help prevent a repeat occurrence in the future.

A newer option some manufacturers are utilizing is the use of wearable technology among their employees. Wearables have been part of IoT since its infancy, and it are just now being utilized in industrial IoT operations.

Wearables help leadership keep tabs on things like employee posture and the surrounding noise levels, and they can then improve work conditions and potentially improve performance. They can also alert employees when they aren't following proper workplace safety procedures, so they can correct their actions and stay safe on the job.

Line Optimization

If the initial utilization of IIoT during Industry 4.0 was about individual machine optimization, today's Industry 5.0 is now more focused on optimizing the entire manufacturing process. IIoT solutions allow for the standardization of work output across an entire production line, making it easier to optimize operations across entire plants.

For example, say you have six plants, each with different capabilities and production lines. Industrial IoT provides the capability to look at the manufacturing process across each plant, allowing you to review factors like machine capabilities, current capacity, and overall availability. These insights make it easier to determine the most efficient place to make a specific product across all sites and how to enable operation efficiencies across different processes in multiple locations.

Digital Twins

Digital twins refer to exact virtual copies of physical objects made possible by IoT, AI, machine learning, and cloud computing. With virtual copies of equipment and spare parts, engineers and managers can simulate numerous processes, conduct experiments, discover issues, and achieve needed results without risking or damaging physical assets.

Digital twins also allow a look at the bigger picture across the entire production line while it's in operation, for a better review of efficiency and performance. Through digital recreations, you can take a deep dive into a representation of a single machines or step back for a larger view of the entire process. This enables you to see where any performance bottlenecks may be occurring. For example, if your feeder is slow, a review of digital representation of the production line could reveal an inefficiency with the packaging system.

Reduced Costs

Knowledge is power, and the knowledge provided to manufacturers via IIoT solutions is giving them the tools they need to reduce costs and generate more revenue. Data-driven insights into operations, production, marketing, sales, and more can steer businesses in a profitable direction.

All of the aforementioned benefits of IIoT - predictive maintenance, fewer errors, improved quality control, and maximized efficiencies - will all boost profits for a manufacturer. Industrial IoT also offers arguably the most valuable tool for leaders of a manufacturing

Remote monitoring of manufacturing operations is now possible 365 days a year, 24/7, from anywhere in the world. This 360-degree view into the entire manufacturing process, and the follow-up service provided to customers in their buying journey, is an invaluable asset. Company insights from anywhere anytime.

8. Assignments

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Collect the IOT devices used in Smart TV and explain the working principle of Smart TV

9. Part A Q & A

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1. What are the ways the IoT helps streamline the production process ?

Here are some ways the IoT helps streamline the production process:

1. It enables manufacturers to collect data from various machines and equipment in the factory, allowing them to identify trends and areas for improvement.
2. It offers critical metrics and allows monitoring of production status in real time. This enables easy replication of the production processes, automated auditing and timely resolution of production-related problems.
3. It connects machines and equipment wirelessly to the internet, which allows manufacturers to remotely monitor and control them, reducing downtime and increasing efficiency.
4. IoT-enabled machines can communicate with each other, allowing for a more coordinated and streamlined production process.
5. IoT can help manufacturers fix problems before they occur, reducing unplanned downtime and increasing productivity.

2. Define Predictive maintenance.

Predictive maintenance is a proactive approach that helps manufacturers avoid equipment failures and downtime. The IoT is increasingly important in predictive maintenance for manufacturing. Connecting devices and machines to the internet allows data to be collected and analyzed in real time to identify potential issues before they cause disruptions.

3. What is the effectiveness of predictive maintenance sensors ?

IoT-enabled predictive maintenance sensors can help improve the efficiency and safety of manufacturing operations and reduce the cost of poor quality (COPQ). These wireless predictive maintenance sensors calculate the vibrations of machines, surrounding temperature, acceleration, displacement and sound frequencies to detect if the machines operate under normal conditions. Because these sensors can take precise temperature measurements, including extremely low and high temperatures, they are ideal for measuring the temperatures of industrial boilers, liquids and food storage units.

4. Mention some applications of some IoT-enabled sensors.

This type of IoT-enabled sensor finds application in:

1. Vibration measurement of compressors, motors, robotic equipment, transport vehicles and conveyors.
2. Machine health monitoring.
3. Future fail detection.
4. By predicting downtime, IoT sensors enable manufacturers to take corrective action in time to prevent disruption in the manufacturing process.
5. In addition, wireless industrial sensors optimize safety by helping predict if a machine is about to explode or is reaching a dangerous working condition.

5. Short notes on asset tracking.

One of the key challenges of asset tracking in industries is the sheer volume of assets that need to be tracked. Additionally, given that assets are often moved around frequently, it can be difficult to keep track of them, leading to lost or damaged assets, which can be costly.

6. Short notes onOptimizing Quality Control

Optimizing quality management effectively involves monitoring a vast array of process and machine parameters influencing product quality. Many manufacturing facilities product quality and process reliability depend on optimal humidity, air quality and temperature control.

There are several reasons why humidity control is so important in manufacturing. High humidity can cause:

1. Material degradation.
2. Increased energy consumption.
3. Microbiological growth.
4. Inaccuracy of testing equipment.
5. Product drying issues.

8. Short notes on quality assurance

In the past, quality assurance in manufacturing was a manual process that was often error-prone. With the advent of the IoT, manufacturers can now track quality parameters such as humidity, temperature, pressure and particulate matter with greater accuracy.

IoT sensors help collect data that can determine which products match quality standards and must be inspected more closely. This is especially important for manufacturers that meet quality standards such as ISO and GMP

9. What is optimizing Quality Control ?

Optimize quality management involves monitoring a vast array of process and machine parameters influencing product quality. Many manufacturing facilities product quality and process reliability depend on optimal humidity, air quality and temperature control.

10. Why should there be effective quality management ? Effective quality management involves monitoring a vast array of process and machine parameters influencing product quality. Many manufacturing facilities product quality and process reliability depend on optimal humidity, air quality and temperature control

11. Why is humidity control so important in manufacturing?

There are several reasons why humidity control is so important in manufacturing. High

12. **Short note on quality quality assurance.**

In the past, quality assurance in manufacturing was a manual process that was often error-prone. With the advent of the IoT, manufacturers can now track quality parameters such as humidity, temperature, pressure and particulate matter with greater accuracy.

IoT sensors help collect data that can determine which products match quality standards and must be inspected more closely. This is especially important for manufacturers that meet quality standards such as ISO and GMP

13. Facilitating Warehouse Management

Logistics is the management of materials, products and equipment. Because of changing demands, rising costs and increasing complexity, logistics has become one of the most critical elements in manufacturing today.

As a result, companies are investing millions of dollars in improving their capabilities. But these investments are not always successful because they often fail to anticipate or address their particular industry's unique challenges.

14. What are the challenges faced in logistics?

1. **Complexity:** The sheer volume of products and services that need to be shipped can make it difficult to manage and control.
2. **Speed:** The speed at which orders can be processed and delivered can also pose a problem. Increasingly complex production processes, growing supply chain complexity, and globalization translate to faster delivery times, shorter lead times and shorter distance traveled by the carrier.
3. **Cost:** As shipping costs continue to rise due to increased fuel prices, it becomes increasingly important for companies to minimize their transportation costs wherever possible
4. **Capacity:** Some of the biggest warehouse management challenges for the manufacturing industry are warehouse capacity, inefficient warehouse layout, managing inventory levels and tracking the movement of goods.

15.List the skills needed by a Test specialist(CO4,K2)

- ✔ Organizational and planning skills
- ✔ The ability to keep track of and pay attention to details
- ✔ The determination to discover and solve problems
- ✔ The ability to mentor and train others
- ✔ The ability to work with users and clients
- ✔ The ability to think creatively

16.What are the steps in forming the test group?(CO4,K2)

- ✔ Upper management support for test function
- ✔ Establish test group organization, career paths
- ✔ Define education and skill levels
- ✔ Develop job description
- ✔ Interview candidates
- ✔ Select Test group members

17.Explain the Test team hierarchy.(CO4,K2)

- ✔ The Test Manager
- ✔ The Test Lead
- ✔ The Test Engineer
- ✔ The Junior Test Engineer

18.What is the use of V-model in testing?(CO4,K2)

The V-model is model that illustrates how testing activities can be integrated in to each phase of the standard software life cycle.

19.What are the various approaches to test cost estimation.(CO5,K2)

- ✔ COCOMO Model
- ✔ Use of test cost drivers
- ✔ Test Tasks
- ✔ Testers / Developers ratio
- ✔ Expert judgment.

20.What is the role of a Test Manager in a Test group?(CO5,K2)

The test manager is usually responsible for, test policy making, customer interaction, test planning, test documentation, controlling and monitoring of tests, training, test tool acquisition, participation in inspections and walkthroughs, reviewing test work, the test repository, and staffing issues such as hiring, firing, and evaluation of the test team members.

21.What is the role of a Test Lead in a Test group?(CO5,K2)

The test lead assists the test manager and works with a team of test engineers on individual projects. He or she may be responsible for duties such as,(i) test planning, (ii) staff supervision, (iii) status reporting. The test lead also participates in test design, test execution and reporting, technical reviews, customer interaction, and tool training.

22.What is the role of a Test Engineer in a Test group?(CO5,K2)

The test engineers design, develop, and execute tests, develop test harnesses, and set up test laboratories and environments. They also give input to test planning and support maintenance of the test and defect repositories.

23.What is the role of a Junior Test Engineer in a Test gro up?(CO5,K2)

The junior test engineers are usually new hires. They gain experience by participating in test design, test execution, and test harness development. They may also be asked to review user manuals and user help facilities defect and maintain the test and defect repositories.

24.What is a Test Incident Report?(CO6,K2)

The tester should record in a test incident report (sometimes called a problem report) any event that occurs during the execution of the tests that is unexpected, unexplainable, and that requires a follow-up investigation.

25.What is a Test Log?(CO6,K2)

The test log is prepared by the person executing the test. It is a diary of the events that take place during the test.

10. Part B Questions

10. PART-B (QUESTIONS)

1. Why is testing planning so important for developing a repeatable and managed testing process?(CO4,K2)
2. What role do managers play in support of a test group? (CO4,K2)
3. Discuss in detail about the test specialist skills. (CO4,K2)
4. Discuss in detail about the test plan components. (CO5,K2)
5. Describe with example test people management. How will you build a testing group, discuss with an example. (CO5,K2)
6. Develop the challenges and issues faced in testing service organization, also write how we can eliminate challenges. (CO4,K2)
7. Briefly explain about Organization Structure for testing teams. (CO4,K2)
8. Describe the role of IIOT in Manufacturing Processes. (CO5,K2)
9. Explain uses of IIOT in plant maintenance practices, Sustainability through Business excellence tools Challenges. (CO5,K2)
10. Narrate the benefits in implementing IIOT. (CO4,K2)

11. Activity based learning

11. Activity based learning

All the students where asked to prepare one question with pictures as clue for answers.

A quiz was conducted by asking the students to share their questions.

Link for activity based learning

https://www.javatpoint.com/software-testing-mcq

- **https://www.softwaretestinghelp.com/some-interesting-software-testing-interview-questions/**

- **Quiz Links:**
- https://www.proprofs.com/quiz-school/topic/software-testing
- https://skillvalue.com/en/quiz/testing/
- https://www.softwaretestinggenius.com/software-testing-quiz-part-1-and-2/

- Video Quiz
- https://www.youtube.com/watch?v=C9jXtP-vnzI
- https://www.youtube.com/watch?v=jpnTaCgieJY

12. Supportive online Certification courses

12. Supportive online Certification courses

1. NPTEL: SOFTWARE TESTING

   https://nptel.ac.in/courses/106/105/106105150/

2. https://www.udemy.com/course/software-testing-qa-fundamentals-and-manual-testing-concept/

3. https://www.udemy.com/course/software-testing-and-career-in-qa/

4. https://www.udemy.com/course/software-manualtesting/

5. https://www.udemy.com/course/test-case/

6. https://www.udemy.com/course/testerbootcamp/

7. https://www.udemy.com/course/software-testing-masterclass-from-novice-to-expert/

8. https://www.coursera.org/specializations/software-testing-automation

9. https://www.coursera.org/learn/introduction-software-testing

10. https://www.coursera.org/learn/ruanjian-ceshi

11. https://www.coursera.org/learn/black-box-white-box-testing

13. Real time Applications in day to day life and to Industry

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- **IBM ENGINEERING TEST MANAGEMENT**

❖ Increase efficiency and quality of software delivery with test planning, workflow control, tracking, and metrics reporting.

❖ Available on prem and as SaaS.

❖ Use comprehensive test plans Use test plans that are customizable live artifacts which capture a variety of testing activity dimensions.

❖ Meet regulatory requirements Provides help to meet regulatory requirements and get ready for compliance audits.

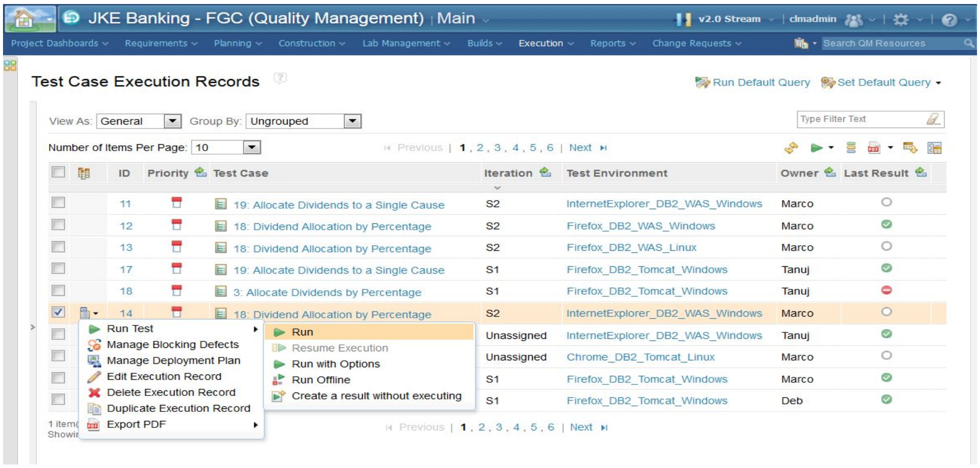
❖ Get reporting with a purpose Always have an accurate real-time status without having to ping each and every team member.

❖ Run test scripts quickly Accelerate manual testing using rich text, in-line images and assisted data entry and validation for precise test definition and execution.

❖ Accelerate time to value Use the cloud to get up and running faster and focus on technological innovation.

❖ Better manage your machines Whether it is a test lab or virtual machines, track all your lab resources in one place.

❖ Make sure that the required resources to execute your test plan are available.



14. Contents beyond the Syllabus

14. Contents beyond the Syllabus

- **Test Management Tools: Jira**

- Test organization and efficient management are indispensable to the overall quality of your product or release. To match the faster release velocity and high volume of production required in the era of digital transformation, everything from the processes, to resources and testing tools need to be Agile.

- Many businesses using Jira to organize and manage projects and tasks within the organization can leverage test management tools that are integrated with Jira for efficiency and user-friendliness. A few reasons why you should consider using tools inside Jira for test management Easier and faster user on-boarding, No need for new infrastructure ,Agile teams are able to include test cases within sprint ,Multi-location teams and interdisciplinary teams can leverage the existing Jira ecosystem,Extends the functionalities of Jira to cover test management

- **QMetry Test Management for Jira**: Designed for DevOps and Agile teams, QMetry Test Management for Jira is a complete test management solution aimed at bringing quality with speed to the testing lifecycle. It is a feature-rich tool with capabilities that include: Complete Test Management ,Authoring, cloning, linking, versioning and reusability within Jira. Test Cycles for Execution, Create Test Runs, carry out bulk updates, link bugs, attach screenshots and view automation test results in test runs with exceptions, clone test runs. Record test executions faster and smartly with cycles. Test Plan ,Enable QA teams to plan and track releases with QMetry Test Plan, link multiple test cycles inside a test plan. Reporting, Make critical quality decisions using Coverage Analytics, Test Run Report and Traceability Reports, customize reports with dashboard gadgets across projects and teams. Integration and Automation, Supports major automation frameworks like Cucumber, Junit, SpecFlow, QAF, UFT, TestNG, etc.; integration for CI/CD tools like Jenkins and Bamboo using free APIs

- **Using Jira for Test case management-How to Create Test Case in Jira**

  https://www.youtube.com/watch?v=kdyfYfu3Wyk

15. Assessment Schedule

15. Assessment Schedule

- FIRST INTERNAL ASSESSMENT TEST

  SCHEDULED ON 24/09/23

- SECOND INTERNAL ASSESSMENT TEST

  SCHEDULED ON 28/10/23

16. Prescribed Text Books & Reference Books

Prescribed Text Books & Reference Books

•TEXT BOOKS:

•1. Srinivasan Desikan and Gopalaswamy Ramesh, ―Software Testing – Principles and Practices‖, Pearson Education, 2006.

•2. Ron Patton, ―Software Testing‖, Second Edition, Sams Publishing, Pearson Education, 2007.

•REFERENCES:

•1. Ilene Burnstein, ―Practical Software Testing‖, Springer International Edition, 2003.

• 2. Edward Kit,‖ Software Testing in the Real World – Improving the Process‖, Pearson Education, 1995.

•3. Boris Beizer,‖ Software Testing Techniques‖ – 2nd Edition, Van Nostrand Reinhold, New York, 1990.

•4. Aditya P. Mathur, ―Foundations of Software Testing _ Fundamental Algorithms and Techniques‖, Dorling Kindersley (India) Pvt. Ltd., Pearson Education, 2008.

E-book reference

•TEXT BOOKS:

•1. Srinivasan Desikan and Gopalaswamy Ramesh, ―Software Testing – Principles and Practices‖, Pearson Education, 2006.

https://drive.google.com/file/d/1i92MFNqIVnHqgcAq79CQzJQAdEhfv-49/view?usp=sharing

•REFERENCES:

•1. Ilene Burnstein, ―Practical Software Testing‖, Springer International Edition, 2003.

https://drive.google.com/file/d/1MAQS8w6kV4nCIg1UkFpyG7KHL40vnFu4/view?usp=sharing

17. Mini Project suggestions

17. Mini Project suggestions

1. Suppose you are working for a very large software development organization. Your company is often involved in developing very large and complex mission critical software for customers affiliated with the defense industry.

- Suggest approaches to organize a test group for your company, keeping in mind the size of the company and the type of software developed.
- Give reasons for your choice.

2. JUnit (A programmer-oriented testing framework for Java)

- Explore this framework and submit a report about it how exactly its help to achieve various testing options.

3. You have completed a project and the live date is next day, you got one big problem but that problem can't be resolved in short time and the estimate is 30 days. What are your options ..?

4. You have tested the application and it is released. The user asks for some changes in the project and gives one week time to complete it. Out of the one week, 6 days is taken by the developer to make the changes. So you have only one day to test it. What will you do in the case in case of manual testing?

5. 5. If there is game which has 20 levels an expert can only play the game upto 20 levels if i am as a normal person or tester can play the game upto 12th level then how i will test the game upto 20th level. Please guide me.

6. What is the difference between testing a product and testing any web -based application?

Thank you

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