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NPTEL ONLINE CERTIFICATION COURSES

Fog Computing – Part I

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Introduction

- ✓ Fog computing or fogging is a term coined by CISCO.
- ✓ The idea of fog computing is to extend the cloud nearer to the IoT devices.
- ✓ The primary aim: solve the problems faced by cloud computing during IoT data processing.
- ✓ an intermediate layer between cloud and devices.

Introduction (contd.)

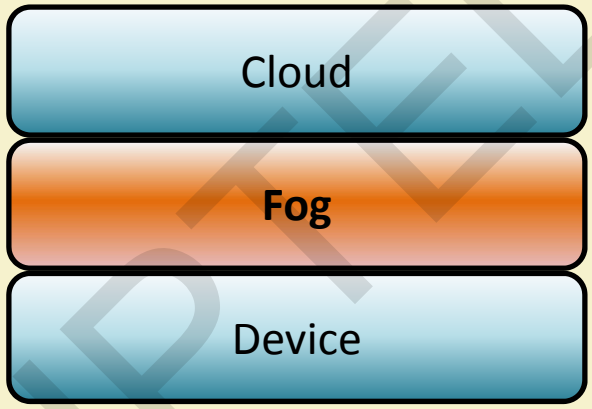


Fig. Fog as intermediate layer between cloud and device

Introduction (contd.)

- ✓ 40% of the whole worlds data will come from sensors alone by 2020.
- ✓ 90% of the world's data were generated only during the period of last two years.
- ✓ 2.5 quintillion bytes of data is generated per day.
- ✓ total expenditure on IoT devices will be $1.7 Trillion by 2020

Introduction (contd.)

- ✓ the total number of connected vehicles worldwide will be 250 millions by 2020.
- ✓ there will be more than 30 billion IoT devices
- ✓ The amount of data generated by IoT devices is simply huge.

Why Fog Computing

- ✓ The ability of the current cloud model is insufficient to handle the requirements of IoT.
- ✓ Issues are:
  - ✓ Volume
  - ✓ Latency
  - ✓ Bandwidth

Why Fog Computing (contd.)

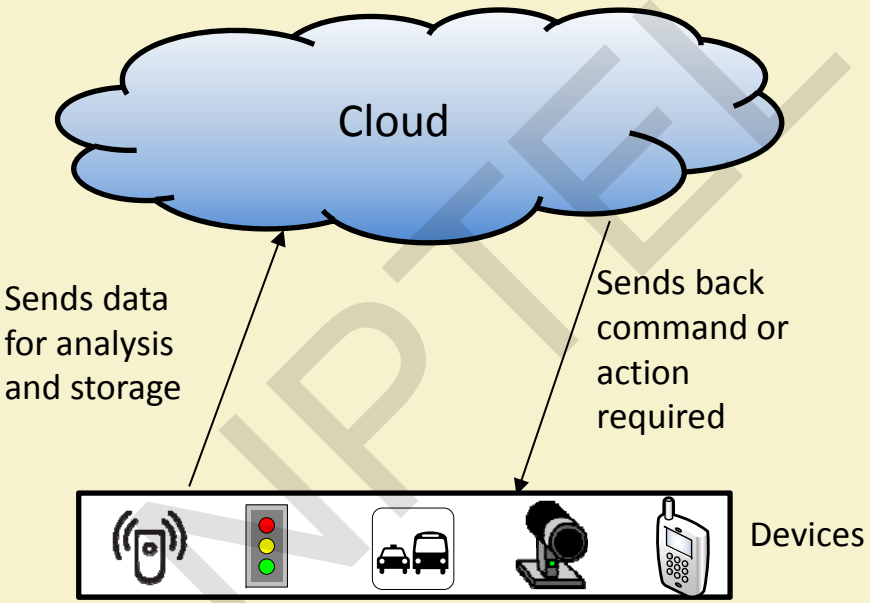


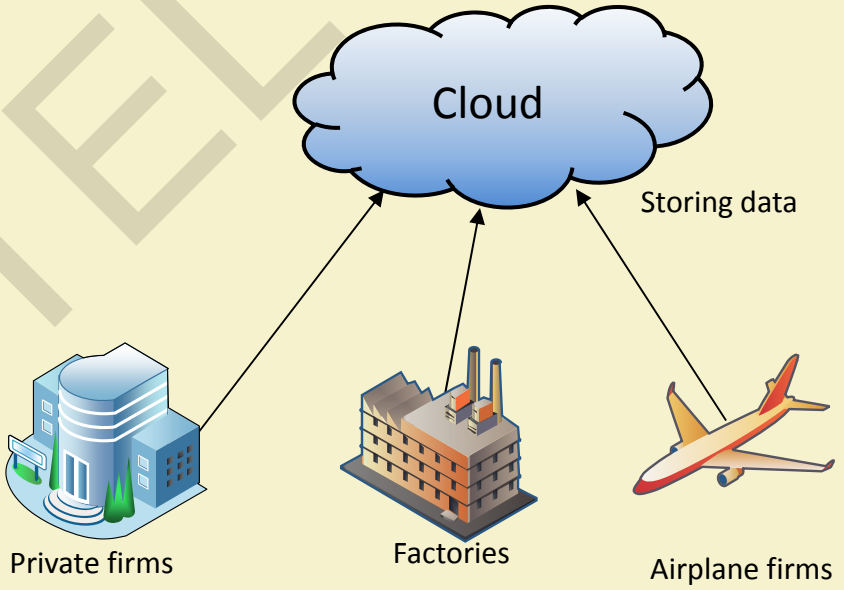
Fig.1: Present day cloud model

Why Fog Computing (contd.)

- ✓ Data Volume:
  - ✓ By 2020, about 50 billion devices will be online.
  - ✓ Presently billions of devices produce exabytes of data everyday.
  - ✓ Device density is still increasing everyday.
  - ✓ Current cloud model is unable to process this amount of data.

Why Fog Computing (contd.)

- ✓ Private firms, Factories, airplane companies produces colossus amount of data everyday
- ✓ Current cloud model cannot store all these data
- ✓ Data need to be filtered



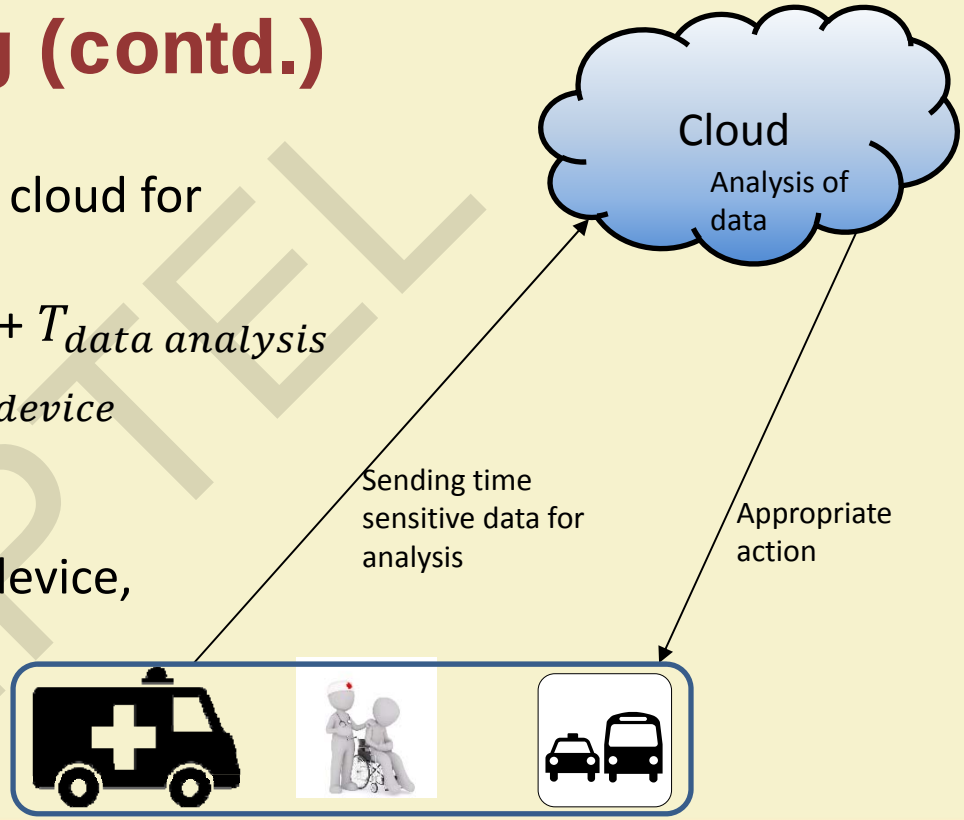
Why Fog Computing (contd.)

- ✓ Latency
  - ✓ Time taken by a data packet for a round trip
  - ✓ An important aspect for handing a time sensitive data.
  - ✓ If edge devices send time sensitive data to cloud for analysis and wait for the cloud to give a proper action, then it can lead to many unwanted results.
  - ✓ While handling time sensitive data, a millisecond can make a huge differences.

Why Fog Computing (contd.)

- ✓ Sending time-sensitive data to cloud for analysis
- ✓ Latency = $T_{from\ device\ to\ cloud} + T_{data\ analysis} + T_{from\ cloud\ to\ device}$

  where T = Time
- ✓ Latency will be increased
- ✓ When the action reaches the device, accident may have already occured

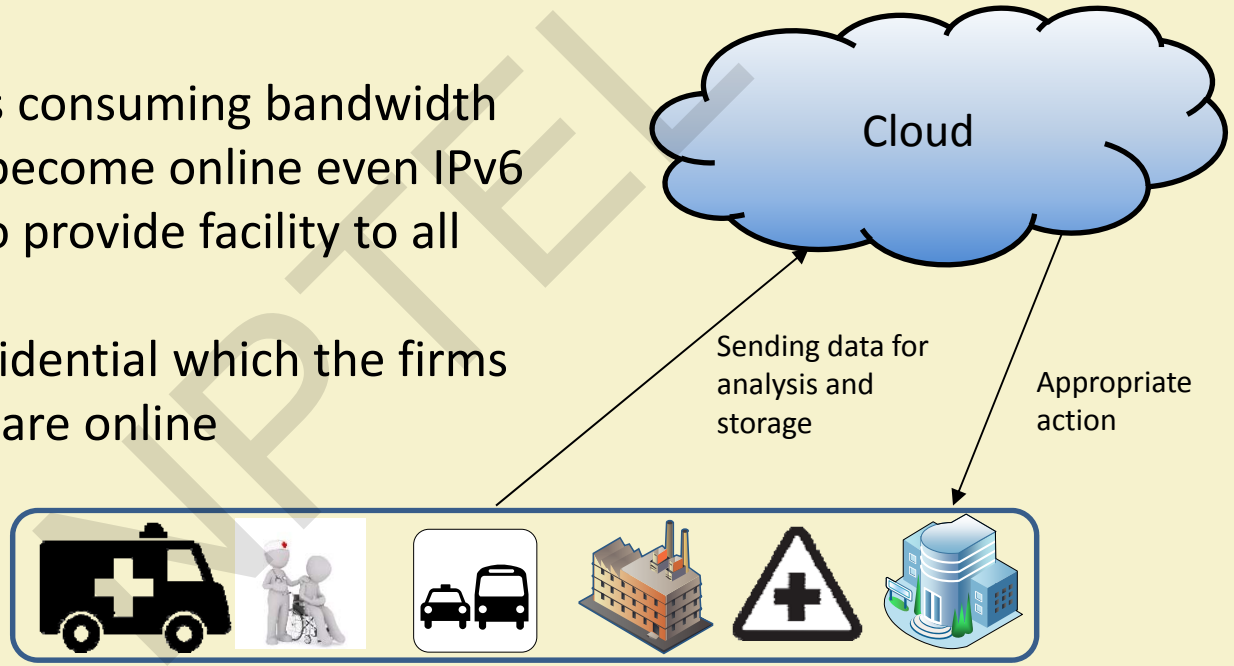


Why Fog Computing (contd.)

- ✓ Bandwidth:
  - ✓ Bit-rate of data during transmission
  - ✓ If all the data generated by IoT devices are sent to cloud for storage and analysis, then, the traffic generated by these devices will be simply gigantic.
  - ✓ consumes almost all the bandwidths.
  - ✓ Handling this kind of traffic will be simply a very hard task.

Why Fog Computing (contd.)

- ✓ Billions of devices consuming bandwidth
- ✓ If all the devices become online even IPv6 will not be able to provide facility to all the devices
- ✓ Data may be confidential which the firms do not want to share online



Requirements of IoT

- ✓ Reduce latency of data:
  - ✓ Appropriate actions at the right time prevents major accidents machine failure etc.
  - ✓ A minute delay while taking a decision makes a huge difference
  - ✓ Latency can be reduced by analyzing the data close to the data source

Requirements of IoT (contd.)

- ✓ Data security:
  - ✓ IoT data must be secured and protected from the intruders.
  - ✓ Data are required to be monitored 24x7
  - ✓ An appropriate action should be taken before the attack causes major harm to the network

Requirements of IoT (contd.)

- ✓ Operation reliability:
  - ✓ The data generated from IoT devices are used to solve real time problem
  - ✓ Integrity and availability of the data must be guaranteed
  - ✓ Unavailability and tampering of data can be hazardous

Requirements of IoT (contd.)

- ✓ Processing of data at respective suitable place:
  - ✓ Data can be divided into three types based on sensitivity
    - ✓ time sensitive data
    - ✓ less time sensitive data
    - ✓ data which are not time sensitive
  - ✓ Extremely time sensitive data should be analyzed very near to the data source
  - ✓ Data which are not time sensitive will be analyzed in the cloud.

Requirements of IoT (contd.)

- ✓ Monitor data across large geographical area:
  - ✓ The location of connected IoT devices can be spread across a large geographical region
  - ✓ E.g. monitoring the railway track of a country or a state
  - ✓ the devices are exposed to the harsh environments condition

When should we use fog

- ✓ If the data should ne analyze with fraction of second
- ✓ If there are huge number of devices
- ✓ If the devices are separated by a large geographical distance
- ✓ If the devices are needed to be subjected to extreme conditions

Thank You!!

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Fog Computing – Part II

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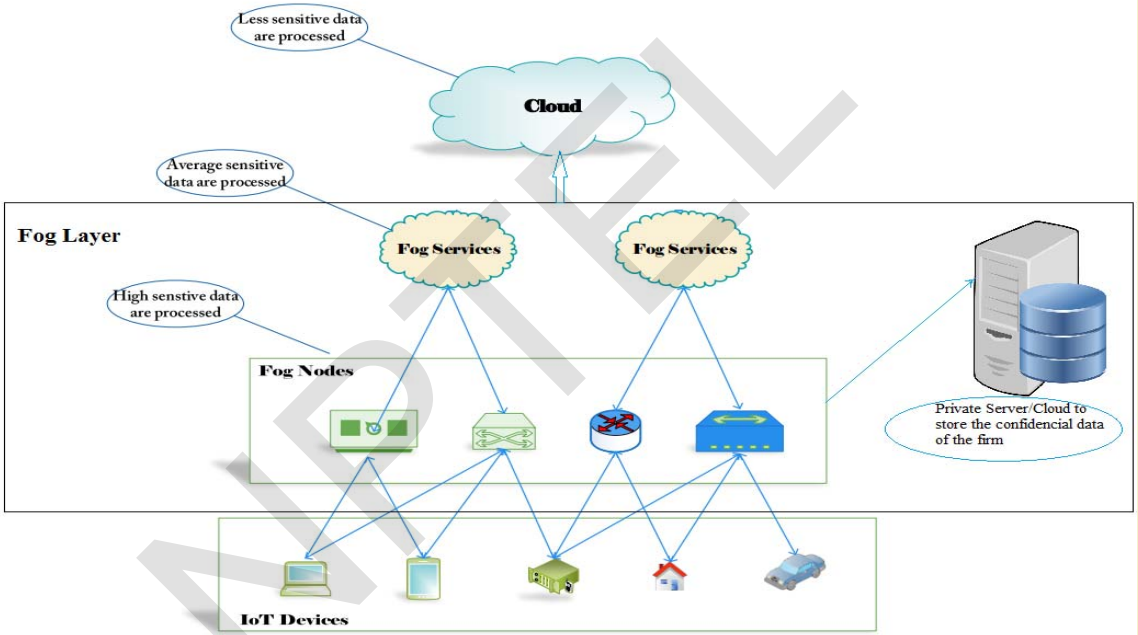
Architecture of Fog

- ✓ Cloud services are extended to IoT devices through fog
- ✓ Fog is a layer between cloud and IoT devices
- ✓ many fog nodes can be present
- ✓ Sensor data are processed in the fog before it is sent to the cloud
- ✓ Reduces latency, save bandwidth and save the storage of the cloud

Architecture of Fog (contd.)



Fog nodes

- ✓ Characteristics for a fog node:
  - ✓ Storage - To give transient storage
  - ✓ Computing facility
    - To process the data before it is sent to cloud
    - To take quick decisions
  - ✓ Network connectivity - To connect with IoT devices, other fog nodes and cloud

Fog nodes (contd.)

- ✓ E.g. - routers, embedded servers, switches, video surveillance cameras, etc.
- ✓ deployable anywhere inside the network.
- ✓ Each fog nodes have their aggregate fog node.

Working of Fog

- ✓ Three types of data
  - ✓ Very time-sensitive data
  - ✓ Less time-sensitive data
  - ✓ Data which are not time-sensitive
- ✓ Fog nodes works according to the type of data they receive.
- ✓ An IoT application should be installed to each fog nodes

Working of Fog (contd.)

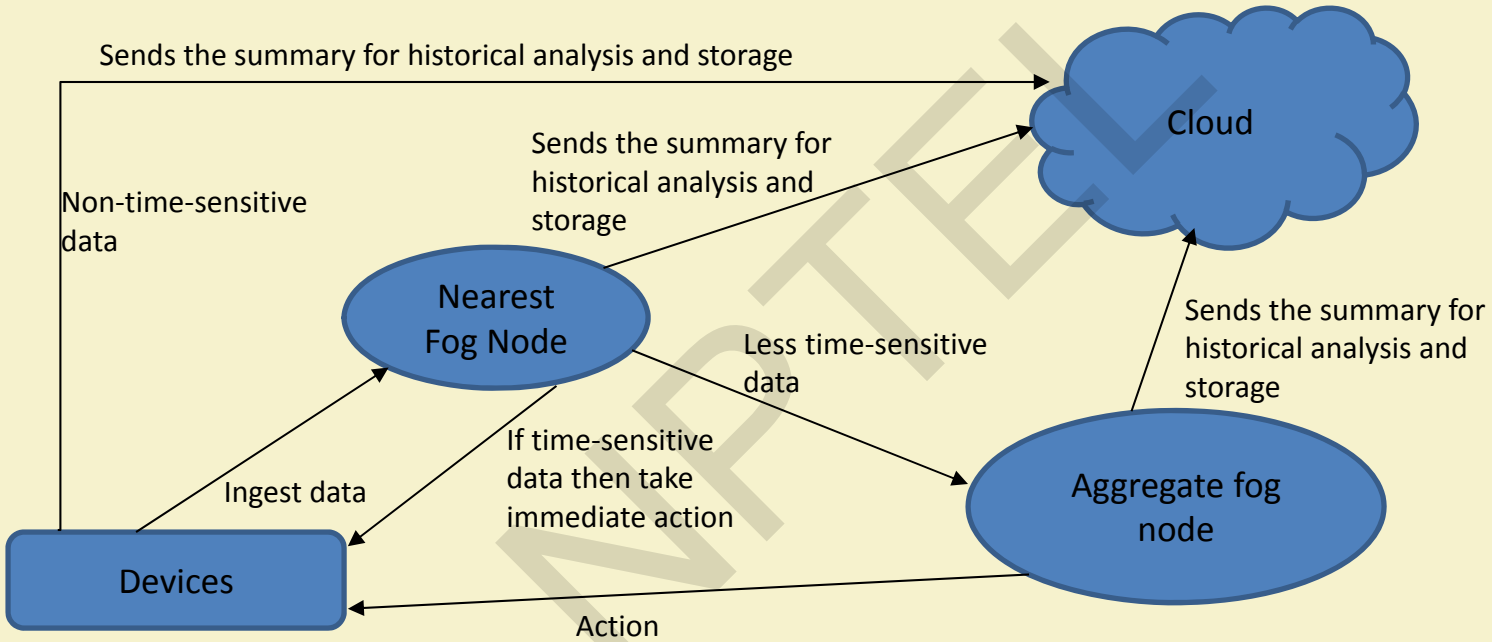


Fig : Working of fog

Working of Fog (contd.)

- ✓ The nearest fog node ingest the data from the devices.
- ✓ Most time-sensitive data
  - ✓ Data which should be analyzed within fraction of a second
  - ✓ Analyze at the nearest node itself
  - ✓ Sends the decision or action to the devices
  - ✓ Sends and stores the summary to cloud for future analysis

Working of Fog (contd.)

- ✓ Less time-sensitive data
  - ✓ Data which can be analyzed after seconds or minutes
  - ✓ Are sent to the aggregate node for analysis
  - ✓ After analysis, the aggregate node send the decision or action to the device through the nearest node
  - ✓ The aggregate node sends the summary to cloud for storage and future analysis.

Working of Fog (contd.)

- ✓ Non-time-sensitive data
  - ✓ Data which can be wait for hours, days, weeks
  - ✓ Sent to cloud for storage and future analysis.
  - ✓ Those summaries from fog nodes can be considered as less time sensitive data.

Working of Fog (contd.)

	Fog node closest to devices	Fog aggregate nodes	Cloud
Analysis duration	Fraction of second	Seconds to minutes	Hours to weeks
IoT data storage duration	Transient	Hour, days	Months to years
Geographical coverage	Very local	Wider	Global

Advantages of Fog

- ✓ Security
  - ✓ Provides better security
  - ✓ Fog nodes can use the same security policy
- ✓ Low operation cost
  - ✓ Data are processed in the fog nodes before sending to cloud
  - ✓ Reduces the bandwidth consumption

Advantages of Fog (contd.)

- ✓ Reduces unwanted accidents
  - ✓ Latency will be reduce during decision making
  - ✓ Quick decision making
- ✓ Better privacy
  - ✓ Every industry can analyze their data locally
  - ✓ Store confidential data in their local servers
  - ✓ Send only those data which can be shared to the cloud

Advantages of Fog (contd.)

- ✓ Business agility
  - ✓ Fog application can be easily developed according to tools available
  - ✓ Can be deployed anywhere we need
  - ✓ Can be programed according to the customer's need
- ✓ Support mobility
  - ✓ Nodes can be mobile
  - ✓ Nodes can join and leave the network anytime

Advantages of Fog (contd.)

- ✓ Deployable in remote places
  - ✓ Can be deployed in remote places
  - ✓ Can be subjected to harsh environmental conditions
  - ✓ Under sea, railway tracks, vehicles, factory floor etc
- ✓ Better data handling
  - ✓ Can operate with less bandwidth
  - ✓ Data can be analyzed locally
  - ✓ Reduce the risk of latency

Applications of Fog

- ✓ Real time health analysis
  - ✓ Patients with chronic illness can be monitored in real time
  - ✓ Stroke patients
  - ✓ Analyze the data real time
  - ✓ During emergency, alerts the respective doctors immediately
  - ✓ Historical data analysis can predict future dangers of the patient

Applications of Fog (contd.)

- ✓ Intelligence power efficient system
  - ✓ Power efficient
  - ✓ Reports detail power consumption report everyday
  - ✓ Suggest economical power usage plan

Applications of Fog (contd.)

- ✓ Real time rail monitoring
  - ✓ Fog nodes can be deployed to railway tracks
  - ✓ Real time monitoring of the track conditions
  - ✓ For high speed train, sending the data in cloud for analysis is inefficient
  - ✓ Fog nodes provide fast data analysis
  - ✓ Improve safety and reliability

Applications of Fog (contd.)

- ✓ Pipeline optimization
  - ✓ Gas and oils are transported through pipelines
  - ✓ Real time monitoring of pressure, flow, compressor is necessary
  - ✓ Terabytes of data are created
  - ✓ Sending all this data to cloud for analysis and storage is not efficient
  - ✓ Network latency is not acceptable
  - ✓ Fog is a solution

Applications of Fog (contd.)

- ✓ Real time wind mill and turbine analysis
  - ✓ Wind direction and speed analysis can increase output
  - ✓ Data can be monitored real time

Challenges

- ✓ Power consumption
  - ✓ Fog use addition nodes
  - ✓ Power consumption is higher than centralized cloud
- ✓ Data Security
  - ✓ Data generating nodes are distributed
  - ✓ Providing authentication and authorization system for the whole nodes is not an easy task
- ✓ Reliability
  - ✓ Maintaining data integrity and availability for millions of nodes is difficult
  - ✓ failure of a node cannot affect the network

Challenges (contd.)

- ✓ Fault tolerance
  - ✓ Failure of a node should be immediately fixed
  - ✓ Individual failure should not affect the whole scenario
- ✓ Real time analysis
  - ✓ Real time analysis is a primary requirement for minimizing latency
  - ✓ Dynamic analysis and decision making reduces danger and increase output
  - ✓ Monitor huge number of nodes is not easy

Challenges (contd.)

- ✓ Programming architecture
  - ✓ Fog nodes may be mobile
  - ✓ Nodes can connect and leave the network when necessary
  - ✓ Many data processing frameworks are statically configured
  - ✓ These frameworks cannot provide proper scalability and flexibility

Conclusion

- ✓ Fog is a perfect partner for cloud and IoT
- ✓ Solves the primary problems faced by cloud while handling IoT data
- ✓ Benefits extends from an individual person to huge firms
- ✓ Provides real time analysis and monitoring

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Thank You!!