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FOG COMPUTING AND ITS APPLICATIONS

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Abstract

Cloud computing is used as a delivery platform which is a promising way for storing user data and provides a secure access to personal and business information. The users are provided with on-demand services through the Internet. Fog Computing extends the Cloud Computing paradigm to the edge of the network, thus enabling a new breed of applications and services. The fog computing provides the services like data, compute, storage and application to end user. Fog Computing is not a replacement of cloud, it just extends the cloud computing by providing security in the cloud environment. With Fog services we are able to enhance the cloud experience by isolating users' data that need to live on the edge. The main aim of the fog computing is to place the data close to the end user. Some characteristics of the Fog are: a) Low latency and location awareness; b) Wide-spread geographical distribution; c) Mobility; d) Very large number of nodes, e) Predominant role of wireless access, f) Strong presence of streaming and real time applications, g) Heterogeneity. In this paper we argue that the above characteristics make the Fog the appropriate platform for a number of critical Internet of Things (IoT) services and applications, namely, Connected Vehicle, Smart Grid , Smart Cities, and in general, Wireless Sensors and Actuators Networks (WSANs).

Keywords: Fog Computing, Sensors, Actuators, Internet Of Things, Latency

Introduction

Fog computing also known as fogging is a distributed computing infrastructure in which some application services are handled at the network edge in a smart device. Fog computing is a paradigm which monitors the data and helps in detecting an unauthorized access. According to Cisco, due to its wide geographical distribution the Fog computing is well suited for real time analytics and big data. Fog computing involves a dense geographical distribution of network and provides a feature of location access. With this any unauthorized activity in the cloud network can be detected. To get the benefit of this technique a user need to get registered with the fog. Once the user is ready by filling up the sign up form he will get the message or email that he is ready to take the services from fog computing. Fog networking consists of a control plane and a data plane. For example, on the data plane, fog computing enables computing services to reside at the edge of the network as opposed to servers in a data-center. Fog nodes provide localization, therefore enabling low latency and context awareness, but the Cloud provides global centralization. The main task of fog is to deliver data and place it closer to the user who is positioned at a location which at the edge of the network. Here the term edge refers to different nodes to which the end user is connected and it is also called edge computing. If we look according to architecture, fog is situated below the cloud at the ground level. Fog computing is a new technology in which mobile devices interact with one another and support the data communication within the Internet of Things. These characteristics make the Fog the appropriate platform for a number of critical Internet of Things (IoT) services and applications, namely, Connected Vehicle, Smart Grid , Smart Cities, and, in general, Wireless Sensors and Actuators Networks (WSANs).

The fog placed at the perfect position

IoT nodes are closer to the action, but for the moment, they do not have the computing and storage resources to perform analytics and machine learning tasks. Cloud servers, on the other hand, have the horsepower, but are too far away to process data and respond in time.

The fog layer is the perfect junction where there are enough compute, storage and networking resources to mimic cloud capabilities at the edge and support the local ingestion of data and the quick turn around of results.

A study by IDC estimates that by 2020, 10 percent of the world's data will be produced by edge devices. This will further drive the need for more efficient fog computing solutions that provide low latency and holistic intelligence simultaneously.

Fog computing has its own supporting body, the Open Fog Consortium, founded in November 2015, whose mission is to drive industry and academic leadership in fog computing architecture. The consortium offers reference architectures, guides, samples and SDKs that help developers and IT teams understand the true value of fog computing.

Analytics software companies are also scaling products and developing new tools for edge computing. Apache Spark is an example of a data processing framework based on the Hadoop ecosystem that is suitable for real-time processing of edge-generated data.

Insights obtained by the cloud can help update and tweak policies and functionality at the fog layer.

Characteristics of Fog Computing

Fog Computing is a highly virtualized platform that provides compute, storage, and networking services between end devices and traditional Cloud Computing Data Centers located at the edge of network.

Edge location, location awareness, and low latency: Fog computing supports endpoints with finest services at the edge of the network.

Geographical distribution: In sharp contrast to the more centralized Cloud, the services and applications targeted by the Fog demand widely distributed deployments. The Fog, for instance, will play an active role in delivering high quality streaming to moving vehicles, through proxies and access points positioned along highways and tracks.

Large-scale sensor: Networks to monitor the environment and the Smart Grid are other examples of inherently distributed systems, requiring distributed computing and storage resources.

Very large number of nodes: As a consequence of the wide geo-distribution, as evidenced in sensor networks in general and the Smart Grid in particular.

Support for mobility: It is essential for many Fog applications to communicate directly with mobile devices, and therefore support mobility techniques, such as the LISP protocol, that decouple host identity from location identity, and require a distributed directory system.

Real-time interactions: Important Fog applications involve real-time interactions rather than batch processing.

Heterogeneity: Fog nodes come in different form factors, and will be deployed in a wide variety of environments

Real time interactions: Fog computing requires real time interactions for speedy service.

Interoperability and federation: Seamless support of certain services (streaming is a good example) requires the cooperation of different providers. Hence, Fog components must be able to interoperate, and services must be federated across domains.

Cisco's IOx Fog Computing Platform and Edge Computing Competition

The Fog computing vision has taken form in Cisco's IOx platform, which brings distributed computing capabilities to the edge of the network by running applications directly on Cisco network devices, such as ruggedized switches, routers and IP video cameras.

While Cisco may have coined the term fog computing, it has competition in the nascent edge computing market from companies like EMC, VMware, Intel and IBM, all of which are rolling out — or are in the process of rolling out — products that deliver edge computing capabilities.

Why Fog and Why Now?

There are four main reasons:

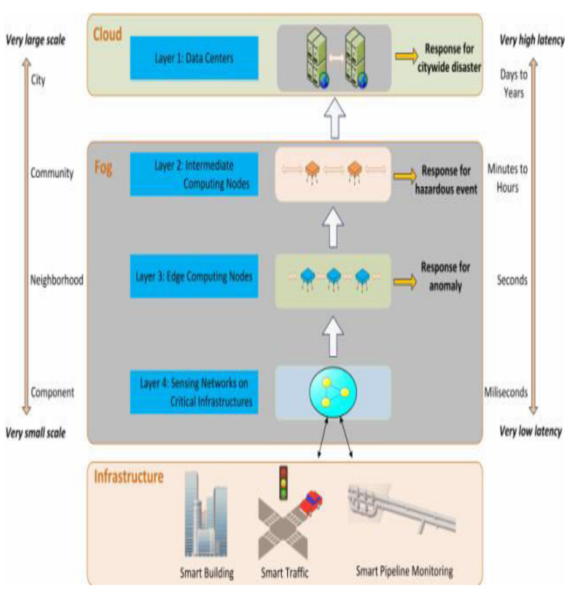
1. Time: Real time processing and cyber-physical system control. Edge data analytics as well as the actions it enables through control loops, often have stringent time requirement and can only be carried out on the edge, “here and now.” This is particularly essential for internet: the vision of millisecond reaction time on networks that enable virtual-reality-type interfaces between humans and devices.

2. Cognition: Awareness of Client-centric objectives. Following the end-to-end principle, some of the applications can be best enabled by knowing the requirements of the clients. This is especially true when privacy and reliability cannot be trusted in the Cloud, or when security is enhanced by shortening the extent over which communication is carried out.

3. Efficiency: Pooling of local resources. There are typically hundreds of gigabytes sitting idle on tablets, laptops and set-top boxes in a household every evening, or across a table in a conference room, or among the passengers of a public transit system. Similarly, idle processing power, sensing ability and wireless connectivity within the edge may be pooled within a Fog network.

4. Agility: Rapid innovation and affordable scaling. It is usually much faster and cheaper to experiment with client and edge devices. Rather than waiting for vendors of large boxes inside the network to adopt an innovation, in the Fog world a small team may take advantages of smart phone API and SDK, proliferation of mobile apps, and offer a networking service through its own API.

Architecture of Fog Computing



In the bottommost layer lie the end devices (sensors), as well as edge devices and gateways. This layer also includes apps that can be installed in the end devices to enhance their functionality. Elements from this layer use the next layer, the network, for communicating between themselves, and between them and the cloud. The next layer contains the cloud services and resources that support resource management and processing of IoT tasks that reach the cloud. On top of the cloud layer lays the resource management software that manage the whole infrastructure and enable quality of Service to Fog Computing applications. Finally, the topmost layer contains the applications that leverage fog computing to deliver innovative and intelligent applications to end users.

Looking inside the Software-Defined Resource Management layer, it implements many middleware-like services to optimize the use of the cloud and Fog resources on behalf of the applications. The goal of these services is to reduce the cost of using the cloud at the same time that performance of applications reach acceptable levels of latency by pushing task execution to Fog nodes.

Application of Fog Computing

Smart Traffic Lights: Video camera that senses an ambulance flashing lights can automatically change street lights to open lanes for the vehicle to pass through traffic. Smart street lights interact locally with sensors and detect presence of pedestrian and bikers, and measure the distance and speed of approaching vehicles. Intelligent lighting turns on once a sensor identifies movement and switches off as traffic passes. Neighboring smart lights serving as Fog devices coordinate to create green traffic wave and send warning signals to approaching vehicles. Wireless access points like Wi-Fi, 3G, road-side units and smart traffic lights are deployed along the roads. Vehicle-to-Vehicle, vehicle to access points, and access points to access points interactions enrich the application of Fog computing.

Connected car: Autonomous vehicle is the new trend taking place on the road. A software is used to add automatic steering, enabling literal "hands free" operations of the vehicle. Starting out with testing and releasing self-parking features that don't require a person behind the wheel. Fog computing will be the best option for all internet connected vehicles why because fog computing gives real time interaction. Cars, access point and traffic lights will be able to interact with each other and so it makes safe for all. At some point in time, the connected car will start saving lives by reducing automobile accidents.

Smart Grids: Smart grid is another application where fog computing is been used. Based on demand for energy, its obtained ability and low cost, these smart devices can switch to other energies like solar and winds. The edge processes the data collected by fog collectors and generate control command to the actuators. The filtered data are consumed locally and the balance to the higher tiers for visualization, real-time reports and transactional analytics. Fog supports semi-permanent storage at the highest tier and momentary storage at the lowest tier.

Self Maintaining Train: Another application of fog computing is self maintaining trains. A train ball-bearing monitoring sensor will sense the changes in the temperature level and any disorder will automatically alert the train operator and make maintenance according to. Thus we can avoid major disasters.

Wireless Sensor and Actuator Networks (WSAN): The real Wireless Sensor Nodes (WSNs), were designed to extend battery life by operating at predominantly low power .Actuators serves as Fog devices which control the measurement process itself, the consistency and the oscillatory behaviors by creating a closed-loop system. For example, in the lifesaving air vents sensors on vents monitor air conditions flowing in and out of mines and automatically change air-flow if conditions become dangerous to miners. Most of these WSNs entail less bandwidth, less energy, very low processing power, operating as a sink in a unidirectional fashion.

Smart Building Control: In decentralized smart building control wireless sensors are installed to measure temperature, humidity, or levels of various gaseous components in the building atmosphere. Thus information can be exchanged among all sensors in the floor and the reading can be combined to form reliable measurements. Using distributed decision making the fog devices react to data. The system gears up to work together to lower the temperature, input fresh air and output moisture from the air or increase humidity. Sensors respond to the movements by switching on or off the lights. Observance of the outlook the fog computing are applied for smart buildings which can maintain basic needs of conserving external and internal energy.

IoT and Cyber-Physical Systems (CPSs): Fog computing has a major role in IoT and CPSs. IoT is a network that can interconnect ordinary physical objects with identified address using internet and telecommunication. The characteristic of CPSs is the combination of system's computational and physical elements. The association of CPSs and IoT will transform the world with computer based control and communication systems, engineered systems and physical reality. The object is to integrate the concept and precision of software and networking with the vibrant and uncertain environment. With the growing cyber physical systems we will be able to develop intelligent medical devices, smart buildings, agricultural and robotic systems.

Software Defined Networks (SDN): SDN is a growing computing and networking concept. SDN concept together with fog computing will resolve the main issues in vehicular networks irregular connectivity, collisions and high packet loss rate.SDN supports vehicle to-vehicle with vehicle-to-infrastructure communications and main control. It splits control and communication layer, control is done by central server and server decides the communication path for nodes.

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 deploy them 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 other parts of your IT environment. Use the same physical security and cyber security solutions.

● **Deeper insights, with privacy control**: Analyze sensitive data locally instead of sending it to the cloud for analysis. 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 of sending it to the cloud for analysis

Conclusion

Fog computing, the new concept of the cloud at the edge of the network, is considered the appropriate platform for many Internet of Things services and applications along with virtualization of WSN/WSAN. Fog computing gives the cloud a companion to handle the extra bytes of data generated daily from the Internet of Things. Processing data closer to where it is produced and needed to solve the challenges of exploding data volume, variety, and velocity. 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 fog computing gain deeper and faster insights, leading to increased business agility, higher service levels, and improved safety. Hence, we can come to the conclusion that fog computing and cloud computing will complement each other while having their own advantages and disadvantages. Fog computing will grow in helping the emerging network paradigms that require faster processing with less delay and delay jitter, cloud computing would serve the business community meeting their high end computing demands lowering the cost based on a utility pricing mode.

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