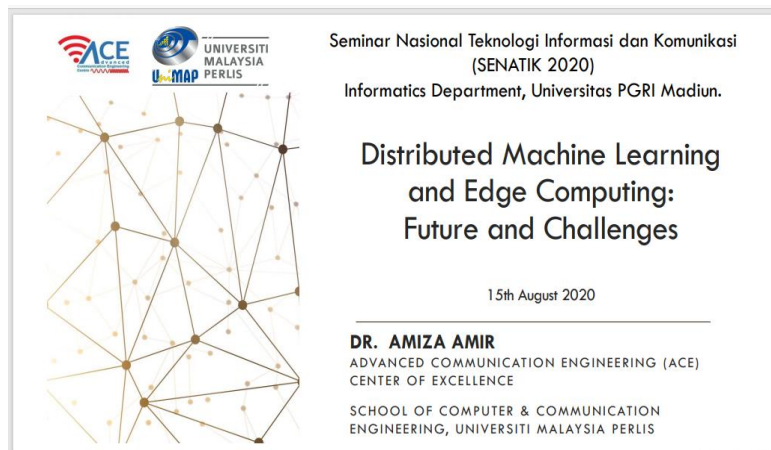


MATERI SEMINAR NASIONAL TEKNOLOGI INFORMASI DAN KOMUNIKASI (SENATIK 2020)

Oleh Pemateri 1

Dr. Amiza Amir

Advanced Communication Engineering (ACE) Center Of Excellence
School Of Computer & Communication Engineering, Universiti Malaysia Perlis



The Future of Edge Computing

According to market research group IDC, companies in many industries around the globe are embracing edge computing and hybrid multicloud. By 2023, the cloud industry is expected to grow to \$652 billion, with edge networks representing 60% of all deployed infrastructures.

Source: <https://www.equinox.nl/resources/webinars/idc-predictions-cloud-edge-computing-2020/>

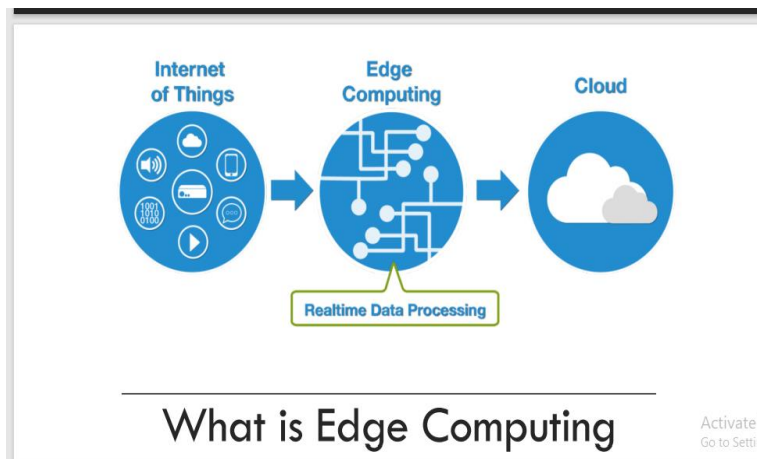
What is Edge Computing

Microsoft: "Edge computing is where compute resources, ranging from credit-card-size computers to micro data centers, are placed closer to information-generation sources, to reduce network latency and bandwidth usage generally associated with cloud computing"

Source: <https://www.microsoft.com/en-us/research/project/edge-computing/>

Research firm IDC: "mesh network of micro data centers that process or store critical data locally and push all received data to a central data center or cloud storage repository, in a footprint of less than 100 square feet."

Source: <https://www.cbinsights.com/research/what-is-edge-computing/>



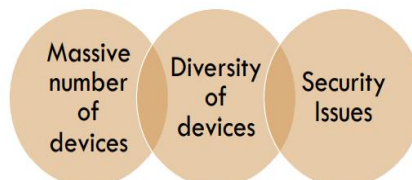
What is Edge Computing

What is Edge Computing

Edge Devices	Edge Servers	Network Edge	Cloud
<ul style="list-style-type: none"> • piece of equipment for a specific function (e.g. robot, car, turbine engine) • IoT Devices with more compute capacity. 	<ul style="list-style-type: none"> • piece of IT equipment for the purpose of computing IT workload (servers, industrial PC) 	<ul style="list-style-type: none"> • facility to bring workload into the network. • Empowered by 5G 	<ul style="list-style-type: none"> • where we end up storing the data. • Aggregate, trend analytics

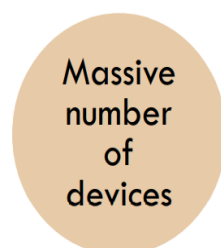
How to make sure the right workloads are placed at the right place at the right time?

Edge Computing Challenges



How to make sure the right workloads are placed at the right place at the right time?

Edge Computing Challenges



In 2020 - 50 billion devices

Source: Talk by Gary Davis of McAfee Inc at the 2018 IEEE International Conference on Consumer Electronics (ICCE)

By 2021, 35 billion devices

Source: Security Today

By 2025, 41.6 billion connected devices, generating 79.4 zettabytes (ZB). Source: IDC

By 2030, 125 billion devices

Source: Martech Advisor

Edge Computing Challenges

- Edge devices outside the boundary without security protection as in IT data center.
- IoT-based DDoS attacks (e.g. Mirai malware)?
- More 5G IoT devices will connect directly to the 5G network than via a Wi-Fi router → more vulnerable to direct attack

Security Issues

- How to ensure the the workload does not get tempered?
- How to ensure the security against the IoT-based attacks?
- How to ensure that we can detect any attacks and response to immediately?
- How to ensure the data associated with the workload is properly protected?

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Edge Computing Challenges


Diversity of devices


- Different purpose, utility
- Different Operating System
- Different compute capability

Edge Computing: Benefits

 Speed and fast data analysis

 Balance network traffic

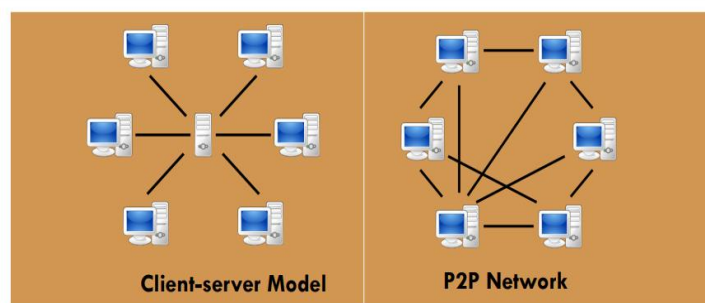
 Lowered operational cost

 Security

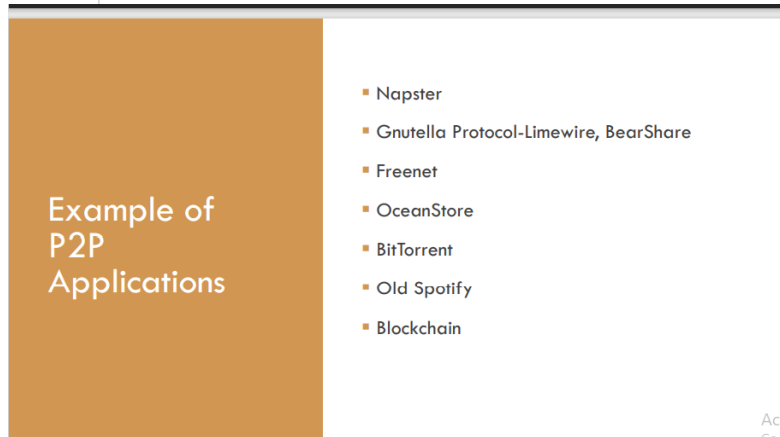
 Improve reliability

 Scalability

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Peer-to-peer(P2P) Networks



Example of P2P Applications

- Napster
- Gnutella Protocol-Limewire, BearShare
- Freenet
- OceanStore
- BitTorrent
- Old Spotify
- Blockchain

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Edge Computing: The Reincarnation of P2P?

- Massive number of nodes that may prevent centralized management.
- Edge nodes are heterogeneous and their availability may be limited.
- Edge devices are privately owned, and operate according to "selfish" objectives.
- A large portion of storage and computation takes place at the bottom layers of the edge hierarchy.
- Untrusted edge devices and unsecure connections present a plethora of security threats.

Source: G Yadgar, O Kolosov, MF Aktas, E Soljanin
2nd USENIX Workshop on Hot Topics in Edge Computing (HotEdge 19)

Edge Computing: The Reincarnation of P2P?

"reincarnation of the P2P model: larger in scale, with enhanced capabilities, and, most importantly, without a feasible alternative."

Source: G Yadgar, O Kolosov, MF Aktas, E Soljanin
2nd USENIX Workshop on Hot Topics in Edge Computing (HotEdge 19)

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Edge Computing: The Reincarnation of P2P?



Utilizing breakthrough in P2P network in solving edge computing issues

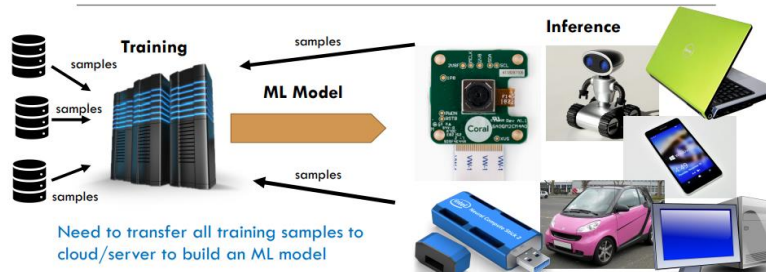


Revisit distributed computing challenges in P2P



Potential distributed data mining/machine learning on edge computing based on previous P2P studies?

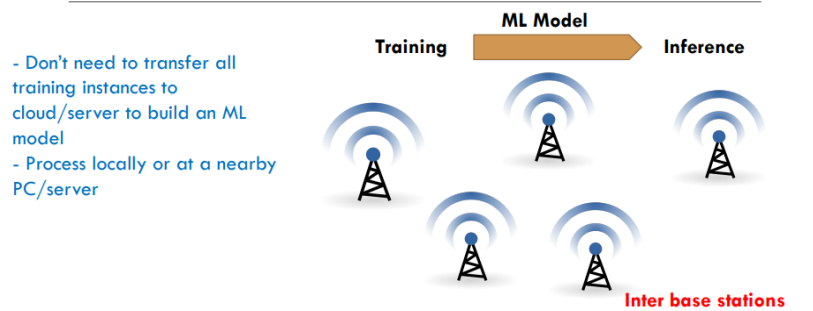
Machine Learning in Edge Computing



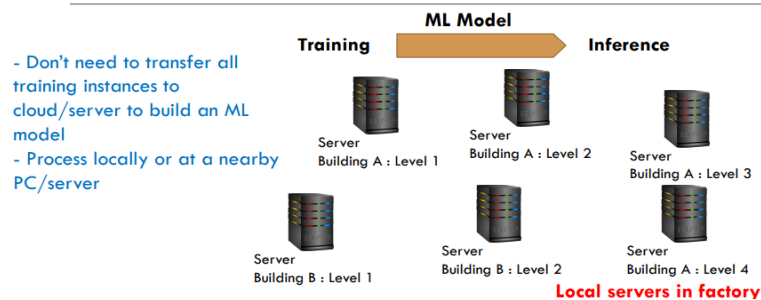
Distributed Machine Learning in Edge Computing?



Distributed Machine Learning in Edge Computing?



Distributed Machine Learning in Edge Computing?



Why people work on distributed machine learning?



to speed up the computation—divide & conquer, parallel processing.



to improve the classification accuracy - to iteratively build a more accurate classifier from many classifiers - ensemble learning or a multi-classifier approach is used.



building a global classifier from a large, naturally distributed network.



to improve the system scalability in dealing with large datasets without sending all data to cloud. - P2P Cloud system, edge computing

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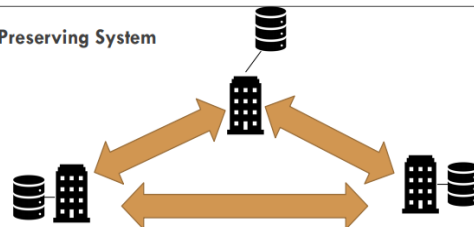
Distributed Machine Learning within Large Networks: Motivation

- **In naturally-distributed environment:** to process the data locally at their locations without moving entire raw datasets to a single location.
- **An economical alternative for large-scale pattern classification (P2P Cloud):** we may use the available computational resources (e.g., P2P computing) to develop such system.
- Our dependence on expensive high performance servers and cloud-based system can be reduced drastically
- **Blockchain**
- **Edge computing**



Distributed Machine Learning within Large Networks: Motivation

- **Privacy Preserving System**



Compare and analyze data from different organizations without disclosing the private data to any other party

Structured or Unstructured Distributed ML System

Well-structured into a **fixed architecture**

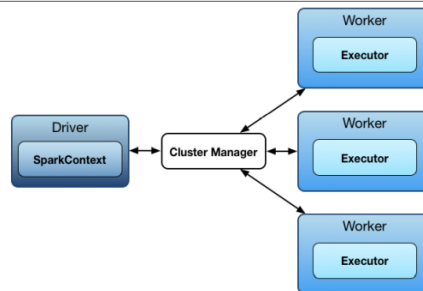
- usually designed to improve accuracy, speed up computation and process large datasets.

Unstructured system with **dynamic architecture**

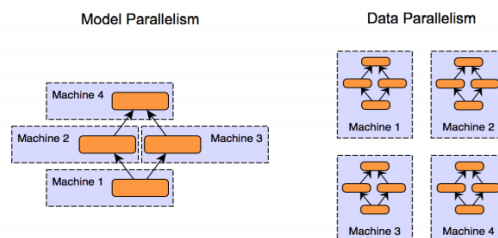
- expands and shrinks depending on the network
- usually used for large distributed networks.

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Distributed ML within Well-Structured Architecture



Distributed ML within Well-Structured Architecture

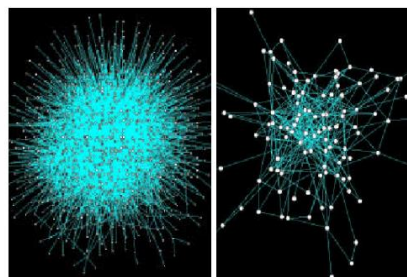


Qi, Xiandong (2017). Intro Distributed Deep Learning
<https://xiandong79.github.io/Intro-Distributed-Deep-Learning>

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Distributed Machine Learning within Large Networks: Challenges

What about large and unstructured networks?



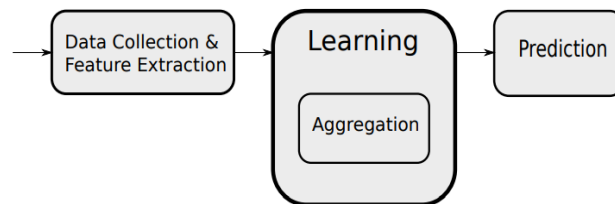
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Distributed Aggregation

- How to combine models/inference?
- Calculate global statistics to combine results from distributed sites.
- Within large networks, distributed aggregation is usually aims to obtain an approximation of global statistics instead of exact values.

Distributed aggregation problems

During learning - to obtain a global classifier C_{G_P} which represents the generalisation of training datasets from all nodes in G_P , $C_{G_P} = \mathcal{C}(\mathcal{D}_{G_P}) = \bigcup_{i \in G_P} \mathcal{D}_i$ where \mathcal{D}_i is the training dataset at node i ; or $C_{G_P} = \bigcup_{i \in G_P} C_i$ where C_i is a local classifier at node i .

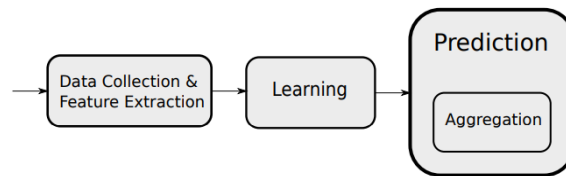


Components of Distributed Machine Learning

AGGREGATION DURING LEARNING

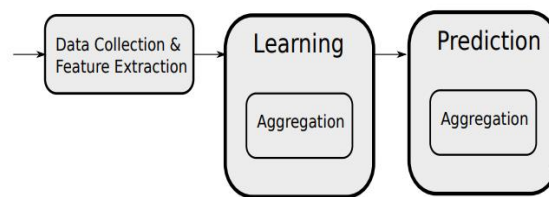
Distributed aggregation problems

During classification - to obtain a global classification result \hat{R}_{G_P} which represents the generalisation of local results from all nodes in G_P , $\hat{R}_{G_P} = \bigcup_{i \in G_P} \hat{r}_i$ where \hat{r}_i is a local classification result at node i .



Components of Distributed Machine Learning

AGGREGATION DURING PREDICTION



Components of Distributed Machine Learning

AGGREGATION DURING LEARNING AND PREDICTION

Distributed ML
 Topologies
 within a Large
 Distributed
 System

semi-distributed : a single host to coordinate or perform some parts of the computation while some parts of the computation are performed in distributed among nodes.

Cluster-based : a group of nodes (which form a cluster) perform a fully-distributed computation in collaboration among nodes within the group.

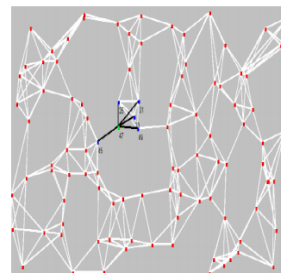
local algorithm : every nodes builds its own global classifier or prediction by communicating with a small set of nodes.

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Locality Sensitive Distributed Algorithm

Local algorithms: communication within the local neighborhood.

Global algorithms : know everything about the entire network.



Source: [Distributed data mining in peer-to-peer networks](#)
 S Datta, K Bhaduri, C Giannella, R Wolff, H Kargupta -
 IEEE internet computing, 2006

Distributed Machine Learning within Large Networks: Challenges



HIGH TRAINING
COMPLEXITY OF MACHINE
LEARNING MODEL



LARGE TOTAL DATA



FREQUENT DATA UPDATE
(HIGH COMMUNICATION
OVERHEAD)

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Distributed Machine Learning within Large Networks: Challenges



HETEROGENEOUS
NETWORKS



DYNAMIC
NETWORKS



LARGE NETWORK
SIZE

Distributed Machine Learning within Large Networks: Challenges



IMBALANCED DATA
DISTRIBUTION



ASYNCHRONOUS
NETWORK



SECURITY

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Efficient Learning

A distributed algorithm performs efficient learning when it:

- i. has a low learning time at each local classifiers and
- ii. has a low learning time at the network level.

Distributed Machine Learning within Large Networks: Requirement

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Lack of synchronisation

The algorithm should have a lack of synchronisation to fit in the asynchronous network.

Distributed Machine Learning within Large Networks: Requirement

Scalability within Large Networks

A distributed algorithm is network-scalable if the communication per host is independent of the network size (N).

Distributed Machine Learning within Large Networks: Requirement

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Model Update with Low Communication Overhead

Only significant updates among nodes must be shared, i.e. updates that has an effect during learning.

Reduce the frequency of data sharing (statistics, models of complex models) among nodes.

Distributed Machine Learning within Large Networks: Requirement

Scalability For Large Dataset

- Algorithm needs to be communication-efficient and resource-efficient in dealing with a large number of training data and a high-dimensional dataset (a dataset with a large number of attributes).
- Can be measured based on its resource efficiency per peer and its communication efficiency for large dataset

Distributed Machine Learning within Large Networks: Requirement

Fault-tolerance

Mapping an algorithm on a dynamic network requires a fault-tolerance approach to ensure a constant availability and accuracy of the prediction.

Distributed Machine Learning within Large Networks: Requirement

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Security

- Incorporating security into distributed system design.
- Include security to be undertaken at every level (network level, device level)
- Encryption, patching and the use of artificial intelligence to monitor for, detect and respond to potential threats are all essential.

Distributed Machine Learning within Large Networks: Requirement

Future Research

Future Research



Work on Cloud P2P-based computing platform.



Distributed algorithm on edge computing.



Improving the efficiency (communication and run-time)



Study a fully-distributed data collection and analysis, feature extraction and selection, and training dataset preparation (labelling process).



Study on the effect of imbalanced data distribution

Future Research



Improving efficiency of task allocation and scheduling



Study the potential network threats and improve the algorithm's robustness against network attacks



Work on distributed multi-label problems



Thanks for listening and
we are looking forward for future
collaboration!!!