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Fog Computing – A Practical overview

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ABSTRACT: Fog Computing is a paradigm that extends cloud computing and services nearer to the edge of the network [1]. Similar to cloud, Fog provides data, compute, storage, and application services to end users. It has low latency and better location awareness. It can send the right data to the cloud for big data analytics and storage. In addition to the strong presence of streaming and real time applications, Fog has wide-spread geographical distribution. It can handle unexpected volume, variety and velocity of data. Fog applications talk directly with mobile devices and supports heterogeneity of connected objects. It keeps data right where Internet of Things needs it. This can be implemented through proper modelling and simulation toolkits and programs.

KEYWORDS: Fog Computing, IoT, Sensors, Actuators, Latency, Modelling and Simulation.

I. INTRODUCTION

The Internet of Things links objects to the internet, enabling data and insights never available before. It is estimated that 50 billion "things" will be connected to the internet by 2020[4]. Thus, it generates unprecedented volume and variety of data. Cloud computing provides the platform to the services required to analyse and act upon such data. But, moving all data from these "things" to cloud for analysis would require vast amount of bandwidth and also it adds latency. Thus, by the time the data makes its way to the cloud for analysis, the opportunities to act upon might be gone. The ideal place to analyse most IoT data is near the devices that produce and act on that data. This is called Fog Computing. Thus, faster operations and services required by IoT can be provided by Fog Computing Model.

Fog Computing, therefore should

- Analyze the most time-sensitive data at the network edge, close to where it is generated instead of sending vast amounts of IoT data to the cloud.
- Acts on IoT data in milliseconds, based on policy.
- Send selected data to the cloud for historical analysis and long-term storage.

Thus, the characteristics of Fog Computing are

- Minimize Latency
- Conserve network bandwidth
- Security
- Reliability in operations
- Diversity in data from all kinds of environment

Fog Computing is a highly virtualized platform that provides compute, storage, and networking services between end devices and traditional Cloud Computing Data Centers, typically, but not exclusively located at the edge of network.

II. 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.

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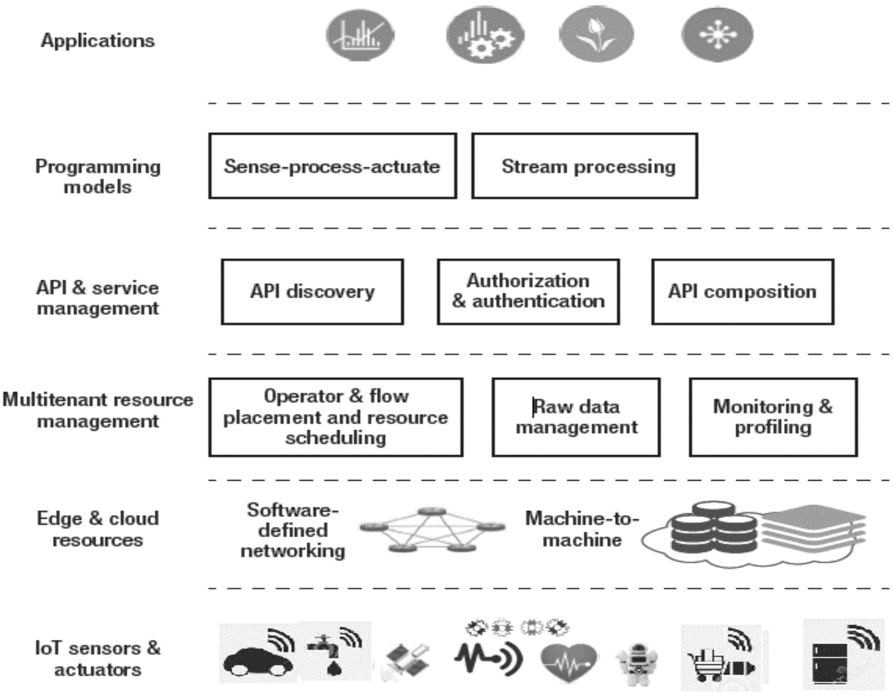

Figure 1 Fog Architecture

In the Lower most layer are end devices, including sensors and actuators; along with applications associated with 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 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.

The architecture supports two models used for IoT applications:

Sense-Process-Actuate Model: The information collected by sensors is emitted as data streams, which is acted upon by applications running on Fog devices and the resultant commands are sent to actuators.

Stream Processing Model: The stream processing model has a network of application modules running on Fog devices that continuously process data streams emitted from sensors. The information mined from the incoming streams is stored in data centers for large-scale and long-term analytics.

III. FOG COMPUTING SERVICES

Monitoring components: These services keep track of the resource utilization and availability of sensors, actuators, Fog devices and network elements. They keep track of the applications and services deployed on the infrastructure by monitoring their performance and status. Monitoring components supply this information to other services as required.

Resource management: This is the core component of the architecture and consists of components that coherently manage resources in such a way that application level QoS constraints are met and resource wastage is minimized. To this end, Placement and Scheduler components play a major role by keeping track of the state of available resources (information provided by the Monitoring service) to identify the best candidates for hosting an application module.

Power monitoring: One of the toughest challenges that most IoT solutions face is utilization of resources of IoT nodes while considering constraints on energy consumption. In contrast to cloud data centers, Fog computing encompasses a large number of devices with heterogeneous power consumption, making energy management difficult to achieve. Hence, evaluating the impact of applications and resource management policies on energy consumption is crucial before deployment in production environments. Therefore, we require a power monitoring component in the architecture that is responsible for monitoring and reporting the energy consumption of Fog devices in the simulation.

IV. FOG-COMPUTING SOFTWARE SYSTEMS

There are four prominent software systems for building fog computing environments and applications.

- Cisco IOx provides device management and enables M2M services in fog environments. Using device abstractions provided by Cisco IOx APIs, applications running on fog devices can communicate with other IoT devices via M2M protocols.
- Cisco Data in Motion (DMo) enables data management and analysis at the network edge and is built into products that Cisco Systems and its partners provide.
- LocalGrid's fog-computing platform is software installed on network devices in smart grids. It provides reliable M2M communication between devices and data-processing services without going through the cloud.
- Cisco ParStream's fog-computing platform enables real-time IoT analytics.

V. DISTRIBUTED DATA FLOW PROGRAMMING MODEL

A DDF is a dataflow program where the flow is deployed on multiple physical devices rather than one. Each physical device may be responsible for the execution of one or more nodes in the flow, forming sub flows. Some inter-node data transfer may happen between devices. Thus, DDF requires mechanisms for data transfer between physical devices to support communication between nodes on different devices. Unlike homogeneous WSNs, heterogeneous devices in an IoT application often need a flexible communications capability between physical devices so that inter-node data transfer can be made independently of the underlying communication protocols.

It also requires a way to dynamically deploy nodes in the flow onto participating devices and servers.

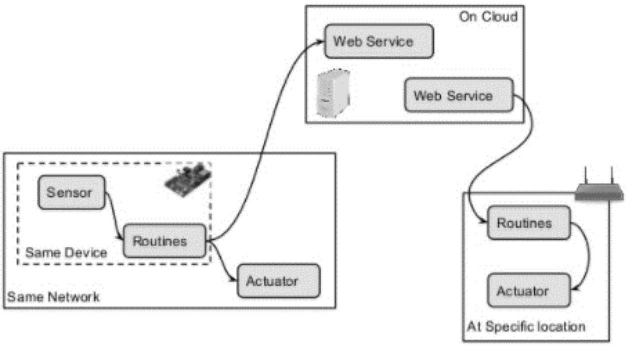

Figure 2 Distributed Dataflow Model

VI. MODELLING AND SIMULATION

To enable real-time analytics in fog computing, various resource-management and scheduling techniques including the placement, migration, and consolidation of stream-processing operators, application modules, and tasks should be verified. This significantly impacts processing latency and decision-making times.

However, constructing a real IoT environment as a testbed for evaluating such techniques is costly and doesn't provide a controllable environment for conducting repeatable experiments. To overcome this limitation, an open source simulator called iFogSim[9] can be used.iFogSim enables the modeling and simulation of fog-computing environments for the evaluation of resource-management and scheduling policies across edge and cloud resources under multiple scenarios, based on their impact on latency, energy consumption, network congestion, and operational costs. It measures performance metrics and simulates edge devices, cloud datacenters, sensors, network links, data streams, and stream-processing applications.

VII. CONCLUSION

Fog computing modeloffers a number of benefits for typical IoT applications (proximityto data, better latency etc), Fog computing can besignificantly more complex from the IoT application developer'sperspective. DDF programming model provides an easy way to design and develop IoT applications by combining application constraints and device capabilities to help drive the dynamic deployment of application logic. iFogSim can be used to model and simulate IoT, Fog, and Edge computing environments. In particular, iFogSim allowsinvestigation and comparison of resource management techniques based on QoS criteria such aslatency under different workloads iFogSimis effective for evaluating resource management techniques includingcloud-only application module placement and a techniques that pushes applications towards edgedevices when enough resources are available. It is capable of supporting simulations on thescale expected in the context of IoT. This toolkit will energize rapid development of innovative resource management policies in the areas of IoT and Fogcomputing with end-to-end modeling and simulation.

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