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pioneers of fog computing

Fog vs Edge Computing

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Can Fog Controllers and Edge Controllers replace hardware PLCs?

Fog and Edge Computing – are not the same.

Relating to Industry 4.0 and the Internet of Things, Fog and Edge computing are often considered as a proven technical concept for providing control functions and transferring data from sensors into a cloud or an ERP system. In this paper, Nebbiolo Technologies, explains the commonalities and differences between Fog and Edge computing and explicates what the two concepts can achieve in diverse applications.

How do you define the terms Fog Computing and Edge Computing?

Fog Computing seamlessly extends cloud computing into edge for secure control and management of domain specific hardware, software, and standard compute, storage and network functions within the domain and enable secure rich data processing applications across the domain.

The main concepts of Fog Computing distilled from the above definition are as follows:

- Fog Computing extends cloud into Fog domain at the edge and performs cloud functions in a single continuum.
- Fog Computing applies its principles horizontally across different types of domains, i.e., IoT verticals like industrial automation, smart cities, oil and gas, transportation of men, material and goods, agriculture etc., to promote a consistent architecture, sharing of technology, resources and data across these domains.
- Fog Computing interconnects different IoT verticals for resource sharing, data sharing and service sharing for productivity, efficiency and other business factors improvement.
- Fog Computing enables secure control and management of multiple fog domain instances called the Fog Federation, comprising of edge devices, computes, networking, storage, and services in a distributed and consistent manner.
- Fog Computing enables end-to-end security from the cloud to the edge devices across IT domain, DMZ domains, and the OT domains.
- Fog Computing brings the much required data collection, processing and analysis closer to the data sources at the edge enabling both edge and fog analytics. Fog analytics is the analysis of data from multiple interoperating edge devices for anomaly detection, failure prediction, and optimization of the eco-system.

Traditionally, since the origin of computing, Edge Computing is the control and the management of a standalone end-point device individually or through a set software functions in the fog domain. This includes, for example, control of a printer, security camera, traffic light, robots, machines etc.,

with or without a control function like MES. Edge computing devices and entities within the domain are standalone or interconnected through proprietary networks with custom security and little interoperability. Modern Edge Computing attempts to redefine the edge computing scope by including some functions of Fog Computing like interoperability, local security etc.; however, it does not extend to the cloud or across domains. The current Edge Computing domain is a subset of Fog Computing domain.

What are the differences between Fog Computing and Edge Computing?

Figure 1: Comparison of Cloud Computing, Fog Computing, and Edge Computing

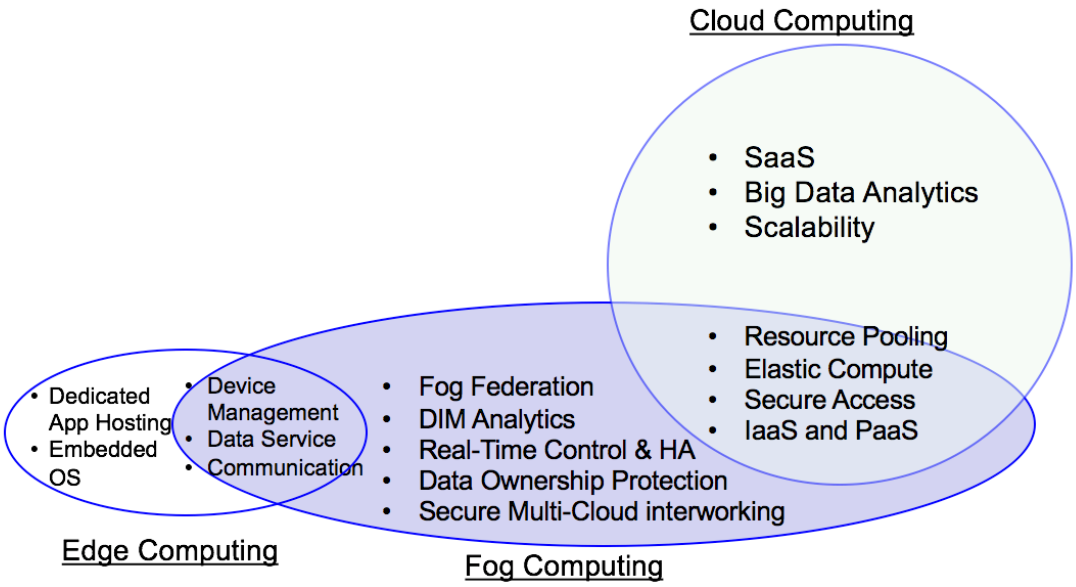

Table 1: Key Features of Edge and Fog Computing

Key Features	Fog	Edge
App Hosting	Yes	Limited
Data Service at Edge	Yes	Yes
Device & App Management	Yes	Yes
Security	E2E, Data Protection, Session & Hardware level	Partial Point Solution VPN, FW
Elastics Compute/ Resource Pooling	Yes	No
Modular Hardware	Yes	No
Virtualization with Windows support	Yes	TBD
Real-time Control High Availability	Yes	No

Table 2: Differences Between Traditional Edge and Fog Computing

No	Edge Computing	Fog Computing
1	Device aware and few services aware, unaware of the entire domain	Device independent, intelligent, and aware of the entire fog domain
2	Limited control in the edge domain	Controls all devices in the domain
3	Cloud unaware	Extends cloud to Fog level in a continuum
4	Limited network scope	Complete network scope
5	No IoT vertical awareness	Supports and enabler for multiple IoT verticals
6	No IoT vertical integration	Integrates multiple verticals
7	Uses Edge Controllers that are focused on edge device command and control	Uses fogNodes that are very versatile and capable of performing a variety of functions like RT Control, application hosting and management.
8	Security scope is limited to devices	End-to-End security
9	Analytics scoped to a single device	Fog Analytics enables collection, processing and analysis of data from multiple devices in the edge for analysis, machine learning, anomaly detection and system optimization.

Table 3: Tasks and Functions Fog Computing and Edge Computing Can Fulfill in IIoT-Based Production Systems

No	Edge Computing	Fog Computing
1	Edge Computing typically is embedded in and controls the edge. Certain devices require hard real time control and others require non real time control, and the Edge Computing performs these functions.	Fog Computing uses the devices and the embedded edge control. However, Fog Computing also enables virtual machines that host soft PLC used in real time control.
2	Edge Computing provides device controller for controlling coordinating a set of edge devices, for example in a production system MES systems act like a controller. However, these controllers are custom built for each operational domain.	Fog Computing provides FogNodes, which are the standard controller for the Fog domain. The FogNode provides the virtualized environment for application hosting. The application hosting function in the Fog Domain enables hosting of virtualized controllers (MES).
3		Fog Computing through data ownership function stores data securely in the cloud.
4		Provides Fog analytics and anomaly detection at the edge.
5	Not designed with virtualization	Enables rich virtualization
6	Security is not paramount	Provides security that enables IT/OT domain interoperation and clear role separation.

Table 4: Tasks and functions Fog Controllers Edge Controllers can adopt from the PLC

No	Edge Computing	Fog Computing
1	Replace the PLC controller using a soft PLC stack.	Enables a real time virtualized domain to host the soft PLC function.
2	Soft PLC stack integrated on the same hardware used in the device.	The virtualized soft PLC function is enabled on FogNodes external to device or on the device.

Can Fog Controllers or Edge Controllers replace the PLC in general?

The Fog Controllers (fogNodes) and the Edge Controllers can replace the PLC in general through soft PLC software stack. Currently, production quality real time control cycle of less than 500 microseconds requires the conventional hard PLC, however, majority of real time control requires a cycle time of 1 millisecond, which is very realistic using soft PLC.

Are Fog Controllers and Edge Controllers able to perform hard realtime?

Yes. Both Fog Controllers and Edge Controllers support hard real time control with a cycle time around 1 millisecond.

With which programming languages can Fog Controllers and Edge Controllers be programmed?

Fog Controllers (fogNode) use a variety of programming languages like C, C++, and Python. FogNodes require a soft PLC stack to support hard real time applications. Edge Controllers can be programmed on all the above languages and can be customized to run the soft PLC stack.

Which role do the IEC 61131-3 programming languages play in this context?

The IEC 61131-3 specification provides the software architecture and the programming languages used in the PLC and provide concepts and guidelines for building PLC. Soft PLC core logic and the control is developed.

What is the roadmap of Nebbiolo Technologies concerning Fog Computing?

Nebbiolo Technologies roadmap is to enable a complete Fog Computing platform that supports a variety of use cases like application hosting and orchestration, asset management, fog federation, virtual private fog, and end-to-end security.

Are there elaborated use cases for the use of Nebbiolo's Fog Controllers?

Nebbiolo FogNodes are intended to support the following use cases: cell controllers in the industrial floor, motor controllers for robots, machine controllers for intelligent machines, and agriculture and farming management. Applications in data centers are power, cooling, thermal, and server management. Use cases in building automation are power, water, and HVAC management. Smart City use cases are - amongst others - traffic, lighting, police, and emergency service.