22AIE305

22AIE305: CLOUD COMPUTING

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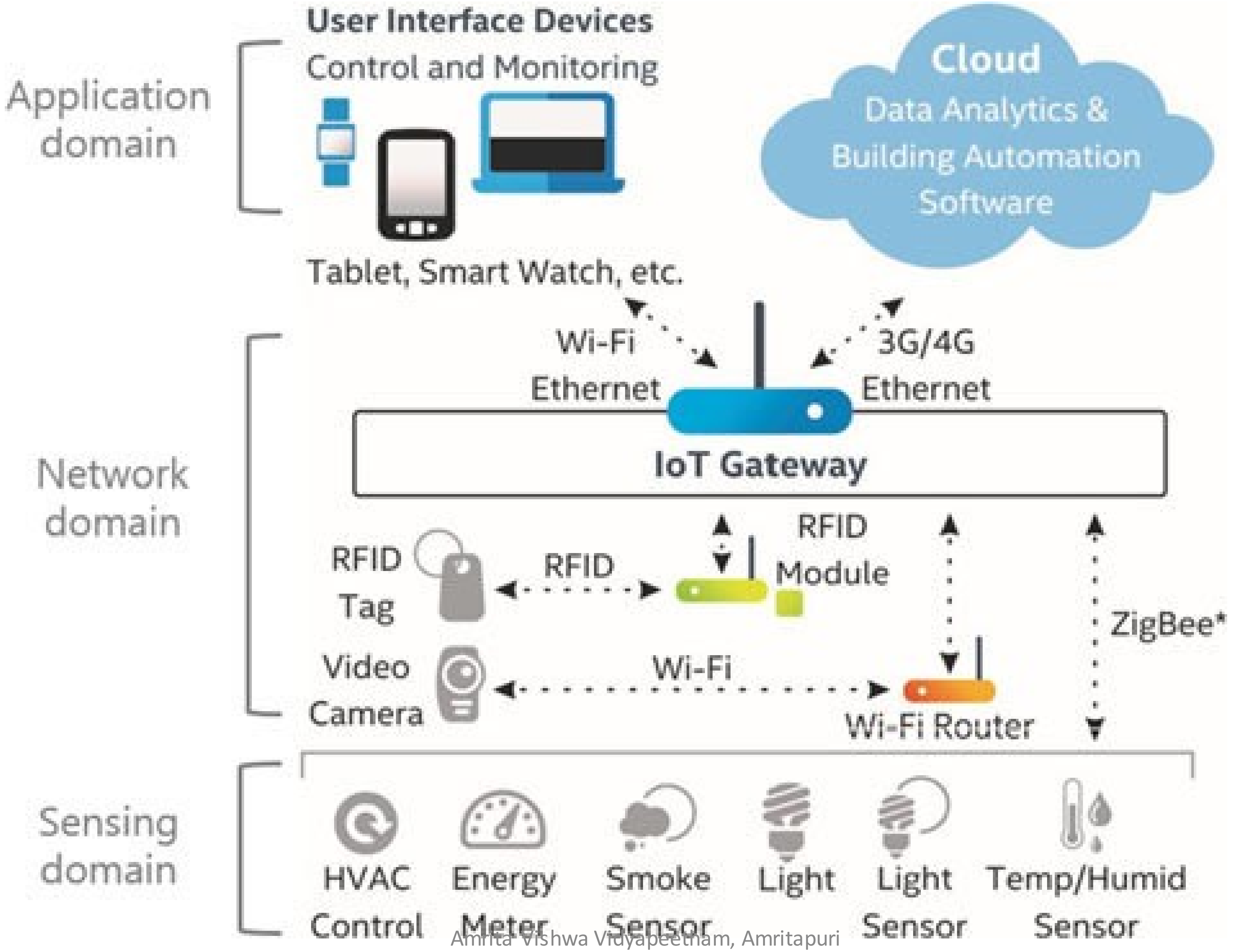

Application domain
User Interface Devices
Control and Monitoring
Tablet, Smart Watch, etc.
Cloud
Data Analytics & Building Automation Software
Wi-Fi
Ethernet
3G/4G
Ethernet
Network domain
IoT Gateway
RFID Tag
RFID
RFID Module
Video Camera
Wi-Fi
Wi-Fi Router
ZigBee*
Sensing domain
HVAC Control
Energy Meter
Smoke Sensor
Light
Light Sensor
Temp/Humid Sensor

Why fog computing?

- The need to extend cloud computing with fog computing emerged during last decade to cope with huge number of IoT devices and bigdata volumes for real-time low-latency applications.
- Fog computing, also called edge computing, is intended for distributed computing where numerous "peripheral" devices connect to a cloud.
- The word "fog" refers to its cloud-like properties, but closer to the "ground", i.e. IoT devices.
- It is a promising solution to deliver services to end-users and provide applications with elastic resources at very low cost.

Local processing

- Many of these devices will generate voluminous raw data (e.g., from sensors), and rather than forward all this data to cloud-based servers to be processed, the idea behind fog computing is to do as much processing as possible using computing units co-located with the data-generating devices, so that processed rather than raw data is forwarded, and bandwidth requirements are reduced.
- Fog networking consists of a control plane and a data plane.
- On the data plane, fog computing enables computing services to reside at the edge of a network as opposed to servers in a data-center.

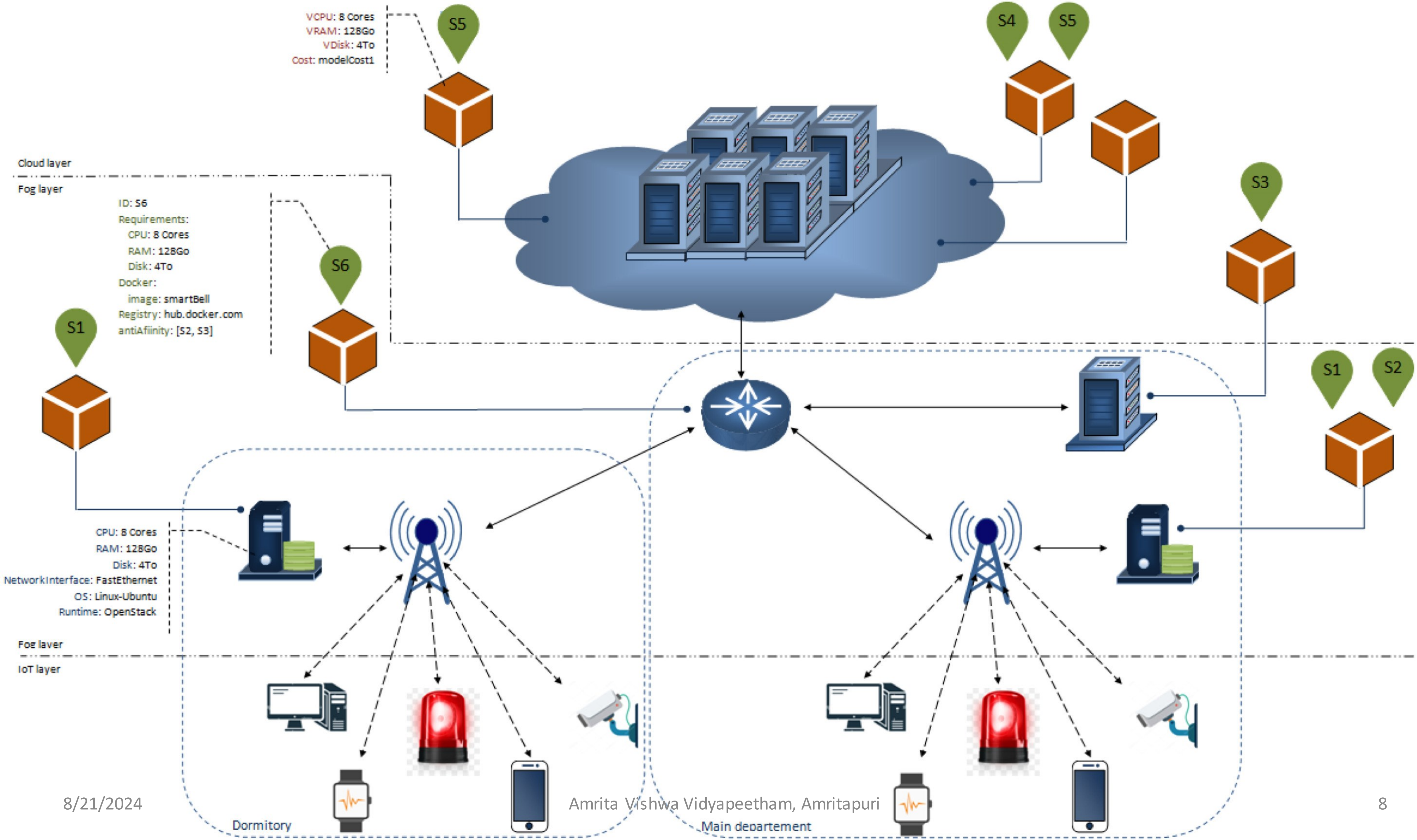
- Compared to cloud computing, fog computing emphasizes proximity to end-users and client objectives (e.g. operational costs, security policies, resource exploitation), dense geographical distribution and context-awareness (for what concerns computational and IoT resources), latency reduction and backbone bandwidth savings to achieve better quality of service (QoS) and edge analytics/stream mining, resulting in superior user-experience and redundancy in case of failure while it is also able to be used in Assisted Living scenarios

Nomenclatures

- Fog is a new breed of applications and services to end users with low latency, high bandwidth, and location-awareness
- It gets the name because fog is analogous to a cloud that is close to the ground
- ***fog nodes*** are facilities or infrastructure providing resources at the edge of the network
- smart TVs/set-top-boxes, gateways, and end-devices have limited processing power (resource-poor) but can be connected

Defining characteristics of the Fog

- Low latency and location awareness
- Wide-spread geographical distribution
- Mobility (as in ships and airplanes)
- Large number of nodes, Scalability using grid topology
- Predominant role of wireless access (Wifi,Bluetooth)
- Strong presence of streaming and real-time applications
- Heterogeneity of the connected devices

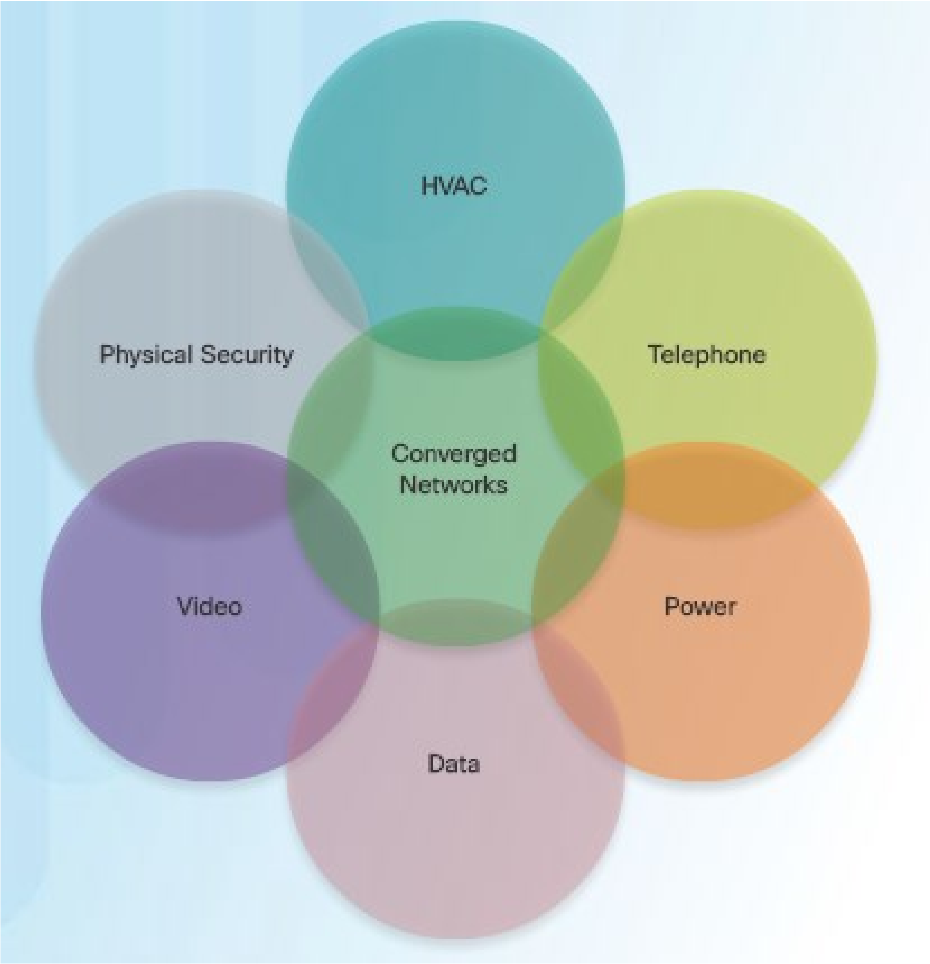

VCPU: 8 Cores
VRAM: 128Go
VDisk: 4To
Cost: modelCost1
S5
S4
S5
Cloud layer
Fog layer
ID: S6
Requirements:
CPU: 8 Cores
RAM: 128Go
Disk: 4To
Docker:
image: smartBell
Registry: hub.docker.com
antiAfiinity: [S2, S3]
S6
S3
S1
S1
S2
CPU: 8 Cores
RAM: 128Go
Disk: 4To
NetworkInterface: FastEthernet
OS: Linux-Ubuntu
Runtime: OpenStack
Fog layer
IoT layer
Dormitory
Main departement

Essential Features

- Geographical partitioning of different devices.
- End-device mobility.
- Collaboratively processes massive user services requests.
- Support heterogeneity in numbers of IoT devices.
- Promote real-time applications.
- Access the set of end-devices and computing nodes through the wireless mode.

The Converged Network and Things

- Dissimilar networks are converging to share the same infrastructure.
- This infrastructure includes comprehensive security, analytics, management capabilities.
- The connection of the components into a converged network that uses IoT technologies increases the power of the network
- Fog computing also called fogging, or fog networking represents a decentralized computing architecture between end-devices and cloud data servers.



How does fog computing work?

- The IoT devices, mobile phones, routers, switches, and other equipment constitute a ’mini cloud’ at the network’s edge.
- Rather than upload/download data to/from a cloud server, end-devices can acquire data from nearby processing devices via direct links such as device-to-device interaction and neighboring little cell
- Fog computing minimizes network overhead by uploading end-device-generated data from selected edge devices where data is highly correlated and time-sensitive
- If data belongs to high priority or time-critical category, then fog devices process data locally or partially offload it to nearby fog devices.
- In this way, sensitive data can be executed locally with low computational delay.
- On the other hand, low priority/less sensitive tasks are offloaded to the centralized data centers for long-term storage, processing, and data analytics
- This hybrid fog–cloud framework helps to optimize the system delay while reducing traffic towards the core networks.

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The Six Pillars of the Cisco IoT System

- Cisco IoT System uses six pillars to identify foundational elements.

round-trip latency

- Applications, such as real-time multi-user gaming, augmented-reality and real-time streaming, are too latency-sensitive to deploy on the cloud.
- those applications and services will suffer unacceptable round-trip latency, when data are transmitted from/to end-devices to/from the cloud data center through multiple gateways.
- Some IoT applications usually require mobility support, geo-distribution and location-awareness (using GPS)

Some use-cases

- Connected Vehicles
- Smart Grid
- Smart-Homes, Smart-buildings, Smart Cities
- Battlefields
- Airlines/Ships in transit
- Space stations
- IoT networks, wearable technology
- Agriculture (identify crop diseases, harvesting time)
- Wireless Sensors and Actuators Networks (WSANs).

Smart-home

- With the rapid development of the IoT, more and more smart devices and sensors are connected at home.
- Products from different vendors are hard to work together.
- Some tasks, which require large amount of computation and storage, e.g. real-time video analytics, are infeasible due to the limited capability of hardware.
- To solve these problems, fog computing is utilized to integrate all debris into a single platform and empower those Smart Home applications with elastic resources

home security

- Widely deployed secure sensors consist of a smart lock, video/audio recorder, various sensor monitors (light sensor, smoke sensor, temperature sensor, motion sensor etc.).
- If the products (a/c,fridge,oven,TV) are not from the same vendor, those smart devices are hard to interconnect.
- Fog computing can provide home security applications: 1) unified interface to integrate all kinds of independent devices, 2) flexible resources to support computation and storage, 3) real-time processing and low-latency response.

- Once the fog platform is set up, each secure sensor is connected as a client. The corresponding server application can be installed in independent VMs.
- Advanced processing logic can also be implemented on VMs, which can process data shared by those secure monitor applications.
- For example, a motion sensor detects a suspicious motion in a certain room, then a cleaning robot with video camera will be commanded to check out the exact location.
- Real-time video analytics will process those video and confirm whether it is a false alarm.
- Notification and report will be sent to house-owner and the system will call the police if necessary (intrusion is confirmed).

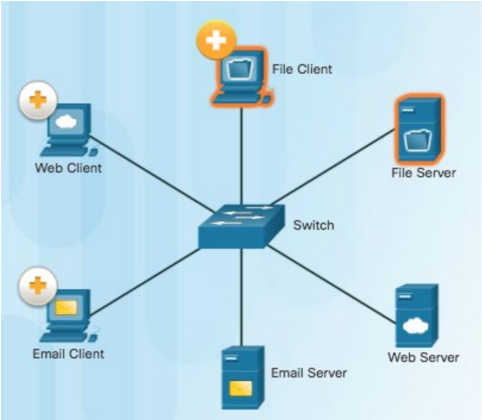
Fog computing can be integrated into vehicular networks.
Depending on whether extra infrastructure is needed, vehicular fog computing can be categorized into two types, infrastructure-based and autonomous.
The former, such as VTube, relies on fog nodes deployed along the roadside; fog nodes are responsible to send/retrieve information to/from the driving-by vehicles.
The latter utilizes vehicles on-the-fly to form fog and/or cloud to support ad-hoc events; each fog can communicate its client within and other fogs.
There are various applications for vehicular fog computing, no matter the first type or the second type.
Popular applications are: traffic-light scheduling, congestion-mitigation, precaution sharing, parking-facility management, road traffic information sharing on highways/streets, etc.

Health data management

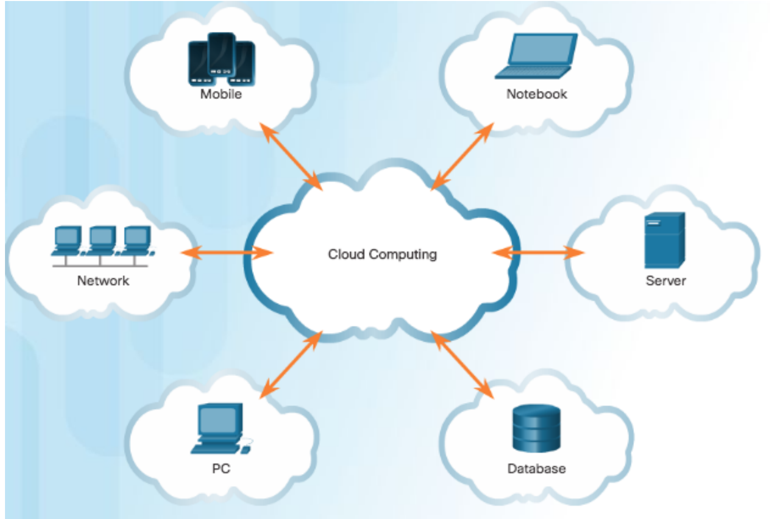
- Health data management has been a sensitive issue since health data contains valuable and private information.
- With fog computing, it is able to realize the goal that patient will take possession of their own health data locally.
- Those health data will be stored in fog node such as smartphone or smart vehicle. The computation will be outsourced in a private-preserving manner when patient is seeking help from a medical lab, emergency contact, or a physicians office.
- Modification of data happens directly in patient-owned fog node.

The Fog Computing Pillar

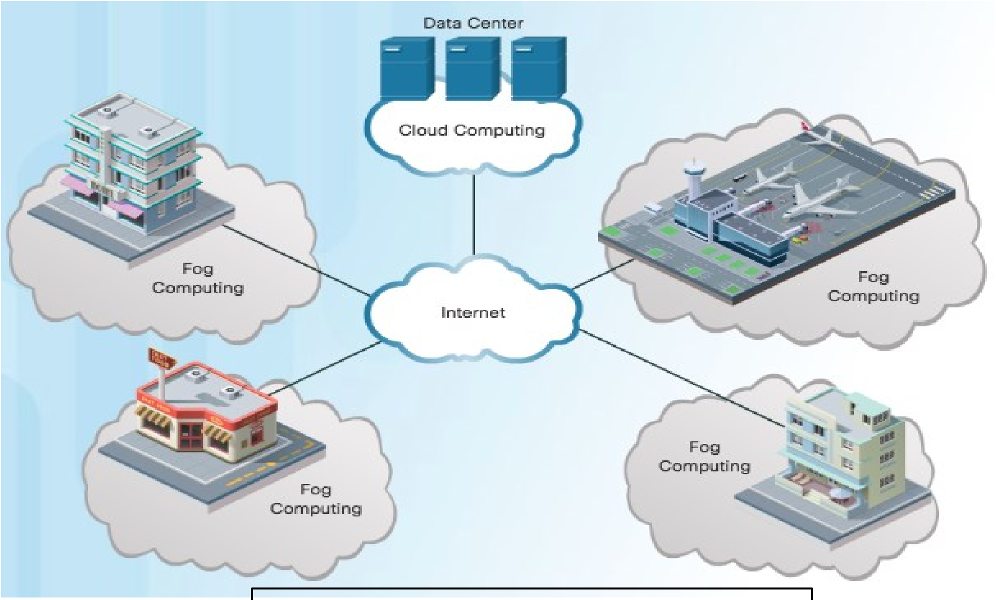
- Fog computing
  - This IoT network model identifies a computing infrastructure closer to the network edge.
  - Edge devices run applications locally and make immediate decisions.
  - Data does not need to be sent over network connections.
  - Enhances resiliency by allowing IoT devices to operate when network connections are lost.
  - Enhances security by keeping sensitive data from being transported beyond the edge where it is needed.



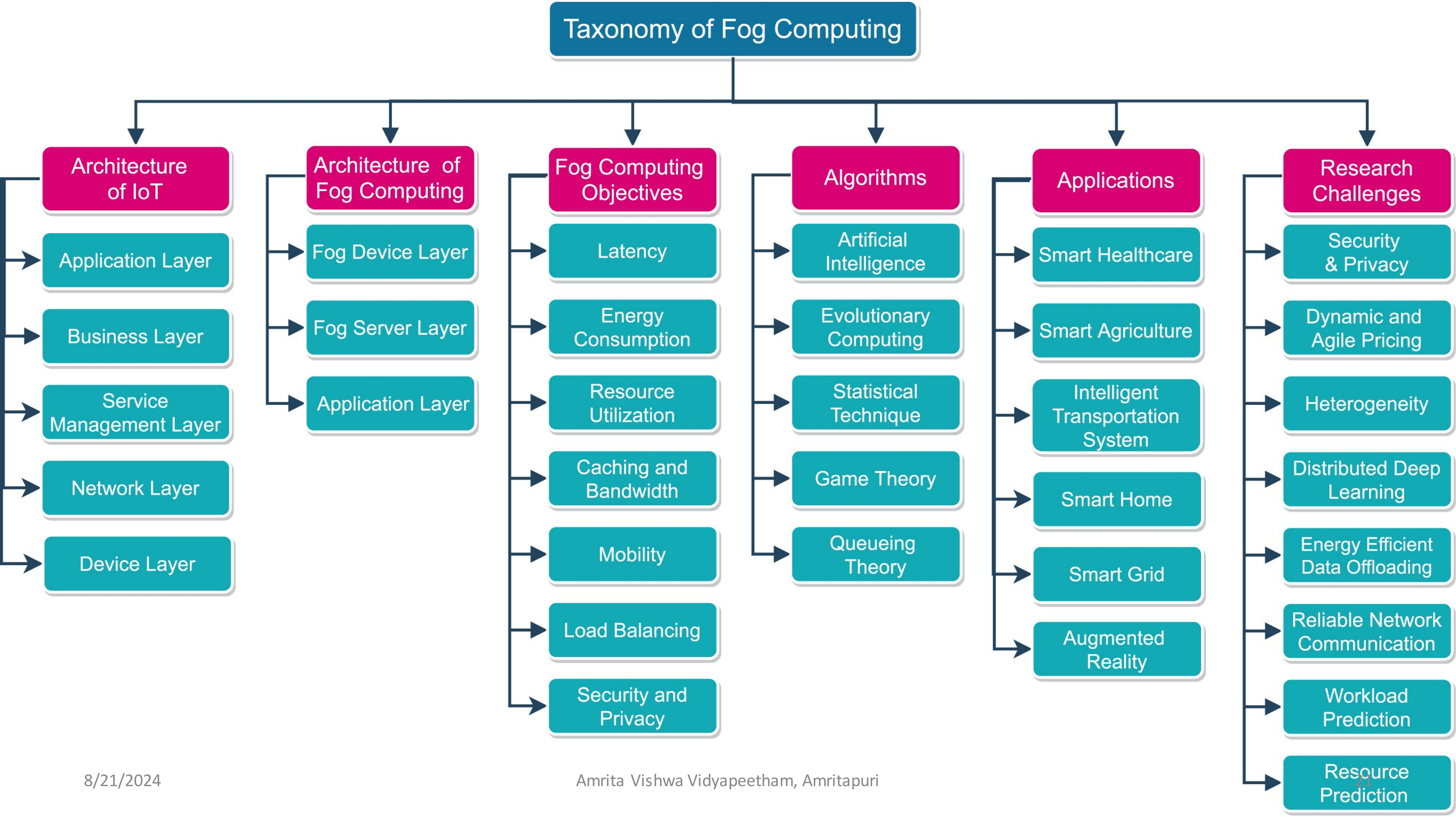
Client-Server Model



Cloud Computing Model



Fog Computing Model


Taxonomy of Fog Computing
Architecture of IoT
Application Layer
Business Layer
Service Management Layer
Network Layer
Device Layer
Architecture of Fog Computing
Fog Device Layer
Fog Server Layer
Application Layer
Fog Computing Objectives
Latency
Energy Consumption
Resource Utilization
Caching and Bandwidth
Mobility
Load Balancing
Security and Privacy
Algorithms
Artificial Intelligence
Evolutionary Computing
Statistical Technique
Game Theory
Queueing Theory
Applications
Smart Healthcare
Smart Agriculture
Intelligent Transportation System
Smart Home
Smart Grid
Augmented Reality
Research Challenges
Security & Privacy
Dynamic and Agile Pricing
Heterogeneity
Distributed Deep Learning
Energy Efficient Data Offloading
Reliable Network Communication
Workload Prediction
Resource Prediction