Fog Computing and the Internet of Things

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Abstract

One of the hottest topics in the field of information technology and information security is the Cloud. The term is almost inescapable and many companies are in the business of ensuring that this term is well known and massively used. Yet in many ways there are many issues with cloud computing. The issues range from the proliferation of mobile devices that access cloud infrastructures from anywhere at any time, which impacts the ability for these cloud environments to serve up requests, too the difficulty of securing the information that is being sent to and from cloud datacenters. Fog computing is what many believe is a viable solution to several of the issues associated with the current state of cloud computing. This article is intended to introduce the concept of fog computing, the anticipated impact of fog computing on the current state of cloud computing, it's projected impact on information technology infrastructures, and the anticipated security issues associated with the fog computing concept.

Keywords: Fog, Computing, Fog Computing, Security, Cloud, Cloud Computing, Information Technology.

Fog Computing and the Internet of Things

In the late 1980's the Graphical User Interface Personal Computer (PC) was born and with it came the changing of the world into the fast paced, endlessly connected world we know today. (Timeline Highlights, 2016) Certainly computers had begun to affect our lives before this, but none had so great of impact as the release of the personal computer, which for the first time brought the benefits of computing home to average users. In these early days the style of computing was localized and users relied on the close proximity of computing resources in order to do work and other computer associated activities. (What is Cloud Computing, 2015) As the years progressed, so did computing, and by the turn of the millennium a new style of computing began to emerge. At this time we began to see the emergence of what would be known as the Web 2.0, and Cloud Computing would become a hot new buzz word of unfathomable popularity. So what exactly is Web 2.0? Well, it refers to the paradigm shift from static content based web sites to dynamic and interactive web sites, like social media, web apps, and cloud service platforms. (What Is Web 2.0, 2008) This occurred primarily because of the increased bandwidth provided by upgraded networking infrastructures and the development of more sophisticated networking protocols. (What Is Web 2.0, 2008) Cell phones and mobile devices also played a large role in this change and would lead us to the state of computing that we are all quite familiar with today, The Cloud.

The Internet of Things

As before, many new concepts have begun to emerge, one of which is the concept of the Internet of Things (IoT). Writers for the International Journal of Communication Systems defined the IoT "…as the networked interconnection of everyday objects, which are often equipped with ubiquitous intelligence." (Xia, Yang, Wang, Vinel, 2012) So why exactly is this

important, and even more pertinent, how will the IoT impact The Cloud and other aspects of the future of computing?

The main problem presented by the IoT is a proliferation of mobile computing devices such as smart phones, laptops, tablet PC's, smart watches, and even smart glasses. As it currently stands there are more internet ready devices than there are people on the planet, and this number is only expected to increase exponentially as we move into the future. (Sizing Up the Internet of Things, 2015) As of 2014, according to projections made by CompTIA, the IoT is expected to grow at an annual compound rate of 23.1% until the year 2020. (Sizing Up the Internet of Things, 2015) In 2014 CompTIA estimated there to be 14.4 billion devices on the internet and by the year 2020 they expect over 50 billion devices to be connected (Sizing Up the Internet of Things, 2015) (for a closer look at CompTIA's projections see Figure 1). These devices not only include many of the devices already mentioned, but also newer, less common devices like embedded systems. Embedded systems are computer systems with a dedicated function that reside in a larger system such as manufacturing equipment, vehicles, buildings, security devices, and even medical equipment. (Tips on Designing for the Internet of Things, 2015) Yet, as the number of these devices continue to grow much of the current computing infrastructure does not. Imagine running a data center in 2025 and having billions of devices trying to connect through the same infrastructure that was designed to handle traffic from the early 2010's. It just isn't going to work without a serious overhaul of the infrastructure, or the development of a new system of computing. One solution to this problem is known as Fog Computing, and it may be one of the best ways we can approach addressing this problem.

Fog Computing

Fog Computing, also known as Fogging, is a term coined by Cisco, and it refers to the concept of computing "...at the edge of the network…" (IoT: Out of the Cloud & Into the Fog, 2014) & (J.S. et al, 2015) It is an approach to computing that focuses on addressing conflicts that are created between cloud computing and the IoT. The major difference between Cloud and Fog computing deals with the differences between centralized computing and distributed computing. Metaphorically speaking, the Cloud is just another term for the internet. (What is Cloud Computing, 2015) More technically speaking Cloud Computing is generally thought of as a centralized data environment in the sky, whereas fog computing could be thought of as a system of endlessly connected, self-aware devices that surround us in our everyday lives. As a fog is a low lying cloud that surrounds us at the ground level, Fog Computing is internet computing where the devices responsible for the computing surround us. Instead of having a data center where all of the processing and storage occurs, fog computing would allow us to bring the devices closer to us and these devices would be responsible for their own processing and storage. So how does this concept help us deal with the problems created by the IoT, and what benefits would this provide us that upgrading the cloud infrastructure couldn't?

Benefits of Fog Computing. The main benefit that would be provided by Fog Computing is the reduced amount of bandwidth needed to support a massive number of devices. (Fog Computing, 2016) With the Cloud Computing concept, when a device needs to access a cloud application or a file stored on a server it must navigate the internet until reaching the server which is almost always hosted behind an army of firewalls and proxy servers designed to protect the information that they guard. This means, sooner or later, a bottleneck will be created where all communications must go in and out. With billions of users, with even more billions of

devices, attempting to access the same servers these bottlenecks will become more and more bogged down. Eventually they will not be able to handle the massive number of request, and cause high latency, packet dropping, and a whole array of other network infrastructure related issues. Fog Computing solves this issue by bring devices capable of performing these same functions closer to the users. (Fog Computing, 2016) Instead of traversing across the internet, fog computing will allow communications to only need traversing across the room, or down the street. This means reduced bandwidth requirements and reduced latency while still providing internet based processing, storage, and applications.

The next question that needs answered is how Fog Computing will be able to achieve the proposed benefits. First of all, it will be able to do this by having end-devices communicate directly with one another whenever possible. (IoT: Out of the Cloud & Into the Fog, 2014) So if the task can be handled by the local resources or resources closer to the user than the data center it will do so, and only send requests to servers when absolutely necessary. (IoT: Out of the Cloud & Into the Fog, 2014) Reducing the need to communicate with servers this way is what will reduce the consumption of bandwidth organizations do have for requests to their data centers. In turn, this will reduce the latency on these connections because, even though more devices will be accessing it, they will be doing so less often. The computational power of end-devices has an added benefit in that they will be able to communicate with one another on the fly and respond to changes in the environment in real time, meaning higher efficiency responses to change. (Xia, Yang, Wang, Vinel, 2012) Computational power at the end devices also means that when communications with servers do occur that less processing and storage will have to happen in order to handle the requests. Only what is necessary to provide the feedback needed by the end-

devices will be done. This means less upgrades for not only the network infrastructure, but for the computational devices in the data center as well. (Fog Computing, 2016)

So what are some of the new features that we will see provided by Fog Computing? Cisco proposes several new apps and services that they predict will be revolutionized by Fog Computing platforms such as the ones they are developing. One such service cited by Cisco is Smart Traffic Lights. According to the developers smart traffic lights will be able to detect the flashing lights of emergency vehicles and be able to control traffic via these lights. So if the system knows where the emergency vehicle is it can control the lights to allow traffic going the same direction to go and get out of the way, while stopping traffic that would impede the emergency vehicles ability to maneuver. (Fog Computing, 2016) Other proposed services deal with concepts such as smart energy distribution and self-maintaining trains, amongst many others. (Fog Computing, 2016)

Fog Networking Devices. Another question you might be asking, is what kind of devices will be needed in order to support this kind of infrastructure? Devices that would support this system include, but are not limited to, Set-top-boxes, wireless access, points, road side units, cellular base stations, on devices or on-board sensors, and hardened smart routers and switches. (YI, S., Qin, Z., Li, Q., 2015) Set-top-boxes would be similar to a cable box that you are used to seeing on top of a television and would provide the computational power necessary to perform the tasks at hand in addition to providing an interface for communicating with other fog networking devices like wireless access points, cellular base stations, road side units, and smart routers and switches. (YI, S., Qin, Z., Li, Q., 2015) The on-board or on-device sensors would be used for the interpretation of changes in the environment and would be responsible for allowing the smart devices to respond to events that occur within a system or within the environment.

(Fog Computing, 2016) For instance events, such as temperature or pressure changes, or changes in the amount of light in a room, or the presence of a person or other living beings. It could then use these stimuli to appropriately respond and provide feedback or services as needed. (J.S. et al, 2015)

Security in the Fog. Unfortunately there are still many issues that need to be worked out with fog computing before it becomes a real world solution and it currently only exist in a state of infancy. Many IT executives already see to many issues with Cloud Computing to even consider implementing that, let alone implementing a system, like Fog Computing that would disperse the various devices which would still need to be secured and maintained. As many as 74% of IT executives already do not trust cloud computing, so it is reasonable to assume that even more do not support Fog Computing. (YI, S., Qin, Z., Li, Q., 2015) This is primarily due to considerations about having a large number of highly distributed devices that provide a massive increase in the number of attack vectors that attackers could use to compromise a system. Fog computing also increases the number of physical assets that would need to be monitored, secured, and maintained which in turn would increase the geographical areas that an organization would be required to deal with. Ultimately this would lead to higher labor cost and higher need for travel of employees which could mean higher cost as well. The real question is whether the benefits will outweigh the losses and whether or not the system will better serve the organizations and their patrons. Either way it is important that Information Security professionals begin to explore this concept now in order to be better prepared for what is to come. Even if this is not a solution for every organization it will likely be so for some and for that reason IT professionals could only serve to better themselves by approaching this head on and not waiting to play catch up once it has become a full-fledged reality.

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Figures

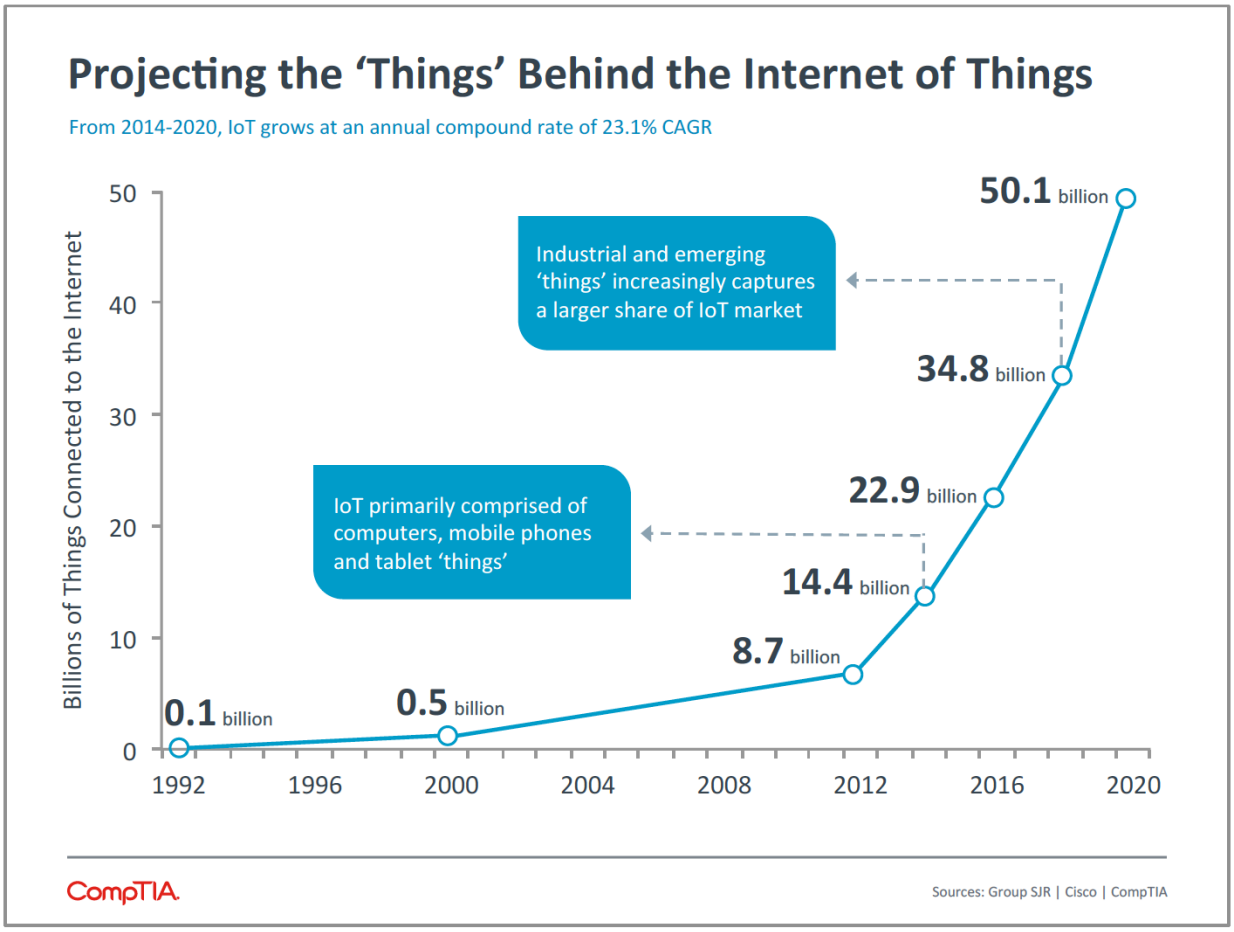

Figure 1. CompTIA's IoT Projections. (Sizing Up the Internet of Things, 2015)