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Data Aggregation & Analysis in IoT

Content

- Basics of Data Collection and Aggregation
- IoT Platforms
- Introduction to Data Analytics in IoT
- Edge Node and Computing

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Recommended Book

https://www.amazon.in/Internet-Things-Surya-Durbha/dp/0190121092/ref=cm_cr_arp_d_bdcrb_top?ie=UTF8

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Introduction

IoT and Data

- The Internet of Things (IoT) is the network of interconnected devices, sensors, and systems that communicate and share data
- IoT enables real-time monitoring, control, and automation in various industries

Data Collection Process

Steps:

- Sensors detect and measure physical parameters.
- Collected data is converted into digital signals.
- Digital data is transmitted to a central processing unit or gateway.

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Data Aggregation

Data Aggregation

- Data aggregation is the process of combining and summarizing collected data from multiple sources.
- Aggregated data provides a holistic view for analysis and decision-making.

Why Data Aggregation?

- Reducing Data Volume
- Enhanced Efficiency
- Improves Privacy & Security
- Facilitating fault detection & anomaly detection
- Enables Real Time Analysis

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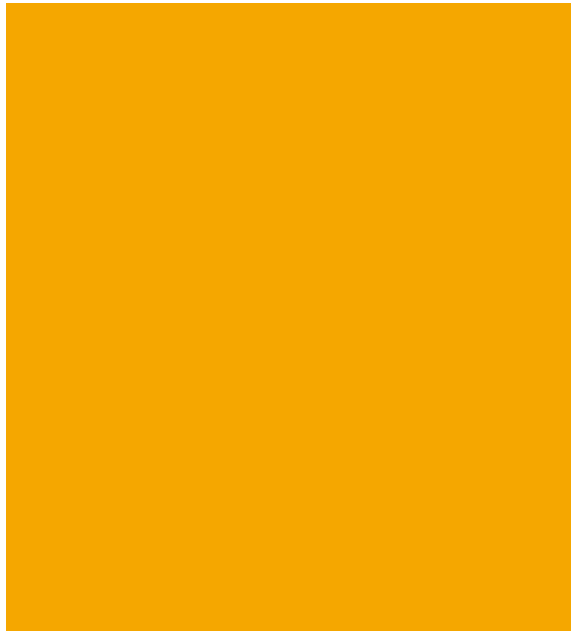
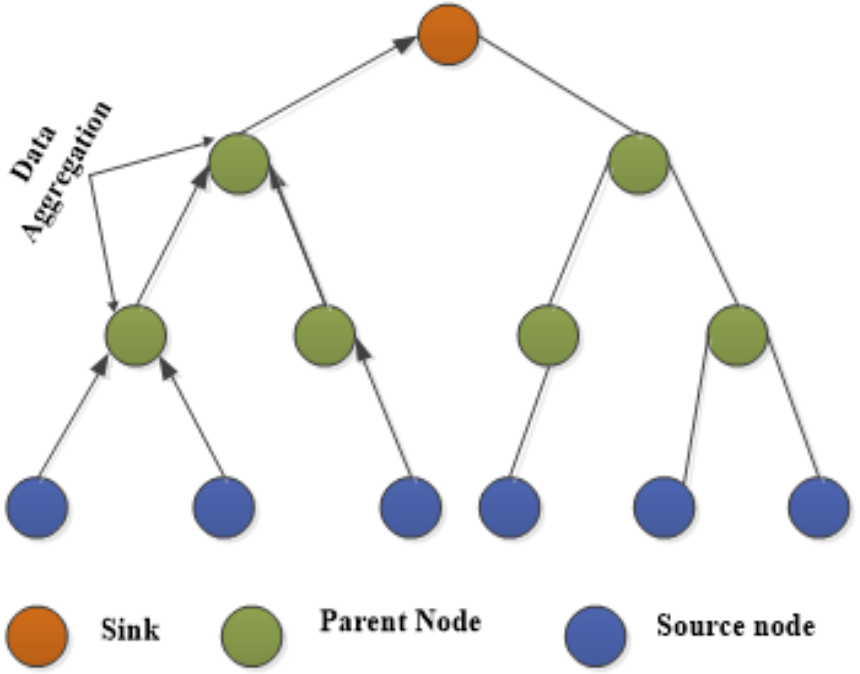
Data Aggregation Types



Tree based aggregation

- Data aggregation through tree like structure
- Aggregation happens at intermediate nodes along the tree
- Root node receives already structured representation of data
- Suited for cases that need in-network aggregation



source:https://www.researchgate.net/publication/368848551/figure/fig2/AS:11431281122839967@1677572603920/Data-aggregation-using-a-tree-based-mechanism-21.ppm

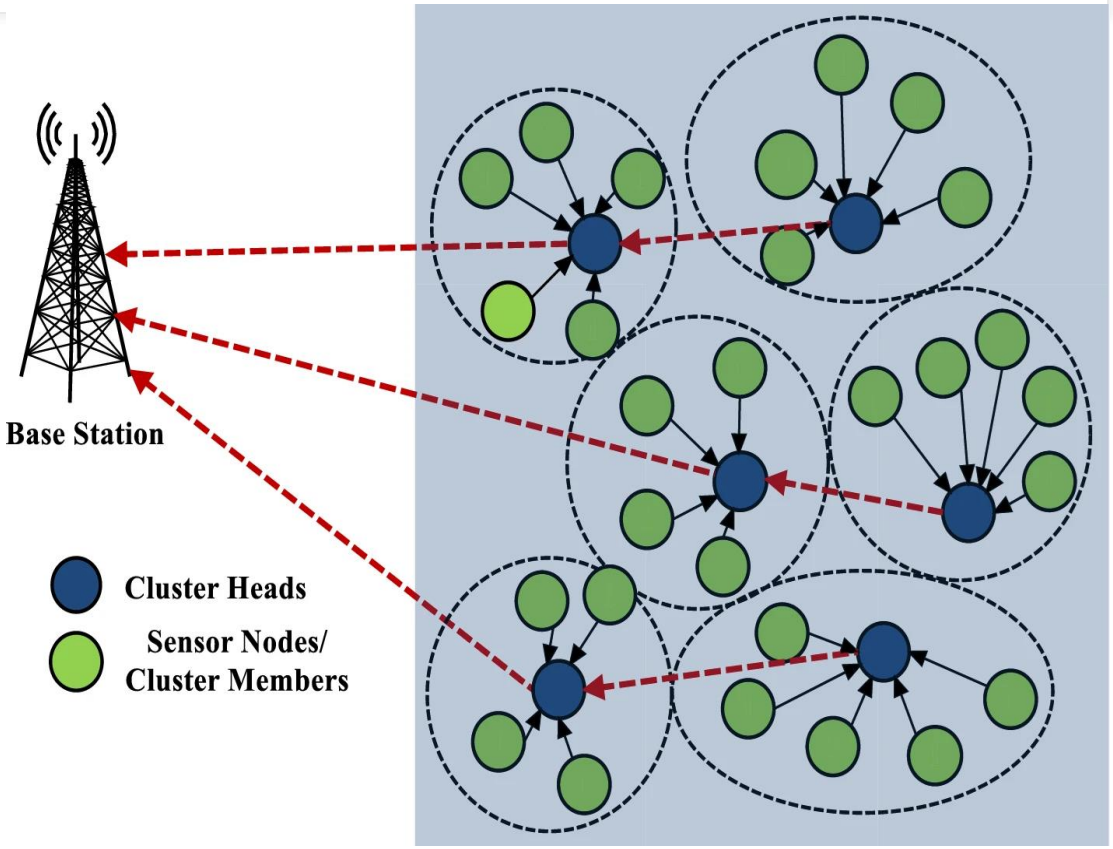
Tree based aggregation

- High energy uniformity, greater strength, flexibility and scalability

- High overhead, creating energy efficient tree and optimization of life span & minimizing transmissions

Cluster based aggregation

- Nodes grouping into clusters based on some criterias
- Cluster heads responsible for coordinating and aggregating data
- Reduces data transmitted over network
- Energy efficient operation and scalability



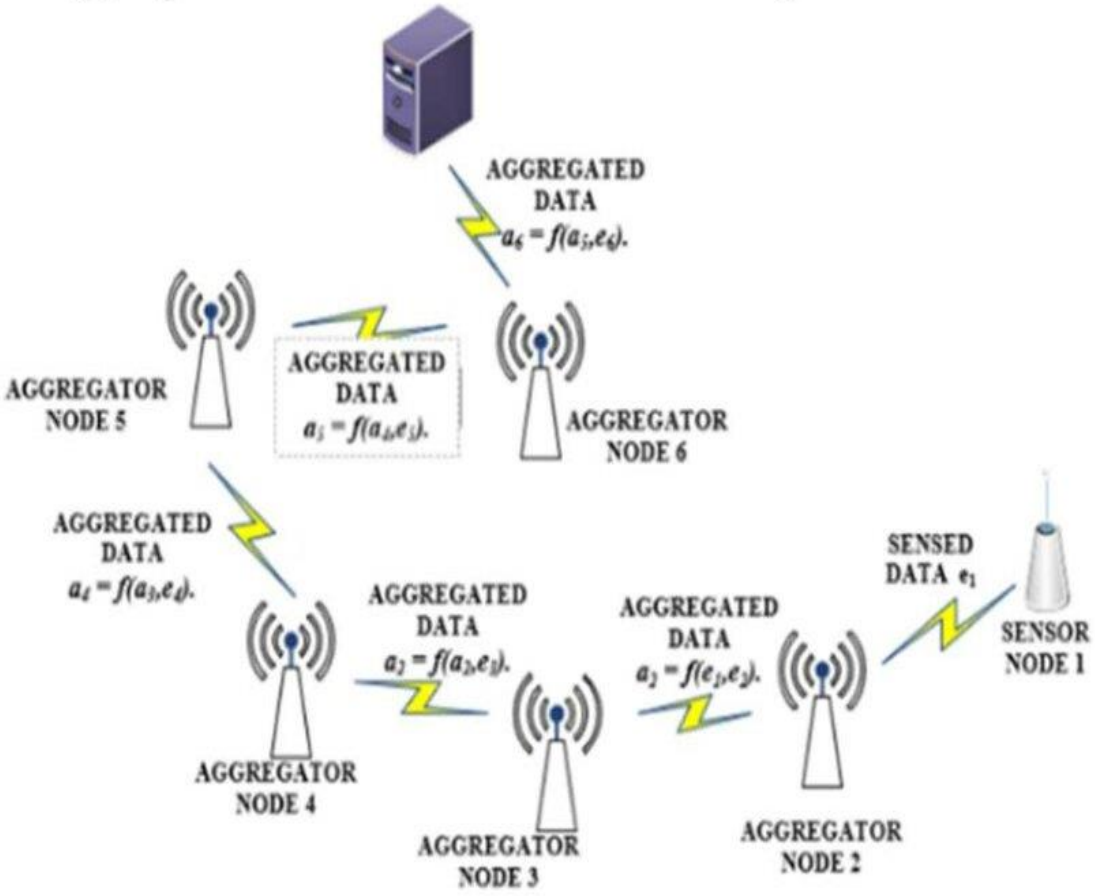
source:https://link.springer.com/article/10.1007/s11277-020-07054-2/figures/1

Cluster based aggregation

- Suitable for cases with heterogeneous network
- Data security and increased network resilience
- Adding or removing devices and clustering can be challenging
- Usage in areas where sensor are distributed across a wide area such as smart cities and building automation

Chain-based aggregation or string-based aggregation

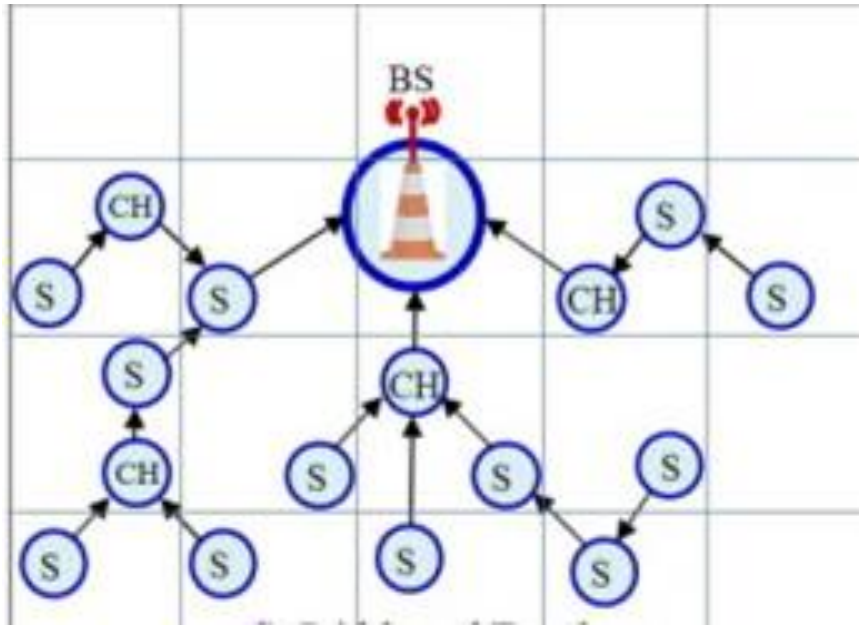
- Sequential, linear data transmission having chain like structure
- Next node aggregates data from previous node
- Unidirectional flow from sensor to a base station
- Reduced energy consumption at each node



source:https://www.researchgate.net/profile/Murtala-Adamu-2/publication/354939039/figure/fig5/AS:1074038722023424@1633082194123/A-chain-based-data-aggregation-structure.jpg

Grid based aggregation

- Sensor field is partitioned into a 2-D logical grid cells
- Node with most residual energy is cell head acting as aggregator
- Data aggregation is localised



source:
https://www.sciencedirect.com/science/article/pii/S1319157823000083

Grid based aggregation

- Adaptable to changes in network structure
- Careful planning needed to deploy in uneven terrains or irregular deployment areas
- Used in agricultural parameters monitoring, structure health monitoring

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Data Analytics

source:https://d1jnx9ba8s6j9r.cloudfront.net/blog/wp-content/uploads/2018/12/Data-Analytics-What-is-Data-Analytics-Edureka-1.png

Data Analytics in IoT

- Data analytics provides a means for analyzing and visualizing data from IoT sensors, actuators, devices, and other connected components of the IoT system.
- The analytics are useful to understand, summarize, and obtain useful insights from large volumes of data coming at very high speed in the form of streams.

IoT Data Analytics

- Automating many decision-making processes so that human intervention is minimized and IoT devices and applications can autonomously perform actions.
- Increasing the efficiency with which processes can be executed. For example, supply chain operations can be made highly efficient by deploying IoT-based solutions.
- Condition-based monitoring and predictive maintenance of equipment, which is critical in many areas such as industries, manufacturing, healthcare, and transportation.
- Service efficiency that encompasses remote management, service chain, material management, etc.
- Analysis of the product usage by customers and accordingly customize the product thus enabling competitive advantage in the market.
- Reducing overall operational expenditure and increasing revenue.

Forms of Data Analytics

- **Descriptive Analysis**: Descriptive analytics provides summaries in the forms of reports, charts, figures, etc. The data from the IoT devices is continuously monitored for providing feedback and enabling situational awareness.
- **Diagnostic Analysis:** Diagnostic analytics can provide the causative factors for a particular problem.
- **Predictive Analysis:** Predictive analytics are developed based on the models that are generated using IoT data in conjunction with various methods for building predictive models
- **Prescriptive Analysis:** Prescriptive analytics provides the steps or rules for action so that a particular task can be accomplished in a more efficient manner.

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Edge Node & Computing

Edge Computing

- Edge computing involves processing data near the source of data generation rather than relying solely on centralized cloud servers.
- Significance: Reduced latency, bandwidth optimization, and improved efficiency in IoT applications.

Edge Node

- An edge node is a device or gateway located at the edge of the network, capable of processing and storing data locally.
- Collects, analyzes, and filters data before sending relevant information to the cloud.

Advantages of Edge Computing

- **Low Latency**: Processing data locally reduces the time it takes for actions to be triggered.
- **Bandwidth Efficiency**: Less data transmitted to the cloud, optimizing network resources.
- **Improved Privacy and Security**: Sensitive data can be processed locally, enhancing privacy and security.

Need for Embedded HPC for Edge Devices

- Currently, IoT data at the edge is gaining increasing importance due to the requirement of real-time applications that need rapid processing of data from IoT devices at the edge itself instead of sending it to cloud-based processing. However, these edge devices currently have limited computing power that can be harnessed to process high-volume and high-speed IoT device data. Due to these limitations, the edge devices are unable to support the use of machine-learning/deep-learning-based models that require sufficient computational capability to execute on the edge.
- Thus, there is a need to have high computational power available on the edge devices that use local computing infrastructure that has minimum latency to deliver results in near real time.

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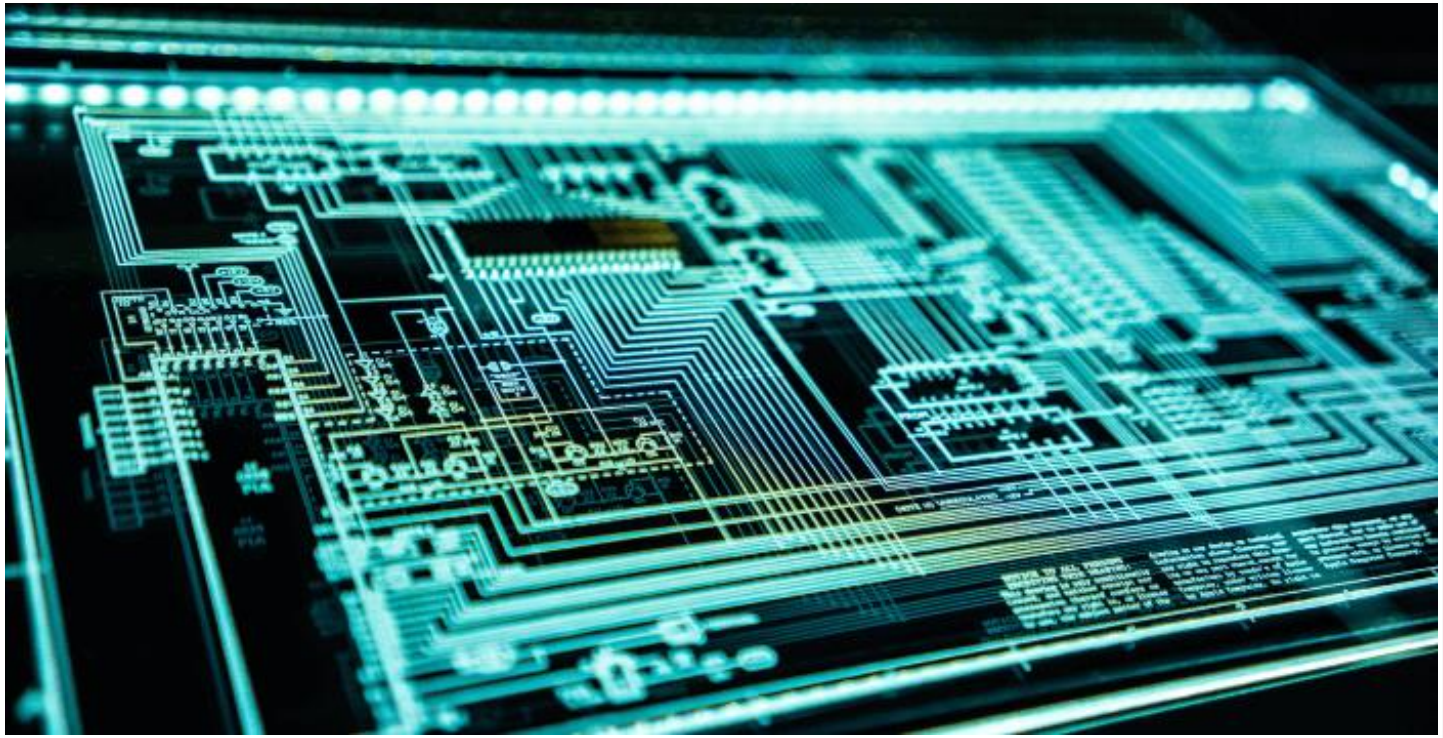
IoT Platforms



source:https://www.hcltech.com/knowledge-library/what-are-iot-platforms

IoT Platform

- Application or service, providing infrastructure
- Provides built-in tools & capabilities to connect every “thing”
- Supports device lifecycle management, device communication, data analytics,integration & app development
- Acts as a centralised and cohesive solution

IoT Platform

- Foundation for building IoT solutions
- Deliver value to business, customers, end users
- Also provide security and control over connected assets
- Helps project off the ground quickly
- Removes technical complexity, so developers can focus on real business outcomes

IoT Platform Capabilities

IoT connectivity : An IoT platform provides out-of-the-box connectivity to many device types and protocols

IoT device lifecycle management : 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

IoT Platform Capabilities

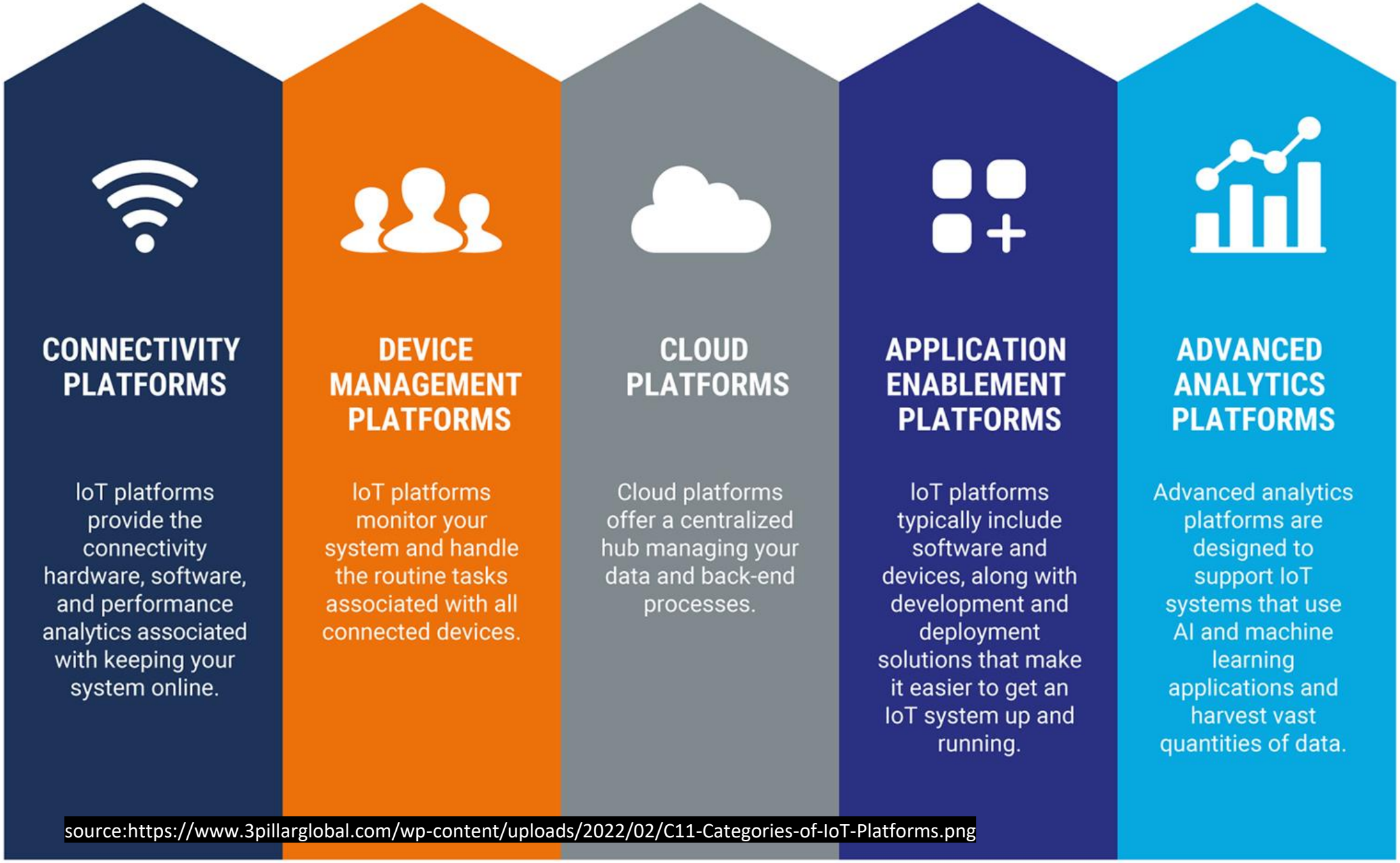
Scalable IoT data management : handles data logging, storing, and processing, and manages data transactions. IoT data comes from many devices and locations, and spans many data types.

IoT integration : 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 Platform Capabilities

IoT application development : Building and maintaining IoT applications involves technical expertise, time and resources

IoT data 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.



source:https://www.3pillarglobal.com/wp-content/uploads/2022/02/C11-Categories-of-IoT-Platforms.png

Various IoT Platforms

Cumulocity IoT Platform

Microsoft Azure IoT Suite

Google Cloud's IoT Platform

AWS IoT Platform

Cisco IoT Cloud Connect

Oracle IoT Platform

IBM Watson IoT Platform

source:https://www.kellton.com/kellton-tech-blog/best-iot-platforms

The World's Biggest Corporations Are Using IoT Platforms

Industry	Corporation	Selected IoT platform vendor(s)
Retail	Walmart	Microsoft
Utilities	enel	C3.ai
Automotive	VW	aws, SIEMENS, Microsoft
Transportation / shipping	Port of Rotterdam	IBM, CISCO
Glass manufacturing	LG CNS	Google Cloud
Food & beverage	Carlsberg	ptc, Microsoft
Shipping	Hapag-Lloyd	ERICSSON, Globe Tracker

Note: Based on publicly information in May 2021. List is not exhaustive and subject to change.
Source: IoT Analytics Research 2021

source: https://iot-analytics.com/5-things-to-know-about-iot-platforms-market/

Databases

A database is a collection of data that is organized and stored in a structured format, allowing for easy access, manipulation, and analysis of the data. Databases can be used to store a wide variety of data, including financial records, customer information, inventory records, and more.

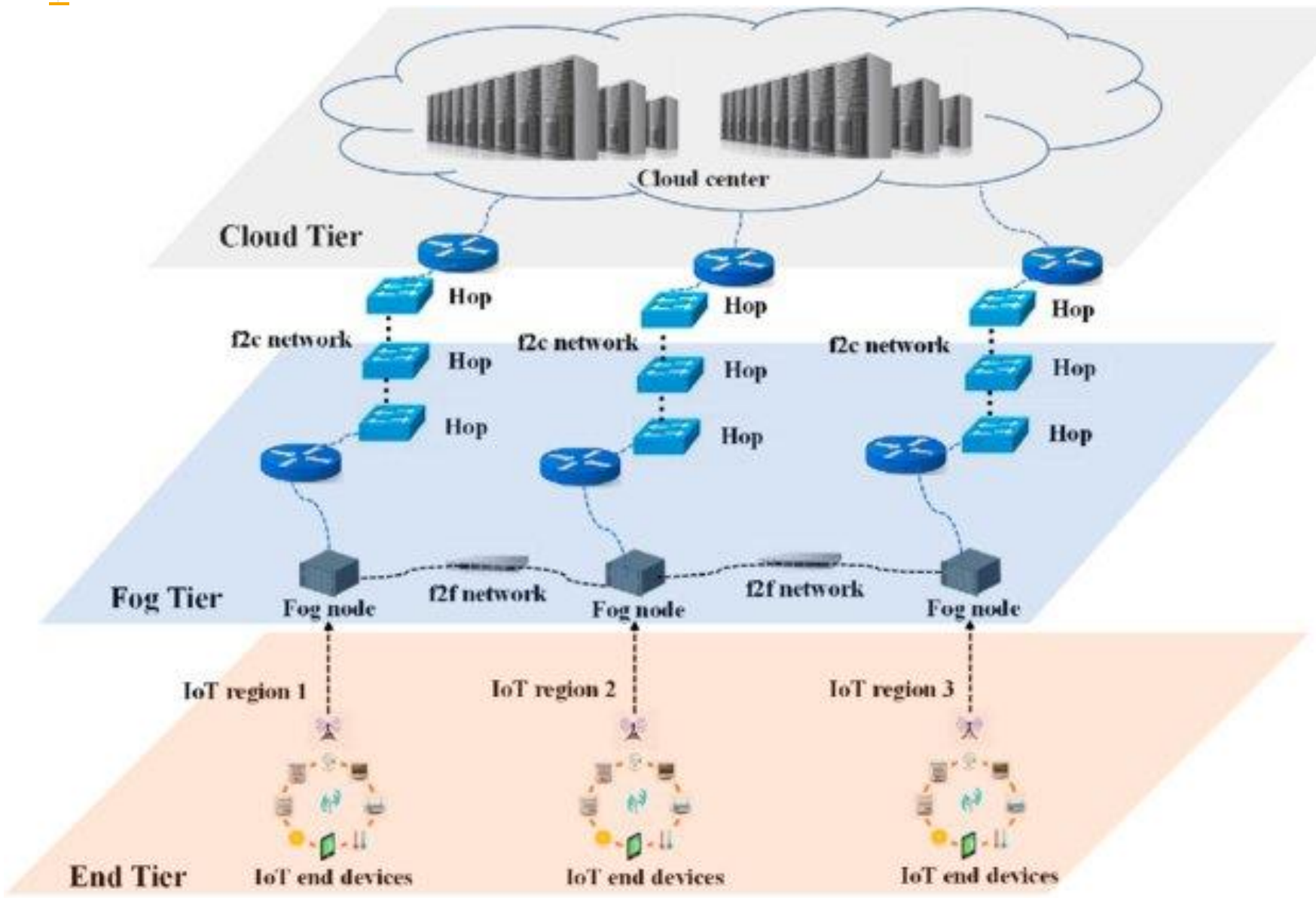
Database store the data into tables.

Controlled by controlled by a database management system (DBMS)

Categorisation of databases

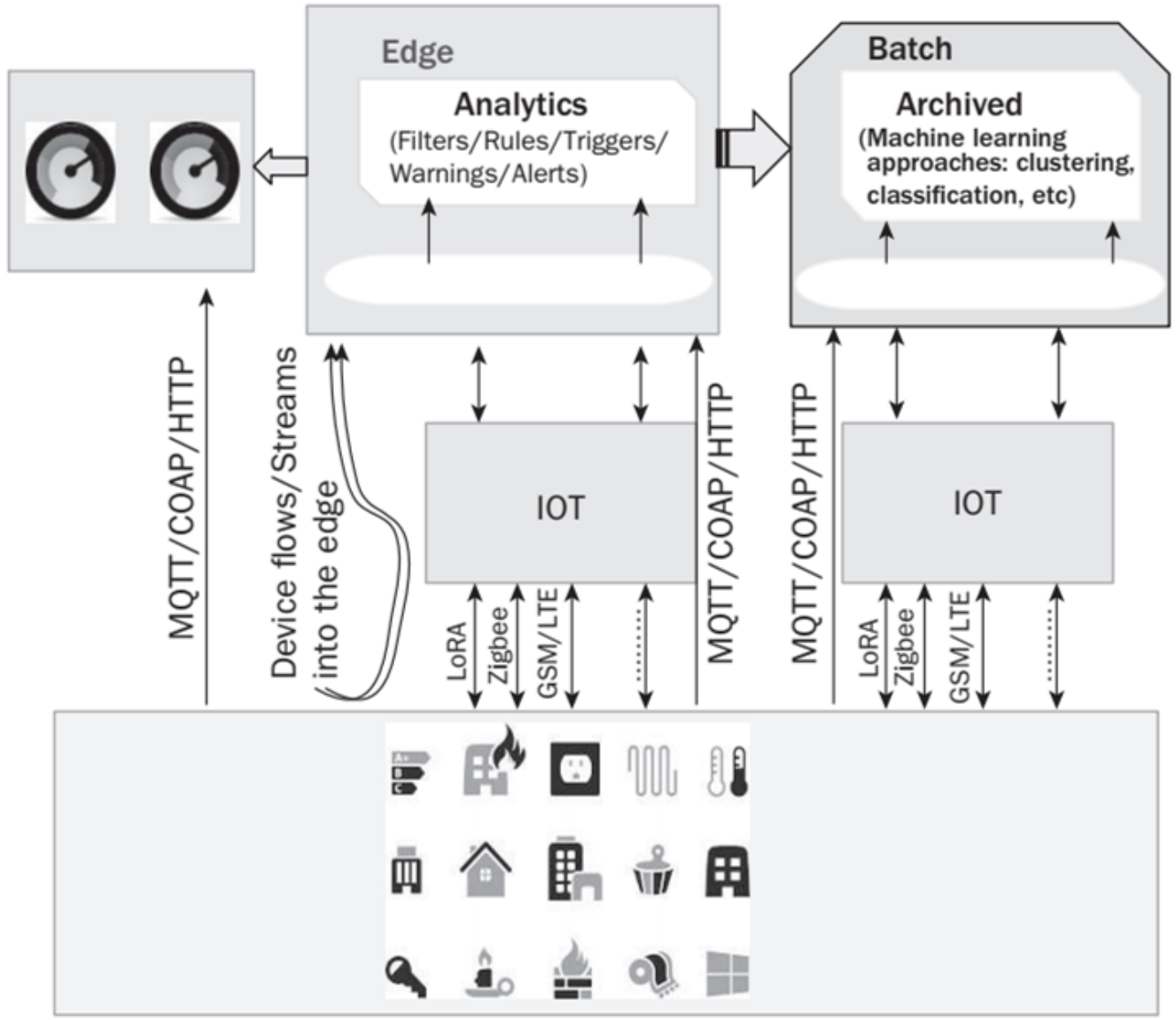
- **Relational Database:** A relational database is made up of a set of tables with data that fits into a predefined category. One information relates to another. Examples: MySQL, PostgreSQL, Oracle, Microsoft SQL Server.
- **Non relational Database:** Non-relational databases, often referred to as NoSQL databases, are designed to handle unstructured or semi-structured data and provide more flexibility than traditional relational databases. They don't strictly adhere to the relational model and can store data in various formats, such as key-value pairs, documents, graphs, or columns. Examples: MongoDB, Cassandra, HBase, Redis, Riak, Neo4J.

Edge-Fog-Cloud in IoT Systems



Resource: Researchgate publication 335622976

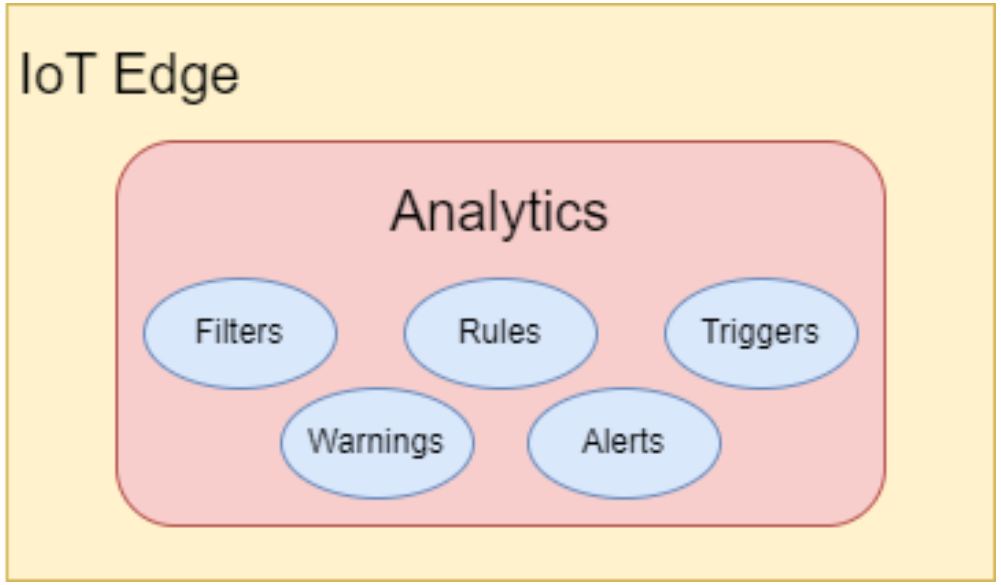
IoT Edge Analytics:



Framework for analytics in IoT

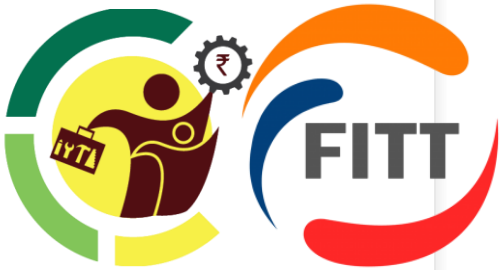
Source: [Internet of Things, Durbha et.al.]

IoT Edge Analytics with Farming:



Resource: https://lvivity.com/iot-in-agriculture-practical-uses40

Python



Introduction to Pandas

Homework

- Discuss about the capabilities of an IoT platforms?
- What is the need for data aggregation?
- Discuss various the aggregation types?
- What is edge, fog computing?

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Thank You!