On The Edge
Powering Through The Fog

A Server Technology white paper by Marc Cram

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INTRODUCTION

The technology industry is riding high once again, much like it was in the late 1990s when personal computer manufacturing was booming, cell phones were on the uptick, and the internet was but a fledgling idea gaining steam. Numerous networking hardware companies grew at a torrid pace thanks to the need to tie together the various systems implemented in the desire to automate, communicate, and collaborate. Today's cause célèbre is the Internet of Things (IoT), or the Internet of Everything (IoE) depending on your chosen "thought leader." The IoT is forecasted to grow at a rate faster even than was seen for smartphone adoption. Soon, data and intelligence will become part of most everything we touch in our daily lives. Roads, cars, bridges, refrigerators, trash cans, mirrors, doorbells, door locks, thermostats, water heaters, light bulbs, strollers, toys, clothing, watches, jewelry, and even our bodies are becoming a part of the IoT. Advances in both hardware and software are bringing new capabilities to the home, the office, the factory, the cruise ship, the airplane, and the amusement park. Whether we are measuring how many g's we felt on a roller coaster, livestreaming our first attempt at surfing, or letting a doctor examine our screaming infant remotely, we are continuously creating new content to be captured, routed, processed, stored, analyzed, shared and commented upon.

Frequently, this data is not consumed at the source but is sent someplace else to be recorded, analyzed, and archived. A remote weather station measuring the water levels in a stream, the temperature, pressure, and humidity of the air, the speed and direction of the wind, and the amount of rainfall or snowfall is connected to a database running on a machine that is located tens, hundreds, or even thousands of miles away. Live video streaming from a cell phone can be shared with thousands or even millions of people across the country simultaneously. An autonomous vehicle can act as both a mobile Wi-Fi hotspot as well as a source of continuously updating information on location, speed, proximity to adjacent vehicles, state of battery charge, temperature of the motor, status of the brakes, and so forth. Just like watching the latest movie on demand, students taking online classes utilizing open courseware featuring high resolution video and audio require the support of content delivery networks with end points close to the point of consumption to minimize the traffic on the network backbones of the campus and the metro area data provider.

EXECUTIVE SUMMARY

Rapid growth in public cloud (centralized compute) adoption is leading to increasing "north-south" bandwidth demands as the proliferation of devices pouring data into the cloud and drawing data back out strain both the wired and wireless internet connecting the devices to the cloud.

Edge, mobile edge, and fog computing are all approaches aimed at decentralizing the compute infrastructure and improving the responsiveness observed by end client devices.

Edge computing of any variety requires coordination of widely dispersed assets, and is best supported with remotely managed intelligent power.

INTRO (CONT.)

Cloud computing is a great solution for those applications where you have uninterrupted high speed access to a server capable of receiving, processing, and responding quickly back to the end device.

Edge computing, mobile edge computing, and fog computing are all terms used to describe data processing that is taking place along the path from point of data creation to the points of processing, storage, and consumption. Later in this paper, the differences between these computing styles and cloud computing will be explained, along with discussing the power infrastructure requirements needed to support them.

There are a great number of resources available to the reader on the topic of edge, mobile edge, and fog computing. See “Appendix 2 – Sources and References” for suggested reading.

DATA CREATION

More digital data is being created today than ever before. More books are being written, more photographs and videos being taken, more social media (blogging, tweeting, texting, videos) uploaded to the cloud. In addition, there are more sensors - on our bodies, in the home, the public park, the office, on the production floor, in our cars and along the streets and highways. Where 20 years ago, a digital still camera was a novelty, today every smart phone carries a camera that is capable of both still images, panoramic images, time lapse photography, and a variety of video modes. Along with that multi-use camera, the smart phone has multi-axis gyroscopes, accelerometers, proximity sensors, GPS, and magnetometers. The data coming from that phone is used to provide a number of services – to show traffic flow information on Google Maps or to provide "find my friend" and "find my phone" services, for example.

There are air quality sensors (carbon monoxide, CO2, ozone) for the home, remotely monitored thermostats, remote security cameras, yard moisture sensors, detectors telling you that mail is present in the mailbox, and even detectors telling you if someone is parked on your driveway. There are high resolution smart TVs with motion sensing and microphones that let the TV determine when to dim/or shut off automatically. Amazon and Google have introduced "always on" voice monitoring in the home to facilitate interaction with their respective services Alexa and Google Now.

The number of sensors deployed per person continues to grow as the popularity of smart home applications grow, along with growing government needs for smart transportation, smart highways, and long term environmental monitoring.

EDGE AND MOBILE EDGE COMPUTING

Edge computing does the following:

- Puts compute and storage close to the point of data generation (at the ISP, or the carrier)
- Speeds analytics by processing data close to the source
- Reduces latencies
- Reduces traffic back to "the cloud"

Mobile edge computing:

- Puts compute and/or storage at the cell site
- Reduces backhaul traffic to the Central Office (CO)
- Can facilitate video on demand streaming to mobile devices

http://bit.ly/2gujWvK

At the same time, there are more people in more countries adopting the technologies that employ these sensors and data services.
As an example of growing data flow, ADSL used to work as a means of data delivery to the home when the home was mostly consuming data created elsewhere through activities such as watching TV and web browsing. Today, the smart home is becoming a data creator due to the proliferation of new connected devices such as Amazon Echo, Nest thermostats, doorbells, garage door openers, water shutoff sensors, wireless meters for water, gas, and electric utilities, window breakage sensors, air quality sensors, fire sensors, and motion sensors for security services.

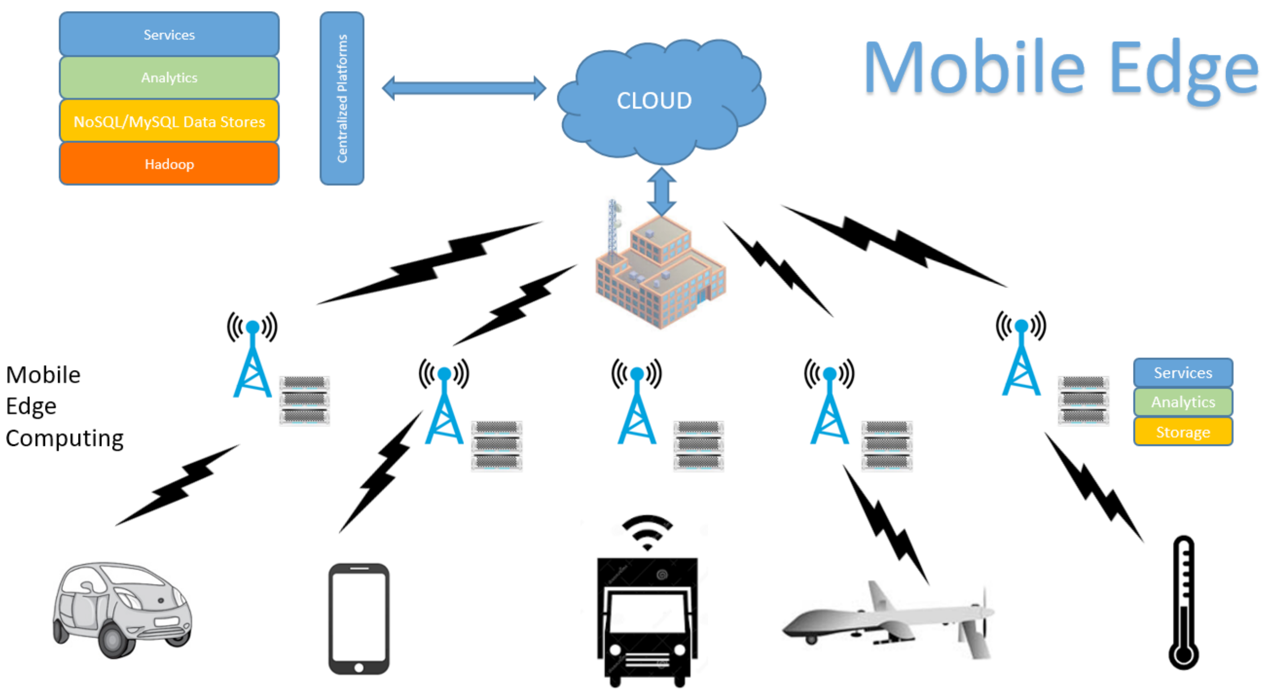
The aggregate bandwidth now going upstream from the home to the cloud data center for processing all these sensor and camera outputs is beginning to tax the legacy telecom infrastructure (both wired and wireless) to the point that in the USA, AT&T and Verizon are shifting customers over to cable and satellite systems for streaming to the home and using wireless bandwidth to supplement landline capacity back to the central office. But that begs the question, why does the data need to go back and forth at all?

WHAT IS EDGE COMPUTING?

Edge computing is best described as putting computational and data storage infrastructure at the point closest to where data is created or consumed. Cloud computing requires that data move from point of creation to a central point (a cloud data center) to be stored, analyzed, archived, and streamed back out to a consumption point. Edge computing might be located at a neighborhood telco or cable TV hut, for example, where popular "on demand" movies have been stored to keep traffic off the main IP backbones. In like fashion, popular Netflix programming may be stored on AWS-controlled infrastructure located at ATT cell tower locations to reduce demand on the backhaul of IP traffic to the telco central office and on to the AWS cloud facilities.

WHERE DOES THE MOBILE EDGE START?

"Where is the edge of a mobile network? If we look at the mobile network architecture, the radio and core network elements in a mobile network are the places where a lot of sophisticated signal processing happens and any application server would be sitting near the core network. Thus, the edge can be assumed to be somewhere between the IP network and the beginning of the mobile network, i.e., the core network. Mobile Edge Computing (MEC) is changing this by bringing traditional IT infrastructure and applications deep into the mobile network, all the way to the radio network elements. MEC is a new standardization initiative supported by market leaders like Nokia, Huawei, NTT, DoCoMo, and Vodafone." [i]



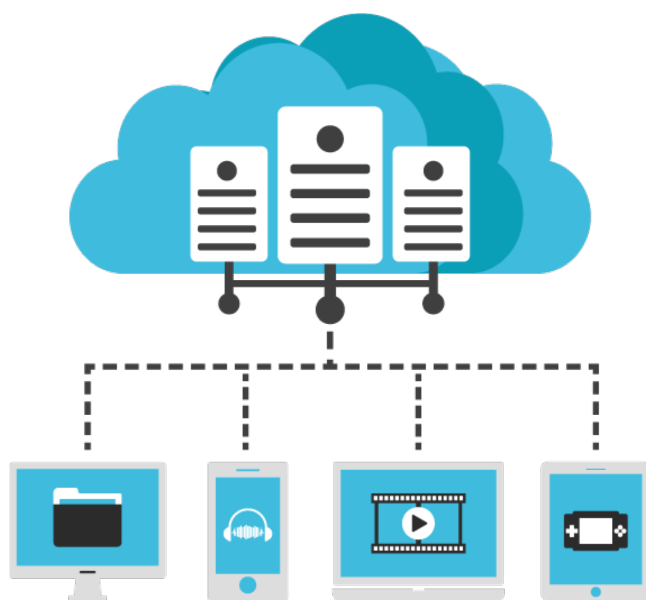
An example of what is driving the need for MEC is the autonomous vehicles now being introduced by Google, Tesla and the many legacy car manufacturers.

"The self-driving car from Google already is a true data creator. With all the sensors to enable the car to drive without a driver, it generates nearly 1 Gigabyte every second. It uses all that data to know where to drive and how fast to drive." [ii]

"Twenty-five gigabytes: that's how much data a connected car will upload to the cloud every hour (PDF). That's equal to about a dozen HD movies and exceeds the storage capacity of most smartphones today. What's the car telling the network in such great volume?

The short answer is: data about everything. Its route, its speed, the wear and tear on its components, and even road conditions. Vehicles today have about 40 microprocessors and dozens of sensors that collect telematics and driver behavior data, and that data can be analyzed in real-time to keep the vehicle's performance, efficiency, and safety in check. It also provides vital feedback for cities and states about traffic volume and roadway design." [iii]

DATA CONSUMPTION



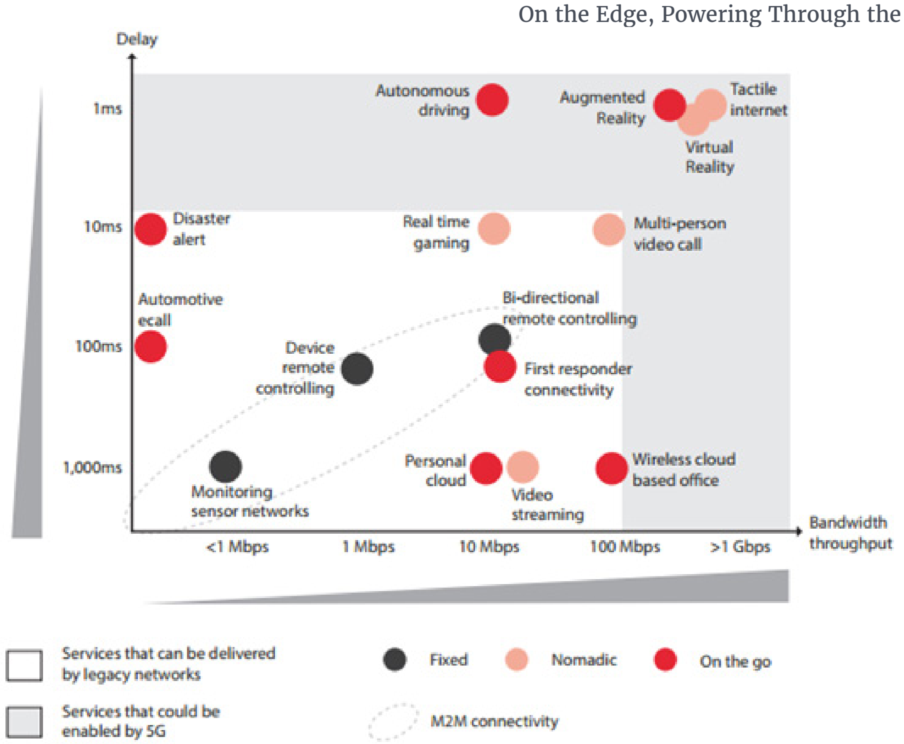
More points of data consumption are available today than ever before. Televisions, Set Top Boxes, Over the Top (OTT) TV, smartphones, tablets, laptops, notebooks, desktops, cars, and VR/AR headsets are delivering cable provided video on demand, Netflix and YouTube video streaming, and audio streaming such as Pandora and Spotify. Anyone with an internet connection can be continuously informed and entertained with more content than they can consume in their lifetime.

Internet browsing, social media, and communication (IM, email, video calls, etc.) used to be the rulers of electronically-fueled data consumption, but a new champion has emerged: video streaming. In 2015, our desire for Netflix binges and falling down YouTube rabbit holes accounted for 70% of the world's internet traffic. By 2020, video streaming will be responsible for 82% of the global community's internet use, meaning that watching all 10 seasons of Friends and laughing at gamers' commentary-laced shenanigans will be responsible for consuming statistically significant amounts of global electricity. [iv]

While video streaming is seeing wider uptake, the resolution of the video being consumed is being increased. In the past several years, we have seen the transition begin from HDTV (1920x1080) to 4K UHD (3840*2160, or 4x the number of pixels of HD). IHS Technology predicts that annual sales of 4K TVs will reach 120M units annually by 2020, with Japan and South Korea leading the way in content development and distribution at this resolution. 8K television could begin to make its way to the consumer market in the 2018-2020 timeframe as well. 8K is defined as having 7680x4320 pixels, or 8x the pixels of HD. 8K formatted video requires larger amounts of storage per program, and larger amounts of bandwidth to deliver that program to the point of consumption.

In addition to video streaming, there are numerous other data consuming processes that are forcing the wireless carriers to look at moving from 4G to 5G data networks. Amongst these are multi-way video calling, virtual reality (VR) and augmented reality (AR) headsets, and the widespread usage of always on personal assistants such as Siri, Alexa, and Google Now. Figure 1 below shows the wireless bandwidth requirements of numerous applications as seen by GSMA Intelligence. Figure 2 shows the maximum theoretical downlink speed by generation.

"Data loses its value when it can't be analyzed fast enough."
- Patrick McGarry, Ryft



Bandwidth and latency requirements of potential 5G use cases
Source: GSMA Intelligence

Virtual Reality/Augmented Reality/Immersive or Tactile Internet

Figure 1 - https://goo.gl/mTNO9b

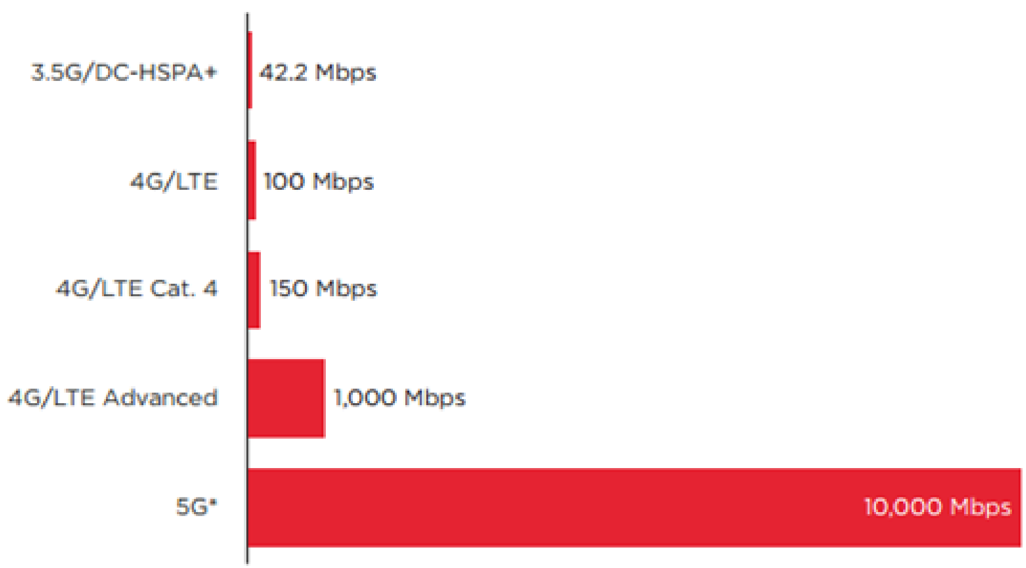


Figure 2: Maximum theoretical downlink speed by technology generation, Mbps
(*10 Gbps is the minimum theoretical upper limit speed specified for 5G)
Source: GSMA Intelligence

Figure 2 - https://goo.gl/5ihr3a

THE DATA JOURNEY

The adoption of cloud technology leads to a journey of many hops from the point of data creation to the point of consumption. Suppose a parent takes a video of their child on the playground and decides to upload that video to YouTube for later viewing by friends and family. The data flow begins at the mobile device, moves onto the wireless carrier network, transits via wired or microwave backhaul to the telco central office, then onto a fiber optic backbone, and is then picked up at one or more Google datacenters where the video is compressed, tagged with metadata, indexed, processed for facial and image recognition (in the event the YouTube gets posted to Facebook) and stored.

When it comes time for distant relatives to view the video on YouTube, the data stream goes back to another central office, and then onto the local cable provider or wireless carrier at the viewers' location, before jumping onto a local Wi-Fi connection for viewing on an iPad.

This same type of multi-hop data flow takes place when the data source is the Nest thermostat at home is talking with a Google data center to decide when to turn off the AC or heater based on time of day and whether or not the home is typically occupied at that time. Or when the smart office turns on multiple network switches and Wi-Fi access points at 6am to support the day's occupants, then ramps them down or turns them off again after 8pm when the building is no longer occupied.

FIVE USE CASES FOR EDGE COMPUTING

Data loses its value when it can't be analyzed fast enough. Edge computing and analytics can solve the challenge for enterprises doing the following:

- IoT sensor data monitoring and analysis
- Retail customer behavior analysis
- Mobile data thinning
- Compliance analysis of financial branch transactions (ATM)
- Remote monitoring and analysis for oil and gas operations

https://goo.gl/X7UuDS

RETHINKING THE ARCHITECTURE FROM CREATION TO CONSUMPTION

According to Patrick McGarry, VP of Engineering at Ryft, "Data loses its value when it can't be analyzed fast enough. Edge computing and analytics can solve the challenge for enterprises ranging from oil and gas production to banks and retailers. [v]

"Organizations are currently reliant on large and complex clusters for data analytics, and these clusters are rife with bottlenecks including data transport, indexing and extract, as well as transform and load processes. While centralized infrastructures work for analyses that rely on static or historical data, it is critical for many of today's organizations to have fast and actionable insight by correlating newly obtained information with legacy information in order to gain and maintain a strong competitive advantage.

"An increasing amount of data is priceless in the seconds after it's collected—consider the instance of a fraudster or hacker accessing accounts—but it loses all value during the time it takes to move it to the centralized data center infrastructure or upload it to the cloud. Losing value from that data due to slow decisions is not acceptable, especially when an edge-computing platform that eliminates moving data provides the near-instant intelligence needed. Organizations cannot afford to wait days, weeks or even months for insights from data. With data analytics at the edge, they do not have to. [vi]

"When you push applications, data and services to devices at the edges of networks to reduce transmission costs, shrink latency, and improve user experience " [vii] , that is edge computing. To address the time sensitive nature of many modern applications, organizations are beginning to look at edge computing as the answer. Edge computing consists of putting micro data centers or even small, purpose-built high-performance data analytics machines in remote offices and locations to gain real-time insights from the data collected, or to promote data thinning at the edge, by dramatically reducing the amount of data that needs to be transmitted to a central data center. Without having to move unnecessary data to a central data center, analytics at the edge can simplify and drastically speed analysis while also cutting costs.

According to Gartner, "Micro and edge computing executes real-time applications that require high-speed response at the nearer edge servers. The communication delay is shortened to a few milliseconds, rather than several hundred milliseconds. It offloads some of the computation-intensive processing on the user's device to edge servers and makes application processing less dependent on the device's capability. [viii]

"Services requiring a delay time of less than 1 millisecond must have all their content served from a physical position very close to the user's device. Industry estimates suggest this distance may be less than 1 kilometer. Such content may have to be at the base of every cell. This will likely require a substantial uplift in CAPEX spent on infrastructure for content distribution and servers. [ix]

"If any service requiring 1 millisecond delay also has a need for interconnection between one operator and another, this interconnectivity must occur within 1 km of the customer." [x]

DEPLOYING FOG TO THE BUILDING

"The cloud is up, while the fog comes down amongst us, the users," as fog computing fans like to say. [xi]

Having a central system in the home to preprocess data created at the home makes a lot of sense. Why store your media in the cloud just to stream it back to the house, when you could store it at the house and only access the cloud when your consuming device is mobile and doesn't have room to store the media itself? This is the rationale for fog computing. Think of it as being like a media server, but for all data types, not just audio and video. Fog computing in the home takes advantage of local processing and storage to reduce the bandwidth demands going back to the ISP and on to the cloud providers.

In like fashion, having fog deployments at the office and the manufacturing facility makes good financial sense along with helping ensure the security of the data being generated. It is easier to secure data that never leaves your physical premises than it is to try to ensure what is in the cloud has not been breached and compromised.

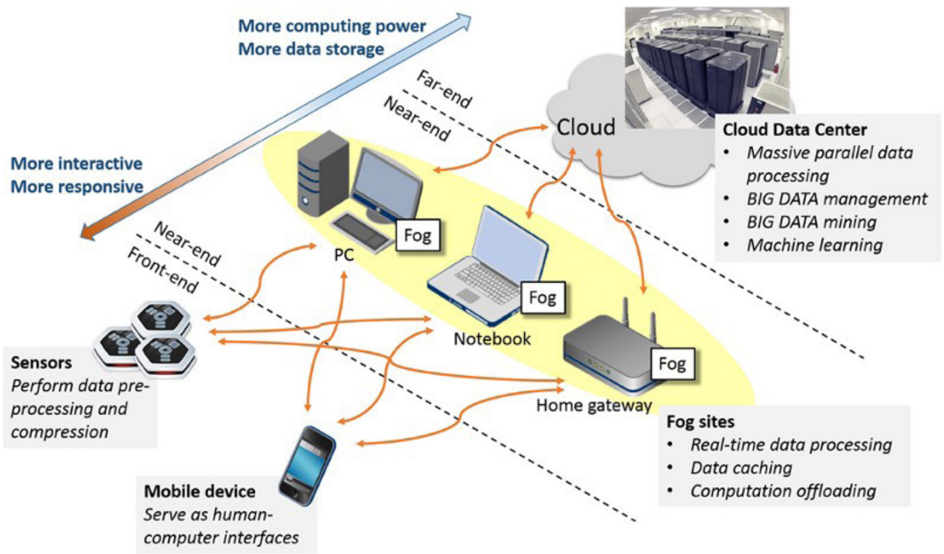


Figure 3
https://goo.gl/tdQn4q

FOG COMPUTING

Fog computing lets data coming from IoT devices be aggregated on premises for pre-processing and real-time analytics before going outside the office or home gateway and traveling to a centralized point for big data analytics and archiving to long term or cold storage.

OpenFog technical workgroups are creating an architecture that enables end-user clients or near-user edge devices to carry out computation, communication, control and storage.

Learn more at
The OpenFog Consortium
www.openfogconsortium.org

REMOTELY MANAGED AC POWER

AC powers most modern data centers. Single phase and three phase power is delivered to the IT rack.

Servers, storage, and networking gear in the IT rack all plug into Zero-U PDUs.

Switched PDUs, AKA managed PDUs, provide a means of exerting remote control over power delivery to the compute, storage, and other IT loads in the rack.

Eight-outlet through 54-outlet PDUs are available to provide remotely managed power for edge, mobile edge and fog computing deployments.

POWER REQUIREMENTS OF EDGE, MOBILE EDGE, AND FOG COMPUTING

"Remote hardware systems supporting edge and MEC usually have firmware and/or software running on them that needs to be fault tolerant, robust enough to be able to run consistently through intermittent communications outages and power availability challenges that result from natural disasters or manmade disruptions.

For widely dispersed networking, storage, and computational assets to work reliably, the underlying hardware needs to be continuously powered on, or else capable of being remotely managed. No utility can guarantee power availability 100% of the time, so the ability to support remote power cycling or being able to schedule on time and down time of the radio base station and the compute hardware are crucial to delivering exceptional service to the customer while minimizing costs to the service provider. Being able to remotely reboot hardware that is malfunctioning frequently helps the remote site operator avoid dispatching a truck with staff to investigate and correct malfunctioning systems.

Mobile edge computing is likely to require a mix of DC and AC powered equipment be located at various cell tower and cable TV hut locations. The most commonly used DC power is -48V DC employed by the telecommunications companies. The most commonly used AC power in the USA is either 120V or 208V single phase AC, with 200-230V single phase AC prevalent in the rest of the world. At the cell tower location, there may be AC power from the local electric utility, AC power from an on-site diesel-powered generator, DC power from battery banks, and DC power. from solar cells.

Fog computing most typically is going to have some form of AC power available from the local electric utility, whether that is at the home, the office, or the factory. Newer homes and office locations may also have some local DC power generation capability in the form of solar cells or fuel cells.

THE CASE FOR INTELLIGENT POWER MANAGEMENT

No computer, server, PLC, network switch, or digital radio is perfect. Each is vulnerable to firmware and software bugs at the operating system and virtual machine level, power disruptions, and natural disasters. To mitigate the risk of service interruptions, it is good engineering practice to implement multiple layers of control interface, both "in-band" and "out of band." Whereas most servers and base station manufacturers offer an IP-based means of resetting the software of their systems, sometimes the control plane of these systems is also incapable of responding. In that circumstance, the "out of band" solution is to cycle power to the device. This out of band access and control is exerted through an intelligent power distribution unit, one capable of switching individual outlets on and off via commands passed through either an on-board Ethernet or serial interface.

Server Technology offers Switched Power Distribution Units (PDUs) in AC and DC power configurations capable of supporting any remote infrastructure installation, whether edge, mobile edge, or fog implementation.

Edge installations most frequently look like miniature datacenters, and are frequently equipped with AC power. For these applications, Server Technology offers the industry's broadest set of standard and semi-custom (Build Your Own PDU) power solutions in a Zero-U (vertical) form factor.

MEC deployments may require a mix of AC and/or DC power. Server Technology Switched AC products most suited to this environment have eight (8) to twenty-four (24) outlets in a horizontal configuration. Server Technology Switched DC products offer between four (4) and sixteen (16) ports of managed DC power. The AC and DC products share a common management interface, simplifying the ability of the infrastructure operator to operate from a single pane of glass with a single management tool, such as the Server Technology Sentry Power Manager (SPM) or a DCIM tool such as Nlyte.

Fog deployments are likely to occur in places where AC power is readily available, such as the home or the office. For this application, horizontal PDUs having from eight (8) to twenty-four (24) outlets are a good choice.

REMOTELY MANAGED DC POWER

DC power has long been the power of choice for the telecommunications industry for a variety of technical reasons, chief among them that DC-powered infrastructure can run directly from batteries.

Where -48VDC is deployed, it can be remotely switched on and off through an interface that is common to that of Switched PDUs distributing AC power, simplifying the job of the IT equipment administrators.

Switched, or remotely managed, four through sixteen port -48VDC PDUs are available for edge, MEC, and fog deployments.

CONCLUSION

Ongoing growth in the creation, storage, processing, and consumption of digital information is driving change in the design of the infrastructure tasked with delivering that content. Whereas the effort of the past decade has focused around centralizing applications running in the cloud (SaaS, PaaS, etc.), those organizations tasked with being the pipeline delivering data to and from the cloud are seeing the wisdom of distributing some of the cloud capabilities out closer to the end points (the "edge") of data creation and consumption. Delivering reliable distributed computing performance in the form of edge, mobile edge, and fog computing requires the usage of intelligent power management that supports both AC and DC power distribution. Server Technology delivers the industry's most comprehensive array of reliable AC and DC power solutions suited to edge computing.

WHY SERVER TECHNOLOGY

Server Technology's power strategy experts are trusted to provide rack PDU solutions for demanding data centers worldwide ranging from small technology startups to Fortune 100 powerhouses. Because power is all we do, you will find us in the best cloud and colocation providers, forward thinking labs and telecommunications operations. Server Technology customers consistently rank us as providing the highest quality PDUs, the best customer support, and most valuable innovation. Let us show you – we have over 12,000 PDU configurations to fit every need, and over 80% of our PDUs are shipped within 10 days. Only with Server Technology will customers Stay Powered, Be Supported, and Get Ahead.
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APPENDICES

- Appendix A - Key Dates for 5G
- Appendix B - Sources and References

APPENDIX A - KEY DATES FOR 5G

2017

Feb 27 – March 2, 2017 Mobile World Congress

April 6, 2017 ETSI Summit on 5G Network Infrastructure

Trial networks expected to appear in S Korea

2018

KT Corp, A S Korean carrier plans to launch a 5G network during the Winter Olympics

Stockholm Sweden and Tallinn Estonia plan to launch 5G technology

Formal standard for 5G expected to be agreed upon.

2019

2020

Target rollout of 5G as stated by the Next Generation Mobile Networks Alliance. China, the USA, Japan, Turkey and numerous other nations plan to deploy in this time frame.

5G Phase 2 specs expected to release

According to Wikipedia, 5G NR (New Radio), or 5th generation mobile networks, are the proposed next telecommunications standards beyond the current 4G/IMT-Advanced standards. 5G is expected to support a higher number of mobile broadband users per unit area and allowing higher or unlimited data quantities in gigabytes per user per month.

5G wireless is expected to occupy spectrum that is at much higher frequencies than used in prior generations. Present discussions are focused on frequencies about 20GHz, in millimeter wavelengths. As such, initial usage is expected to be for fixed wireless to the home rather than mobile. Mobile development will require new chipsets and antennas that support MIMO (Multiple Input Multiple Output) technology.

5G is expected to pave the way for driverless vehicles that interact with other cars and smart roads that improve safety and manage traffic. ATT is promising speed in Gigabits per second, 10-100 times faster than 4G. Qualcomm, the largest provider of mobile smartphone chips, predicts that the 5G value chain will be worth $3.5T by 2035.

APPENDIX B - SOURCES AND REFERENCES

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