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Fog Computing a Survey of Integratng Cloud and IOT

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ABSTRACT: IoT environments generate unprecedented amounts of data that can be useful in many ways, particularly if analyzed for insights. However, the data volume can overwhelm today's storage systems and analytics applications. Cloud computing could help by offering on-demand and scalable storage, as well as processing services that can scale to IOT requirements. Recent analysis of a healthcare-related IoT application with 30 million users showed data flows up to 25,000 tuples per second. And real-time data flows in smart cities with many more data sources could easily reach millions of tuples per second. To address these issues, edge computing was proposed to use computing resources near IoT sensors for local storage and preliminary data processing. This would decrease network congestion, as well as accelerate analysis and the resulting decision making. However, edge devices can't handle multiple IoT applications competing for their limited resources, which results in resource contention and increases processing latency. Fog computing which seamlessly integrates edge devices and cloud resources helps overcome these limitations. It avoids resource contention at the edge by leveraging cloud resources and coordinating the use of geographically distributed edge devices.

KEYWORDS: IOT, fog nodes, cloud computing, latency, SDN, edge computing ,sensors

I. INTRODUCTION

The fog extends the cloud to be closer to the things that produce and act on IoT data. These devices, called fog nodes, can be deployed anywhere with a network connection: on a factory floor, on top of a power pole, alongside a railway track, in a vehicle, or on an oil rig. Any device with computing, storage, and network connectivity can be a fog node. Examples include industrial controllers, switches, routers, embedded servers, and video surveillance cameras.

Fog computing is a distributed paradigm that provides cloud-like services to the network edge. It leverages cloud and edge resources along with its own infrastructure, as Figure 1 shows. In essence, the technology deals with IoT data locally by utilizing clients or edge devices near users to carry out a substantial amount of storage, communication, control, configuration, and management. The approach benefits from edge devices' close proximity to sensors, while leveraging the on demand scalability of cloud resources

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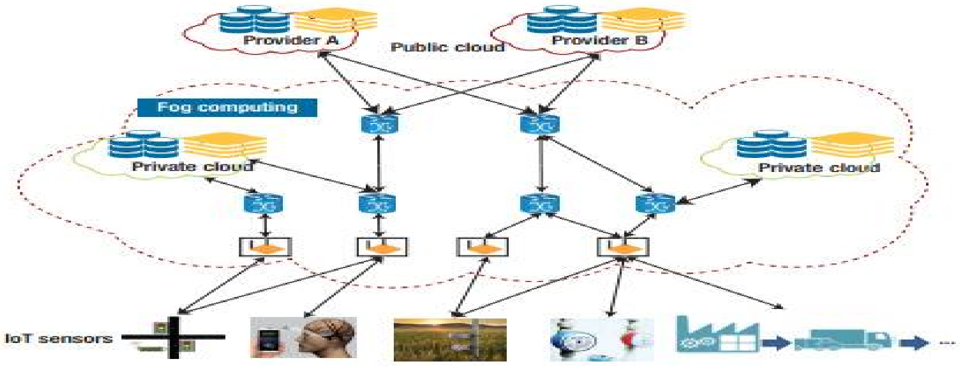

Figure 1. Distributed data processing in a fog-computing environment. Based on the desired functionality of a system, users can deploy Internet of Things sensors in different environments including roads, medical centers, and farms. Once the system collects information from the sensors, fog devices—including nearby gateways and private clouds—dynamically conduct data analytics.

II. RELATED WORK

IoT environments generate unprecedented amounts of data that can be useful in many ways, particularly if analyzed for insights. However, the data volume can overwhelm today's storage systems and analytics applications.

Cloud computing could help by offering on-demand and scalable storage, as well as processing services that can scale to IoT requirements. However, for health-monitoring, emergency-response, and other latency-sensitive applications, the delay caused by transferring data to the cloud and back to the application is unacceptable. In addition, it isn't efficient to send so much data to the cloud for storage and processing, as it would saturate network bandwidth and not be scalable

III. SCOPE OF RESEARCH

When to Consider Fog Computing?

- Data is collected at the extreme edge: vehicles, ships, factory floors, roadways, railways, etc.
- Thousands or millions of things across a large geographic area are generating data.
- It is necessary to analyze and act on the data in less than a second.

How Does Fog Work?

Developers either port or write IoT applications for fog nodes at the network edge. The fog nodes closest to the network edges ingest the data from IoT devices. Then—and this is crucial—the fog IoT application directs different types of data to the optimal place for analysis, as shown in Table 1:

- The most time-sensitive data is analyzed on the fog node closest to the things generating the data. In a Cisco Smart Grid distribution network, for example, the most time-sensitive requirement is to verify that protection and control loops are operating properly. Therefore, the fog nodes closest to the grid sensors can look for signs of problems and then prevent them by sending control commands to actuators.
- Data that can wait seconds or minutes for action is passed along to an aggregation node for analysis and action. In the Smart Grid example, each substation might have its own aggregation node that reports the operational status of each downstream feeder and lateral.
- Data that is less time sensitive is sent to the cloud for historical analysis, big data analytics, and long-term storage (see sidebar). For example, each of thousands or hundreds of thousands of fog nodes might send periodic summaries of grid data to the cloud for historical analysis and storage

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Table 1. Fog Nodes Extend the Cloud to the Network Edge

	Fog Nodes Closest to IoT Devices	Fog Aggregation Nodes	Cloud
Response time	Milliseconds to subsecond	Seconds to minutes	Minutes, days, weeks
Application examples	M2M communication Haptics[2], including telemedicine and training	Visualization Simple analytics	Big data analytics Graphical dashboards
How long IoT data is stored	Transient	Short duration: perhaps hours, days, or weeks	Months or years
Geographic coverage	Very local: for example, one city block	Wider	Global

What Happens in the Fog and the Cloud Fog nodes:

- Receive feeds from IoT devices using any protocol, in real time
- Run IoT-enabled applications for real-time control and analytics, with millisecond response time
- Provide transient storage, often 1–2 hours
- Send periodic data summaries to the cloud
- Receives and aggregates data summaries from many fog nodes
- Performs analysis on the IoT data and data from other sources to gain business insight
- Can send new application rules to the fog nodes based on these insights

IV. DISCUSSION

FOG-COMPUTING COMPONENTS

Figure 2 presents a fog-computing reference architecture. Fog systems generally use the sense-process-actuate and stream-processing programming models. Sensors stream data to IoT networks, applications running on fog devices subscribe to and process the information, and the obtained insights are translated into actions sent to actuators. Fog systems dynamically discover and use APIs to build complex functionalities. Components at the resource-management layer use information from the resource monitoring service to track the state of available cloud, fog, and network resources and identify the best candidates to process incoming tasks.

With multitenant applications, the resource-management components prioritize the tasks of the various participating users or programs. Edge and cloud resources communicate using machine-to-machine (M2M) standards such as MQTT (formerly MQ Telemetry Transport) and the Constrained Application Protocol (CoAP). Software-defined networking (SDN) helps with the efficient management of heterogeneous fog networks.

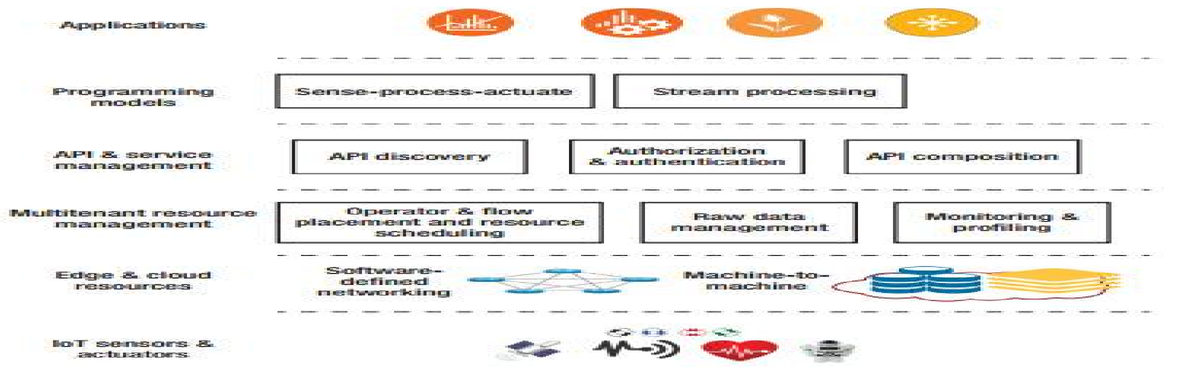

Figure 2. Fog-computing architecture. In the bottom layer are end devices—including sensors and actuators—along with applications that enhance their functionality. These elements use the next layer, the network, for communicating with edge devices, such as gateways, and then with cloud services. The resource-management layer runs the entire infrastructure and enables quality-of-service enforcement. Finally, applications leverage fog-computing programming models to deliver intelligent services to users.

FOG-COMPUTING APPLICATIONS

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Fog applications are as diverse as the Internet of Things itself. What they have in common is monitoring oranalyzing real-time data from network-connected things and then initiating an action. The action can involvemachine-to-machine (M2M) communications or human-machine interaction (HMI). Examples include locking door, changing equipment settings, applying the brakes on a train, zooming a video camera, opening a valve inresponse to a pressure reading, creating a bar chart, or sending an alert to a technician to make a preventiverepair. The possibilities are unlimited.
Production fog applications are rapidly proliferating in manufacturing, oil and gas, utilities, transportation, mining and the public sector

Benefits of Fog Computing
Extending the cloud closer to the things that generate and act on data benefits the business in the following ways:
● **Greater business agility:** With the right tools, developers can quickly develop fog applications and deploythem where needed.
Machine manufacturers can offer MaaS to their customers. Fog applications program
the machine to operate in the way each customer needs.
● **Better security:** Protect your fog nodes using the same policy, controls, and procedures you use in otherparts of your IT environment. Use the same physical security and cybersecurity solutions.

● **Deeper insights, with privacy control:** Analyze sensitive data locally instead of sending it to the cloud foranalysis. Your IT team can monitor and control the devices that collect, analyze, and store data.

● **Lower operating expense:** Conserve network bandwidth by processing selected data locally instead ofsending it to the cloud for analysis.

V. CONCLUSION AND FUTURE WORK

Fog computing gives the cloud a companion to handle the two exabytes of data generated daily from the Internet of Things.Processing data closer to where it is produced and needed solves the challenges of exploding data
volume, variety, and velocity.
Fog computing accelerates awareness and response to events by eliminating a round trip to the cloud for analysis.It avoids the need for costly bandwidth additions by offloading gigabytes of network traffic from the core network.It also protects sensitive IoT data by analyzing it inside company walls. Ultimately, organizations that adopt fogcomputing gain deeper and faster insights, leading to increased business agility, higher service levels, and
improved safety.

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