IIT KHARAGPUR

NPTEL ONLINE CERTIFICATION COURSES

IIoT Applications: Healthcare

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Introduction

- Earlier so many people died due to lack of health care.
- People forget about their health due to busy life.
- IIoT makes the healthcare easier.
- IIoT based healthcare service is cheapest.
- ECG, blood pressure, glucose level, and temperature can be monitored from patient's home.
- If any critical conditions are there, it sends alert.

Healthcare Challenges

- Populations are ageing all over the world
- Different diseases are increasing
- Expenditure of hospitals and medical clinic are increasing

Largest Age Group

- Populations are growing older
  - Between 2017 to 2050, person's aged 60 years or over is expected to increase more than double.
  - In 1980, there were 382 million older person all over the world.
  - In 2050, it is expected to be 2.1 billion older person worldwide.

- Telecare applications, smart home or telemedicine helps older people to live safely.

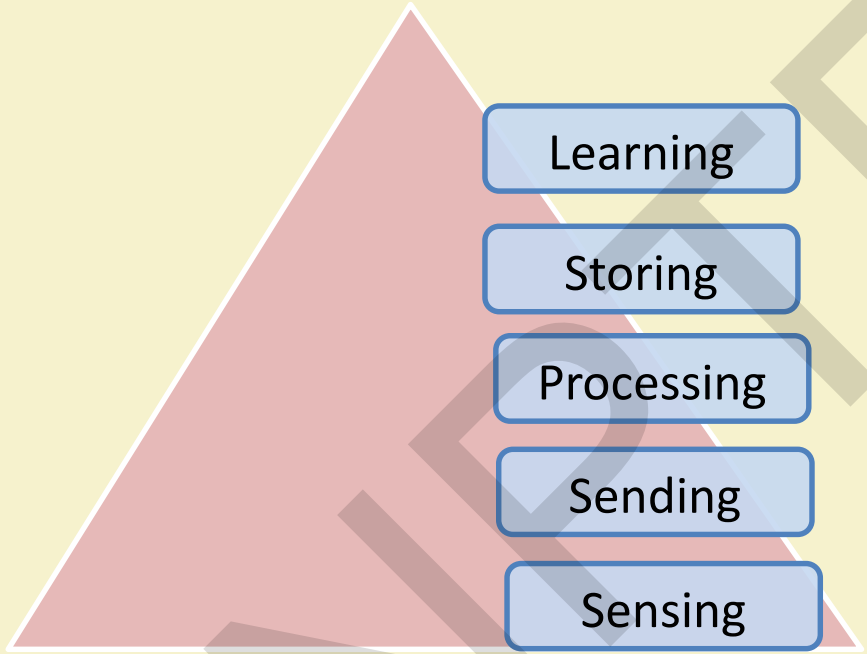
Increase of Diseases

- Different diseases are increasing.
- Telecare applications, smart home or telemedicine helps older people to live safely.
- Continuous monitoring of patient's health reduces hospitalizing.
- Sensors collects blood pressure, respiration, pulse rate, heart rate, and weight. It triggers alarm, if any abnormal situation is there

Reduce the Expenditure

- IIoT based healthcare device
  - Different wearable healthcare devices which reduce the cost of checkup.
- Remote monitoring
  - Patient's health condition can be monitored by sensors, which reduce the cost.
- In hospitals, smart beds can send notification about patient's activity.

IIoT Healthcare Architecture



Source: Nguyen et. all, "A Review on IoT Healthcare Monitoring Applications and a Vision for Transforming Sensor Data into Real-time Clinical Feedback", in Proc. 21st Comp. Supported Cooperative Work in Design, IEEE, 2017

Benefits of IIoT in Healthcare

- Monitor patient's health condition remotely.
- Hospital staff can predict the arrival of a patient in PACU.
- Hygiene monitoring system can detect the cleanliness of hand.
- Medical staff can provide quality medical service with small budget using IIoT.

IIoT Based Electrocardiogram Monitor

- Wireless ECG monitor.
- Bio signals are collected by ECG sensors.
- The collected data are sent to the cloud.
- Medical staffs can analyze the health related data in real time.
- QardioCore is an example of wireless ECG monitoring device.

IIoT Based Glucose Level Monitor

- Diabetes is metabolic disease, glucose level is high.
- Monitoring the glucose level helps meal planning, physical activity, medication.
- Glucose sensor devices are used to check the glucose level.
- It notifies the doctors and patients if any abnormal situation occur.
- Dexcom develops continuous glucose monitoring devices.

IIoT Based Blood Pressure Monitor

- Using IIoT device, the patient's blood pressure is measured and compared with the other blood pressure.
- Doctors can monitor patient's blood pressure in real time.
- Medicines can be prescribed based on this.
- iHealth BP5 is IoT based blood monitoring system.

IIoT Based Body Temperature Monitor

- Wearable sensor to continuous monitoring human body temperature
- It measures skin temperature
- The WBAN is used to connect to gateway
- Kinsa smart thermometer is IoT based body temperature monitoring devices

IIoT Based Oxygen Saturation Monitor

- Oxygen saturation= ratio of oxyhemoglobin to total hemoglobin
- Pulse Oximetry measures the oxygen saturation.
- IoT is integrated with Pulse Oximetry.
- Bluetooth is used for connectivity.
- Low cost device to remotely monitor patient's health.

IIoT Based Contact Lenses

- The IIoT based smart contact lense support WiFi signal, conneted with smart phone.
- It consists of micro camera, sensors.
- Sugar level can be measured by tears. Smart contact lenses can monitor the sugar level.
- It can monitors human health conditions.
- It can detect various diseases, if any abnormal situation is found.

IIoT Based Asthma Treatment

- Asthma is lifelong disease, can be controlled, not cured.
- Inhaler is commonly used to give proper dose of drugs.
- Smart Inhaler can keep track via GPS.
- ADAMM Intelligent Asthma Monitoring device.
- Wearable device, connected with Bluetooth or WiFi.
- From the body temperature, cough rate, heart rate, it predicts pre symptoms of asthma attack.

Smartphone :Healthcare Solution

- Electronic devices consist of sensors, which are supported by smartphone
- Smartphone is used to monitor the health of user and detect diseases.
- Smartphone's healthcare app provides low cost healthcare service.
  - Diagnostic apps detect patient's health condition.
  - Medical communication apps connect patients with hospitals.
  - Medical education apps provide tutorials.

Smartphone Based Healthcare App

- Health Assistant: Keeps track of health condition
- Google Fit: Keeps track of different physical activity
- ECG Self Monitoring: Serves as ECG device, based on "ECG Self Check" software.
- Instant Heart Rate: Measures heart rate using smartphone's camera
- Fingerprint Thermometer: Determine body temperature from the fingureprint

IIoT Healthcare Technology

- Cloud computing: Provide facilities to shared resources.
- Big data: Includes heath data generated from sensor nodes.
- Networks: WBAN, 6LoWPAN, WSN are part of IIoT based healthcare.
- Ambient intelligence: It involves continuous learning and analyze based on the learning.

IIoT Healthcare Security Requirement

- Confidentiality: It ensures medical data is not accessible by unauthorized users.
- Integrity: It ensures medical data is not altered by any third party.
- Authentication: It ensures the identity from which the data is coming.
- Availability: It ensures the accessibility of data to valid users

IoT Healthcare Challenges

- Less computational capability, not able to perform expensive operations.
- Less on device memory.
- Energy limitation, sensor has low power battery.
- Not static, mobile devices. Designing mobile enabled algorithms are challenge.
- Designing scalable algorithm without compromising security is challenge.

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IIoT Applications: Power Plants

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Introduction

- Data collected from IIoT enabled devices increase productivity and efficiency.
- Using IIoT, the equipment can be monitored remotely.
- Sensors collect data and sends to cloud.
- Different machine learning and artificial intelligence based algorithms are used to analyze the data.

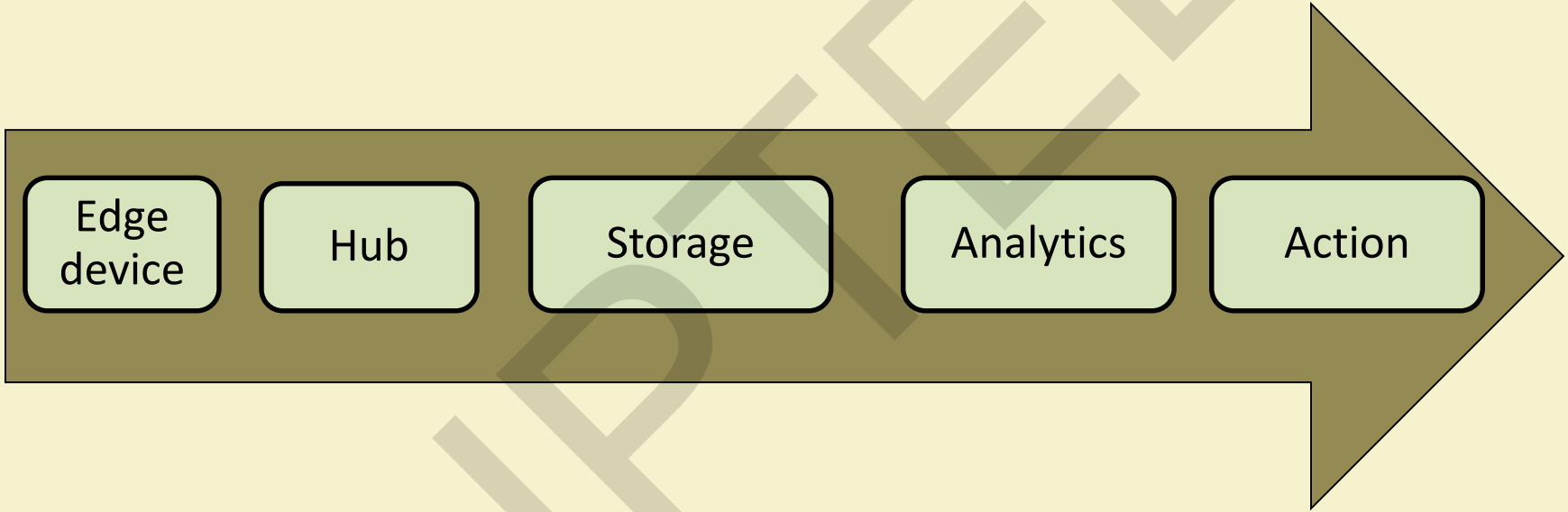
Drivers of IIoT in Power Plant

- Low cost powerful chips
  - WiFi chip, cameras, sensors, accelerometers are used.
- Standardization with IPV6
  - 3G, 4G, 5G networks are used, the devices are standardized with TCP/IP and IPV6 protocol.
- Standardization with software technology
  - Use of artificial intelligence algorithms, and cloud computing software makes it easier.

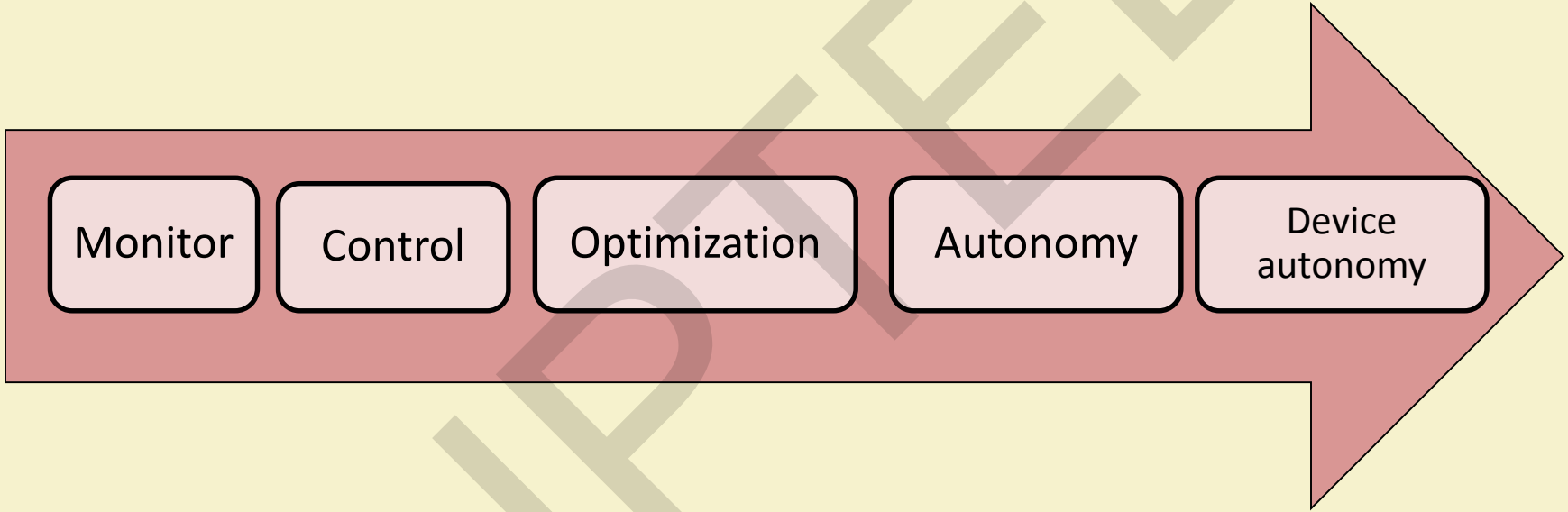
Digital Power Plant Benefits

- Increase efficiency
  - Smart grid- automated devices increases efficiency and reduces manpower.
- Reduce cost
  - Automated devices- no need of money for manpower, fuel, maintenance.
- Improves performance
  - Turbine's performance improvement, remote monitoring.
- Reduce energy demands
  - Helps users to learn how to use energy in real time.

Architecture



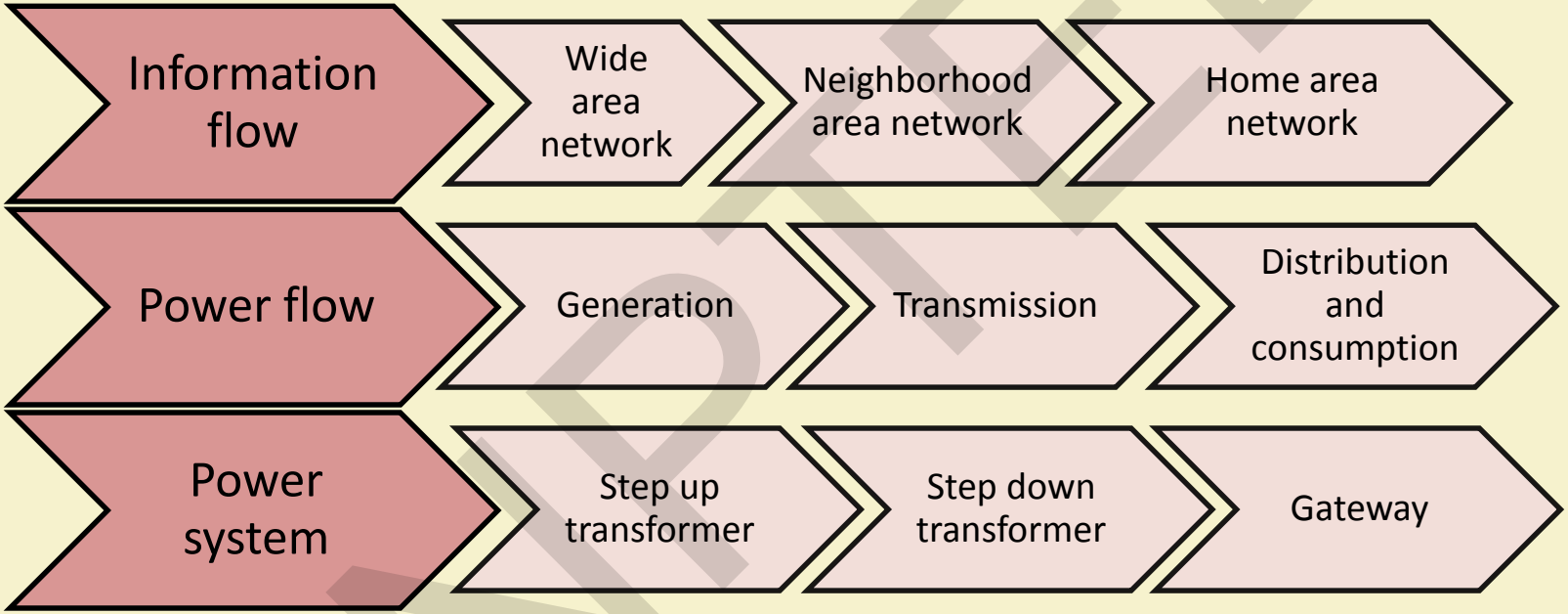
IIoT Maturity Model



Communication Network

- Home area network
  - Covers in-home IoT devices. Wireless: Zigbee, 6LowPan
- Neighborhood area network
  - Distribution domain networks. Data collected from smart devices and sent to gateways.
- Field area network
  - Distribution domain networks. It includes controller, regulators, and data collector. Wireless: WiMAX, 3G, 4G. Wired: Eathernet.
- Wide area network

Smart Grid in Power System



IIoT in Power Plants Applications

- Digital twins
  - Considered as virtual power plant, reduce fuel and energy consumption by incorporating data.
- Supply chain management
  - Sensors monitor product condition and optimize delivery time.
- Smart pumping
  - Combined with sensors and software. Automated flow control.

IIoT in Power Plants Applications

- Smart boiler
  - Customer can control it by mobile application
  - Energy efficient usage
  - Automatically reports if any defects are there
- Smart water monitoring
  - Detect flow of water and volume of water of a pipe in a time period.
  - Sends data to cloud storage.
  - Saves wastage of water.

IIoT in Power Plants Applications

- Smart metering
  - Important element of smart grid
  - IoT reduces operational costs as operations are remotely managed.
  - Reduces the chance of energy loss.
- Building automation
  - Monitors the building remotely.
  - Elevators, lighting systems, and other electronic systems are connected through internet.

Supervisory Control And Data Acquisition (SCDA)

- Software and hardware allows organization to process locally or remotely.
- Sensors gather real time data.
- Programmable logic controller or remote terminal units communicate with different objects and route the data to SCDA software.
- SCDA software processes the data. Then users analyze the data to make decision.

Advanced Metering Infrastructure(AMI)

- It comprises whole infrastructure- smart meters, communication networks.
- Smart meters: collect information about energy, water etc. Transmits the data to network.
- Communication network: Broadband over PowerLine, Fixed radio frequency are used.
- Meter data acquisition system: gathers data from smart meters
- Meter data management system: analyze the data.

IIoT in Electricity Sector

- Efficient power grid system
  - Collect data from sensors
  - Use the data to manage resources
  - Optimization, stakeholders take decision about power usage.

- Data collected from sensors can easily predict if any failure in grid.
- Predict earlier if any accident is going to happen.

IIoT in Water Sector

- Saves water using smart sensors.
- IoT sensors track water pressure, water quality etc.
- The gathered data is sent to utility company to analyze the data.
- It gives public useful information about how to stop wastage of water.
- It also predicts the water leakage.

IIoT in Wind Energy Sector

- In wind energy sector, large turbines are used. The factories also locate at remote location, It is hard to maintain.
- With IoT, the local control system can adjust switches and software.
- The remote location of farm is not an issue with IoT.
- IoT can predict any issues of turbines easily and it can be addressed earlier before any large scale damage.

IIoT in Solar Energy Sector

- In IoT based solar energy sector, sensors monitor their performances from the control panel.
- The gathered data is sent to cloud server to analyze.
- IoT helps to understand the problem of device whether it is hardware related problem or network related problem.
- IoT helps to detect any problem in real time.
- IoT can manage the largest solar grid.

Challenges of IIoT in Power Plant

- Security issues
  - Privacy issues, chances of denial of service attack.
- Low power devices
  - IoT devices are resource constrained devices, battery powered devices.
- Scalability issues
  - Number of devices are increasing, Increase of data bandwidth.

Challenges of IIoT in Power Plant

- Determinism of network
  - Using cloud makes the process delay about 200 msec or more.
- Poorly designed
  - Most of the devices are poorly designed as different protocols are used.
  - It lacks of standard authentication for the edge devices.

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Thank You!!

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IIoT Applications: Inventory Management & Quality Control

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Inventory Management

- Inventory

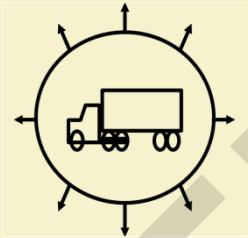
  "a usable but idle resource having some economic value"

  [P. Vrat, Materials Management]

- Inventory Management
  - Activities entailing management of inventory such as:
    - Controlling, overseeing and ordering
    - Storage
    - Determine supply for sale

Supply Chain and Inventory Management

Raw Material



Distribution

Retail

Supplier

Factory

Customer

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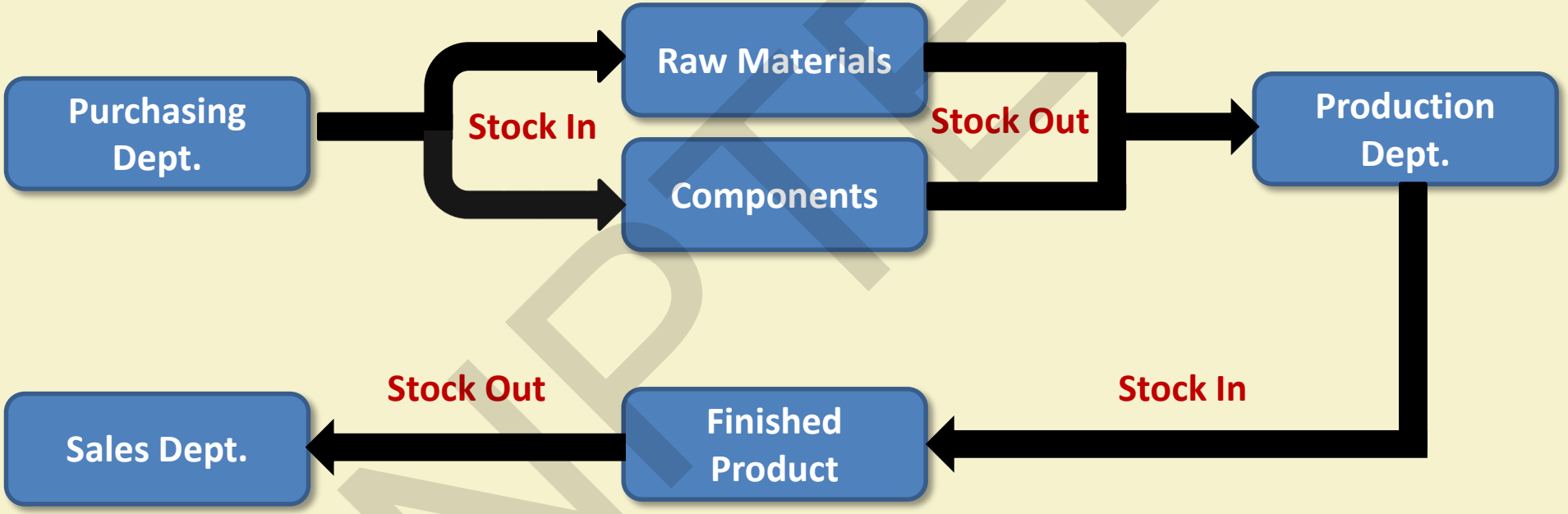
Inventory Management and IIoT



Functions of Inventory Management

- Meet anticipated demand
- Smoothen the production requirement procedure
- Decouple components of the production-distribution system
- Protection against stock outs
- Proper order cycles
- Hedge against price increases or to take advantage of quantity discounts
- Smoothen the flow of operations

Requirements for Effective Inventory Management

- Keep track of the inventory
- Forecast of demand
- Manage lead times and lead time variability
- Estimate inventory holding costs, ordering costs, and shortage costs
- Classification of inventories

Quality Control

- *"system of routine technical activities, to measure and control the quality of the inventory as it is being developed"*

  [IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories]
- Internally maintained by the management to provide product satisfaction to the customers

Objectives:

- Routine and consistent checks
- Ensure data integrity, correctness, and completeness
- Rectify errors and omissions
- Document and archive inventory material and record all QC activities

Radio Frequency Identification Devices (RFID) tags

- Used in an identification system
- Uses Radio waves for communication
- RFID Tagging system consists of:
  - The RFID tag
  - Read/write device
  - Host System
- Two types:
  - Active RFID tags
  - Passive RFID tags
- Finds scope in data collection, processing, and transmission applications

https://c1.staticflickr.com/4/3856/14891130616_d155bbf0cd_b.jpgt

Passive RFID Tags

- No internal power source
- Relies on ***backscattering***
- Wait for a signal from an RFID reader
- Powered by electromagnetic energy from this signal
- Have shorter range than Active RFID tags
- Small in size and thickness

Active RFID Tags

- Battery powered
- Broadcasts information signal in the form of a ***beacons***
- Have longer range and memory than passive RFID tags
- Bulky and expensive as compared to passive RFID tags

Semi-Passive tags

- Has an onboard battery to power the IC
- But no active transmitter
- Relies on ***backscattering***
- Does not depend on signals from reader for power
- Does not create additional noise

RFID tags over Barcodes

- Barcodes are printed on paper and plastic which makes them vulnerable
- Barcodes need to be on Line of Sight of the readers
- Only one barcode can be read at a time
- Barcodes have less security and hence can be forged
- Barcodes cannot contain any added information

Applications

- Identification of products
- Added information along with ID
- Comprehensive visibility
- Built in GPS
- Warehouse management

Applications (contd.)

- Added information along with ID:
  - Current storage temperature
  - Weather condition
  - Damage (if any)
  - etc

Applications (contd.)

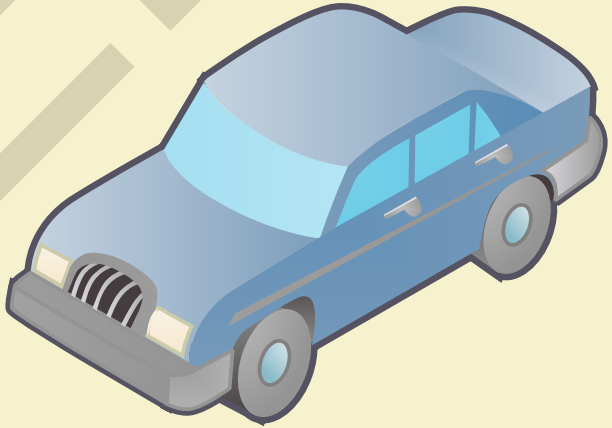
- Comprehensive Visibility
  - Inventory levels
  - Expiration dates
  - Item location
  - Forecast demand
  - etc

Applications (contd.)

- Warehouse management
  - Shrink, Shortage, Overstock of commodities
  - Identification of efficient areas based on demand

Applications (contd.)

- Similarly in transportation modes
  - Track time and place of congestion
  - Compute delay and alternate routes
  - Commute with efficient time and mode



Problems that can be eliminated

- Data inconsistency
- Staff training expenses
- Human errors
- Data scattering
- Lapse in security
- Slow operation
- Other hidden costs

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IIoT Applications: Plant Security and Safety

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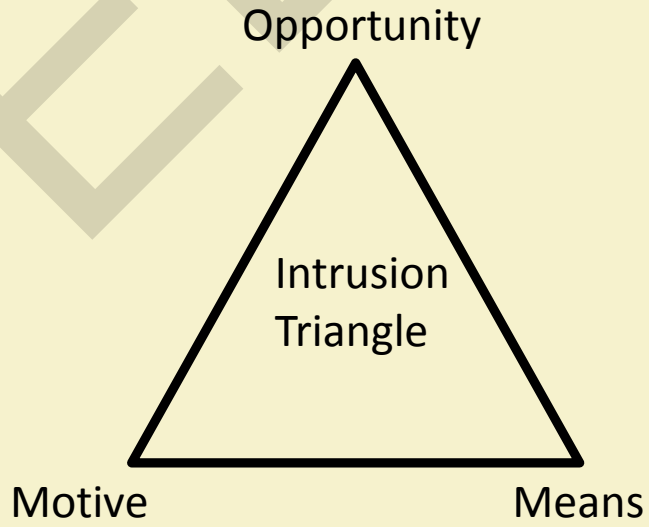
Plant Security and Safety

"freedom from risk or danger; safety"

[The American Heritage Dictionary]

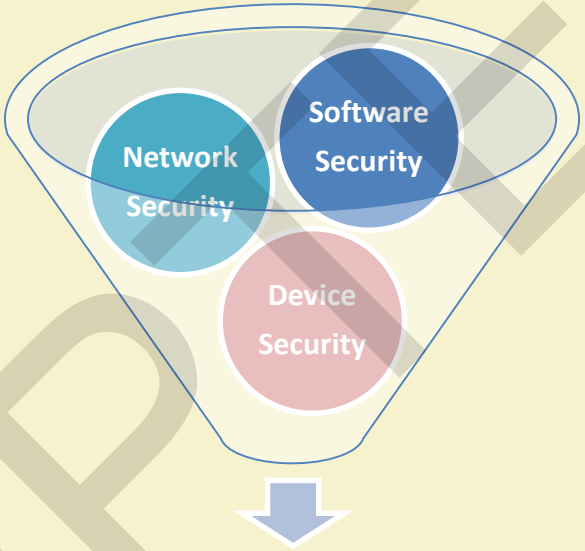


Plant Safety

- Health and well being of the industry as a whole
- Hazards in a plant are catastrophic
- Aim: Protection of human and plant resources

https://pixabay.com/en/helmet-engineer-hard-hat-hardhat-35053/

Plant Security and Safety



Plant Security and Safety

Need for Software Security

- Steal valuable information
- Unauthorized monitoring of sensitive content
- Corrupt behavior of software
- Denial of Service (DoS) attacks
- Overflows, Overrides and Overwrites
- Padding

Software Security

Integrity

- Assurance of an uncorrupted data
- Correct functioning even under malicious attack
- Maintain consistency, accuracy, and trustworthiness of data over its entire life cycle
- Assurance that data is not altered by unauthorized people

Authentication

- Identification of user
- Verification of credentials entered (local or remote)
- Access control based on these credentials
- Protection of resources

Availability

- Ratio of time of functioning to the total time
- Extent to which the software continues functioning when a component or set of components fail
- Strong relation between availability and reliability

Requirements

- Good programming techniques
- Install good firewalls
- Detect intrusions
- Good preventive measures

Network Security

- Maintain usability and integrity of network and data
- Management of access to the network
- Both hardware and software
- Protection against variety of threats

Types of Network Security

- Access control
  - Provide access based on user identity
- Antivirus and antimalware software
  - Scan for malware detection and prevention
- Application security
  - Protection of software after creation

Types of Network Security (contd.)

- Behavioral analytics
  - Detection of abnormal behavior by the network
- Data loss prevention
  - Prevention of unauthorized sharing of sensitive data
- Email security
  - Protection against phishing attacks

Types of Network Security (contd.)

- Firewalls
  - Barrier between trusted internal network and the external networks
- Intrusion prevention systems
  - Detection and blocking attacks
- Mobile device security
  - Device level security

Types of Network Security (contd.)

- Network segmentation
  - Divide the network into smaller parts and enforce security policies explicitly
- Security information and event management
  - Gather information for security staff to identify and respond to threats
- Virtual Private Network (VPN)
  - Encrypt connection from an endpoint to a network

Device Security

- Protection of sensitive information stored on and transmitted by portable devices
- Portable devices:
  - Smart phones
  - Tablets
  - Laptops
  - Other mobile devices

Components

- Endpoint security
  - Monitoring of mobile devices (files and processes) that access a network
- Virtual Private Network (VPN)
  - Encrypt connection from a mobile device to a network
- Secure web gateway
  - Identification of an attack on one location and prevention of the same at other locations (integration of security with the cloud)

Components (contd.)

- Email security
  - Protection against phishing attacks
- Cloud access security broker
  - Securing the tasks being performed on the cloud

Virtual Reality (VR)

- Computer generated interactive environment
- Transpose the user
- Isolate the user from the current world
- Example: Oculus Rift, Samsung Gear VR, Google Cardboard

Augmented Reality (AR)

- Enhanced reality (adds a digital layer over the real world)
- Does not isolate the user to a different world
- Can add details to things a user tries to examine (can be used by retailers to sell their products)
- Examples:
  - Bus stop prank by Pepsi Max
  - Pokémon Go

Risks (AR/VR)

- Prone to attacks by hackers
- Compromised content on the screen
- Intellectual Property (IP) rights
- Privacy and Security issues
- Risks pertaining to user's health

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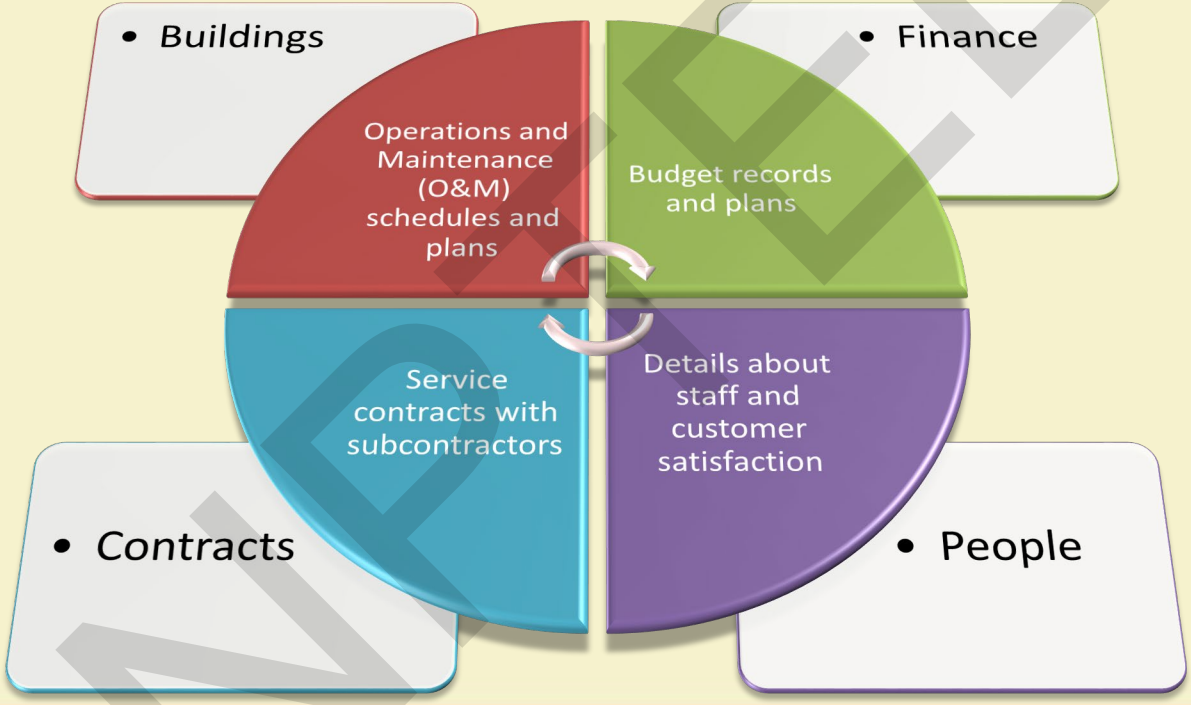
Facility Management

"guiding and managing the operations and maintenance of buildings, precincts and community infrastructure on behalf of property owners"

[Facilities Management Good Practice Guide]

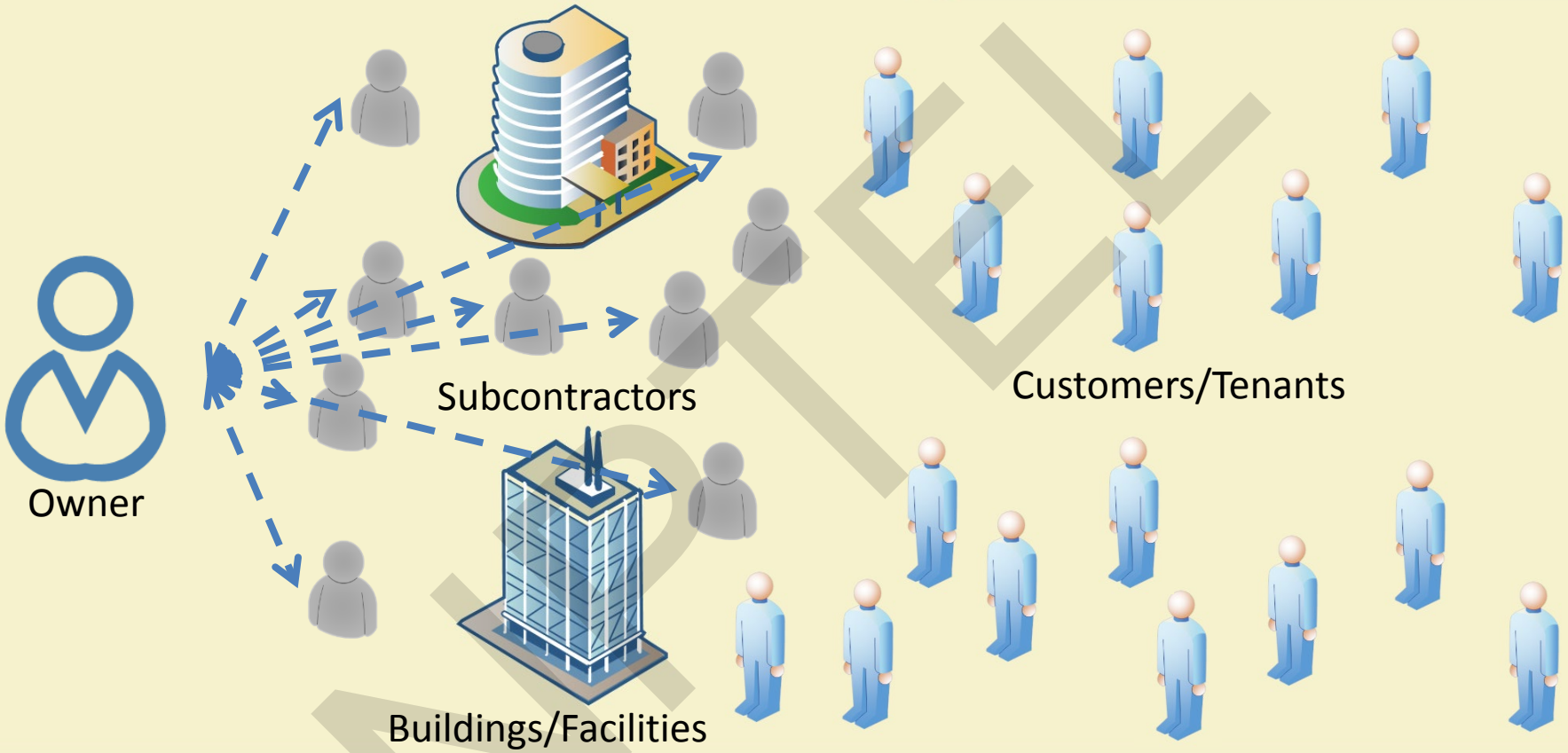
Facility Management



Facility Management

- Support services for organizations
- Integrates people, place and process
- Improve quality of working environment
- Improve productivity

Closely related to the operations conducted in a building


Owner
Subcontractors
Buildings/Facilities
Customers/Tenants

Scope of IoT in Facility Management

- Accessing new insights:
  - Gather data, reduce power consumption
- Implementing new technology:
  - Implementing new technology like Li-Fi (Light Fidelity) and data security
- Addressing cost barrier:
  - Increases operating efficiency and reduce maintenance cost

Support Services

- Finance
  - Planning and reviewing of budget
- Information Technology
  - Improve the ability to co-ordinate among the installed devices
- Human Resources
  - Improve the quality of workforce and the environment

Support Services (contd.)

- Administrative Support
  - Monitoring, gathering, disseminating relevant information and take decisions
- Marketing
  - Research potential customers
- Knowledge
- Business Development
  - Overall growth of business

Key Idea

- Comprehensive detail of every machine
  - Faults, history, usage and modifications
- Data consistency
- Harmonized decisions

Real Power

- Predict events before they occur
- Measures to prevent predicted hazards

Need for Big Data and advanced analytics to analyze them

Optimization

- Optimized usage of resources:
  - Manpower
  - Assets
  - Technology
  - Cost-effectiveness

Challenges

- Cost management
  - Balancing the quality of the facility and its budget
- Ageing inventory
  - Need for proactive preventive and maintenance procedures
- Changing regulatory and compliance standards
  - Need for improvement and new ways to stand out from competitors
- Security Management
  - Security against breaches and threats

IoT Application in Facility Management

- Lighting
- Refrigeration
- Smart Meters
- Fire Suppression Systems
- Appliances with Embedded Sensors/Software

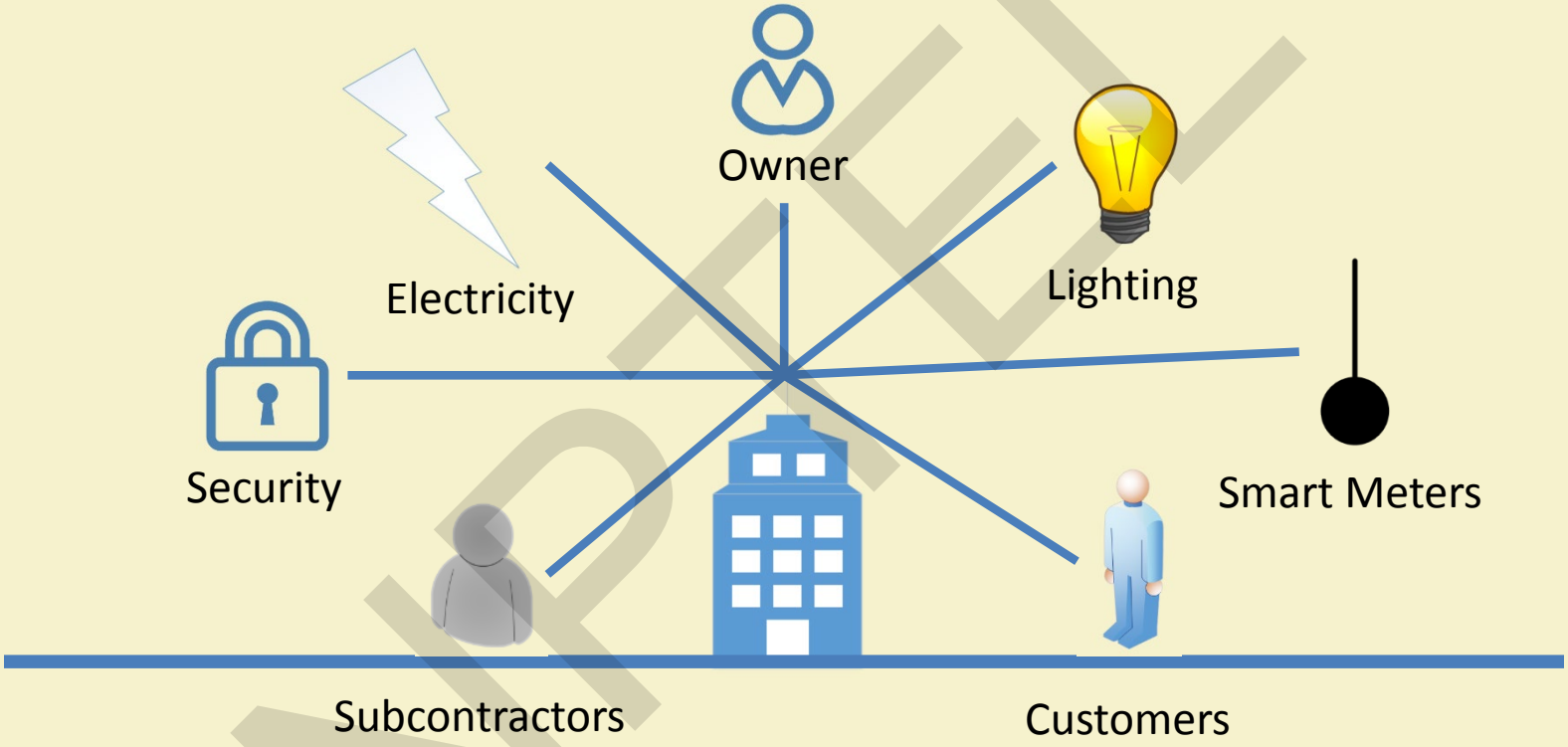
IoT Application in Facility Management (Contd..)

- Security and Safety Alarms
  - Monitor alarms, smoke detector, other life safety systems remotely
  - Real time information about emergency
- Central Heating Ventilation and Air-Conditioning (HVAC)

  "*we will start to see an ecosystem of tools and services develop that will make the HVAC system more efficient and easier to operate*," Dan McJacobson, McGuire Engineers

IoT Application in Facility Management (Contd..)

- Room Reservation and Scheduling
  - Checking real time status of meeting rooms and avoid double-booking
- Monitoring Stock and Usage of Supplies
  - Monitor usage of restrooms
  - Efficient supply management
  - Water management
  - Monitor transmission lines and pipes


Owner
Electricity
Lighting
Security
Smart Meters
Subcontractors
Customers

Analytics in Facility Management (contd..)

- Managing Energy Consumption
- Data-driven Decision-making
- Operational Cost-optimization
- Remote Monitoring of Facilities
- Determining the Exact Square-foot Utilization of Office Space

Benefits

- Improve customer experience
- Prevent unauthorized access
- Real-time tracking
- The ability to do more with less

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Thank You!!