IOT in 5G

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Internet of things in 5G

IOT in 5G :

There are three different types of clouds:

- Data centres
- Backbone IP networks
- Cellular core networks

Responsible for computation , storage , communication & network management.

FOG

Fog :

- It refers to an architecture for computing , storage , control or communication network and that as a network architecture it may support variety of applications.
- Three dimensions :
- Carry out a substantial amount of storage at or near the end user.
- Carry out a substantial amount of communication at or near the end user.
- Carry out a substantial amount of computing & management , control & configuration at or near the end user.

Fog :

- Fog Networking architecture
- Fog computing architecture
- Fog storage architecture
- Fog control architecture

Computation & management of Fog

Paradrop :
An edge computing platform in home gateways

Introduction :

- Cloud computing platforms such as Amazon EC2 & Google app engine have become a popular approach to provide ubiquitous access to services across different user devices.
- Netflix & dropbox are popular cloud based services.
- For better user experience , computation is performed close to end user referred to as " edge computing " & comes in various flavours including :
  Cyber foraging , cloudlets and fog computing

Paradrop :

- Unique edge computing framework
- It allows developers to leverage one of the last bastions of persistent computing resources in the end customer premises: the gateway (wireless Access point or home setup box).
- Paradrop framework allows multi tenancy through virtualisation, dynamic installation through the developer API and resource control through managed policy design.

Paradrop : Enabling multi-tenant wireless gateways & applications

Enabling multi-tenant gateways & apps

- We want to push computation onto home gateways (e.g APs or setup boxes) for reasons :
- Home gateways can handle it.
- Internet gateway is there in the home.
- Pervasive hardware

Paradrop capabilities :

- Privacy
- Low latency
- Local networking context
- Proprietary friendly
- Internet disconnectivity

BANDWIDTH

Leveraging the Fog :

- User based system - example of fog networking paradigm.
- Fog like architecture allows users to better control services they receive.
- Fog networking can be applied to a broad range of systems , ranging from distributed storage and computing to network bandwidth allocation.

Socially aware cooperative D2D & D4D communications towards Fog Networking

Cooperative communication :

- It is an efficient D2D & D4D communication paradigm where devices can serve as relays for each other.
- Cooperative D2D & D4D communication can achieve BW by exploiting different types of spectrum bands to support D2D communications :
- Inband D2D & D4D communication.
- Outband D2D & D4D communication.

Storage & Computation in Fog

Distributed caching for enhanced communication efficiency :

Wireless data traffic expected to increase by almost 10000 % over next 5 years.

Type of data traffic increasing properties :

- User activity is highly asynchronous.
- High content reuse.

Two caching methods :

- Femto - Caching : small dedicated “ helper nodes” can cache popular files & serve requests from wireless users by enabling localized wireless communication.
- The devices “pool” their caching resources so that different devices caches different files and then exchange them, when occasion arises , through short range , highly spectrally efficient , D2D communication known as user caching.

Two caching methods :

- User - caching enables the users to “ pool “ their caching resources so that different files & then exchange them through short range , highly spectrally efficient , local D2D communication which results in further gains in spectral efficiency.

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User caching

Cluster based caching & D2D comm. :

- In D2D network architecture , where devices act as caches.
- Let no. of files cached at each user & “K” be finite & do not assume any helper stations.
- If device cannot obtain a file through D2D communication, it can obtain it from macro cellular BS through conventional cellular transmission.

Wireless Video Fog

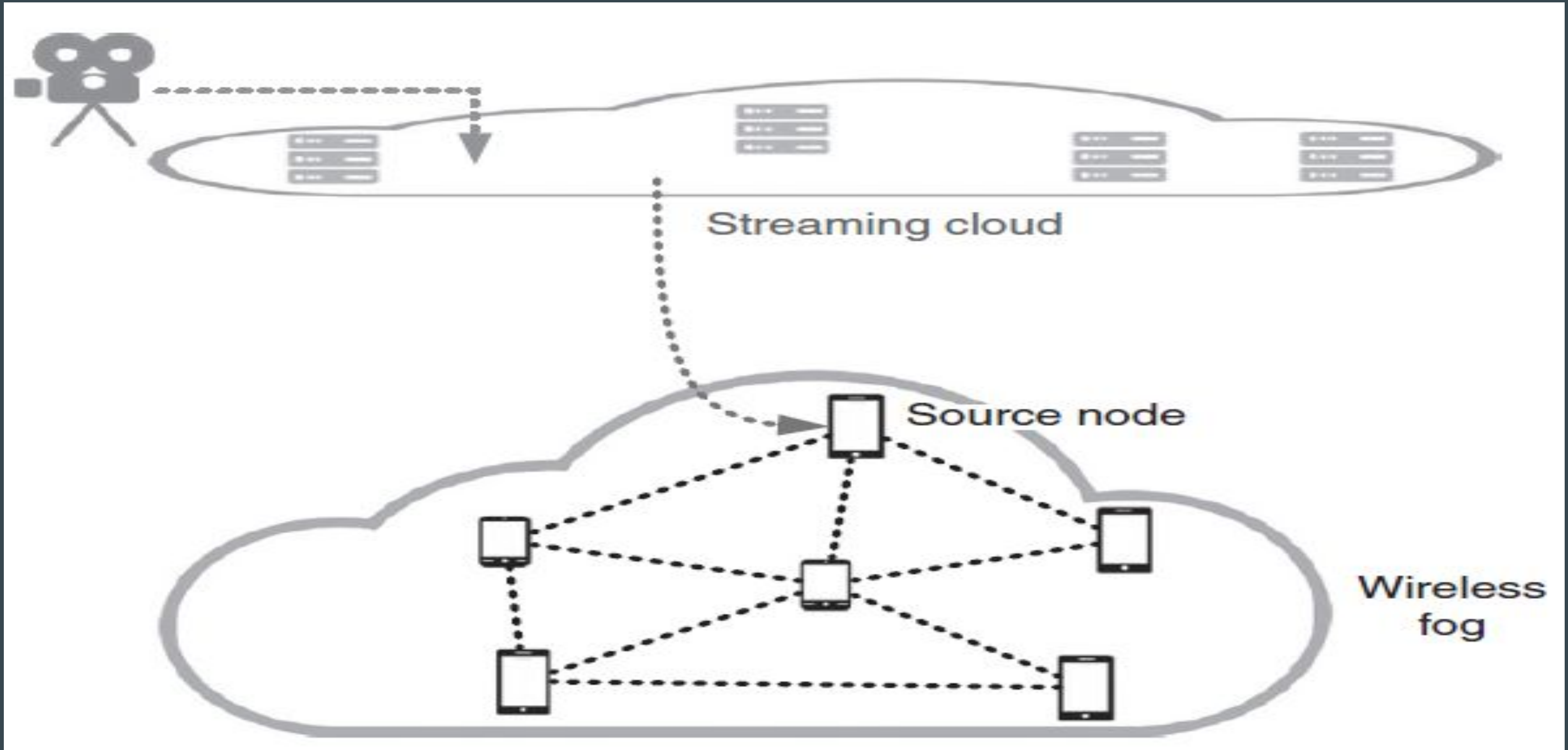
Wireless video Fog :

- To serve geographically distributed clients , the stream is distributed using a cloud , with the wireless clients independently pulling the stream via Access point or Base station.
- In wireless Fog for live video , the devices hence donate their resources (computing power, storage and communication BW) to scale up the system in a cost effective manner.

Wireless video Fog :

- The cloud is integrated with a wireless fog.
- In the fog, a source node first pulls the stream from a nearby cloud server through an AP or BS.
- It then distributes its stream to nearby clients.
- By cooperatively relaying their received packets , nodes can efficiently distribute the live stream within the fog.

Wireless video Fog :



Wireless video Fog :

- In a wireless fog, conventionally the live stream is distributed using the “ store - and - forward “ approach , where selected broadcasters simply forward their received packets to their neighbors.

Elastic Mobile device clouds :

Elastic mobile device clouds :

- The cloudlet system move computation closer to mobile devices, creating a two tier architecture .
- A mobile device can offload to a nearby, less capable server, at low latency and high bandwidth rather than offloading to the cloud.
- In the cloudlet vision , these nearby servers would be located in public & commercial spaces where people congregate.

Vision of Edge based clouds :

Two observations :

- While gap remains between truly mobile devices(handheld , wearable) & high capacity servers, mobile devices have grown increasingly powerful especially when laptops are included.
- From an architectural perspective , it is possible use the cloudlet , responsible for receiving tasks, scheduling their computation and returning results & a complete cluster responsible for performing the computation.

Mont Blanc :

- This project aims to develop an energy and cost efficient exascale HPC architecture.
- It utilizes energy efficient mobile device processors and assembles a set of these processors.

Goal of Mont Blanc project :

- Maximizing the performance of every single processor.
- Efficiently clustering multiple processors.

To maximize the performance gains from each processor, the authors address a set of hardware challenges such as lack of cooling infrastructure as well as software challenges

Computing while charging :

It is a distributed computing infrastructure that uses smartphones as the main computing nodes.

It consists of :

- Data center that has tasks to execute.
- Mobile devices with idle capacities that are charging their batteries & connected to the data center via internet.

Computing while charging :

- The CWC architecture is designed to enable a data center to utilize idle capacity in mobile devices to enhance its performance and/or reduce data center energy consumption.
- The CWC cluster environment is stable.
- The mobile devices are connected to power sources, which means they do not move & they have good energy availability.

Femto Cloud :

Femto cloud :

- It is a system designed & implemented tp leverage mobile devices to provide mobile computing services at the edge.
- It is designed to cluster co-located mobile devices in environments where mobile devices presence times can be estimated.
- Femto cloud architecture consists of a control device & a set of executing mobile devices.

Femto cloud :

The Femto cloud architecture predicts task characteristics , estimates device capacities , presence times & uses the acquired information to distribute tasks across different executing devices as follows :

- Task/cloud interface : it relies on the control device, which is relatively stable compared to rest of devices in a Femto cloud to provide a stable & discoverable interface between femto cloud & its potential users.

Femto cloud :

- Execution prediction : it relies on a generic task model where a task is coordinated by its input size , output size and computational load.
- Femto cloud only needs to estimate its output size & its computational load.
- It relies on task originator to send the task with an estimate for its computational load.

Femto cloud :

- Device management : it is divided into three sub-tasks implemented by control device and the computing mobile devices :
- Discovery & registration
- Estimating device capacity
- Estimating the device presence time

Femto cloud :

- Network management : it utilizes the shared wireless spectrum to send tasks to their executing devices & gather their results .
- Task assignment & scheduling module

Applications of Fog :

Role of Fog computing in the future of the Automobile :

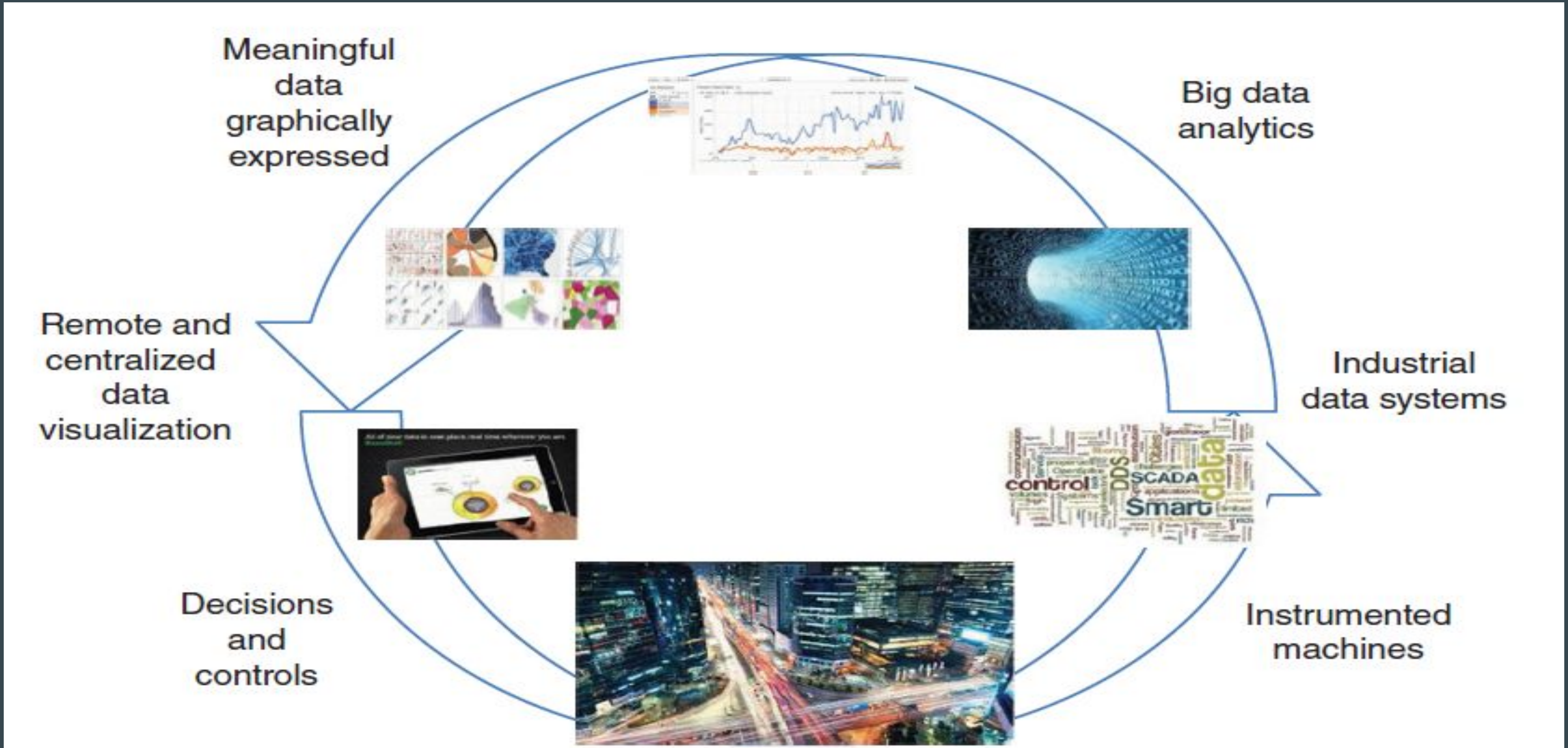
Role in Automobiles :

- Future automobiles will look more powerful, compact, scalable data centres on wheels or fog computing nodes on wheels travelling within highways & cities equipped with powerful fog computing capabilities at their intersections & along their pathways.
- Fog computing an ideal bridge between modern IT & operational technologies.
- Time triggered technologies based on precise time distribution

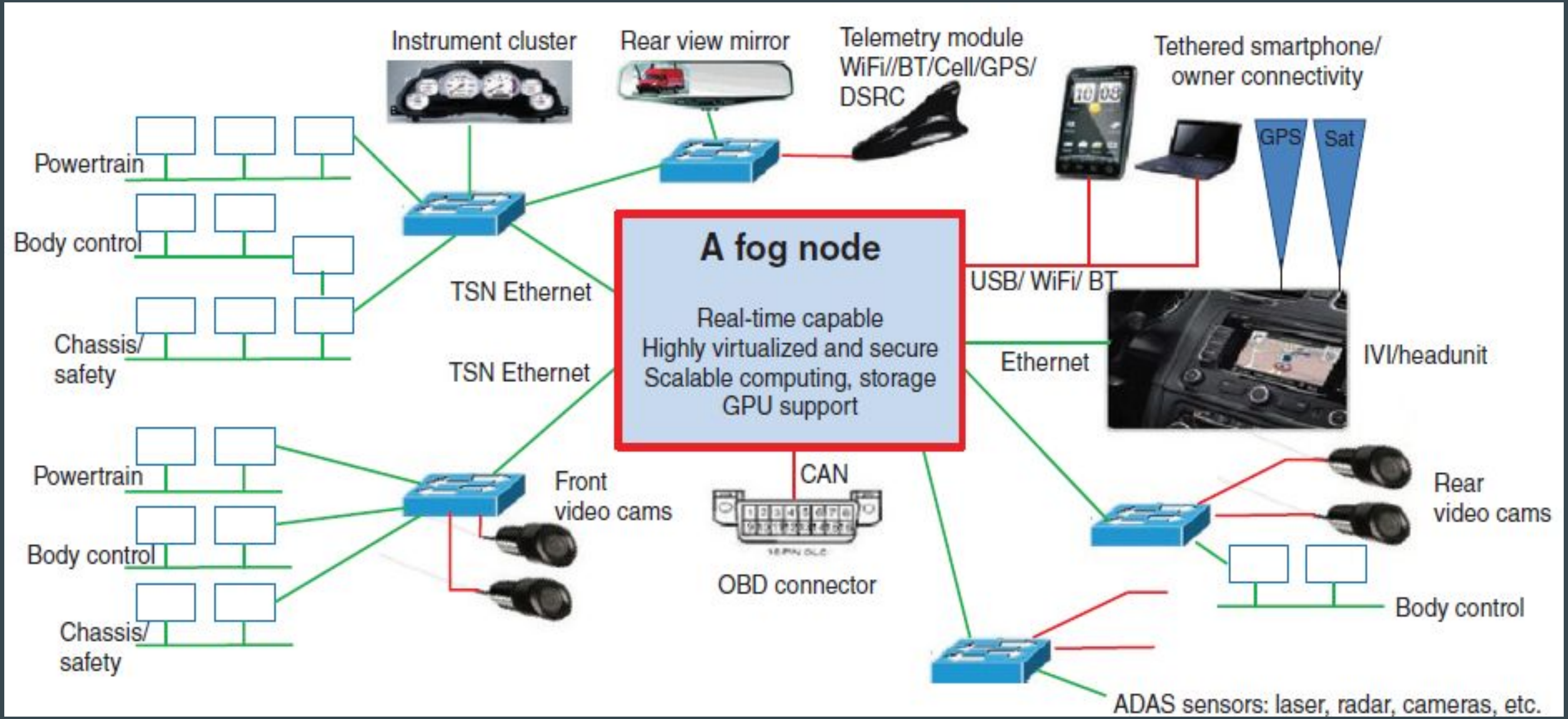
Role in Automobiles :

- Introduction of standard networking technologies such as ethernet,wi-fi, bluetooth.
- Adoption of modern security applications.
- Exposure to models of computation & resource virtualization.
- Advances in real time computing & deterministic networking.

IOT virtuous information cycle :



Future automotive E/E architecture :



Geographic addressing for field networks :

Field networking :

Field networking :

- Data communication networks enables devices in large scale physical environment to communicate in order to support real world tasks.
- In addition to emergency response & games , other applications of field networking include Geosensing & data collection , process control , drone airspace awareness & control , military operations & force protection , military training , connected & autonomous vehicles.

Field networking :

- Field networking scenarios involve fog networking scenarios.
- Firefighters need maps that come from servers in the cloud & may upload logged sensor data to the cloud to support action reviews.

Geographic Addressing :

- It refers to communication protocols that allow a sender to specify the intended recipients with traditional schemes, such as IP addressing.
- The address refers exactly to the set of devices that are in the area at the time the message is transferred , a set whose extension changes rapidly with time.

IOT capabilities towards 5G :

IOT capabilities towards 5G :

- LTE IOT, which includes enhanced eMTC
- Long term evolution for machines
- Narrowband IOT

Executing use cases :

- Ubiquitous coverage : coverage of challenging locations by optimizing the device link budgeted for low - data rates.
- Ultra - low current : it enables efficient use of device battery life to maximize years of useful operation in the field.
- Increased capacity : to efficiently support dense connections per km2.
- Low complexity : scaling the IOT for low end , single mode use cases.

On the way to 5G & IOT :

- Connecting & managing growing no. of cars , meters , machinery sensors and consumer electronics profitably will require innovative business models.
- The vast majority of operator IOT revenues come from connectivity.
- Operators capable of creating & managing

From IOT to IOE :

From IOT to IOE :

- IOT is a novel computing platform that is rapidly gaining space in terms of modern communication technologies.
- IOT idea implied other concepts, such as
  IOS - internet of service
  IOE - internet of everything
  WOT - web of things

Internet of everything :

- IOE connects people, data , things and processes in networks of billions or trillions of connections.
- There are three keys in which IOE will significantly impact our lives as described :
  IOT will automate connections
  IOE will enable fast personal communication & decision making
  IOE will uncover new information

IOE’s individual concepts :

- People
- Data
- Things
- Process

Architecture :

Architecture recommended by IAB :

RFC 7452 presents four common interaction models between the actors of the IOT :

- Communication between objects
- Communication from objects to the cloud
- Communication from objects to a gateway
- From objects to back end data sharing

Three tier architecture :

A large number of groups have embarked on the development of a standard architecture for the IOT.

Applications
Cloud computing
Sensor network

Layered Architecture

This architecture is often used to describe the structure & existing relationship between different IOT actors :
This architecture takes form of superimposed layers:

- Physical devices & controllers
- Connectivity
- Edge computing
- Data accumulation
- Data abstraction
- Applications
- Collaboration & processes

Steps & technologies in ecosystem of IOT

- Identity
- Capture
- Connect
- Integrate
- network

Steps :

- Identifying : Knowing how to precisely determine which object is connected to what in what way and in which location.
- Capture : in order for CO's to fulfill their role of bridge between the physical and virtual worlds, sensors are indispensable.
- Connection : linking objects with each other so that they can exchange data in a more autonomous manner.
- Integrate : connecting CO's to the virtual world with the help of wireless communication method.
- Networking : users want to able to interact remotely with their objects while the providers want to collect the data generated , that is often the service basis.

Fog Computing :

Basics :

- Introduction of IOT brings billions of devices to the internet.
- To overcome the challenges of these devices and meet the requirements of the application domain .
- The concept of fog computing is the latest descendant in the line of physical separation of functional units.

Characteristics of Fog layer :

- Fog layer is closer to the perception layer & this proximity provides a range of advantages that characterize the layer.
- Location awareness comes due to the large scale geographical distribution of devices that make up the Fog layer.
- This subset of of resource constrained devices are located close to each other and the managing gateway can easily locate each device.

Characteristics of Fog layer :

- The geographical distribution of the Fog layer & subsequently the offered low communication latency are among the critical features of fog layer.
- The IOT in general is dominated by wireless networks.
- There are many wireless protocols mostly tailored for low power operation , coverage or bandwidth.

Characteristics of Fog layer :

- The majority of these protocols connect sensor nodes to the fog layer to get access to the internet.
- Fog layer provides an additional benefit of acting as interpretability layer among these heterogenous protocols.
- The gateways in the Fog layer can also perform lightweight analytics at the edge to give feedback , command and notification to the end users as well as sensor nodes in real time.

Design & organization of Fog layer :

- In a larger environment, multiple access points can be arranged to provide users with seamless connectivity throughout the intended area.
- In addition to simply passing network packets , these networked smart gateways can process the data or store it when necessary.
- Distributed smart gateways communicate with the cloud , the sensor layer and among themselves.

Fog computing services :

These services are organized into three layers :

- Compute
- Storage
- Network

Computing services :

- There are multiple configurations of sharing the computing load among the different layers in the IOT based systems.
- Beside data management, events can be handled at the Fog layer.
- There are many middleware that leverage the fog layer to manage devices through abstraction , agent based management & virtual machines.

Storage services :

- The storage services helps to enhance the reliability of the system by maintaining proper behavior of client nodes.
- Combined with computing service, stored data can be filtered, analyzed and compressed for efficient transmission.

communication services :

- The communication in the IOT is dominated by wireless nodes.
- The Fog layer is located in a strategic place to organize multitude of wireless protocols and unify their communication to the cloud layer.
- This helps in managing sub-networks of sensors and actuators providing security, channeling messaging among devices & enhancing reliability of the system.

Management of Fog layer :

IOT Resource estimation challenges :

- Fog will act like a mediator & will be able to perform tasks that may not be efficiently done by distant cloud.
- Fog would be present close to the underlying nodes for the purpose of offloading the tasks & preprocessing the raw data.
- Fog will also be responsible to minimize delay & enhance service quality.

Resource management :

- Resource scheduling is tricky in case of mobile nodes.
- Resource underutilization become problem when underlying nodes are mobile.
- Fog plays an important role in resource management , being in proximity to the users and to make decisions in a more realistic way.
- Mission critical & latency sensitive IOT services require very quick response & processing.

Resource management :

- The concept of fog networking is to bring networking resources near the nodes that are generating data .
- Fog resources lies between the perception layer & cloud layer.
- For mobile nodes , fog provides low latency and high quality streaming through proxies & access points located across highways & tracks.
- Resource & power constrained individual nodes , WSNs & virtual sensor networks would be able to take advantage from the presence of fogs.

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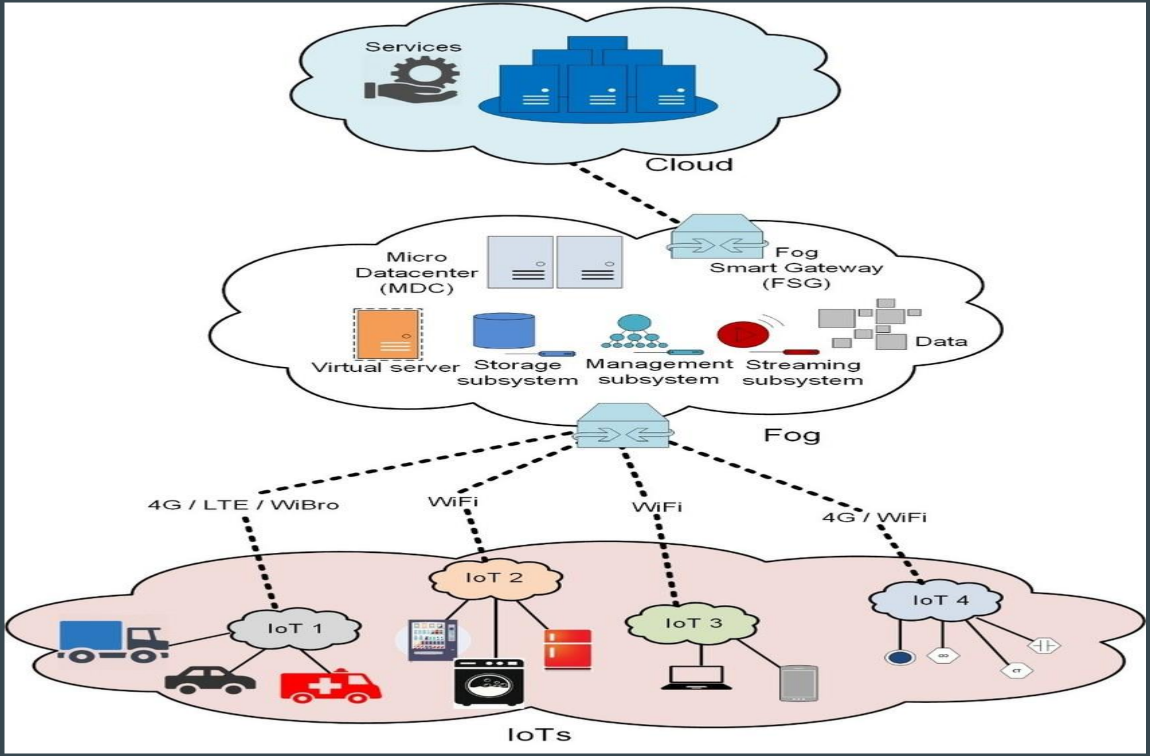
Fog Resource estimation & its challenges :

Fog Resource estimation & its challenges :

- Depending upon the type of IOT service , the underlying nodes can be devices as well as dumb objects.
- A multitude of mobile nodes , including fast moving vehicles would also be among the pool of nodes requiring resources from a fog.

Fog as a middleware between IOT & Cloud :

Fog as a middleware :



Device type :

- A resource rich computer or laptop with ample resources a lot of resource with high quality expectations.
- A sensor would be resource constrained.
- Fog has to allocate resources keeping in view the power or battery status of the sensor.
- Processing resource would be the key as the data generated from them may have to be accumulated, trimmed & processed before sending it to the cloud or creating services locally.

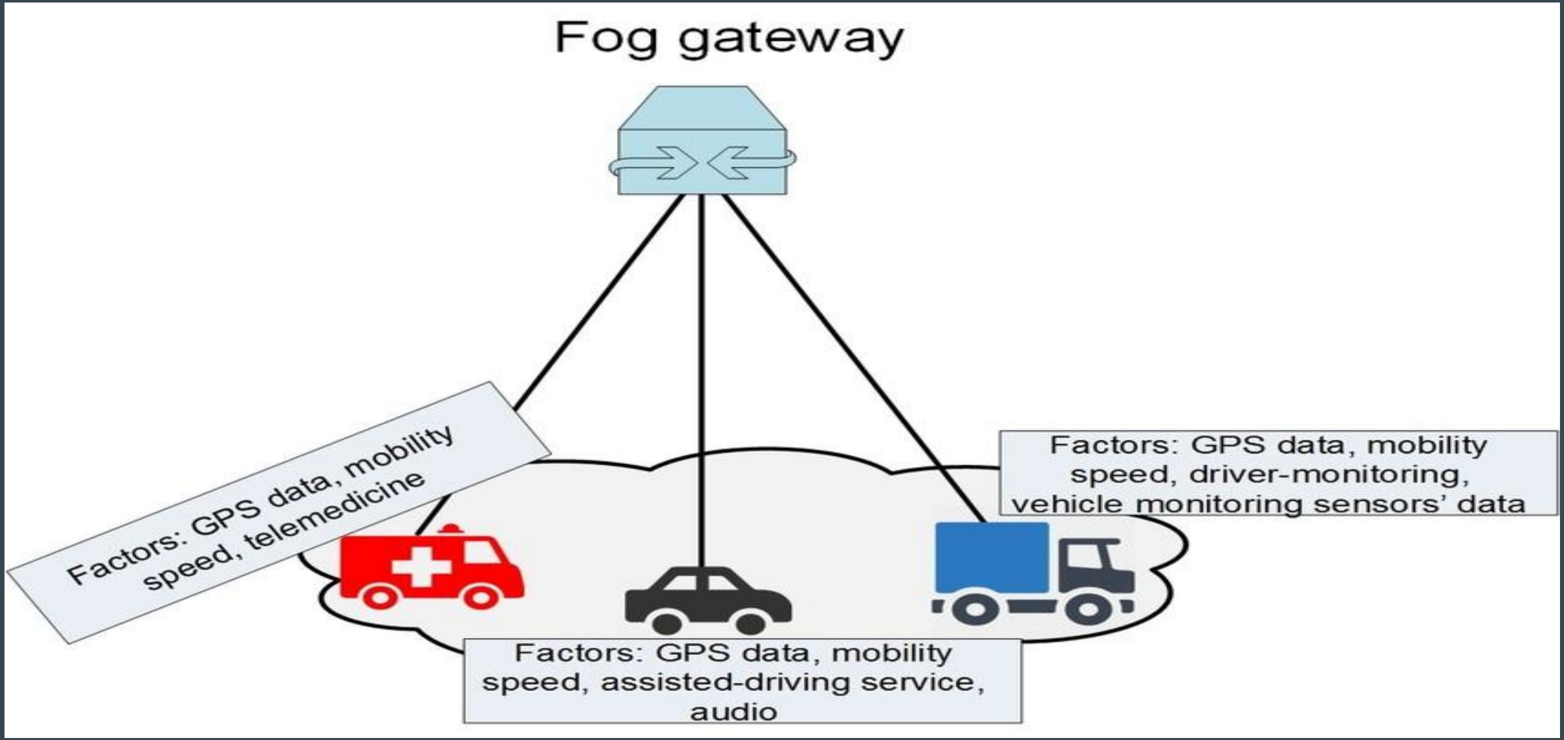
Mobility on the ground :

- With mobility , the resource procurement becomes more of challenge.
- Several crowdsensing applications will take benefit from fog based IOT services.
- Several sensors within a vehicle will be working under a fog.
- Fog has to take into account the type sensor, the way they are being powered, data communication frequency, mobility speed & mobility pattern while deciding about reasonable resources.

Mobility in the Air : internet of Drones

- For flying objects , resource estimation would be way beyond the conventions.
- IOD would require much faster processing & high bandwidth.
- Some drones would generate HD video data , some will be responsible for imagery , and some would be equipped with sensors or an array of sensors.

Fog monitoring various factors for resource allocation



Power utilization & status

- Fog is responsible for monitoring power and deciding when to offload tasks from devices.
- The resource estimation would be performed dynamically in real time.

Data types

- Types of data plays an important role in accessing the time and amount of resources.
- Multimedia data would require processing , memory, storage & GPU.
- Storage & memory depends on type of data and nature of application.

Security

- It is of two types : data security & communication security
- Data security refers to making the data unreadable for unintended party.
- Communication security means the data is transferred through a secure channel.

Customer’s reliability & loyality of service utilization

- It would be very difficult to forecast if a requiring customer is going to fully utilize the resources requested for.
- With mobile nodes, reliability can not be guaranteed.
- If a certain check is set on customer’s behavior and service utilization pattern , better resource estimation can be performed.

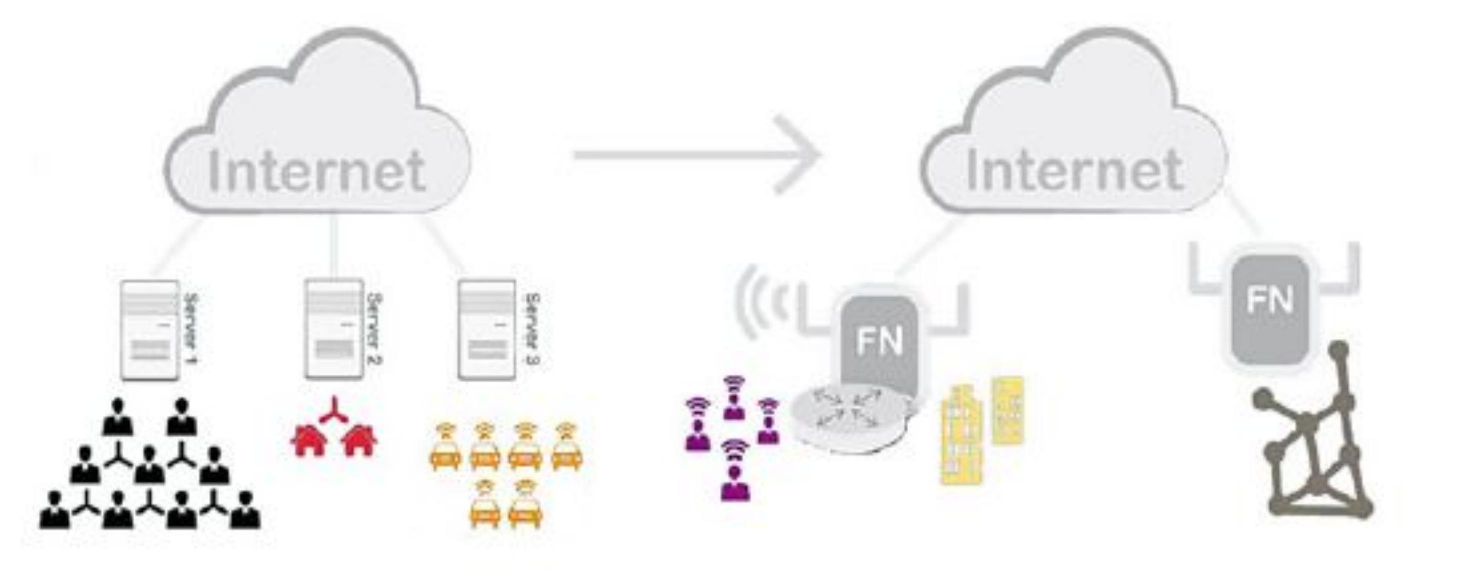
Fog’s role within ULSS

Architecture

- Sensors & actuators are responsible for gathering information & acting on the environment.
- Heterogenous fog nodes , which constitute the aggregation points.
- The “things” & “nodes” communicate mostly through wireless technologies , since both things & nodes can move.

Architecture

- The cloud constitutes the highest layer, offering a large pool of resources low-cost without any latency requirements.



Fog ‘s role within ULSS

- These systems can exploit the location of the fog nodes & their hierarchical organisation to communicate & to become aware of their extent.
- Fog nodes have visibility over a wider geographic range than the one available to individual “ things”.
- Fog nodes can transmit information such as road conditions to optimize cars trajectories in real time.

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Fog ‘s role within ULSS

- When “things” move out of the range they get disconnected from that node.
- If another node is available in the next location , the process can continue.
- This technique eliminates the need of migrating data from one node to the next node because the “thing” itself carries the necessary information.

Services of Fog layer :

Blockchain

- It is a decentralized ledger of all Bitcoin transactions across a peer to peer network.
- The nodes with in the network validate the transaction and the user's status by using known algorithms to ensure that the same bitcoins were not spent previously.

Blockchain

- A verified transaction can involve cryptocurrency , contracts, records & other information.
- Using this technology , users can confirm transactions without the need for a central certifying authority , normally enforced by central banks.

IOT , Fog computing & Block chain

- IOT devices normally have limited resources that are not enough to properly support cryptocurrency mining due to its computational cost.
- Mining of blocks is time consuming & creates signalling overhead traffic , which is undesirable. Moreover , blockchain does not properly scale with the ever increasing introduction of nodes in the network.

IOTA

- It is a novel transactional settlement and data transfer layer for IOT.
- It is based on a new distributed ledger , the tangle which overcomes the deficiencies of blockchain designs & introduces a new way of reaching consensus in a decentralized peer - to -peer system.
- IOTA enables companies to explore new B2B models by making every technological resource a potential service to be traded in an open market.

IOTA

- New approaches for IOT have been proposed with the introduction of Fog & Mist.
- IOTA combines both Fog & Mist into a new distributed computing solution.
- This can be seen as a combination of smart sensors with built-in computational capabilities (mist computing) with nearby processing stations (Fog computing).

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Services of Fog layer :

ADEPT :

Autonomous decentralized P2P Telemetry

- By using the devices themselves as computational, storage & communication nodes , we can build “hybrid” IOT systems where the edge complements centralized systems.
- IBM & Samsung have developed ADEPT proof of concept.
- This work is supported by three distinct protocols:
- Bit torrent
- Ethereum
- Telehash

Autonomous decentralized P2P Telemetry

- Use case : decentralized advertising marketplace using large format displays to share & publish content without a centralized controller. The concept in LFD as compared with conventional is that we can share the content with anyone.

Multi party computation :

Multi party computation

- Secure multi-party computing is a technique that can be used here , since its purpose is to have multi parties exchanging secret information privately without the need of trusted third party.
- MPC consists of two or more parties where each part has their own secret input.

Self Aware fog computing in private & secure spheres :

Self aware fog computing

- Wearable sensors for measuring our leisure & sports activities as well as our health conditions have proliferated & gained acceptance.
- The advances of sensing, computation & communication technology are also being utilized in military applications.

Cloud , Fog & Mist computing networks

- The functional & non-functional system parameters are affected by the selection of computing architecture when choosing between Fog, Mist & cloud computing architectures.
- Some of these parameters include latency of control loops, bandwidth usage , storage requirements , security & privacy aspects , system robustness & reliability.
- In applications where low latency from the sensor to the data consumer is critical - mist computing architecture is beneficial.

Cloud , Fog & Mist computing networks

- Cloud computing is applicable where we are either processing big amounts of data, for which processing methods may be complex.
- Fog computing brings computation closer to the edge of the network. In Fog computing , a more capable device bears the responsibility for data processing or IOT application execution.

Self aware data processing

The umbrella term self awareness encloses a no. of concepts such as :

- Self - adaptation
- Self - organization
- Self - healing
- Self - expression and other self - properties

Self aware data processing

A self aware system should fully understand its own situation & detect its own misbehavior or underperformance due to :

- Faults, that may be caused by aging , accidents or physical attacks
- A malicious attack on its functions
- Functional design errors in its hardware or software

Control as a service in cyber physical energy systems over Fog computing

Power grid & energy management

- Localized distributed energy system is called microgrid.
- The primary purpose of microgrid is to ensure local , reliable and affordable energy security for communities.
- The growing number of devices & customers in the power grid increases the demand for electrical energy consumption.

Energy management methodologies

- Smart & energy efficient appliance control
- Utilizing renewable energy
- Electricity demand management

Cyber physical energy systems

- The cyber system brings the capability of computation , communications & control.
- The smart grid which leverages the cyber and physical interaction is called CPES.
- It brings multi level monitoring & control capability to the power grid in order to improve its reliability, flexibility, efficiency & cost effectiveness.

Cyber physical energy systems

- Multitude of sensors at different levels of the system responsible for monitoring multiple variables indicating state of the system.
- Major requirements of the architecture :
  Interoperability
  Scalability
  Ease of deployment
  Open architecture
  Play & plug capability
  Local & remote monitoring

Control as a service

- The energy management platform can be used for any type of buildings & various domains of operation e.g microgrid or home.
- The energy management may have various purposes:
  Monitoring & metering the power consumption of each device e.g home power consumption
  Managing the energy consumption by controlling the devices efficiently.

Residential cyber-physical energy system

- The implementation of caas on top of fog computing platform is applied to two prototypes of HEM & microgrid- level energy management to demonstrate its advantages for different domains.

Home energy management

- In the home , multiple smart devices such as : HVAC, water heater & EV charger.
- Each device is monitored & controlled by the HEM control panel.
- The devices have their own control panel to monitor their status & set their configurations,
- The home is being monitored by a network of four sensor devices .
- The sensor network is defined as a subsystem inside the platform.

Micro grid level energy management

- The micro level energy management platform comprises three homes connected to a transformer.
- A control panel is implemented in the transformer to monitor and manage the power consumption of each home.
- The transformer level control panel monitors the load of each home and may decide to send demands to their HEM in order to reduce power consumption.

Micro grid level energy management

- In this platform a transformer management has been implemented as a service.
- The controller monitors the home connected to the transformer in order to prevent overloading of the transformer.
- It receives information about the array of homes connected and the total load on the transformer.
- The controllers are implemented in the micro-grid level fog computing platform.

Leveraging Fog computing for Healthcare IOT

Healthcare services in Fog layer

- This layer provides computing , networking, storage and other domain specific services for IOT systems.
- The healthcare domain has a set of requirements that uniquely identify it from other IOT apps.
- The physical proximity of Fog layer to Body area networks of sensors & actuators allows us to address the requirements of healthcare IOT.

Data management

- It has an important role in Fog computing by which sensory data is locally processed to extract meaningful information.
- Fog layer continuously receives a large amount of sensory data in a short period of time from the sensor network.
- Different gateways in smart e-health gateway:
  Local storage
  Data filtering
  Data compression
  Data fusion
  Data analysis

Local storage

- The gateway needs to store received data from several sources in a local storage to be able to utilize it in the near future analysis.
- The local storage in the gateway can be used to store files in encrypted or compressed format based on type, size and importance of data.
- Using local storage , the gateway is able to export data to medical standard formats such as Health level seven (HL7) if required.

Data filtering

- It is the first data processing unit to implement filtering methods at the edge after receiving data from sensor network.
- Available light weight filtering in some of the sensor nodes reduces these accumulated noises although it might be insufficient in practical cases.
- Data filtering unit in Fog layer enables to remove noise and increase aspects of the signals using various filters before any other local data analytics.

Data compression

- In health care IOT applications, loss-less compression is more preferable in most of the cases because lost data can cause inappropriate disease diagnosis.
- In some cases loss-less algorithms can be successfully operated at sensor nodes but they cause a large power consumption and latency.
- With fog computing all limitations can be avoided.

Data fusion

- It is the data processing unit to integrate sensory data from multiple sources to obtain more robust data and meaningful information.
- Data fusion can be divided into 3 classes :
  Complementary
  Competitive
  cooperative

Data analysis

- Data analysis unit at the edge enables the health care to process the sensory data locally.
- This unit improves the system performance by decreasing response latency and data transmission to the cloud servers.
- Data analysis at the edge could manage the system's functionality locally , store the sensory data as well as the calculations in the local storage and subsequently synchronize the Fog layer with the remote control after reconnecting to the network.

Event management

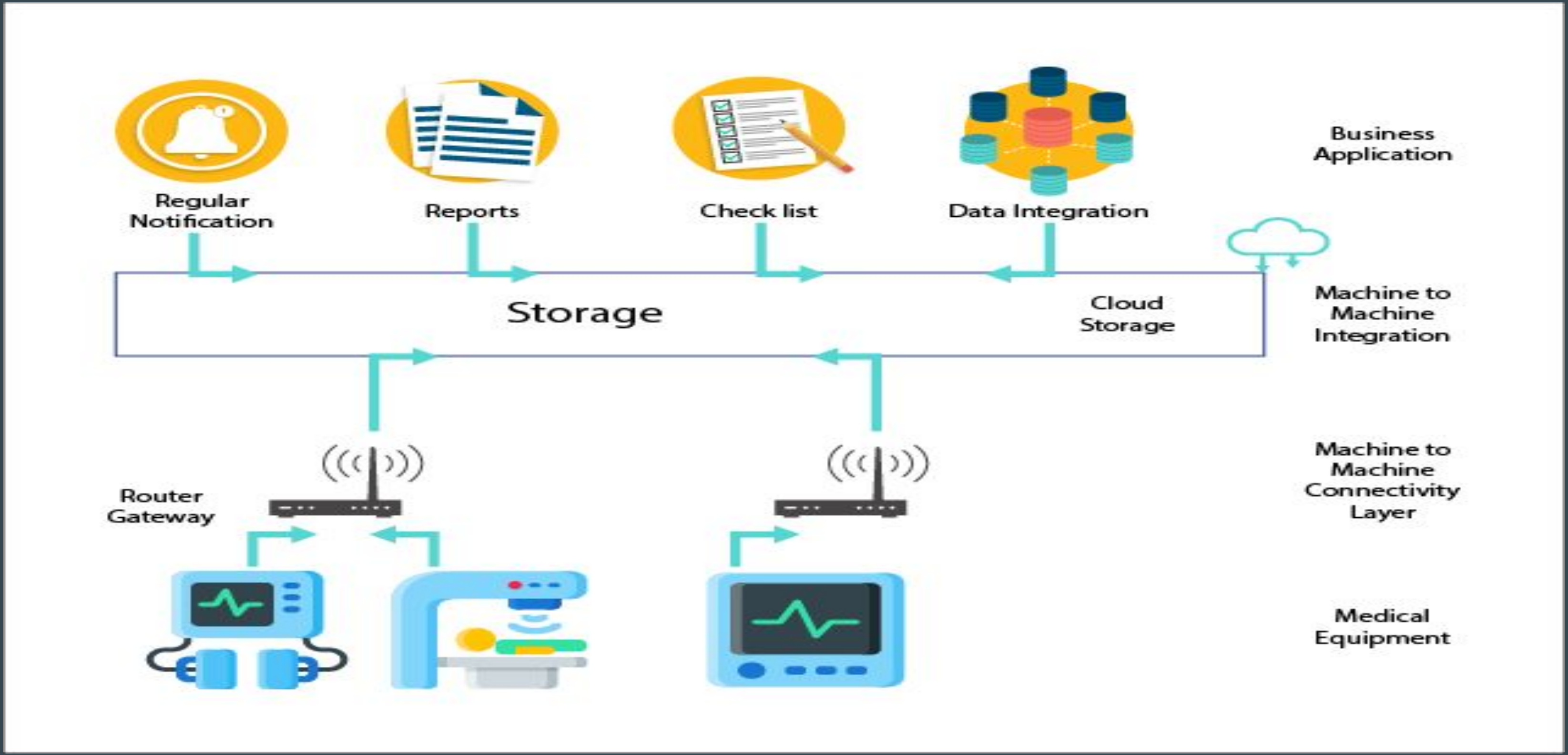
- Fog computing provides low latency communication which helps to notify health experts , caregivers and even patients very fast in case of serious events.
- The real time and fast response of actuators are important in some medical events

System architecture of Healthcare IOT

System architecture

- The architecture of a system provides information about the components , interaction and organization of the parts.
- It is one of the key elements for achieving graceful scaling and performance.
- It is designed to meet functional requirements of the application domain.

System architecture



System architecture

In healthcare scenario , this architecture is composed of three main parts in each layer :

- Medical sensors and actuators
- Smart e-health gateways
- Cloud platform

Internet of things in 5G

IOT in 5G

5G technology is expected to provide :

- Faster speeds
- Lower latency
- Network support for massive increase in data traffic
- Expansion of cell sites

IOT in 5G

- 5G technology is expected to handle 1000 times more data than current cellular technologies.
- 5G technology will become backbone of IOT technologies connecting multiple devices together.
- IOT will be ideal application of 5G.
- The use of millimeter wave communications for many applications of IOT.

IOT in 5G

- 5G technology will be fully functional along with IOT enabled systems like smart homes , smart mobile , smart city ,vehicular, sports and leisure.
- 5G technology will transmit data 10 times faster than 4G systems.
- Smart city is a bigger concept implemented by 5G faster network where things communicate and decide best decision and devices.

Why 5G is compatible with IOT

- IOT applications require low latency.
- IOT applications require high data rates.

IOT & 5G research

- Connected homes
- E-health
- Entertainment
- Home automation
- Security
- Smart architecture
- Smart cars
- Smart grid
- Smart mobility
- Smart parking
- Smart wearables

Thanks

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