FOG Computing and Its Role in Internet

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ABSTRACT:

Fog computing extends the Cloud Computing paradigm to the edge of the network, thus enabling a new breed of applications and services. Defining 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).

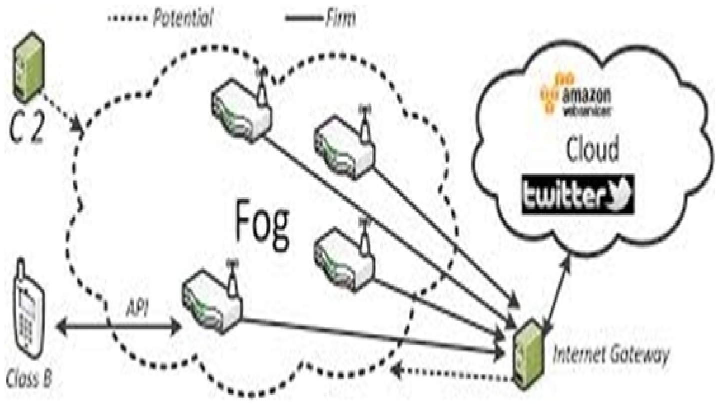
Keywords:

Fog Computing, Cloud Computing, IoT, WSAN, Software Defined Networks, Real Time Systems, Analytics.

1. INTRODUCTION:

The "pay-as-you-go" Cloud Computing model is an efficient alternative to owning and managing private data centers (DCs) for customers facing Web applications and batch processing. Several factors contribute to the economy of scale of mega DCs: higher predictability of massive aggregation, which allows higher utilization without degrading performance; convenient location that takes advantage of inexpensive power; and lower OPEX achieved through the deployment of homogeneous compute, storage, and networking components. Cloud computing frees the enterprise and the end user from the specification of many details.

This bliss becomes a problem for latency-sensitive applications, which require nodes in the vicinity to meet their delay requirements.An emerging wave of Internet deployments, most notably the Internet of Things (IoTs), requires mobility support and geo-distribution in addition to location awareness and low latency. We argue that a new platform is needed to meet these requirements; a platform we call Fog Computing [1], or, brief, Fog, simply because the fog is a cloud close to the ground. We also claim that rather than cannibalizing Cloud Computing, Fog Computing enables a new breed of applications and services, and that there is a fruitful interplay between the Cloud and the Fog, particularly when it comes to data management and analytics.



2. THE FOG COMPUTING PLATFORM:

2.1 Characterization 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, typically, but not exclusively located at the edge of network. Figure 1 presents the idealized information and computing architecture supporting the future IoT applications, and illustrates the role of Fog Computing.

Compute, storage, and networking resources are the building blocks of both the Cloud and the Fog . "Edge of the Network", however, implies a number of characteristics that make the Fog a non-trivial extension of the Cloud. Let us list them with pointers to motivating examples.

• Edge location, location awareness, and low latency. The origins of the Fog can be traced to early proposals to support endpoints with rich services at the edge of the network, including applications with low latency requirements (e.g. gaming, video streaming and augmented reality)

• 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 1, 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.

• Predominance of wireless access.

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

• 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.

• Support for on-line analytic and interplay with the Cloud. The Fog is positioned to play a significant role in the ingestion and processing of the data close to the source.

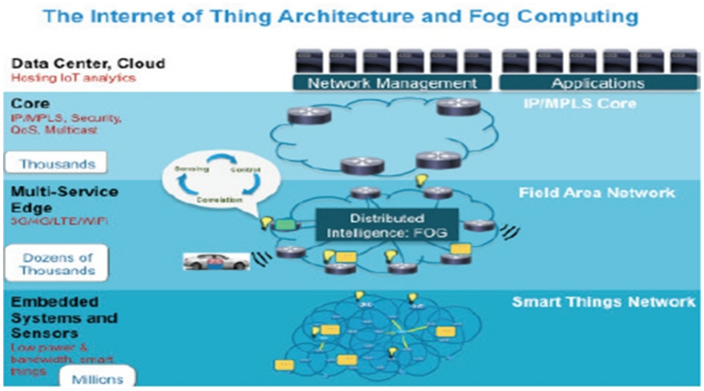


Figure 1: The Internet of Things and Fog Computing

2.2 Fog Players: Providers and Users:

It is not easy to determine at this early stage how the different Fog Computing players will align. Based on the nature of the major services and applications, however, we anticipate that:

• Subscriber models will play a major role in the Fog (Infotainment in Connected Vehicle, Smart Grid, Smart Cities, Health Care, etc.)

• The Fog will give rise to new forms of competition and cooperation between providers angling to provide global services. New incumbents will enter the arena as users and providers, including utilities, car manufacturers, public administrations and transportation agencies

3. FOG COMPUTING AND ITS APPLICATION:

The role the Fog plays in three scenarios of interest: Connected Vehicle, Smart Grid, and Wireless Sensor and Actuator Networks.

3.1 Connected Vehicle (CV):

The Connected Vehicle deployment displays a rich scenario of connectivity and interactions: cars to cars, cars to access points (Wi-Fi, 3G, LTE, roadside units [RSUs], smart trac lights), and access points to access points. The Fog has a number of attributes that make it the ideal platform to deliver a rich menu of SCV services in infotainment, safety, trac support, and analytics: geo-distribution (throughout cities and along roads), mobility and location awareness, low latency, heterogeneity, and support for real-time interactions.

3.2 Smart Grid:

Smart Grid is another rich Fog use case.

3.3 Wireless Sensors and Actuators Networks:

The original Wireless Sensor Nodes (WSNs), nickname dmotes [2], were designed to operate at extremely low power to extend battery life or even to make energy harvesting feasible. Most of these WSNs involve a large number of low bandwidth, low energy, low processing power, small memory motes, operating as sources of a sink (collector), in a unidirectional fashion. Sensing the environment, simple processing, and forwarding data to the static sink are the duties of this class of sensor networks, for which the open sourceTinyOS2 is the defacto standard operating system.

Motes have proven useful in a variety of scenarios to collect environmental data (humidity, temperature, amount of rainfall, light intensity, etc.).

4. CONCLUSIONS:

We have outlined the vision and defined key characteristics of Fog Computing, a platform to deliver a rich portfolio of new services and applications at the edge of the network. The motivating examples peppered throughout the discussion range from conceptual visions to existing point solution prototypes.

We envision the Fog to be a unifying platform, rich enough to deliver this new breed of emerging services and enable the development of new applications. We welcome collaborations on the substantial body of work ahead:

1) Architecture of this massive infrastructure of compute, storage, and networking devices;

2) Orchestration and resource management of the Fog nodes; 3) Innovative services and applications to be supported by the Fog.

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