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IIoT Analytics and Data Management: Introduction

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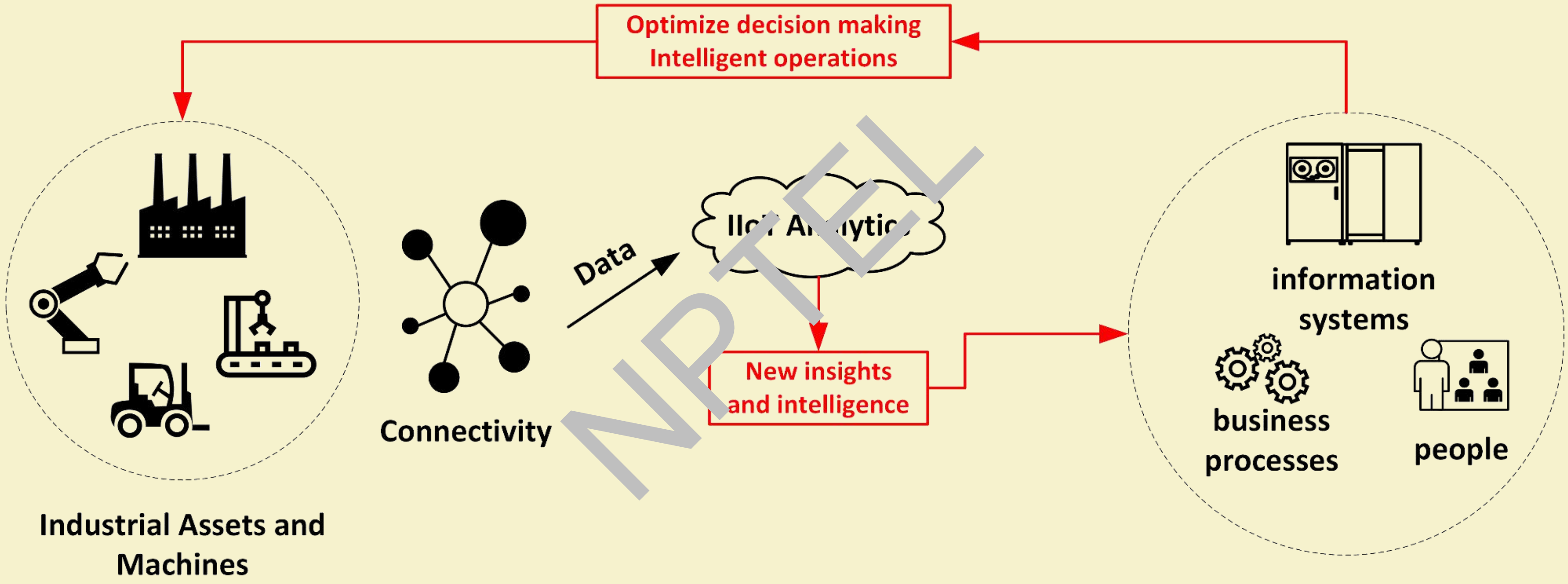
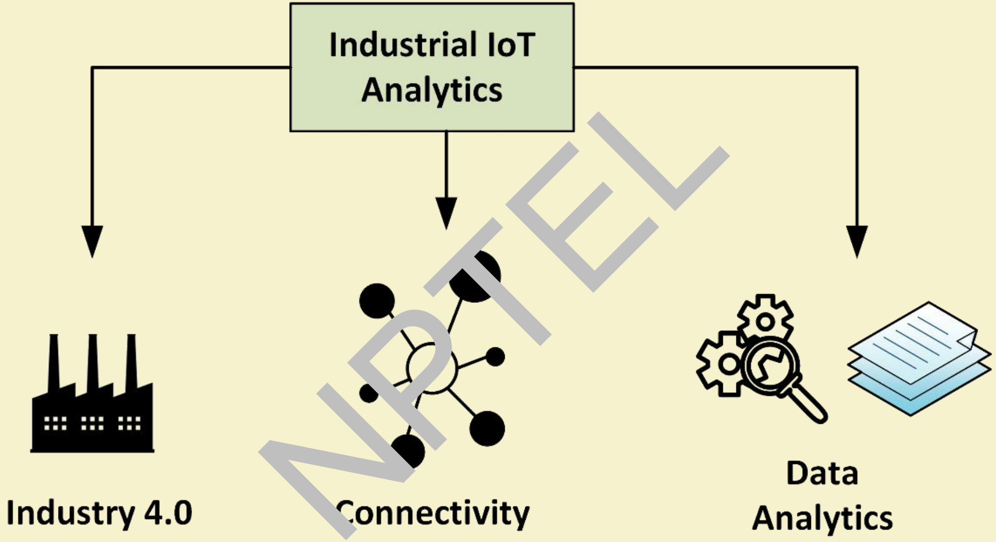
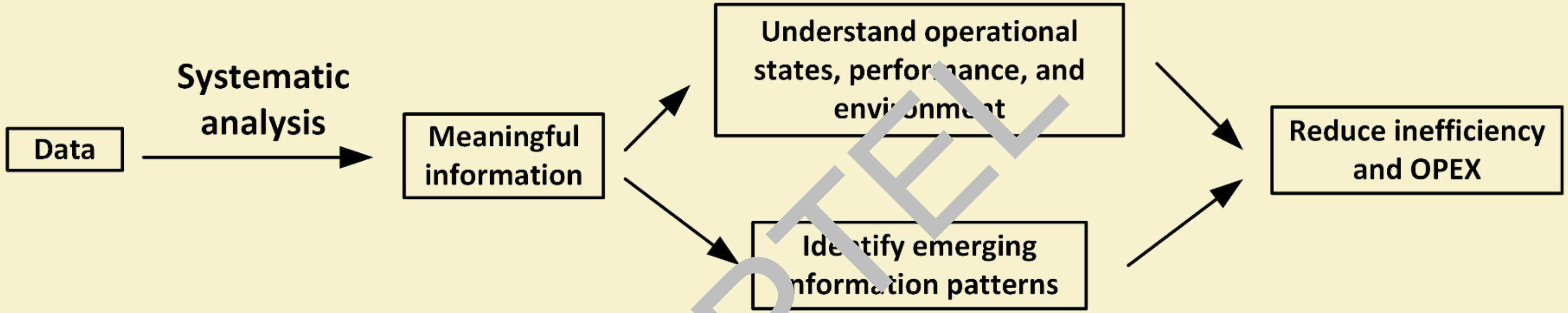
IIoT Analytics : Necessity



IIoT Analytics : Definition

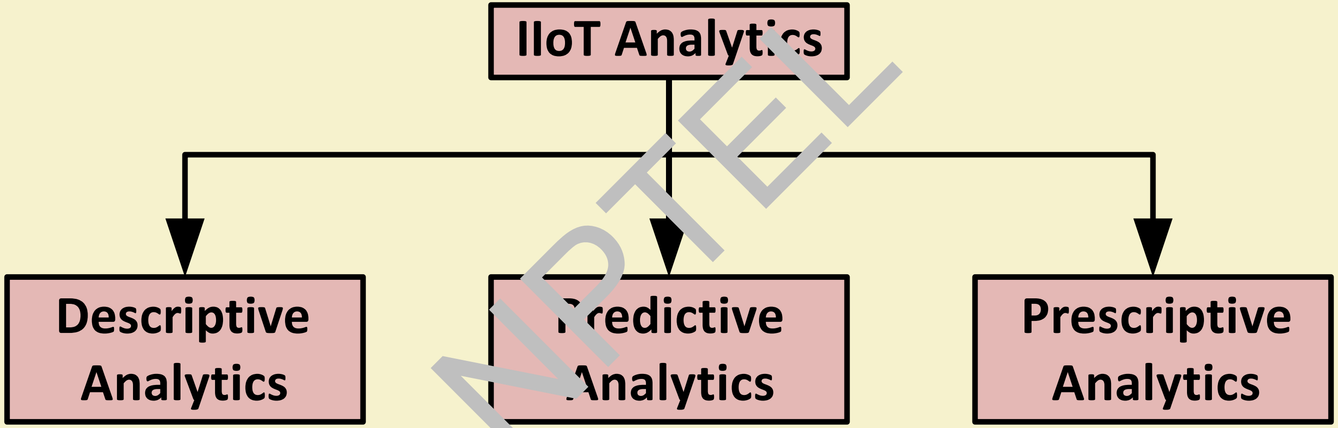


IIoT Analytics : Definition (cont.)

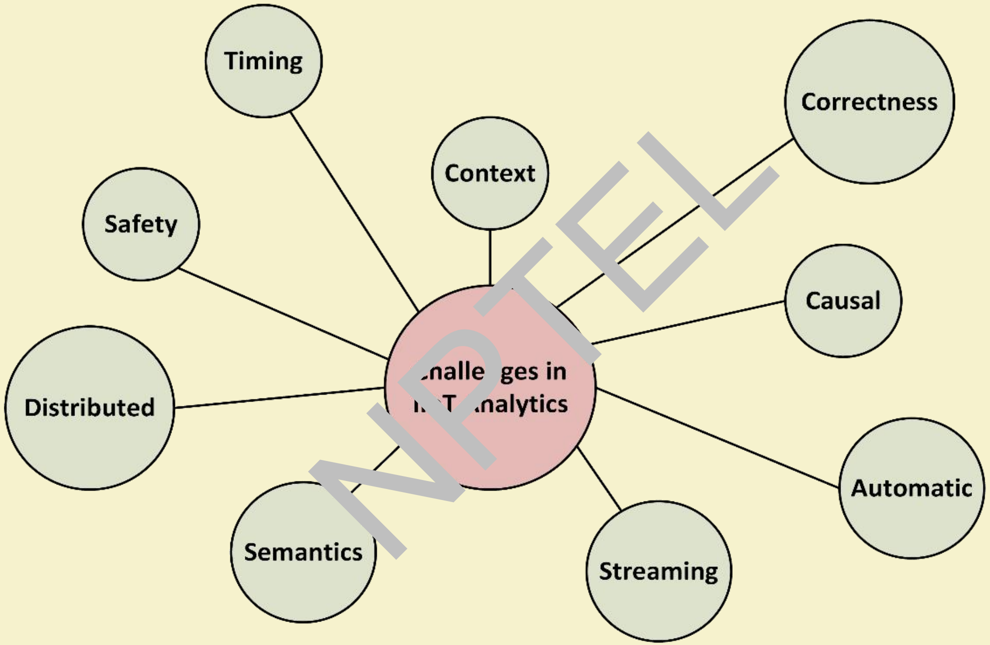


- Dynamic operations optimization
- Prognostic maintenance
- Real-time data analysis

IIoT Analytics : Types



IIoT Analytics : Challenges



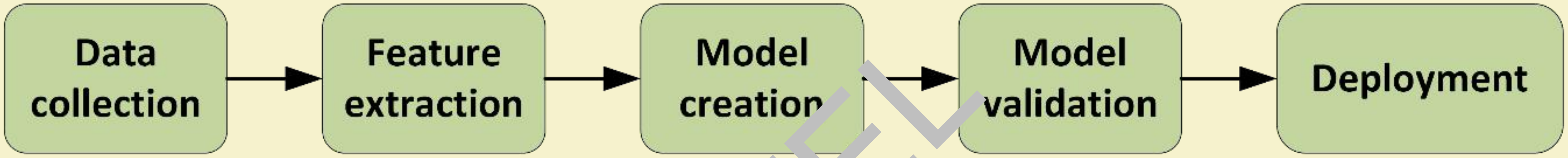
IIoT Analytics: Data Science

- Big Data Analytics
  - Volume, velocity, variability, veracity, variety
  - Industrial automation, system health monitoring, predictive maintenance, remote monitoring

- Artificial Intelligence
  - Deep Learning (DL)
  - Machine Learning (ML)

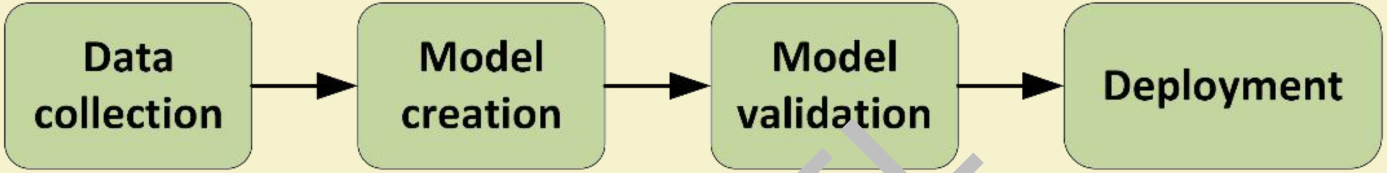
Instead of physics-based models, ML and DL enable a data-driven system modelling approach.

IIoT Analytics: Machine Learning



- May be *supervised* or *unsupervised*
  - **Feature extraction:** Convert raw data to information that relates to the physical state of the asset.
  - **Supervised algorithms** are useful when it is feasible to acquire training data for the different states (or classes) that need to be modeled.
  - **Unsupervised** methods do not use labeled data. These algorithms find structure in the input data on its own.

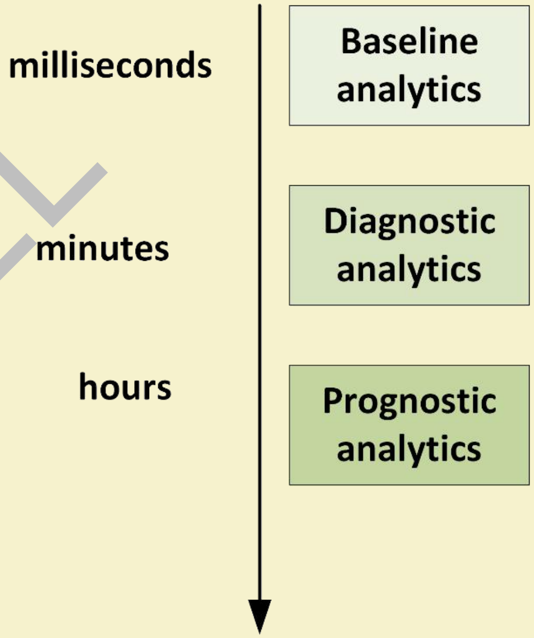
IIoT Analytics: Deep Learning



- Feature engineering is absent
  - Raw data from sensors is directly fed into deep learning algorithms
  - Learns features automatically without manually specifying them
  - Largely based on <u>neural networks</u>
  - Require large amount of computation power (GPU servers)
  - Gaining popularity due to advances in computing

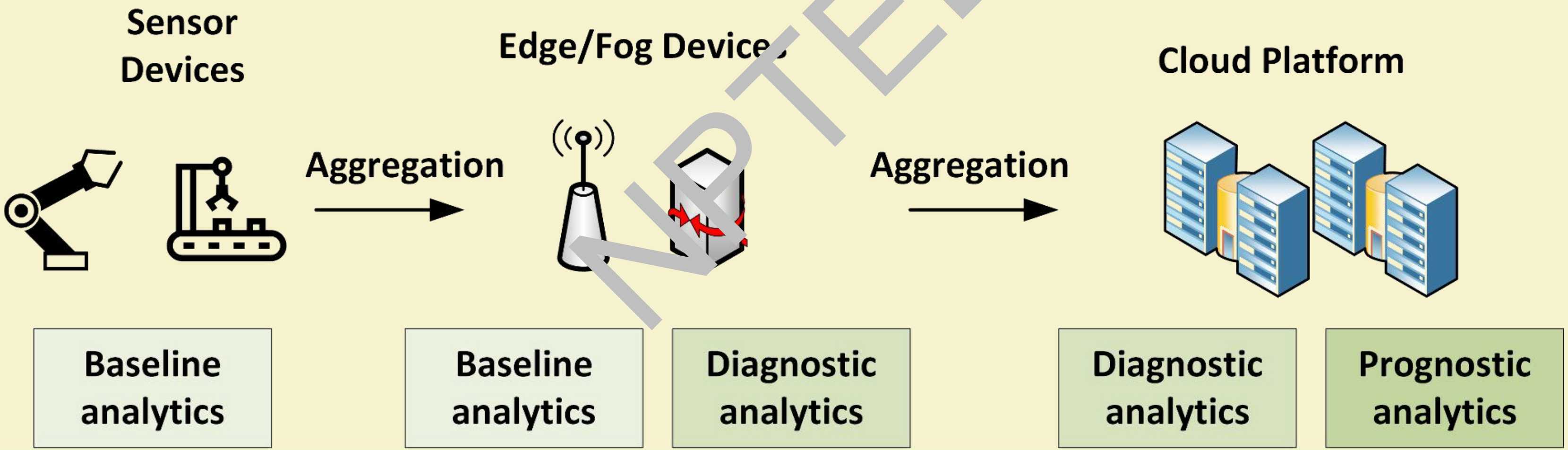
IIoT Analytics: Timescales

- Baseline analytics (ms)
  - Detect irregular behavior of asset quickly
- Diagnostic analytics (min)
  - Identify root cause of anomaly
- Prognostic analytics (hrs)
  - Inform about remaining useful life of an asset



IIoT Analytics: Deployment

- Deployment of analytics typically consists of three steps:
  - *train* a (predictive) analytics model
  - *test and validate* the model on previously unseen data
  - *deploy* the model to make predictions on real (streaming) data.



IIoT Analytics: Real-time

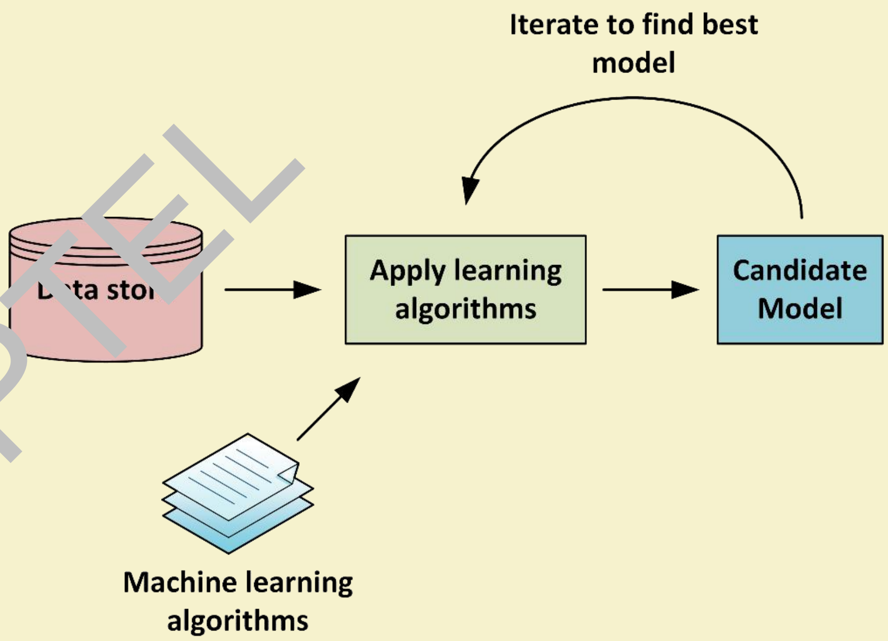
- Streaming real-time analytics
  - Most often used for IoT processing
  - Take action immediately on some event with the source
    - Send out alert on temperature sensor reaching a threshold
    - Send out notification about low tire pressure in smart car
  - Generating instant alerts requires stream processing. Process events in real-time to match a predefined set of rules
  - Edge processing, data aggregation and down-sampling
  - Complex Event Processing software such as Apache Storm, Esper etc may be used.

IIoT Analytics: Batch Processing

- Batch-oriented analytics
  - Improve accuracy of the streaming layer analytics
  - Useful for long-term statistics
    - Average temperature in room for last month
    - Power usage of house in last year
  - Distributed analytics: Batch processing can be used to get a better overall picture by aggregating data sources from geo-distributed sources.
  - Software such as Apache Hadoop and Apache Spark may be used

IIoT Analytics: Model Building

- Anomaly detection (e.g., Gaussian Mixture Model)
- Classification (e.g., Support Vector Machine)
- Regression (e.g., Bayes Regression)



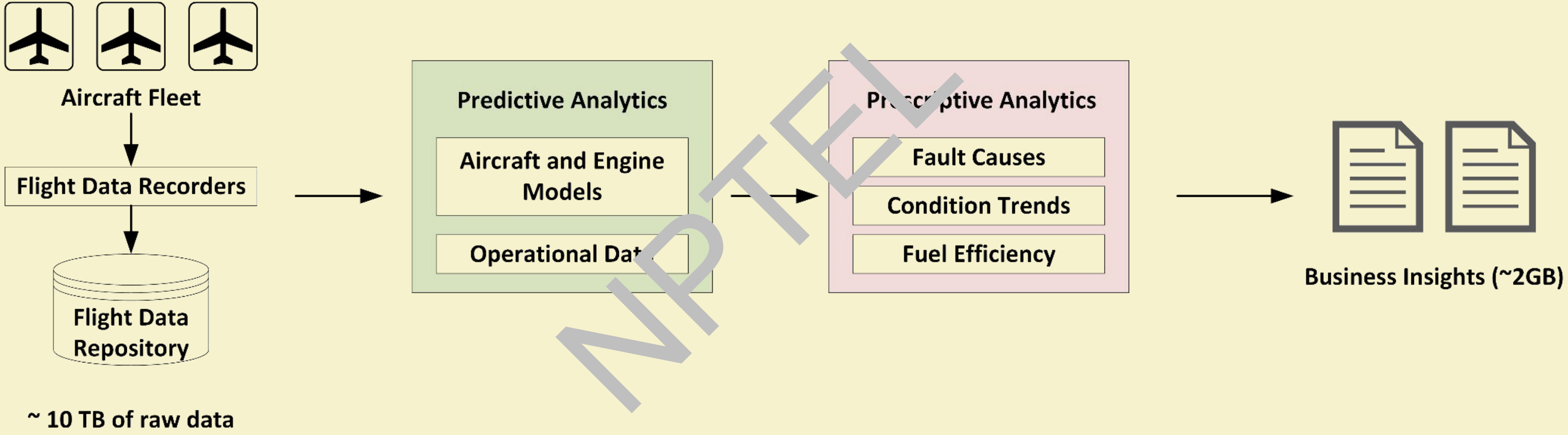
IIoT Analytics: Value Drivers

- New revenue streams
  - Upgrading existing products
  - Changing the business model
  - Creating new business models
- Reduce costs
  - Data-driven process optimization
  - Data-driven process automation
  - Data-driven product optimization

IIoT Analytics: Applications across the value chain

- R&D: Analyze product usage characteristics and <u>feed back generated data to improve the product</u> in the next cycle
- Manufacturing / Operations
  - Predictive maintenance
  - Decision support systems for industrial processes
  - Optimizing machine parameters: Correlated cause and effect parameters such as machine speed
- Logistics / Supply chain
  - Supply chain optimization: forecast shortages, reduce overall inventory levels etc
  - Fleet management: optimize to reduce transportation and fuel cost
- Marketing and Sales: Propose suitable upgrades as per user behavior

IIoT Analytics: Aircraft Example



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2IoT Analytics Inc., "Industrial Analytics 2016/2017: The current state of data analytics usage in industrial companies", *Tech Report*, 2016.

3 A. Minteer, "Analytics for the Internet of Things (IoT)", Packt Publishing, 2017

4S. Verma, Y. Kawamoto, Z.M. Fadlullah, H. Nishiyama, N. Kato, "A Survey on Network Methodologies for Real-Time Analytics of Massive IoT Data and Open Research Issues ", IEEE Communication Surveys & Tutorials, vol. 19, no. 3, pp. 1457–1477, 2017.

Thank You!!

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IIoT Analytics and Data Management: Machine Learning and Data Science – Part 1

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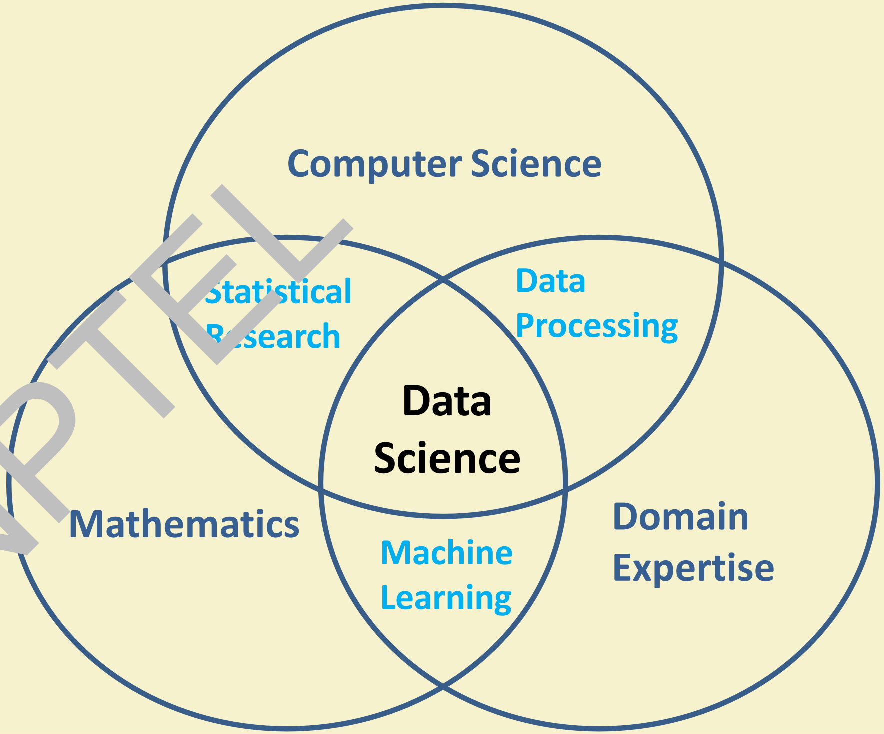
Basics of Machine Learning

What is Machine Learning?

Machine learning is a subset of Artificial Intelligence which enables machines to make decisions based on their experience rather than being explicitly programmed.

Source: Google Cloud AI Adventures, figure redrawn from URL:https://towardsdatascience.com/what-is-machine-learning-8c6871016736

What is Data Science?



Source: Quora
URL: https://www.quora.com/What-is-data-science

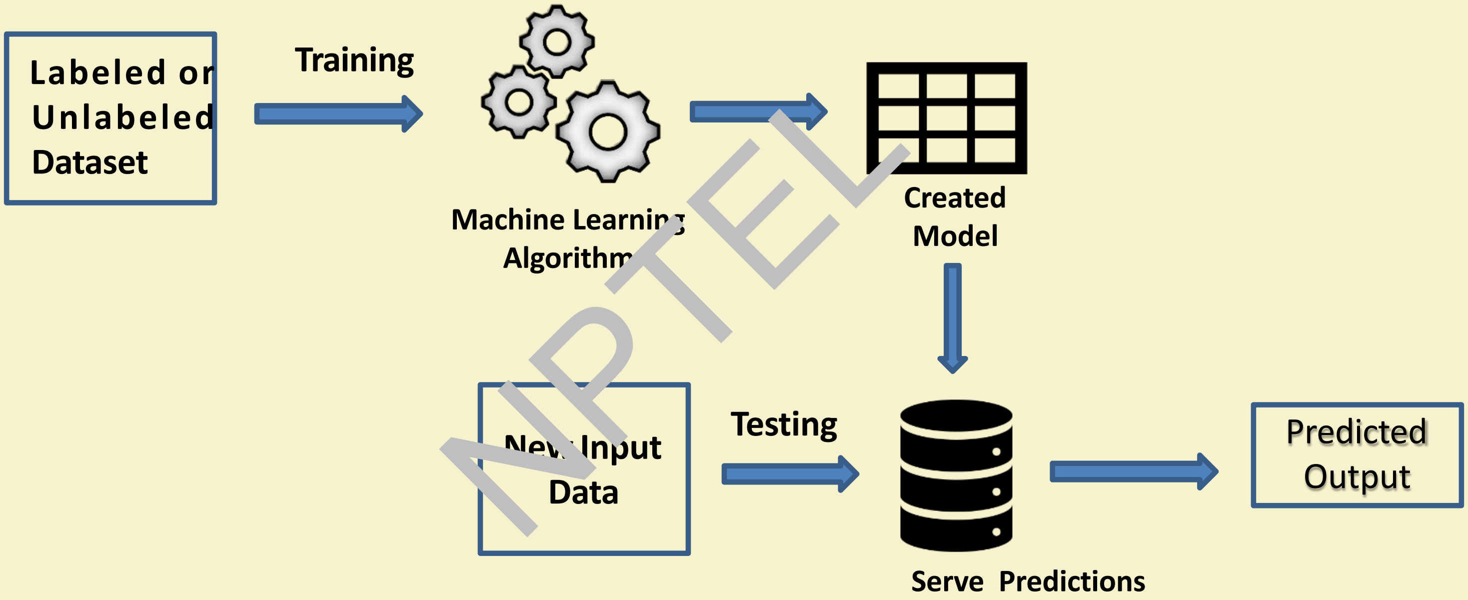
Machine Learning

Using data to answer questions

Training	**Prediction**
Using Data	***Answer questions***
	

Source: Google Cloud AI Adventures, figure redrawn from URL:https://towardsdatascience.com/what-is-machine-learning-8c6871016736

How Machine Learning works?



Source: Google Cloud AI Adventures, figure redrawn from URL:https://towardsdatascience.com/what-is-machine-learning-8c6871016736

Types of Machine Learning Algorithms

Machine Learning

1. Unsupervised Learning

2. Supervised Learning

3. Reinforcement Learning

1. Unsupervised Learning

This machine learning technique is used to identify similar groups of data, coined as clustering. The segregation of data is performed on unlabeled dataset, based on the inner structure of the data without looking into the specific outcome.

Clustering

- **Hard Clustering**: Data points belong to completely one cluster. Ex. **K-Means**
- **Soft Clustering**: Data points may belong to more than one cluster. Ex. **Fuzzy c-Means**

Source: analyticsvidya website URL: https://www.analyticsvidhya.com/blog/2016/11/an-introduction-to-clustering-and-different-methods-of-clustering/

Difference between K-Means and Fuzzy c-Means Algorithm

K-Means

1. One data point may belong to only one cluster

2. K-Means may not be as fast as FCM

Fuzzy c-Means

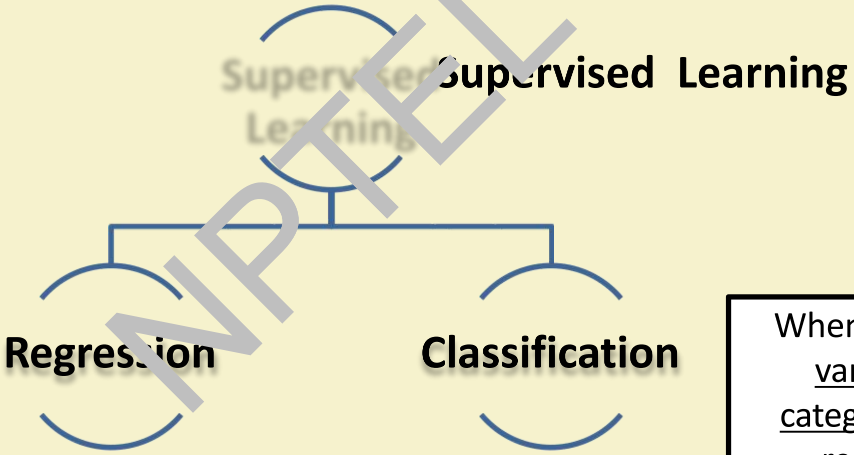
1. One data point may belong to more than one cluster

2. FCM is extremely faster than K-Means

2. Supervised Learning Algorithm

It is used to classify the dataset by learning the mapping function from the labeled dataset.

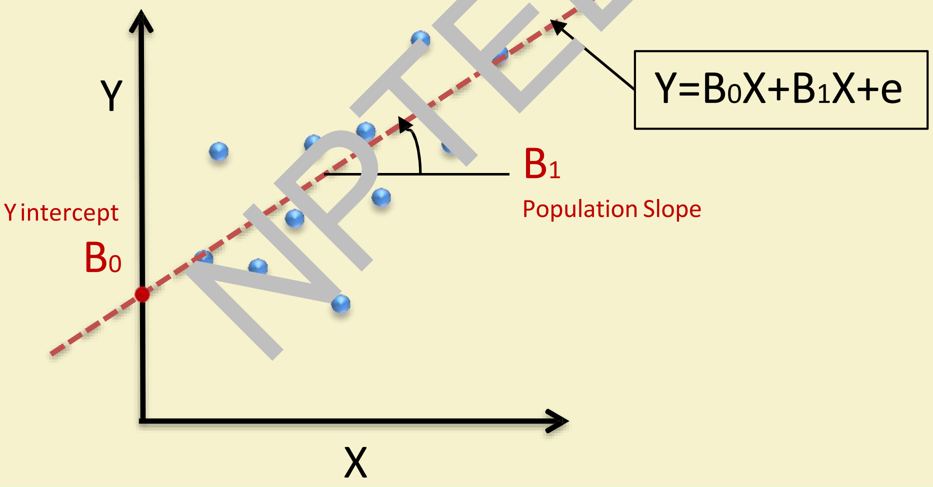
When the output variable is a real number such as dollars or weight



When the output variable is a category such as red or blue

Regression : Linear Regression

It is supervised learning problem which learns a linear function from the given instances of X (independent variable) and Y (dependent variable) values, so that it can predict Y for an unknown X.



Classification: Decision Tree

- Tree-based machine learning algorithm used for <u>classification</u>
- Non-linear function with two types of nodes: <u>decision nodes</u> and <u>leaf nodes</u>
- ***Decision node*** is used to test or decide the outcome based on some value of an attribute
- ***Leaf node*** denotes the classification of an example

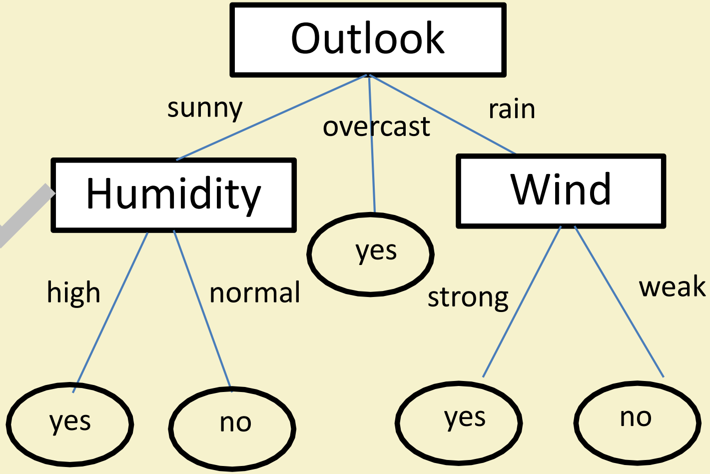
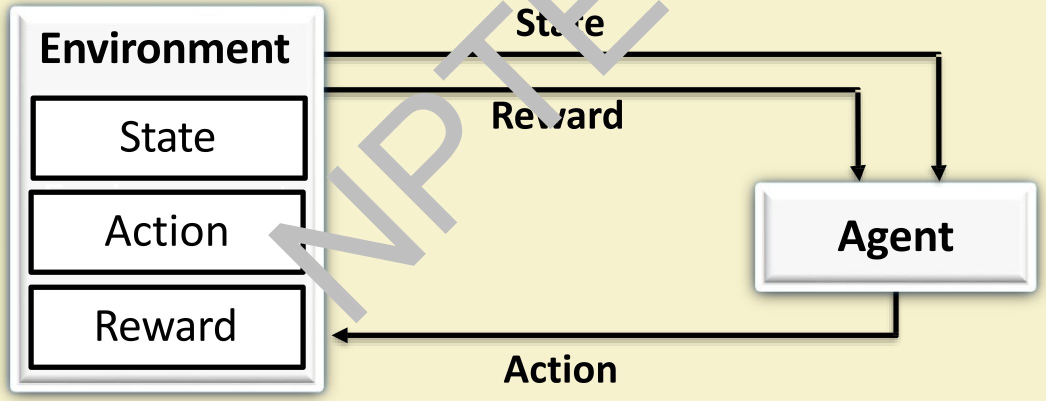


Figure redrawn from URL: https://nullpointerexception1.wordpress.com/2017/12/16/a-tutorial-to-understand-decision-tree-id3-learning-algorithm/

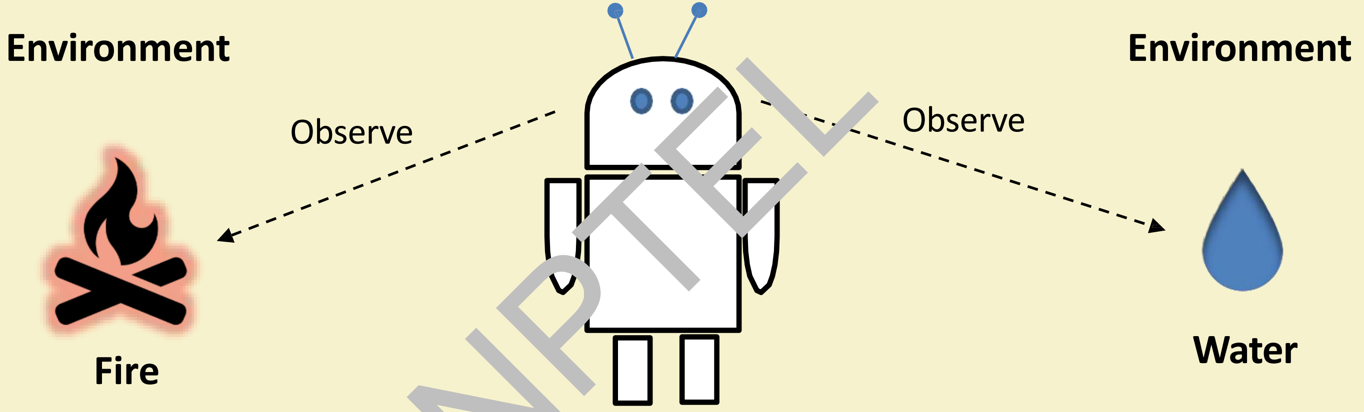
3. Reinforcement Learning Algorithm

It is a machine learning algorithm which enables machines to <u>improve its performance</u> by automatically learning the ideal behaviors for a specific environment.



Source: *"Learn Unity ML-Agents – Fundamentals of Unity Machine Learning"* by Micheal Lanham

RL – An Analogy



Differences between RL and Supervised Learning

Reinforce ment Learning

1. There is no external supervisor to guide the agent.
2. No problem faced during the circumstances. The agent has many combinations of subt[illegible]sks [illegible] achieve the objective.
3. There is a reward functio[illegible] which acts as a feedback to the agent.

Super-vised Learning

1. Here agent is guided by an external supervisor who has the knowledge of the environment.
2. Problem faced during the circumstances. The agent has many combinations of subtasks to achieve the objective.
3. There is no reward function.

Source: Analytics Vidhya URL:https://www.analyticsvidhya.com/blog/2017/01/introduction-to-reinforcement-learning-implementation/

Difference between RL and Unsupervised Learning

Reinforcement Learning

1. There is a mapping between input and output.
2. It builds a knowledge graph from the constant feedbacks of the corresponding actions.

Unsupervised Learning

1. There is no mapping between input and output.
2. It finds the underlying pattern.

Source: Analytics Vidhya URL:https://www.analyticsvidhya.com/blog/2017/01/introduction-to-reinforcement-learning-implementation/

Integration of Machine Learning with IIoT

Various industries utilizing IIoT with Machine Learning

- Retail
- Travel
- Health care
- Finance
- Social media

Applications of IIoT with Machine Learning (Contd…)

- Pfizer exploits IBM Watson for drug discovery
- Genentech provide personalized treatment for patients

Healthcare

Source: Top 10 Industrial Applications of Machine Learning
URL: https://www.dezyre.com/article/top-10-industrial-applications-of-machine-learning/364

Applications of IIoT with Machine Learning (Contd…)

- Fraud detection
- Targeting focused account holders

Finance

Source: Top 10 Industrial Applications of Machine Learning
URL: https://www.dezyre.com/article/top-10-industrial-applications-of-machine-learning/364

Applications of IIoT with Machine Learning (Contd…)

- Product recommendation
- Improved customer service

Retail

Source: Top 10 Industrial Applications of Machine Learning
URL: https://www.dezyre.com/article/top-10-industrial-applications-of-machine-learning/364

Applications of IIoT with Machine Learning (Contd…)

- Dynamic price setup
- Sentiment analysis to act as trip advisor

Travel

Source: Top 10 Industrial Applications of Machine Learning
URL: https://www.dezyre.com/article/top-10-industrial-applications-of-machine-learning/364

Applications of IIoT with Machine Learning (Contd...)

- Facebook uses ANN for tagging faces
- LinkedIn uses machine learning technology for suggesting job

Social media

Source: Top 10 Industrial Applications of Machine Learning
URL: https://www.dezyre.com/article/top-10-industrial-applications-of-machine-learning/364

Instances of IIoT with Machine learning

ThingWorx platform

- Perform complex analytical process
- Deliver real-time perception
- Ability of condition monitoring
- Ability of predictive analytics and recommendation

Source: Deliver Industrial IoT Analytics with ThingWorx
URL: https://www.ptc.com/en/products/iot/thingworx-platform/analyze

Instances of IIoT with Machine learning (Contd…)

Toumetis ➡

- Help oil and gas engineers to access real time data and <u>predict anomalies</u>
- Making more advanced smart home automation

Source: Toumetis URL: https://toumetis.com

References-I

1 Google cloud AI Adventures
URL:https://towardsdatascience.com/what-is-machine-learning-8c6871016736
2 An introduction to clustering and different methods of clustering
URL: https://www.analyticsvidhya.com/blog/2016/11/an-introduction-to-clustering-and-different-methods-of-clustering/
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4 M. Lanham (2018) Learn Unity ML-Agents – Fundamentals of Unity Machine Learning. Packt publishing
5 Deep Reinforcement Learning Demystified
https://medium.com/@m.alzantot/deep-reinforcement-learning-demystified-episode-0-2198c05a6124
6 Top 10 Industrial Applications of Machine Learning
URL: https://www.dezyre.com/article/top-10-industrial-applications-of-machine-learning/364 [7]Toumetis URL: https://toumetis.com
[8] Deliver Industrial IoT Analytics with ThingWorx
URL: https://www.ptc.com/en/products/iot/thingworx-platform/analyze

Thank You!!

IIoT Analytics and Data Management: Machine Learning and Data Science – Part 2

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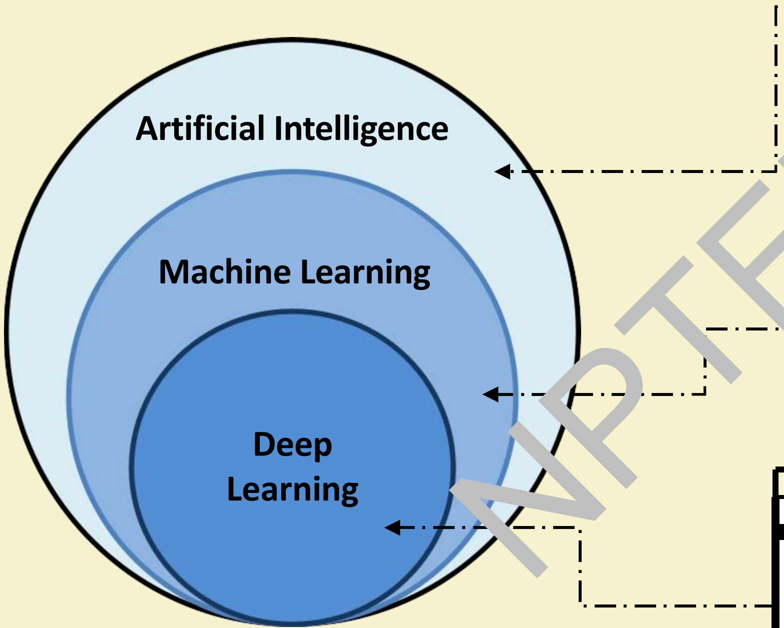
AI vs Machine learning vs Deep learning



Artificial Intelligence

Making of intelligent machines which take decisions on its own without being explicitly programmed

Machine Learning

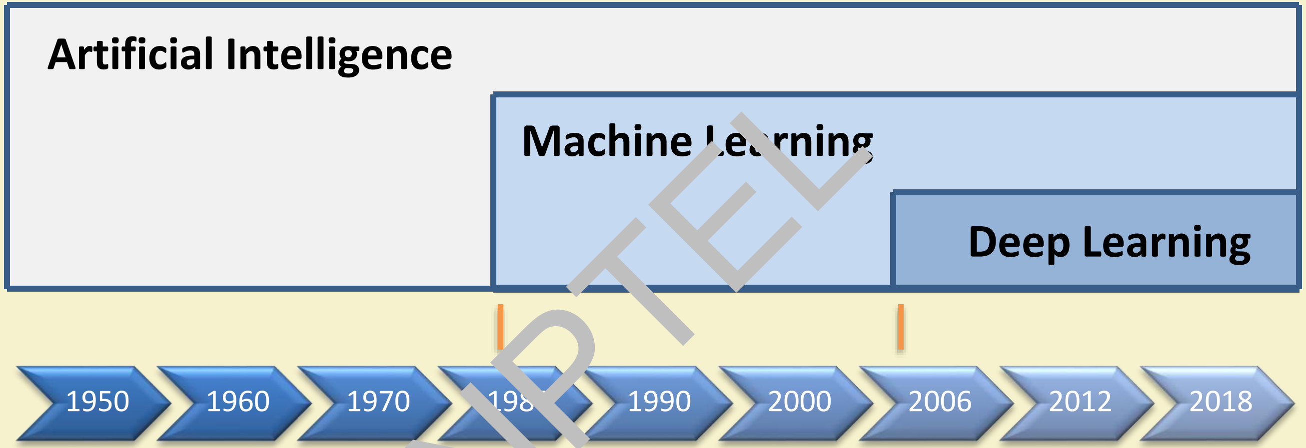
Subset of AI which can learn automatically from the object features

Deep Learning

Subset of machine learning which can learn automatically by finding the features of the object on its own

Source Edureka website
URL: https://www.edureka.co/blog/what-is-deep-learning

Timeline



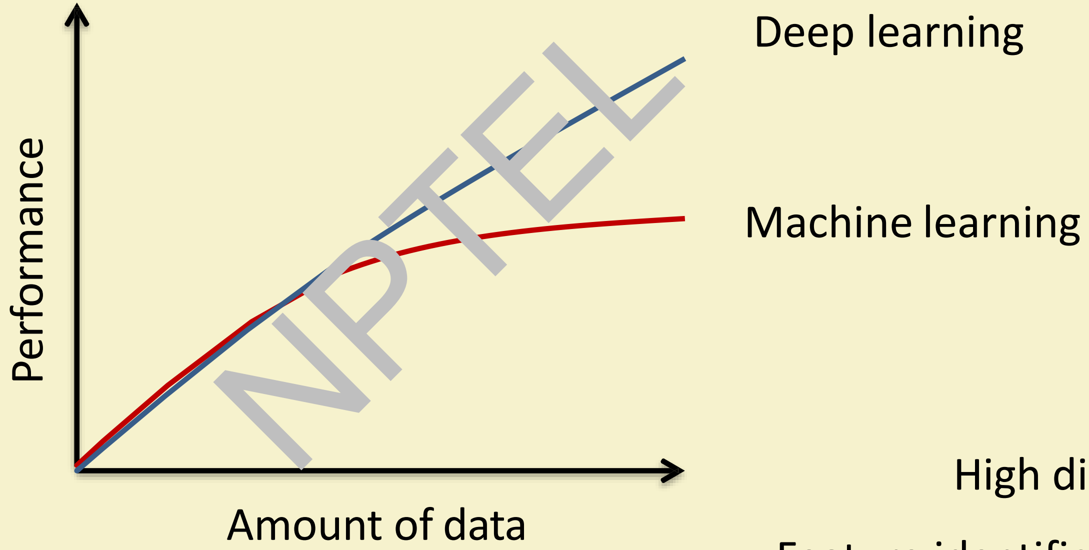
Source Edureka website
URL: https://www.edureka.co/blog/what-is-deep-learning

Limitations of Machine learning

1. ML algorithms are not useful for high dimensional data
2. Features have to be explicitly mentioned

Solution
Deep Learning

Limitations of Machine learning (cont..)



High dimensional data

Feature identification/extraction

Source Edureka website
Figure redrawn from URL: https://www.edureka.co/blog/what-is-deep-learning

Deep Learning

- It is a subfield of machine learning, capable to learn the right features by its own, basically mimics the working function of billions of neurons in our brain.

- Deep learning learns features by own
- Deep learning gives better performance like accuracy, when the amount of data is huge

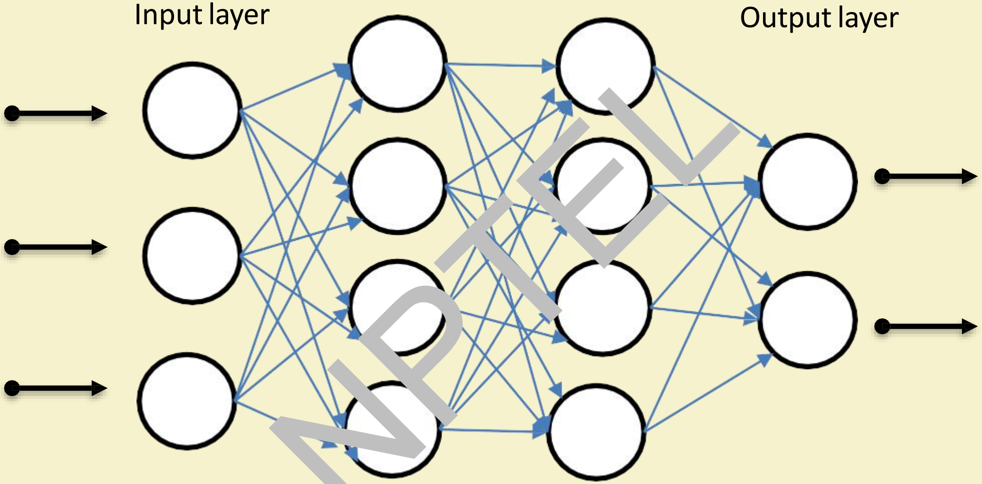
How it works

Deep learning : deep neural network

- Signals travel between neurons in artificial neural network
- In neural network, each neuron is assigned with weightage value
- A high weighted neuron exerts more effect on next layer than others
- Final layer combines all weighted inputs to emerge with a result

Source: Mathworks website
URL: https://in.mathworks.com/discovery/deep-learning.html

How it works (cont..)

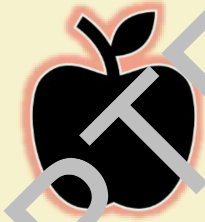


Deep refers to number of hidden layers, deep network can have up to 150 hidden layers

Source: Mathworks website Figure redrawn from URL: https://in.mathworks.com/discovery/deep-learning.html

Understanding analogies of Deep Learning

Let we want to recognize an *apple,*



- First check *shape* if **Yes**
- Then check *color* if **Yes**
- Then check its *taste* if **Yes**

Apple ✓

So it is a **nested hierarchy of concept**

Deep learning also follows the concept of nested hierarchy, it breaks the complex task into simple tasks

Difference between machine learning and deep learning

- Deep learning is an "end-to-end learning", which <u>extracts features on its own</u>. On the contrary, in machine learning <u>features are to be explicitly mentioned</u>.

- In deep learning performance level often improves as the size of the data increases, whereas in machine learning, shallow learning converges

Source: Mathworks website
URL: https://in.mathworks.com/discovery/deep-learning.html

Deep learning in IIoT

Impacts of deep learning in IIoT

IIoT × Deep learning

Improve speed

Improve accuracy

- For optimization of manufacturing lines in factories
- For stable operations of energy and transportation system
- For system shutdown in emergency

Reason for usefulness of deep learning in IIoT

The most important reasons that have made deep learning so useful <u>recently</u> are:

- Requires **large amount of labeled data**
- Requires **high end computational power**

Source: Mathworks website
URL: https://in.mathworks.com/discovery/deep-learning.html

Critical requirements of deep leaning in IIoT

The important factors required by deep learning methods in IIoT for solving critical issues

- Large ***Quantity*** of data

- High ***Quality*** and accuracy of reliable data

Source: TOSHIBA website
URL: https://www.toshiba-sol.co.jp/en/articles/tsoul/20/001.htm

Values provided by deep learning in IIoT

Three values provided by deep learning to customers in various business segments

1. Identification or recognition using cameras, sensors etc
2. Prediction/ Inference of human behavior
3. Autonomous decision control

Source: TOSHIBA website
URL: https://www.toshiba-sol.co.jp/en/articles/tsoul/20/001.html

Deep learning as strength of technology

TOSHIBA is using **Collaborative Distributed Deep Learning** technology between edge and cloud

Learning process is performed in cloud for high processing

Inference process is conducted in edge for real time processing

Source: TOSHIBA website
URL: https://www.toshiba-sol.co.jp/en/articles/tsoul/20/001.html

Deep learning as strength of technology (Contd...)

TOSHIBA →

- Improve yield and productivity in semiconductor factory
- Adopted drone navigation control system to find damage in power transmission line
- Predict behavior of workers in warehouses through wearable devices
- Forecasting power generation in solar power system

Source: TOSHIBA website
URL: https://www.toshiba-sol.co.jp/en/articles/tsoul/20/001.html

Deep learning as strength of technology (Contd…)

- **H2O** platform utilizes deep learning platform
- **Intel's** innovation **Nervana**, a deep learning processor
- **Zebra medical vision** systems is applying deep learning techniques

URL: https://www.h2o.ai/, https://ai.intel.com/, https://www.zebra-med.com/

References-I

1What is Deep Learning? Getting started with Deep Learning URL: https://www.edureka.co/blog/what-is-deep-learning

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https://www.kaggle.com/kanncaa1/deep-learning-tutorial-for-beginners

4 D. L. Poole, A. K. Macworth (2017). Artificial Intelligence. Cambridge University Press

5 R. Chopra (2012) Artificial Intelligence. S. Chand & Company Pvt. Ltd.

6 TOSHIBA, URL:https://www.toshiba-sol.co.jp/en/articles/tsoul/20/001.html

7H2O, URL:https://www.h2o.ai/, Intel URL: https://ai.intel.com/, Zebra-med https://www.zebra-med.com

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IIoT Analytics and Data Management: Cloud Computing in IIoT – Part 1

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Research Lab: cse.iitkgp.ac.in/~smisra/swan/

Introduction

- IIoT support for Industry 4.0
  - Sensing
  - Communication
  - Computing
  - Networking
- Achieves digitization in manufacturing and production process

Source: "Industry 4.0: The Industrial Internet of Things", Apress, 2016

IIoT and Big Data

- Digitization Process
  - Data acquisition
  - Asset management
  - Resource management
  - Knowledge management
- Bulk amount of data due to the time series data streams from end devices

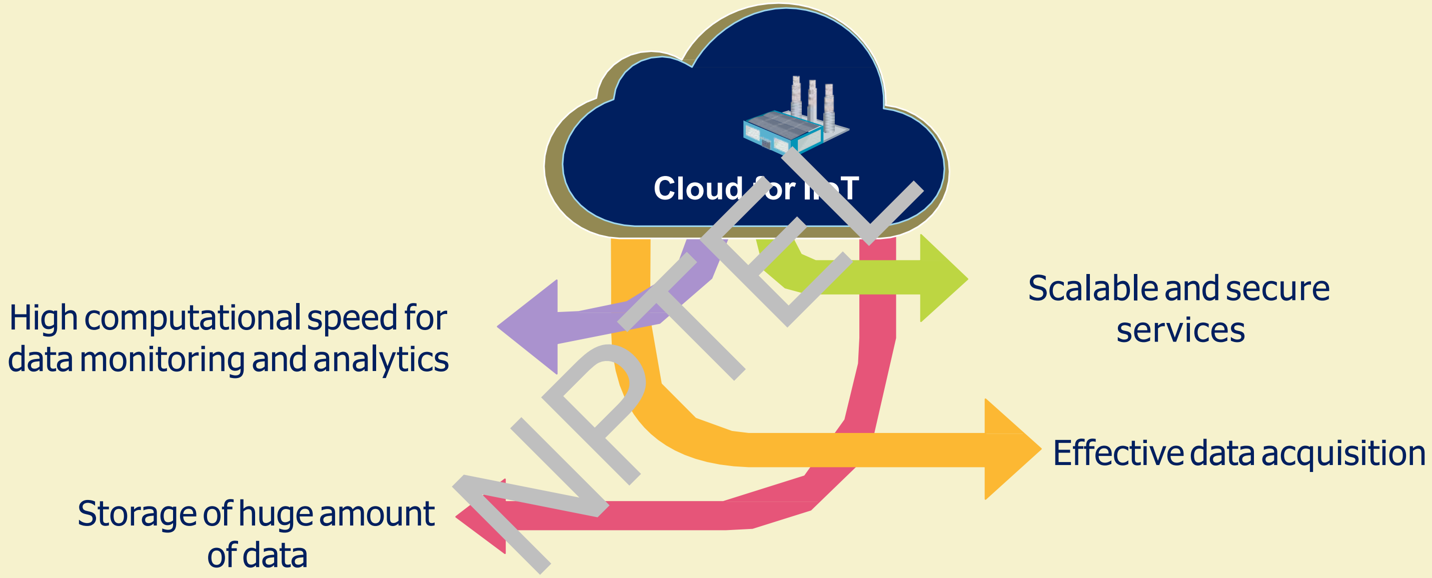
Source: "Industry 4.0: The Industrial Internet of Things", Apress, 2016

Need for Cloud

- Major concern to handle huge amount of data
- Nature of data
  - Unorganized
  - M2M sensor data
  - From heterogeneous big number of devices
  - Varying data quality

Source: "Industry 4.0: The Industrial Internet of Things", Apress, 2016

Need for Cloud (Contd.)



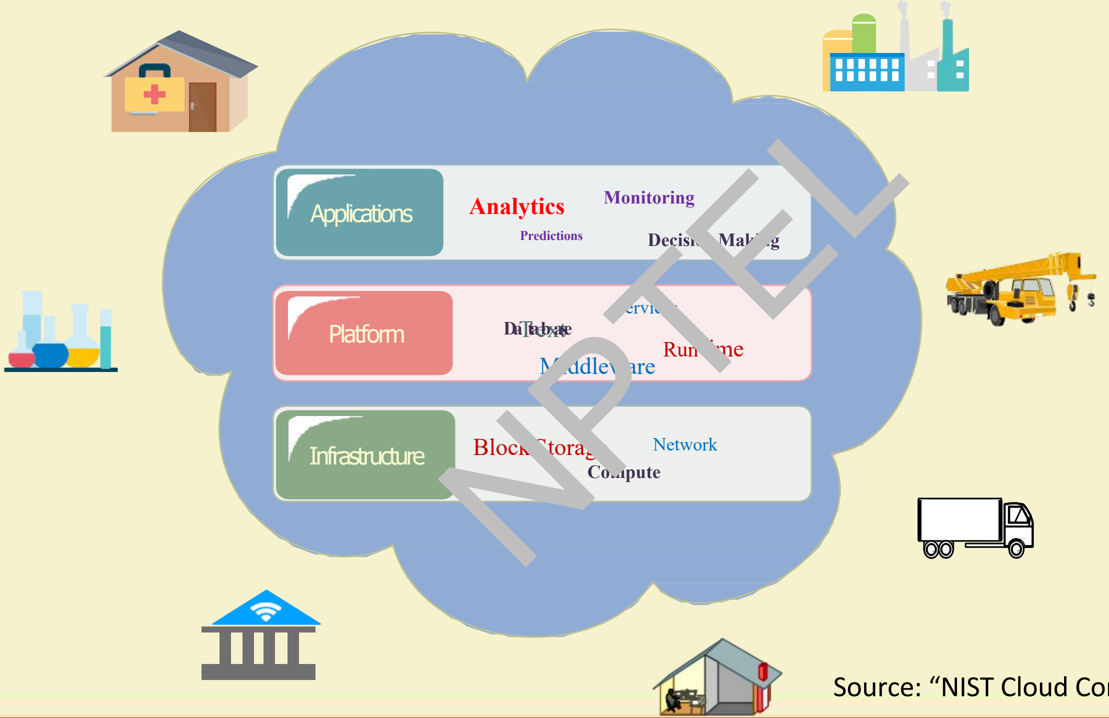
Source: "Industry 4.0: The Industrial Internet of Things", Apress, 2016

Cloud Computing – Basics

- Suitable for its scientific and business adaptability
- Fulfills the need of <u>what</u>, <u>when</u> and <u>where</u> solutions
- Secure storage and access
- Supports a coherent, expandable and coordinated business model
- Supports mobile devices

Source: "NIST Cloud Computing Reference Architecture", NIST

Cloud Computing



Source: “NIST Cloud Computing Reference Architecture”, NIST

Cloud Computing in IIoT: Services

- Three types of services: SaaS, PaaS and IaaS
- Software-as-a-Service (SaaS)
  - Industrial applications with web or program Interface
  - Subscribe-and-use feature to industry clients with final product
  - Everything managed by the service provider
  - Ex: Industrial Machinery Catalyst from Siemens is a SaaS for industrial use

Source: "NIST Cloud Computing Reference Architecture", NIST

Cloud Computing in IIoT: Services

- Platform-as-a-Service (PaaS)
  - Allows industries for self-development of applications
  - Clients have control over the application and the configuration environment
  - EX: Predix (GE), Sentience (Honeywell), and MindSphere (Siemens) are some industrial PaaS providers
  - Software firms like Cumulocity, Bosch IoT, and Carriots offer PaaS for IoT industries

Source: "NIST Cloud Computing Reference Architecture", NIST

Cloud Computing in IIoT: Services

- Infrastructure-as-a-Service (IaaS)
  - Access to the servers, network and storage and provisioning
  - Clients can use cloud to operate a virtual data center
  - Used to deploy PaaS and SaaS
  - Ex: Microsoft Azure, Google Compute Engine, IBM SmartCloud Enterprise, Rackspace Open Cloud, Amazon Web Services (AWS), etc.

Source: "NIST Cloud Computing Reference Architecture", NIST

Cloud Computing in IIoT: Deployment Models

Public

- Cloud set-up for use of any person or industry
- Virtualized resources are publicly shared
- Examples: Google Compute Engine, Amazon Web Service (AWS), Microsoft Azure, etc.

Private

- Cloud set-up for a single organization
- Virtualized resources are shared with the client only
- managed by the client itself or a third party
- Highly Secure

Hybrid

- Cloud set-up by two or more unique cloud set-up (private or public)
- Designed to have advantages of both private and public
- Flexibility for data and applications movement between private and public clouds

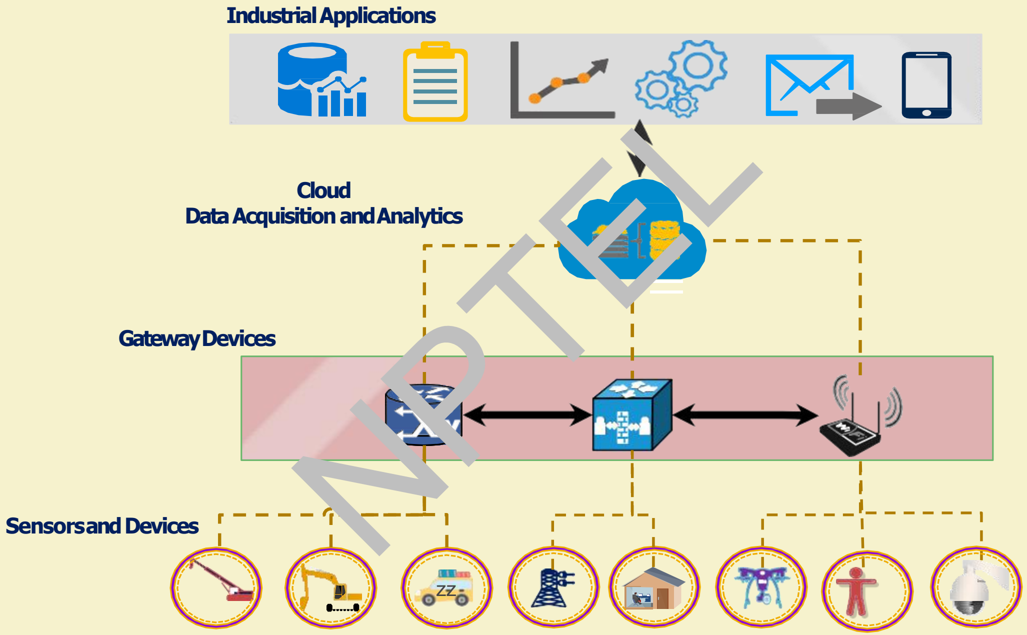
Source: "NIST Cloud Computing Reference Architecture", NIST

Cloud Computing in IIoT: End-users

- End-users are the industries who actually avail the cloud services
- Services differ form firm to firm based on their products and services
- Domain of use for IIoT lies in many areas like Healthcare, Transportation, Manufacturing plants, Refineries, Mining, Marine and many more.

Source: "Industry 4.0: The Industrial Internet of Things", Apress, 2016

Cloud-Based IIoT Architecture



Source: Gubbi et al., 2013

Cloud Computing in IIoT

- Industrial big data storage
- Heavy weight algorithms for data analytics
- Prediction of failures before occurrences
- Device provisioning and configuration remotely
- Real-time device monitoring
- Data privacy and security

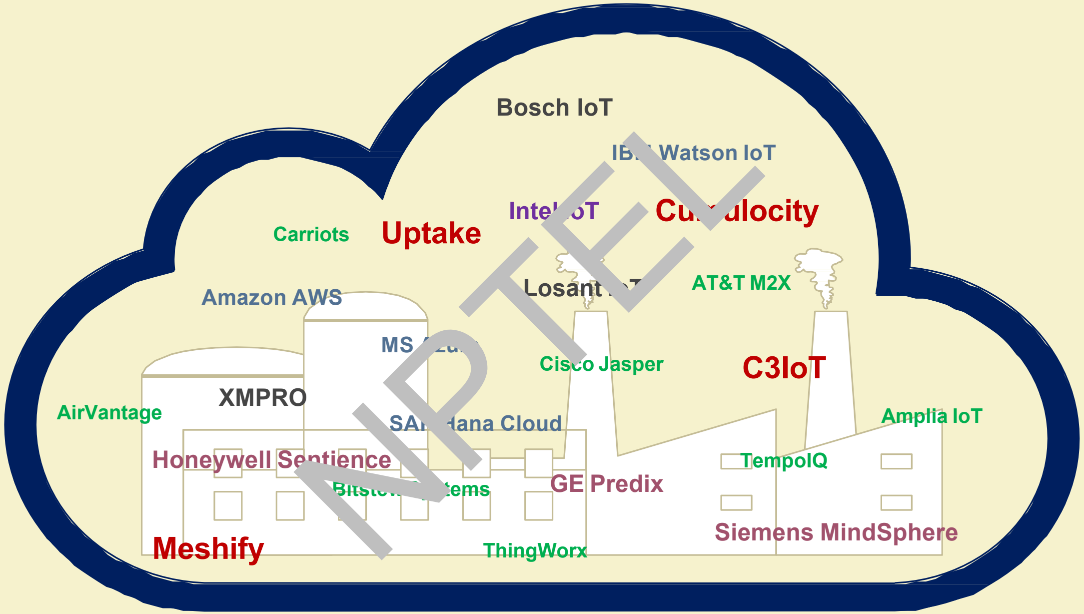
Source: "Industry 4.0: The Industrial Internet of Things", Apress, 2016

Consumer vs. Industrial IoT Cloud Platforms

- Consumer IoT cloud platform
  - Very specific applications for end users
  - Modest security
  - Cost sensitive
- Industrial IoT cloud Platform
  - Large number of data points
  - QoS
  - Robust security
  - Return on investment (ROI) sensitive

Source: "The Future of Industrial IoT", Industrial Internet Consortium

Industrial Cloud Platform Providers



Source: “The List of Industrial Cloud Platform Providers”, Element 14

Industrial Cloud Platform Providers: Our Discussion

- By industrial companies
  - GE Predix
  - Siemens MindSphere
  - Honeywell
- By Software development firms
  - C3 IoT
  - Uptake
  - Meshify

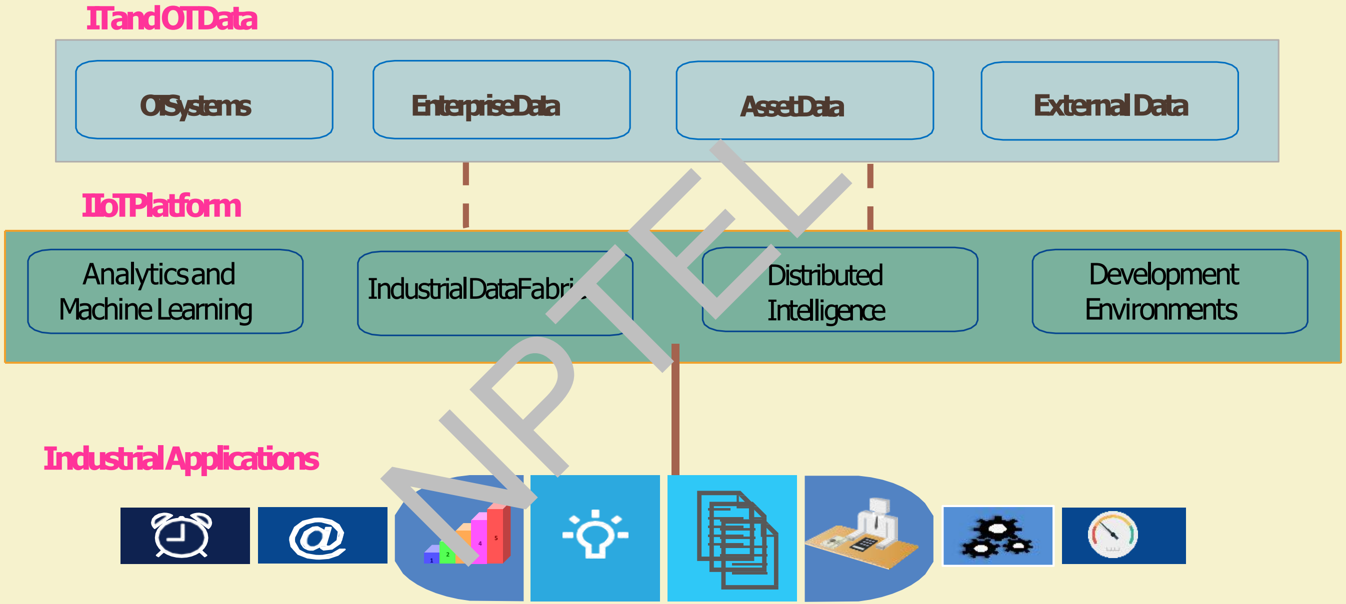
Source: "Will There Be A Dominant IIoT Cloud Platform?", Element 14

Predix

- Platform-as-a-service
- Tracking, management and enhancement of capital
- Defines the organization of the system and subassemblies components of services
- Enables differentiated functionalities of applications
- Digital Twin Technology for learning, estimating, optimizing and representation of assets

Source: "Industrial Capabilities of Predix", Predix

Predix (Contd.)



Source: "Industrial Capabilities of Predix", Predix

MindSphere

- Cloud-based operating system platform for IoT
- Open platform-as-a-service in addition to AWS cloud service
- Brings together IoT data from product, factory, machine and system to exploit the its prosperity
- Enterprise oriented solutions

Source: “MindSphere The cloud-based, open IoT operating system”, MindSphere

MindSphere (Contd.)

Features

- Security supports
- Procurement and distribution
- Various APIs for analysis
- Automated exploitation of performance and intelligence

Advantages

- Large system network
- Ecological industry solutions
- Extensive analysis and innovations along with Digital twins
- PaaS with cloud services

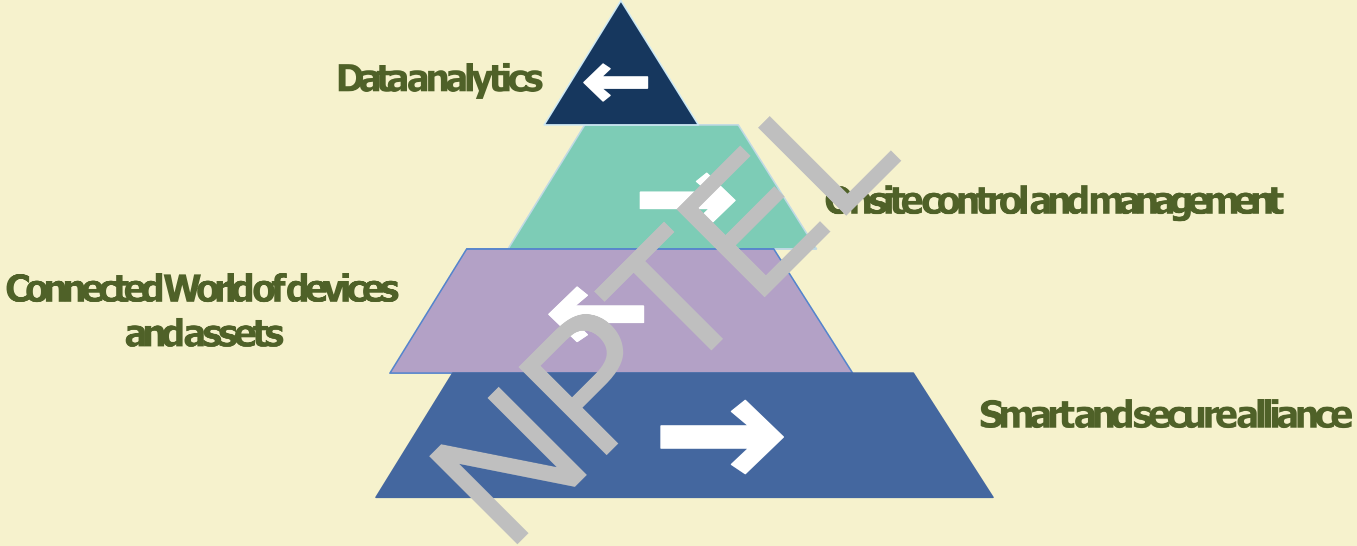
Source: "MindSphere The cloud-based, open IoT operating system", MindSphere

Honeywell

- Cloud software service for performance optimization
- Deeper insights of processes, driving agents and design skills
- Efficient solution for oil and gas industries
- Secure, scalable and standards-based platform
- Supports for SaaS business models

Source: "Honeywell Industrial Internet of things-Cloud Software", Honeywell

Honeywell (Contd.)



Source: “Honeywell Industrial Internet of things-Cloud Software”, Honeywell

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Thank You!!

IIoT Analytics and Data Management: Cloud Computing in IIoT – Part 2

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Industrial Cloud Platforms Providers: Our Discussion

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  - Meshify

Source: "Will There Be A Dominant IIoT Cloud Platform?", Element 14

C3 IoT

- Platform offers services including analysis and prediction
- Secure framework: authentication and authorization
- Artificial Intelligence powered analytical tools
- C3 Data Lake: Storage service for unstructured data in RESTful format

Source: "C3IoT: Products + Services Overview"

C3 IoT (Contd.)

- C3 IoT Platform tools
  - Data Integrator
  - IDE
  - Data Explorer
  - Analytics Designer
  - Ex Machina
  - Data Science Notebook
  - Type Designer

- C3 IoT SaaS Products
  - Predictive Maintenance
  - Inventory Optimization
  - Supply Network
  - Energy Management
  - Fraud Detection
  - Sensor Health

Source: "C3IoT: Products + Services Overview"

Uptake

- Enterprise solutions equipped with latest technologies to provide high value low cost
- Identifying the strength and goals of business through trade discussions
- Smarter ways of achieving the goal

Source: “Predictive Analytics Solutions for Global Industry l Uptake”, Uptake Digital

Uptake (Contd.)

Better resource utilization

- Effective cost computations
- Avoid replications
- Growth in production

Technological supports

- Build constant revenue flow for subscribed user services
- Automation and technological advancements
- Ease of buy and sell process

Customer satisfaction

- Secure services
- Smarter storage solutions
- Compliance with legal rules and regulations

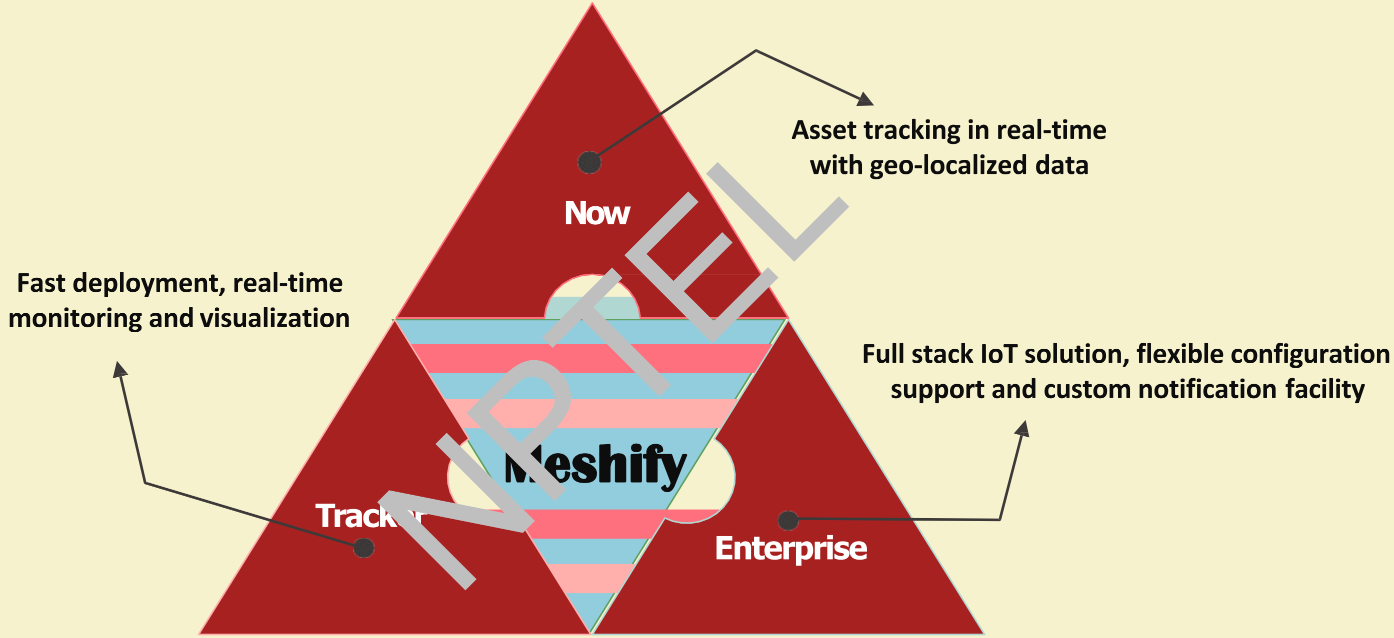
Source: “Predictive Analytics Solutions for Global Industry l Uptake”, Uptake Digital

Meshify

- Provides industrial IoT platform
- Faster development and deployment processes
- Real-time monitoring
- Low-cost solutions
- Solutions:
  - Now
  - Tracker
  - Enterprise

Source: "Meshify - Complete IoT Solution", Meshify

Meshify (Contd.)



Source: "Meshify - Complete IoT Solution", Meshify

Cloud-Platform for Device Management

- Need for device management:
  - Increase in number of devices makes an IIoT ecosystem more complex
  - Not deploy and forget scenario for installed devices
  - Change in standards and services
  - Replacement of faulty devices
  - Security requirement
- Device management is dependent on few other functionalities
- Better way to keep device management service at cloud

Source: "Fundamentals of IoT device management", IoT Design

Cloud-Platform for Device Management

- Features that cloud platform provider should offer for device management:
  - Provisioning and authentication
  - Fault diagnosis and monitoring
  - Updates, security patches and maintenance
  - Configuration and control
  - Device decommission

Source: “Fundamentals of IoT device management”, IoT Design

Cloud-Platform for Device Management

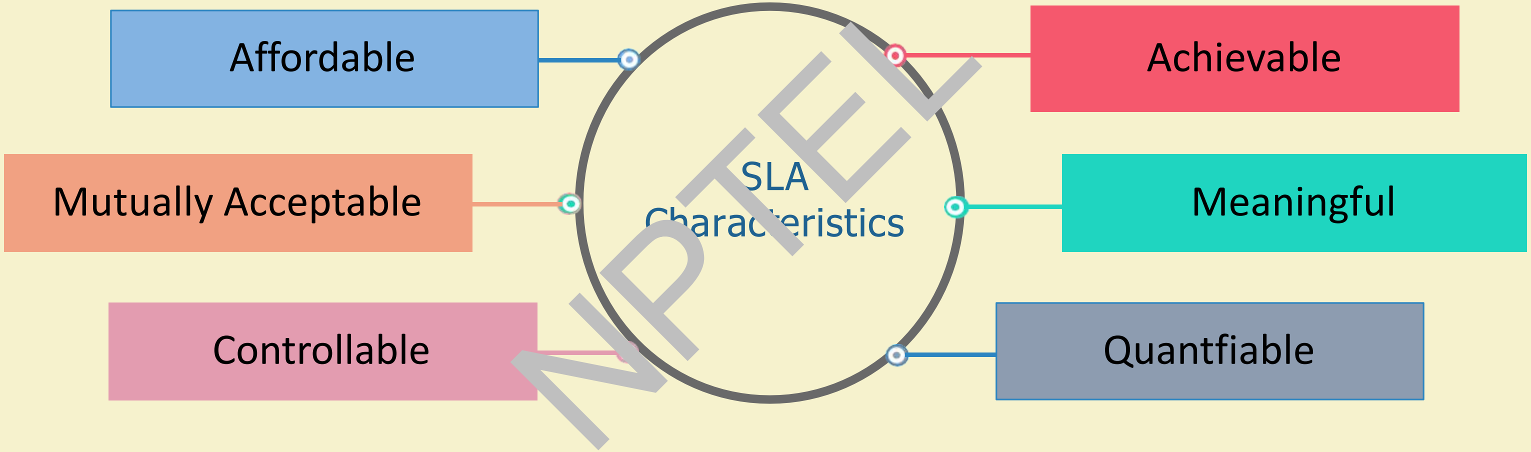
- Example of cloud platform providers with device management facility:
  - Bosch IoT Remote Manager
  - AWS's IoT Device Management
  - Verismic's Cloud Management Suite
  - ICP DAS's IoTstar
  - Software AG's Cumulocity

Service Level Agreement (SLA) for IIoT

- Many IIoT applications are real-time and include safety measures
- Framework should achieve the goals as per plan
- Services should be as per the agreement with cloud provider
- A SLA helps the cloud provider in promising the deliverables
- SLA helps the industrial client to check what and how good the cloud provider gives service

Source: Papadopoulos et al. , 2017

Characteristics of a Good SLA



Source: Sturm et al., 2000

Current Status and Future of SLAs in IIoT

- SLA complied cloud service in IIoT is at infant stage for following reasons:
  - Quality of services offered has interdependencies
  - Methodologies and frameworks of IIoT are not well developed
  - Life cycle management of an SLA in industrial context is not clear
  - Lack of SLA enforcement policies for both provider and consumer
- SLA support for IIoT is crucial along with business models
- Future IIoT needs a standardization of SLA and its management

Source: Papadopoulos et al. , 2017

Choosing the Right Cloud Vendor for IIoT

- Cloud is the heart of an IIoT ecosystem and choosing the correct platform is crucial
- Market of Many cloud vendors available with similar services
- A proper checklist of needs and cross checking with services from vendors

Source: "Top 10 selection criteria to choose your IoT platform", IOTIFY

Choosing the Right Cloud Vendor for IIoT

- Points to consider:
  - Scalability support
  - Bandwidth requirement
  - Communication protocols
  - Security
  - Interoperability
  - Edge Intelligence feature
  - Infrastructure management

Source: “Top 10 selection criteria to choose your IoT platform”, IOTIFY

Limitations in Cloud-Based Approach

- Volume, velocity and variety
- Higher latency
- Bandwidth requirement for huge data volume
- Reliability for the big network
- Need for scalable security

Source: “Introduction to Edge Computing in IIoT”, Industrial Internet Consortium

Centralized vs. Decentralized Approach

- Cloud based centralized approach suffers from many limitations
- Decentralized approach decreases the load at cloud
- Real-time operations feasibility
- More scalable IIoT network and features
- Greater mobility support

Source: "Today's Centralized Cloud And The Emerging Decentralized Edge", Forbes

Industry 4.0 Objectives

- Robust solutions
- Higher production
- Better Customer satisfaction
- Expanded security
- Better performance
- Entire world of industry at one place

Source: “Industry 4.0: The Industrial Internet of Things”, Apress, 2016

Industry 4.0 Requirements from IIoT

- Aims to achieve greater production, optimized decisions, efficiency and availability
- Deeper insights of analysis and prediction
- Establishing a connected world of machines, systems, products and environments
- Collection of data from each sector and performing analytics to exploit the wealth at its best

Source: "Industry 4.0: The Industrial Internet of Things", Apress, 2016

Solution

- A Decentralized or distributed approach along with cloud
- Handling time-sensitive data
- Immediate action and quick response
- Delay in proper action at proper time may create hazardous situation
- Thus, Fog emerges to be a solution

Source: "Introduction to Edge Computing in IIoT", Industrial Internet Consortium

Fog Computing

- An added layer between the edge and the cloud layer
- Not a replacement but an addition to cloud
- Identify useful data thus reducing the amount of raw data sent to cloud
- Increased scalability with reduced traffic

Source: Bonomi et al., 2014

Fog Computing (Contd.)

- Intelligent devices deployed at edge
- Intelligent compute devices known as fog nodes
- Intelligent in providing services like filtering, aggregation and translation
- Distributed at one level, centralized on the other

Source: Bonomi et al., 2014

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