Impact Of IoT (Internet of Things) On Cable MSOs

A Technical Paper Prepared for SCTE/ISBE by

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Introduction

It is projected that the number of connected devices will increase to 50 billion by 2020. IoT devices coming online will drive this growth. This creates new challenges and opportunities for Internet Service Providers and cable MSOs.

The challenges are in scaling the number of connected devices and the bandwidth required to service them. The pace of adoption of IPv6 addressing will accelerate. With IoT devices, such as surveillance cameras, upstream bandwidth demand will increase, as sensor data is back-hauled for analysis. To meet the trend of large numbers of IoT devices coming online, the DOCSIS protocol will need to continue to scale downstream bandwidth (as video consumption increases) while also provide additional upstream bandwidth.

There are several opportunities. First, IP sensor devices could reside in the home, commercially or in public infrastructure. MSOs could offer additional hosted services for IoT devices for deploying and managing these sensors Secondly, data analytics and policy application on sensor data will occur at the edge and centrally. This will result in server and IoT data analytics software deployments, which cable MSOs could offer. Third, new service subscription opportunities will be created in areas of dense sensor deployments, resulting in increased demand for extent and coverage of the MSO network.

To meet these challenges, the CCAP-Core (Converged Cable Access Platform) will need to scale to allow more devices per serving group, higher downstream and upstream bandwidth, higher proportion of upstream bandwidth compared to downstream and more serving groups hosted on the CCAP-Core.

This paper examines IoT through breadth of topics, including why it might be relevant to cable MSOs, various IoT verticals MSOs could address, the new types of connectivity needed to interface to IoT devices, sensors types and characteristics. This paper also introduces the notion of fog computing in addition to discussing typical bandwidth, packet size and security requirements of IoT sensors and their typical deployment density in homes, commercial areas, and in public infrastructure. Additionally, this paper provides projections on scaling the CCAP-Core and edge compute requirements in these typical deployment scenarios.

In summary, the paper explains the impact predicted explosive proliferation of IoT devices will have on MSO networks, analyzes trends in device and bandwidth scaling, and suggests how the cable operators can capitalize on these trends for new revenue opportunities.

Content

1. What is IoT

There is a growing trend to connect sensors to the Internet. These sensors control and/or detect changes in prevailing conditions. IoT sensors will be deployed in many industries. The industries are called “vertical” in IoT terminology. Verticals range from factory or industrial automation, public infrastructure such as cities, bridges, buildings, parks, city lighting, safety and security, power grid, agriculture, hospitality, healthcare, businesses, homes, and the Internet network itself. The collection of these sensors and their connectivity to the Internet is called the “Internet of Things” or “IOT.” Figure 1 depicts the myriad verticals that comprise the IoT universe.

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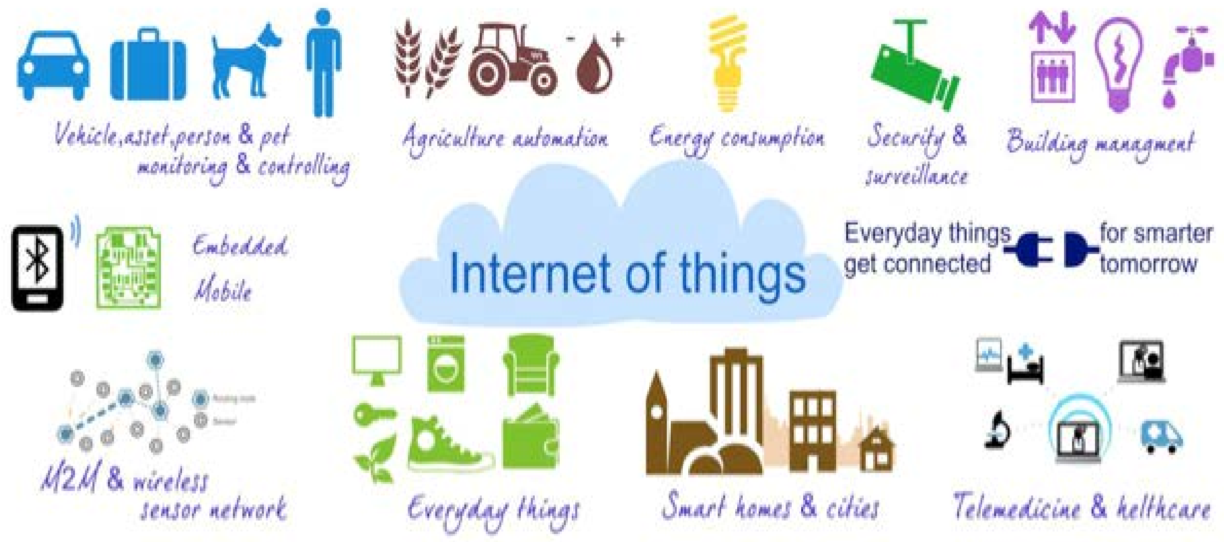

Figure 1: The Internet of Things (IoT)

Sensors have been widely used in some verticals such as safety and security, industrial automation, and healthcare. They are usually connected via proprietary technologies in closed proprietary systems. In other areas sensors have been deployed with alarm systems such as flashing lights or sirens. The new trend is to use ubiquitous networking infrastructure to connect these devices.

There are unique advantages to connecting sensors to the Internet. First, data can be stored digitally and historic trends can be computed. Second, it will be easier to act on the data and send notifications. Third, it will be easier to co-relate sensor data from multiple sources. By applying policies and artificial intelligence algorithms (machine learning), unique cross co-related insight could be gleaned.

The perceived value of connecting sensors across different verticals to the Internet and “mining” sensor data is high and this is leading to a proliferation of sensors.

IoT does bring with it challenges. Securing the network and network connections itself becomes very important as network connections become easily accessible. Securing data is also very important because it would be easier to “turn out the lights,” so to speak. With some verticals IoT solutions data may not leave the premise. Lastly, the sheer volume of data is projected to be huge, making storing, searching and managing it a challenge.

2. The IoT Opportunity For Cable MSOs

With every challenge comes opportunity. As illustrated in Figure 2 from IDC research, the projected scale of IoT is staggering. From a skeptical standpoint, even if the numbers were scaled down by a tenth or a hundredth—even if one were to add another 5 years—the scale is still gigantic.

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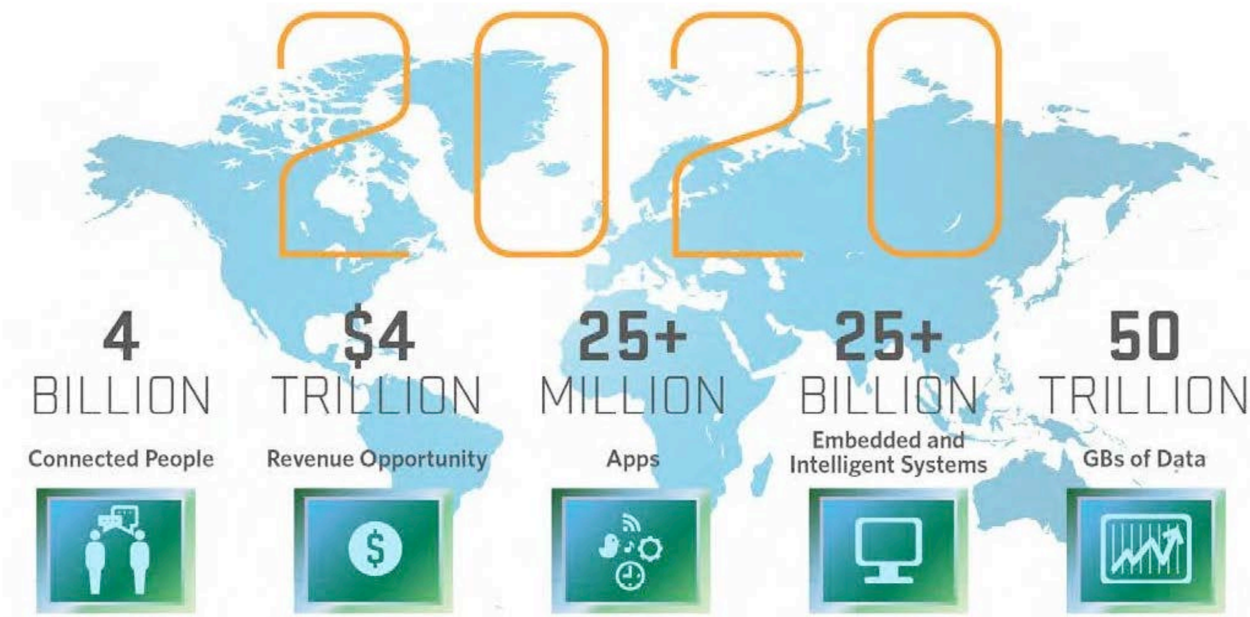

Figure 2: IoT Projected Growth & Financial Impact *Source: Mario Morales, IDC*

Even a small portion of this pie represents a large opportunity for cable MSO revenue in addition to the current home subscriber revenues.

It is projected that there will be six IoT devices per connected human (as shown in Figure 3 below). Figure 3 also shows the need for migration to IPV6 addressing for both connected people and connected devices.

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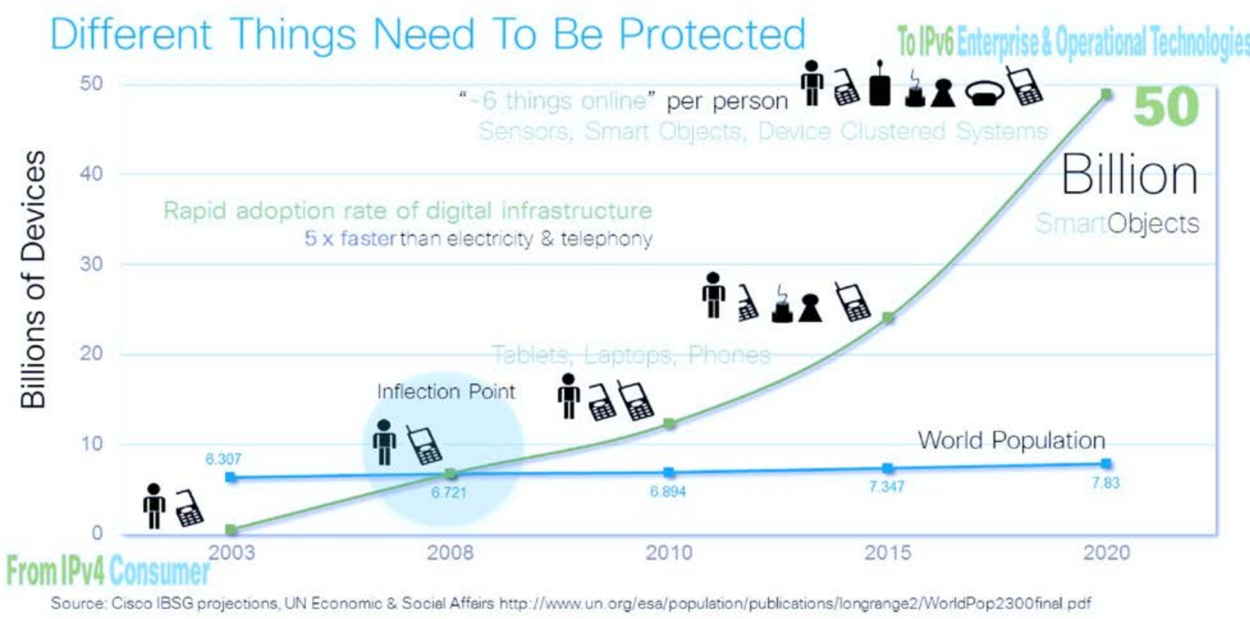

Figure 3: IoT Devices per Connected Person

With a current serving group (SG) of 1000 households past (HHP), 50% penetration and 2.63 persons per household (US Census data), there will be 500 * 2.63 * 6 = 7890 IoT Devices/SG by 2020. This represents 16x Subscribers/SG. Clearly, the distribution of IoT devices will vary by geography and will not exactly overlap and map onto the distribution of humans but it is still a large number.

Cable MSOs are uniquely positioned to take advantage of IoT because their networks reach deep into where a lot of sensors will be deployed. The home is the most obvious vertical for cable MSOs; however, there are several others that could be addressed. This will open up vast subscriber acquisition and revenue opportunities.

It must also be mentioned that, should cable MSOs limit their reach to homes and home automation, the IoT opportunity will lead to creation of other players in the market who might also turn into residential service providers as home connectivity will just become another "device" to which one connects. IoT efforts today are largely skewed towards cellular technologies, partially because of their ubiquitous coverage and partially because cellular providers are looking to address the IoT opportunity holistically rather than restricting themselves to certain segments. One example of this is the acquisition of satellite providers by cellular providers. It greatly increases IoT sensor coverage via satellite uplinks.

3. IoT Verticals

Figure 2 represents worldwide data. In order to derive the opportunity for cable MSOs, the data needs to be scaled down to United States (for example) and then scaled down further. Figure 4 shows a breakdown of the revenue opportunity per vertical, worldwide. The author has not been able to find one comprehensive research slide that shows every single vertical, however, Figure 4 is quite a good representation.

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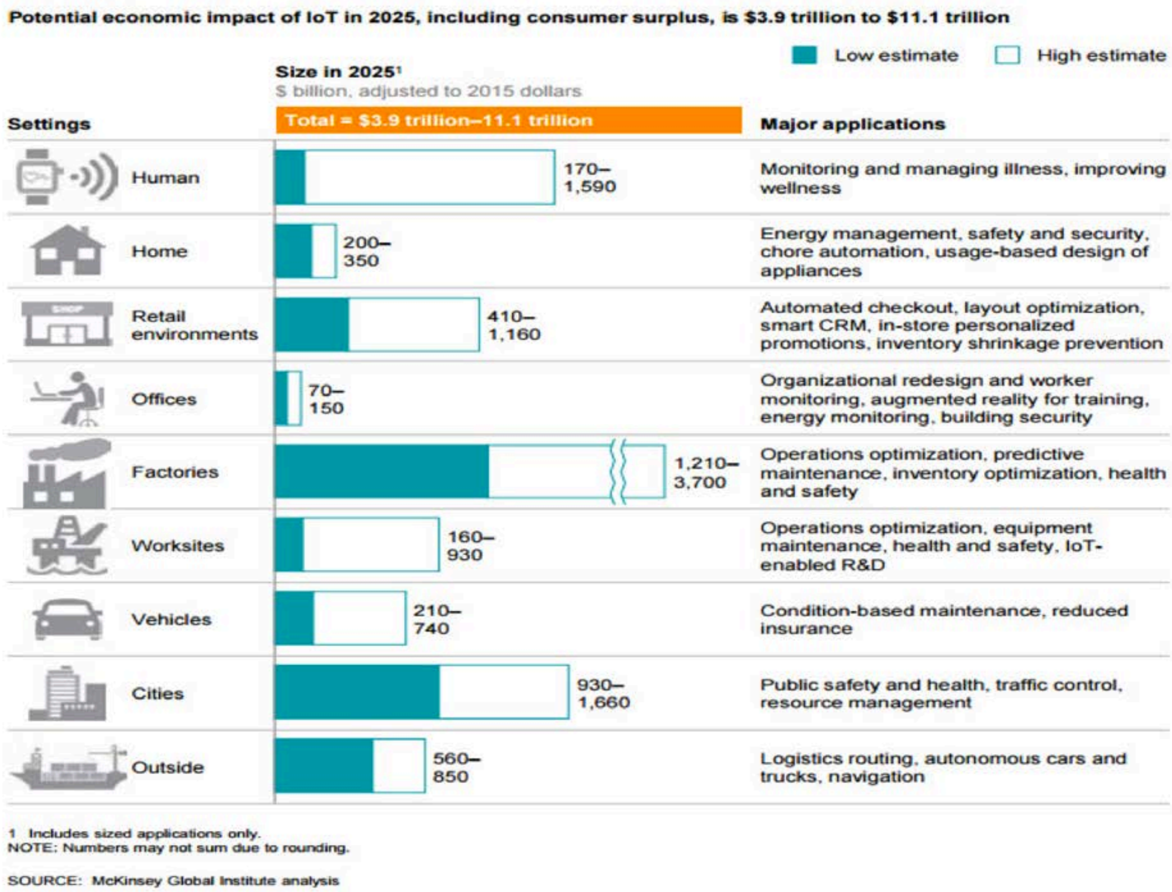

Figure 4: IoT Vertical Breakdown

The addressable portion of the vertical varies for cable MSOs. It varies because the density of IoT verticals where the cable MSO network is varies.

Clearly, the cable MSO network today is primarily to the home. Cables MSOs offer limited business services and offer Wi-Fi in some densely populated areas. The cable network will require enhancements in connectivity and reach to address some of the verticals mentioned below. These enhancements are discussed later in the paper. First, let us look at the opportunity for cable MSOs as it may help decide whether it is worthwhile to upgrade network reach and connectivity to address the market.

It will also help to understand which verticals might be easier to address. This is operator-dependent, depending on the where they operate and which verticals provide significant opportunities in their operating geography.

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Table 1: Portions of IoT Verticals Addressable by Cable MSOs

IoT Vertical	% Addressable By Cable MSOs	Notes
Humans	30%	• This category represents wearables. For the time the human is at home they could connect to the home cable network. • Outside the home they could choose to be an IoT cable MSO services subscriber, so their IoT data is routed to the cable MSO network even though it might be acquired on their smartphone (for example).
Home	100%	• No surprise! The home market is completely addressable by the cable MSO. • The competition from cell phone providers, home entertainment and over the top (OTT) players will be stiff. Customer retention will become challenging resulting in subscriber loss or the cable MSO just providing opaque connectivity.
Retail Environments	100%	• Cable MSOs provide some business services or broadcast TV, however, there are many small businesses looking for a one-stop shop with managed services for all their needs. IoT will become just another service in the overall service catalogue. The cable network could extend to these customers. • Connectivity options include cable, Wi-Fi or small cell.
Offices	100%	• Offices present a similar proposition to retail environments. • The difference in some cases may be that offices require all data to be resident on premise.
Factories	10%	• Cable MSOs operate in many states in the United States that have industries and factories. This is, thus far, an untapped market because there is little to no intersection of cable services with this vertical. • Cable today concentrates on providing broadcast TV and Internet connections for human consumption. However, once the network is enhanced with other access technologies, cable MSOs could penetrate this vertical as well.

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Work Sites	0%	• Work Sites typically need temporary connectivity. It is possible for cable MSOs to provide this. This vertical currently seems a little further away from the services cable operators provide today.
Vehicles	30%	• Vehicles, like wearables, are an adjacent market to the home. Cable MSOs could extend their reach by providing service at least when the vehicle is within the range of the home network or outside plant. • Cable MSOs as add-on subscription could offer vehicle IoT data management services.
Cities	100%	• Public infrastructure IoT is ripe for the taking for cable MSOs. Cable MSOs already provide free Wi-Fi access in urban areas. They could leverage this existing infrastructure to provide IoT sensor aggregation.
Outside (Cargo Handling)	0%	• This vertical includes shipping, cargo movement, and transport infrastructure. The preferred uplink for sensor data is satellites. It will be difficult for cable MSOs to significantly impact this infrastructure. There is perhaps opportunity to do so at ports, stations and truck stops.

Overall the cable network could address several verticals of IoT. Some extensions of coverage will be needed to aggregate sensors in the currently unaddressed verticals.

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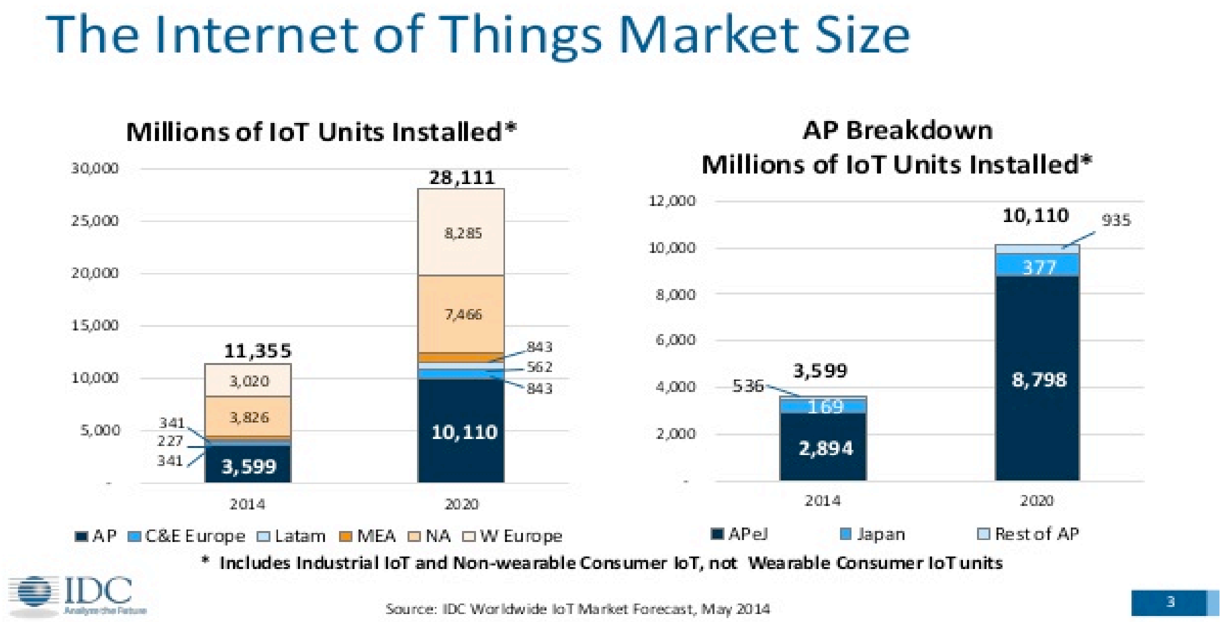

Figure 5: IoT Breakdown by Geography

In order to derive the addressable market for cable operators, we need to look at the breakdown across geographies. Figure 5 below shows this breakdown. The number of IoT devices installed in North America and Europe ranges from 33% to 25% respectively at the high to low end of the total devices deployed. We can use 29% as a mean.

Putting it together, the IoT market size addressable by cable MSOs is illustrated in the table below:

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Table 2: Cable MSO Market Share Projection

IoT Addressable Market by Cable MSOs	Market Size	Notes
Verticals Addressable by Cable Operators Worldwide	$1.8T – $4.4T	• Applying the percentages of each vertical in Table 1 to the total range in Figure 4.
North America (NA)/Europe Addressable Market	$522B – $1276B	• The share of the total market is 29% each for North America and Europe.
Cable MSO Market Share	$104B – $255B	• Assuming cable operators take 20% of the market.

The IoT market is HUGE! It is a great opportunity for adding new subscribers and additional revenue via new services. Winners in the IoT space will become formidable competitors.

4. IoT Sensors, Fog Computing, And The IoT Stack

4.1. Sensors

Generically, IoT sensors are devices that generate a reading or data for the condition(s) they are sensing. They may also support actuation of actions. Some sensors may also have a degree of programmability to actuate basic actions on occurrence of some pre-defined conditions. The cost of sensors can range from a few dollars to thousands.

Each IoT vertical has a set of sensors associated with it. They range from streaming video cameras to temperature to humidity sensors. Some sensors may be common to many IoT verticals but most are unique, for example sensors used in the health care vertical are unique to it. Sensor density and quantity also varies widely per IoT vertical.

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Technology	2G	3G	LTE	WIFI	Zigbee	802.15.4g	LPWA (Lora/ Sigfox, etc)
Log Range	Yes (10s KMs)	Yes (10s KMs)	10s KMs	No	No	Limited (1.5KM)	Yes (10s KM)
Tx Current Consumption	200-500mA	500-1000mA	600-1100mA	19-400mA	34mA	~35mA	20-70mA
Topology	P2P	P2P	P2P	P2P/Mesh	Mesh	Mesh	P2P
Standby Current (3V)	2.3mA	3.5mA	5.5mA	1.1mA	0.003 mA	~0.005mA	0.005mA
Energy Harvesting	No	No	No	No	Possible	Possible	Possible
Module Cost	4-8 Hours (com) 36 days (idle)	2-4 Hours (com) 20 days (idle)	2-3 Hours (com) 12 days (idle)	4-8 Hours (com) 50 hours (idle)	60 hours (com)	Variable	10-20 Years
Cost	$12	$35-$50	$40-$80	$5-$8	$6-$12	$3	$2-$5
Spectrum	Yes	Yes	Yes	No	No	No	No

Figure 6: IoT Sensor Cost, Back-Haul, Power Consumption, and Life Span

Figure 6 tabulates sensor uplink technologies and considerations for deployment and managing sensors (such as battery life, range, and cost). Some sensors are able to connect directly to an IP (Internet Protocol) while others need collector gateways to encapsulate sensor data in IP datagrams.

Even if sensors are able to connect directly to the IP network, they may not be able to connect securely or the IP stack running on the sensors may not be secure. The ability to securely back-haul sensor data is going to be a key for IoT. Insecure sensor will be weak points in the network for hackers to exploit.

Some sensors stream data continuously, while others might upload data once a month or only based on some infrequent event or condition the sensor is monitoring. Sensors may not have the ability to resend data. It is critical to be able capture the data when they transmit.

Sensors use many different uplink technologies such as cellular, Wi-Fi, and unlicensed spectrum technologies. Some of these uplink technologies are long range which helps with sparsely located collection points, while others need collection gateways located fairly close to the sensors.

Collection gateways may use a variety of uplink technologies to connect to the network. In addition to the technologies mentioned above (cellular and Wi-Fi), collection gateways might use wire line technologies or satellite uplinks.

Wire line links such as Ethernet have the ability to supply power as well. Satellite uplinks are also particularly interesting as they enable ubiquitous connectivity and can pick up data from remote areas and even from unreachable locations such as cargo ships and war zones.

There is one more important characteristic of IoT sensors to highlight: how they may be powered. Indoor sensors could be powered with discrete power lines or power over Ethernet. It is usually cost-prohibitive and/or insecure to run power lines to sensors located outdoors.

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Outdoor sensors may be powered via solar power or by batteries. Sensors that upload data infrequently are better suited for battery power. It is important to conserve the battery by minimizing "uptime" for the sensor. Reducing protocol handshake to a minimum when the sensor uploads data minimizes uptime. This may also include using UDP (User Datagram Protocol) and transmitting insecurely.

4.2. Fog Computing

Fog computing is the notion of bringing computing resources closer to sensors. It is in opposition to aggregating all sensor data at the cloud or data center. This is illustrated in Figure 7. There are several advantages to placing computing resources closer to sensors.

This approach facilitates aggregation of sensors at the edge of the network, which may reduce the bandwidth requirements for backhauling sensor data. Fog computing also increases availability, as the backhaul path may be unavailable to the cloud. It provides a shallow reservoir to store events from sensors if the backhaul path is unavailable.

A fog compute node also becomes a local edge policy enforcement point. The idea is that local sensors are more relevant to local policies and their data can be co-related and acted upon locally. Latency is another important aspect of policy enforcement. Fog computing reduces the latency of application of local policy versus backhauling everything to the cloud by applying policy and taking actions at the edge.

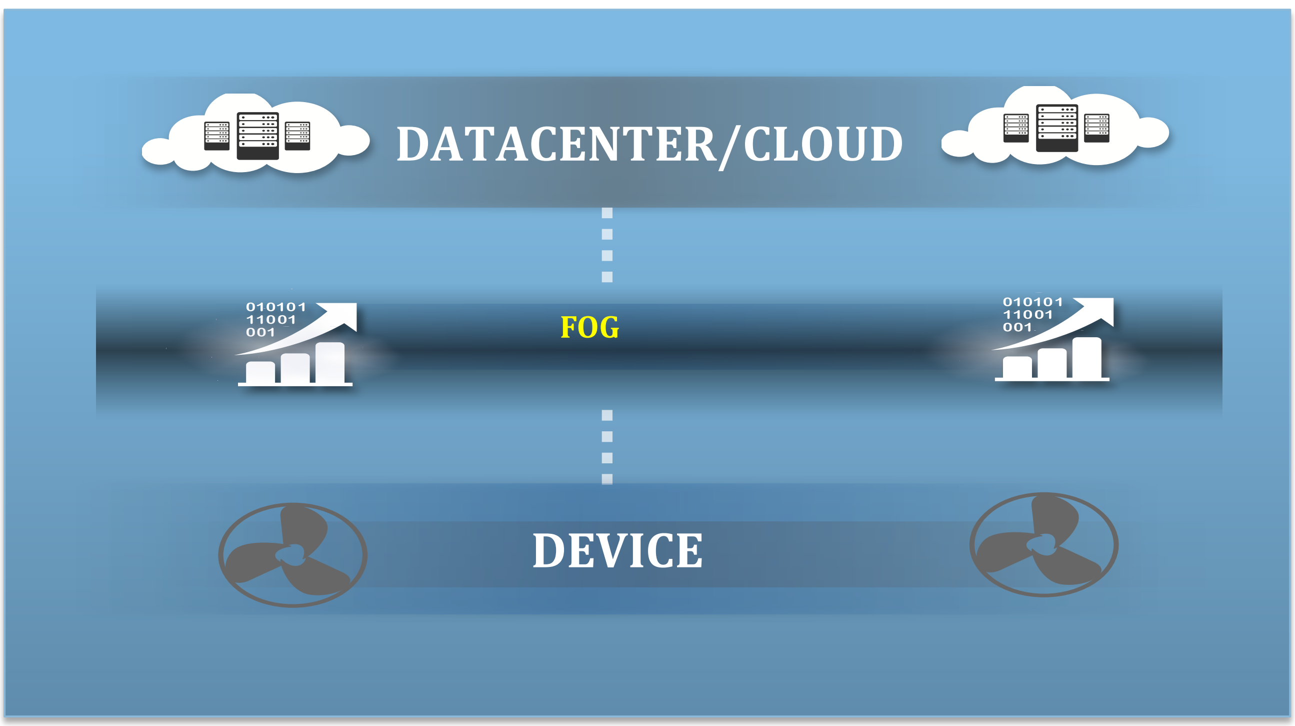

Figure 7: Fog Computing

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Fog computing nodes can also aid in upgrading images on sensors. A node can host sensor images and provide secure image upgrade services.

A fog computing node can also operate as a collector gateway for sensors that do not natively speak IP.

It is envisioned that a fog compute node would be a lightweight computer. Say a 4-8 core CPU with 1-2 GB memory and a small hard disk of about 1TB. This minimal compute capability could easily reside in discrete small (hardened) boxes, or could be added to Wi-Fi routers, cable modems, or set top boxes.

Fog computing could also reside in the MSO hub next to the CMTS where it is securely located, takes minimal footprint and is close to sensors.

4.3. Layering the IoT Stack

An interesting and insightful layering of IoT functionality is illustrated in Figure 8.

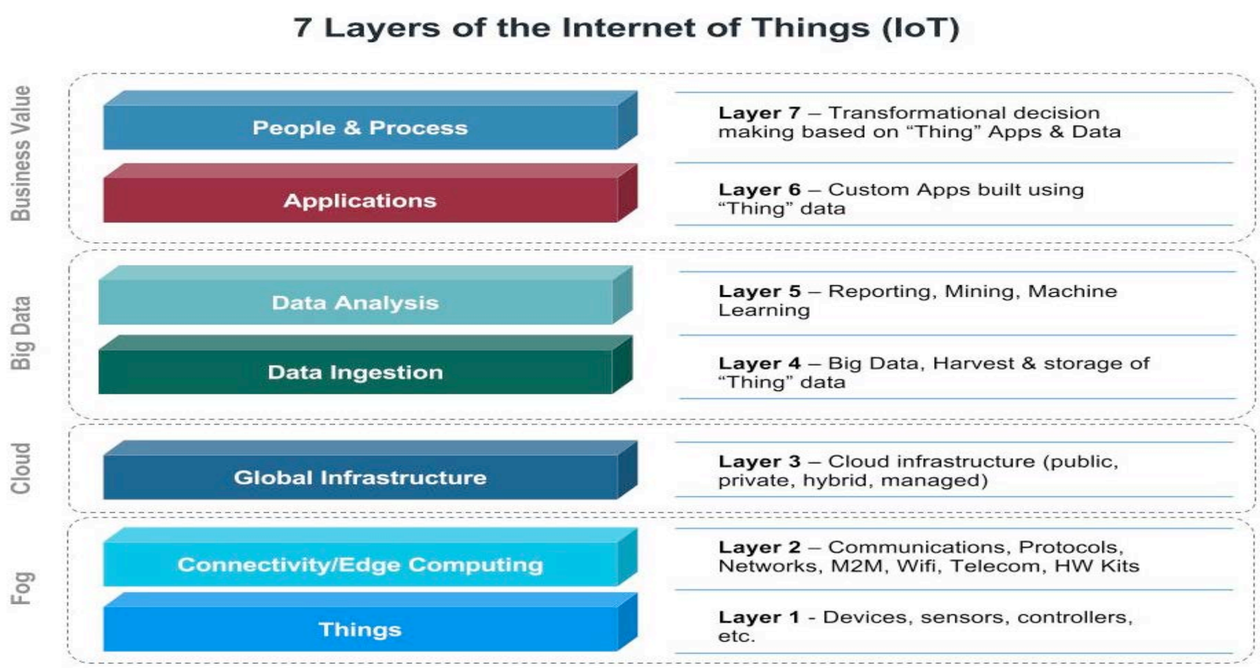

Figure 8: IoT Functional Layers

Each layer represents unique functionality and value, starting at the bottom from sensors to data aggregation, mining, and reaching all the way to people and business logic. It is possible to extend to different layers of the stack per vertical. Cable MSOs can choose in which layers of the stack they extend their coverage to address the IoT market.

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5. MSO Network Externsions For IoT

Figure 9 illustrates the typical MSO cable data network today. Figure 10 illustrates the extensions to the existing cable data network to address the IoT market.

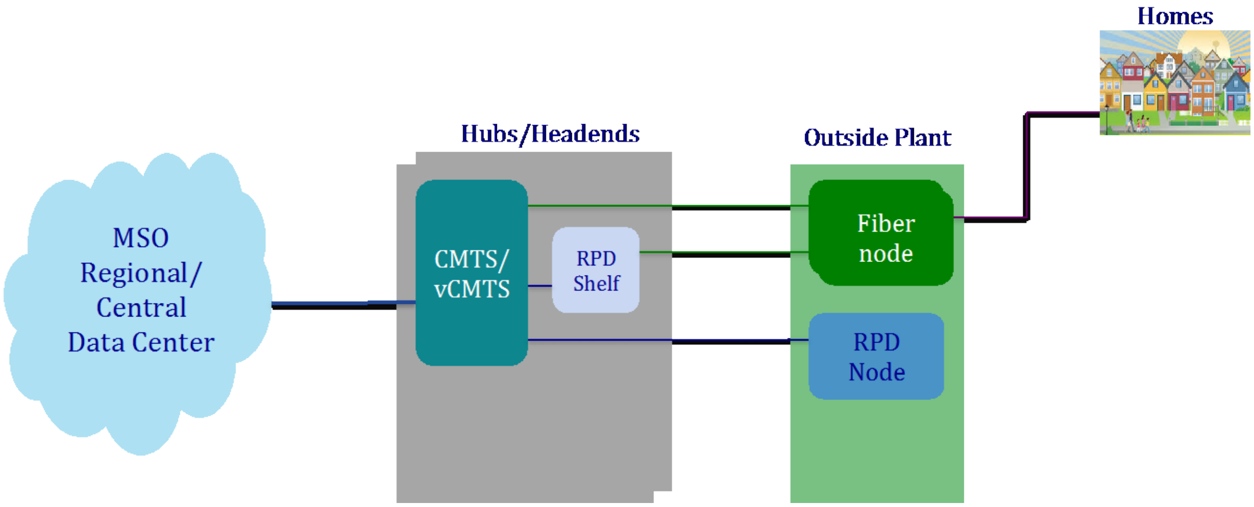

Figure 9: Typical Cable MSO Data Network

As can be seen, there are few new components to add to the existing data network to start addressing the IoT market. These new components are sensors, fog computing nodes and servers and hosting IoT data processing services in the cloud.

Not so apparent in figure 10 is the fact that the scale of the network will change. The network will need to reach more verticals, manage and aggregate more sensors and devices, depending on the density of sensors, and backhaul more data.

Extending the reach of the cable network to other verticals provides opportunities in areas outside of traditional cable services and IoT. New opportunities will be to acquire new subscribers and provide new services such as cloud hosting, virtual computing, and security—to name a few. It could be viewed as a self-perpetuating proposition where cable MSOs could become the one-stop shop for all of their customers' computing needs.

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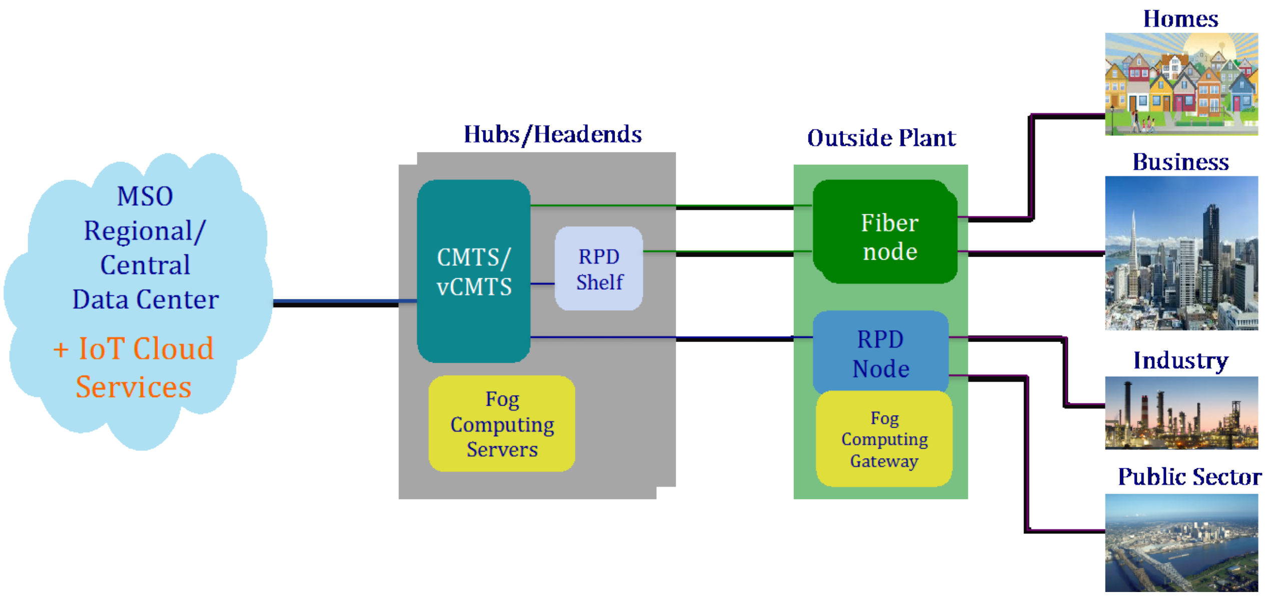

Figure 10: Cable Network Enhancements For IoT

6. IoT Service Mapping To MSO Network

Figure 11 illustrates the overlay of IoT functions and value on the cable MSO network. The following paragraphs describe each functional block, starting from left to right. The functions described here map to the seven-layer IoT stack.

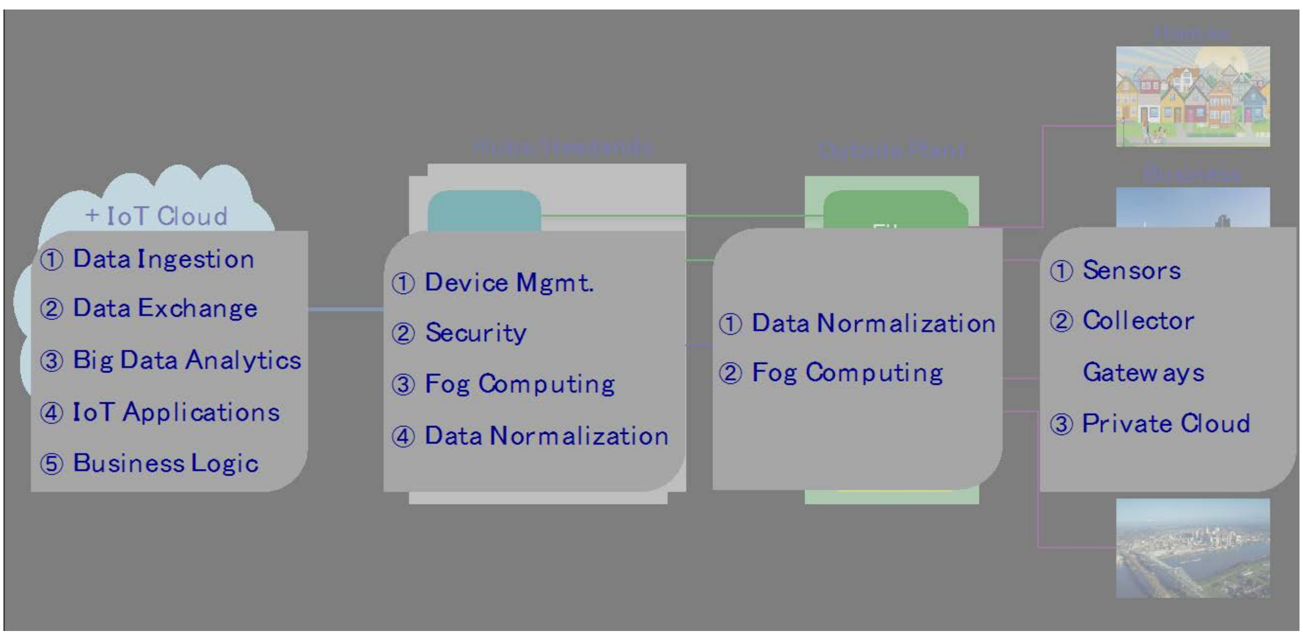

Figure 11: IoT Functional Mapping

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The first block at the customer premise (home, business, factory, public infrastructure, etc.) represents the deployment of sensors, collector gateways, and hosting private clouds. The sensor and collector gateway lifecycle will need to be managed. This includes deployment, configuration, image upgrades, security, and collecting data from sensors and collector gateways. Collector gateways are needed to interface to sensors that do not speak native IP. Some verticals will need IoT data to be hosted on-premise. This is an additional service opportunity for the cable operator.

The second block in the field or at the outside plant covers fog computing and data normalization. Fog computing helps with local policy decisions and provides a layer of resilience from network outages. Data normalization is required to represent sensor data in a common format. This helps upper layers of the IoT stack, such as data mining and analysis, operate on the data seamlessly.

The third block at hubs and headends covers security, device management, data normalization, and fog computing. Device management is hosted at the hub or headend. The hub or headend is the secure end of the provider network where security tunnels originate to sensor devices.

The fourth and final block hosts the data collected from sensors. This is the block where value-added services are deployed. These services are:

1. **Data Hosting:** The cable operator owns sensor data. The cable operator provides hosting data services on behalf of customers it is servicing with sensors.
2. **Data Exchange:** Data could be sold as bulk to other providers or big data analytics companies.
3. **Analytics Access & Hosting:** The cable operator could provide API access to its raw data and charges for every API access. Analytics software hosting from 3rd parties is another service that could be provided.
4. **Business Logic:** When the cable provider provides data analytics, they could further provide policy authoring and execution services to their customers.

Conclusion

IoT opens a HUGE revenue opportunity for cable operators. It enables them to acquire new subscribers and provide new services both within and outside the IoT space. Several players from the cellular and OTT space are positioning themselves to gain market share. Cable operators have the choice to become IoT service providers also OR remain as basic service providers at home.

Abbreviations

2G, 3G, 4G	Cellular Communication Technologies
AP	Access Point
DOCSIS	Data Over Cable System Interface Specification
HFC	Hybrid Fiber-Coax
GB	Gigabyte
HD	High definition
Hz	Hertz
IP	Internet Protocol
MSO	Multi Service Operator
OTT	Over The Top

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RPD	Remote PHY Device
TCP	Transmission Control Protocol
UDP	User Datagram Protocol

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