Out of the Fog:

Use Case Scenarios

Industry	Smart Cities
Application	Smart Buildings



Executive Summary

Today's smart buildings are beginning to leverage the Industrial Internet for improved business outcomes, such as better energy efficiency, sustainable technology, improved occupant satisfaction and lower operational costs. When coupled with 5G and other building communications, fog computing can provide local processing and storage as well as optimize network usage that enhance the value of smart building applications.

In smart building scenarios, the OpenFog Reference Architecture model can be extended into the building's control hierarchy to create a number of smart, connected spaces within each building. A fog node can be responsible for:

- Performing emergency monitoring and response functions.
- Performing building security and safety functions.
- Controlling climate and lighting.
- Providing a more robust compute, communications and storage infrastructure for building residents to support smartphones, tablets and desktop computers.
- Uploading granular analytics to the cloud that help achieve cost-savings through increased system efficiency, enhanced building performance, and occupant convenience features.

Challenges

- Smart buildings typically contain thousands of sensors that measure various building operating parameters, including temperature, security, elevators, and so on.
- Telemetry data is sent from thousands of sensors simultaneously.
- Some processing and response is extremely time-sensitive, e.g. turning on fire suppression systems in response to a fire event, or locking down an area if an unauthorized person gains entry.
- New security cameras stream video for enhanced building security, requiring immediate analysis to identify potential situations

Solution

- Fog computing uses a distributed computing approach to create smart, connected spaces.
- Fog nodes for individual rooms can perform all monitoring and response functions.
- Fog gateways can share information across individual fog networks to prevent information silos.
- Fog nodes can lower infrastructure and equipment costs by supporting requirements such as security and storage.

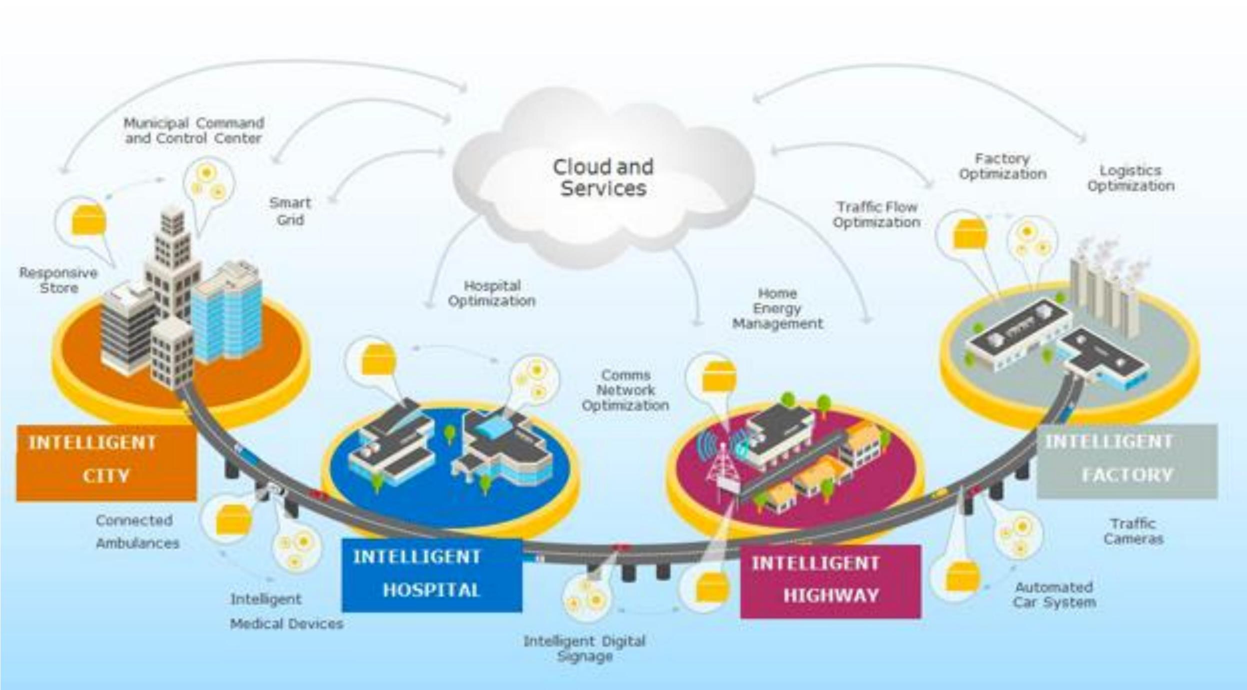
Technology

- 5G enabled for intelligent building applications.
- Real-time response is enabled by processing in close proximity to the building infrastructure and security monitoring devices.
- By providing secure data and distributed analytics, fog computing will play a key role in addressing public safety and security issues for smart buildings and cities.

Opportunities for Smart Buildings in Smart Cities

According to IoT World News, the value of smart buildings is keeping pace with the exponential growth of the Internet of Things. By 2018, cities will be home to 3.3 billion IoT devices globally. One-third of these devices will exist in smart buildings, where they will provide the foundation for smart technology networks.

Fog computing and networking enables greater efficiency and economic realities of smart city operations. In smart buildings, fog can be used to upload operations data to the cloud to perform analytics to help achieve cost-savings through increased system efficiency and enhanced building performance. For example, analytics on building data offers the ability to automate and regulate lighting, air conditioning, power consumption, etc.



The figure above illustrates the various aspects where fog computing can impact smart cities including but not limited to:

- Intelligent city with smart buildings, parking, shopping, and infrastructure.
- Intelligent hospitals linking all aspects for greater patient care and healthcare delivery.
- Intelligent highway systems to optimize utilization of infrastructure.
- Intelligent factories and software defined industrial systems.
- Building processes and employee activity.

While most modern cities have one or more cellular networks providing city-wide coverage, these networks often have capacity and peak bandwidth limits that just barely meet the needs of their existing subscribers. This leaves little bandwidth for the advanced municipal services envisioned in a smart city.

OpenFog Reference Architecture deployments coupled with 5G, LoRa, WiFi and other communication technologies provide an opportunity to address this concern. Fog nodes can provide local processing and storage as well as optimize network usage. Improved management and structure around day-to-day data can also help buildings meet regulatory requirements for energy efficiency.

Safety and Security

Standard IT security practices are ineffective in smart buildings. The lack of standards in building automation systems leads to a lack of operational visibility across the network. As a result, smart buildings are vulnerable to safety risks. Smart city planning includes critical public safety and security requirements. For example:

- Municipal networks carry sensitive traffic and citizen data (e.g., police dispatches), and operate life-critical systems (e.g., first responder communications)
- Video security and surveillance systems capture suspicious or unsafe conditions (e.g., utility network problems, unauthorized use of public spaces, etc.)

Note that smart cars and traffic congestion (which is covered as a separate use case) are also top priorities for smart cities. By providing secure data and distributed analytics, fog computing will play a key role in addressing public safety and security issues for smart cities.

Smart Buildings

The smart building market today is characterized by hundreds of diverse product categories and vendors that makes developing solutions difficult. By providing an open, interoperable architecture, the OpenFog Reference Architecture enables disparate systems from various vendors to work together.

With fog computing, smart building technology suppliers have the ability to collaborate with customers to create more targeted, outcome-based solutions. It can also provide significant comfort, convenient and occupant-friendly features to make fog-enabled smart buildings some of the most desirable real estate in town.

Smart buildings may contain thousands of sensors to measure various building operating parameters, including temperature, humidity, air quality, occupancy, door open/close, keycard readers, parking space occupancy, security, elevators, electrical use, water use, and air quality. These sensors capture telemetry data at various intervals and transmit this information to a local storage server. Once this information is processed (analyzed), controller-driven actuators will adjust building conditions as necessary.

Some of this processing and response requirements are extremely time-sensitive, such as turning on fire suppression systems in response to smoke or locking down an area if an unauthorized person tries to gain entry. Time-sensitive means real-time response, which requires processing in close proximity to the infrastructure devices.

Key Features Enabled by Fog Computing

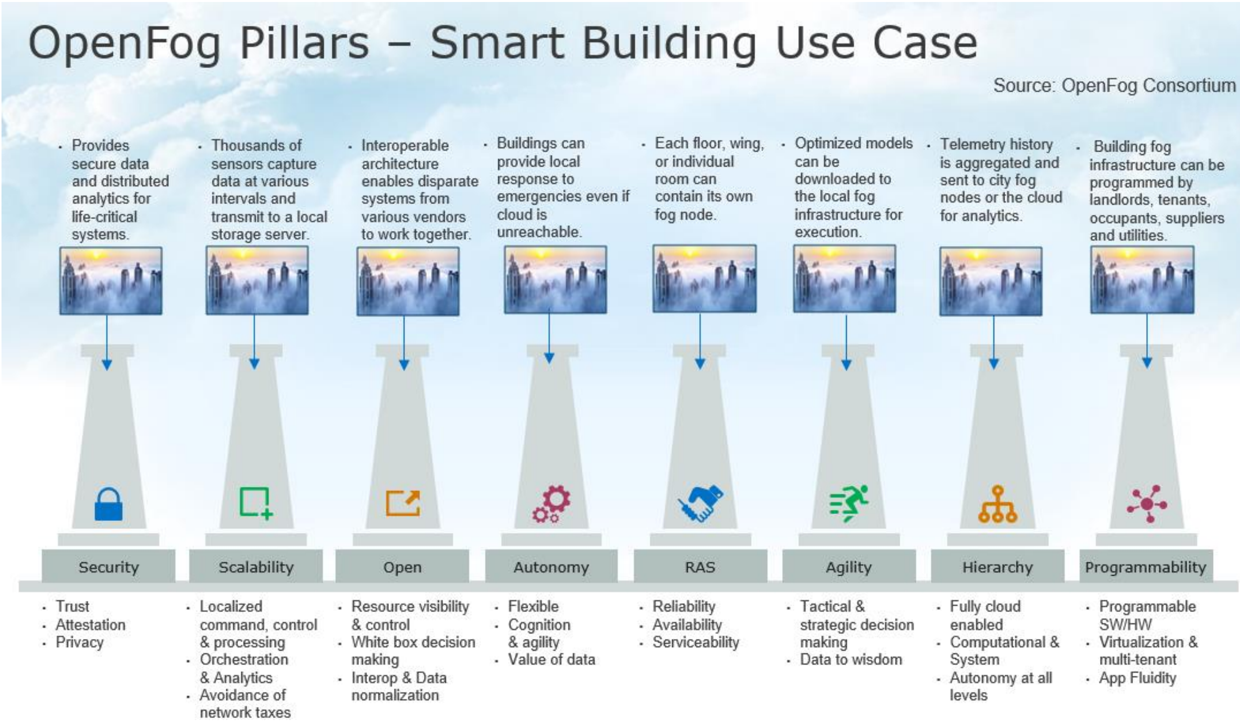
The OpenFog Reference Architecture model can be extended into the building's control hierarchy to create a number of smart, connected spaces within each building. Using the hierarchical design of fog computing, each floor, wing, or even individual room could contain its own fog node.

A fog node could be responsible for:

- Performing emergency monitoring and response functions.
- Performing building security functions.
- Controlling climate and lighting.
- Providing a more robust compute and storage infrastructure for building residents to support smartphones, tablets and desktop computers.
- Responding to building occupant preferences and special requests to make buildings more convenient and comfortable.

Locally stored operational history can be aggregated and sent to the cloud for large-scale analytics. These analytics can be applied to machine learning to create optimized models, which are then downloaded to the local fog infrastructure for execution.

An Architectural View of Fog Deployments in a Smart Building



What is Fog Computing?

Fog computing is a system-level horizontal architecture that distributes resources and services of computing, storage, control and networking anywhere along the Cloud-to-Things continuum. Fog computing is:

- **Horizontal architecture:** Supports multiple industry verticals and application domains, delivering intelligence and services to users and business.
- **Cloud-to-Thing continuum of services:** Enables services and applications to be distributed closer to things, and anywhere along the continuum between Cloud and Things.
- **System-level:** Extends from the Things, over the network edges, through the Cloud, and across multiple protocol layers – not just radio systems, not just a specific protocol layer—not just at one part of an end-to-end system, but a system spanning between the Things and the Cloud

About the OpenFog Consortium

Smart buildings are just one of many industry use case scenarios whose commercial viability will depend on fog computing in order to achieve the rapid response, bandwidth and communication necessary in advanced digital applications.

The OpenFog Consortium is a global nonprofit formed to accelerate the adoption of fog computing in order to solve the bandwidth, latency, communications and security challenges associated with IoT, 5G and artificial intelligence. Our work is centered around creating a framework for efficient and reliable networks and intelligent endpoints combined with identifiable, secure, and privacy-friendly information flows in the Cloud-to-Things continuum based on open standard technologies. To discuss how fog computing works in your environment, please contact us at info@OpenFogConsortium.org or visit www.OpenFogConsortium.org.