Infoblox
CONTROL YOUR NETWORK

WHITEPAPER

How Businesses Can Measure Network Complexity—and Why They Should

Introduction

Information technology (IT) networks are the circulatory system of businesses around the world.

With the new bring-your-own-device (BYOD) culture, the need for 24/7 uptime, and a move towards virtualization and the cloud, business networks are wrestling with increasing complexity. Without proper management, this growing complexity might have a significant impact on the way businesses function as well as on their balance sheets and brand reputation.

In this paper, we will look at the reasons why network complexity should matter to a business, and why there's a need for complexity to be expressed quantitatively. We'll then introduce the Bailey-Grossman equation, a new scientific approach to carrying out this measurement, before discussing what this should mean to a business, and suggesting possible next steps and ways to capitalize on the equation's findings in order to enhance network control.

Networks and Network Complexity

Our definition of a network is "a collection of things that interact to perform a service."

Take a social network for example, with communities made up of individuals passing information back and forth in order to stay up to date on the latest news and events. Or consider a botnet which, in IT terms, is a perfect illustration of this general definition. It is, essentially, a group of devices that interact with each other to help cyber-criminals carry out their insidious work.

According to this general definition, a business's IT network isn't the boxes and cables that hold everything together. For 30 years, the technology industry has thought of the network as a subsystem, or as plumbing, but the network is much bigger than switches, routers, and load balancers. It's a collection of endpoints—the people, data, devices, and infrastructure—that all interact in order to make things happen. Whether providing personalized medicine to pediatric cancer patients, ensuring ships safely enter and leave ports of call, or enabling global businesses to grow, it's an organization's network that determines whether or not these activities happen.

This is a radical shift in the definition of networks that should be increasingly useful for businesses moving critical processes to the cloud, embracing BYOD, continuing to invest in virtualization, and increasing the number of sensors and automated systems on premises. A typical Fortune 500 company today has critical business processes that are executed on a network of devices, applications, and sensors which the organization often did not purchase and which may be virtualized in the organization's own data centers and distributed across many cloud and managed infrastructure providers.

Focusing on how endpoints relate to a business at any given time allows the infrastructure to continue to be more dynamic, as in the case of spinning up and down virtual machines on demand; more distributed, as in the case of moving certain functions to multiple cloud providers; and more volatile, as in the case of allowing previously unknown devices to participate immediately in business processes.

From the perspective of business processes, a network's complexity can be judged by the number of interconnected endpoints, the number of connections between these endpoints, and the way information moves through these connections to perform business processes. Who actually purchased and owns the assets and where the assets reside physically are no longer the primary concerns for understanding network complexity.

Simply put, the more endpoints such as virtual machines, cloud-resident services, inventory scanners, trading applications, and tablets that support a business, and the more critical business processes that utilize those end points, the higher the level of complexity. This will be especially true as we move closer to an "Internet of Things" era, where cars, coffee machines, assembly-line robots, office climate controls, and kitchen appliances are all IP-enabled in order to communicate with each other and rely on the network to interact.

What Does Network Complexity Mean to a Business?

If we were to apply a similar logic to that of Moore's Law,[1] we could speculate that network complexity will continue to grow exponentially. After all, as its customers become ever more connected, a business's network may need to grow too, and will likely be ever more entwined within a widening circle of users, devices, sensors, and apps.

Assuming this is the case, the biggest impact to business networking could be the cost of managing this growth. While being more connected can undoubtedly make some businesses more valuable to their customers, there's a risk that the rising cost of managing network complexity can outweigh the value.

Also, while a network remains small it can usually be managed through manual processes with no significant impact from any mistakes. But, as the network grows, and users, devices, sensors, and apps are added, it can lead to a risk of greater inefficiencies and vulnerabilities. If network complexity is allowed to increase without sufficient checks and measures in place, in other words, it could have dire consequences.

It's a truism now more than ever that if the network goes down, you go home.

In the worst possible situations, a network failure could see electric power plants going off line, planes remaining on runways at airports, consumers unable to withdraw cash from ATMs, and McDonald's unable to serve Big Macs and fries.

A recent real-life example is what happened to the NASDAQ in August 2013, when the second-biggest stock exchange in the United States shut down for three hours,[2] its network reportedly overwhelmed by the complexity of its core functions.

Take also the case of mobile-service provider O2, whose millions of customers in the United Kingdom, accustomed to always-on service, took to Twitter to vent their frustration over the network's two-day outage[3] in October 2012.

Measuring Network Complexity

When monitored and managed, continuing growth in network complexity needn't result in such negative outcomes. Indeed, Internet giants such as Google and Amazon are able to successfully manage an ever-increasing volume of demand and resulting complexity, increasing the reach and scope of their organizations' networks, while maintaining relative constancy in cost.

As a result, we argue that a key factor in successfully managing the growth of a network's complexity is the ability to measure the rate of that growth, by quantifying the complexity level at any given moment in time.

Putting a number to network complexity can raise awareness of a situation which, while it may have been identified, hasn't yet been fully understood. An insight into its network's complexity will provide a business with a sense of perspective, enabling it to more efficiently and appropriately manage its network's growth and eventually include the full network—not just networking hardware—as an entry on balance sheets.

Such a measure can be used as a strategic guide post, allowing businesses to focus on taking the steps necessary to drive costs down—or at least keep them constant—while ensuring that they are able to efficiently carry out core business functions as their network complexity increases.

The Bailey-Grossman Equation and the Network Complexity Index

Aware of the problems that network complexity presented customers, Infoblox's Founder and Chief Technology Officer, Stuart Bailey, had long considered the issue and was eager to develop a reliable and useful quantitative means of measuring network complexity.

Prof. Robert Grossman at the University of Chicago, a long-time collaborator of Bailey's since their time working together at the National Centre for Data Mining,[4] was able to offer a mathematical perspective on the problem.

While discussing the issue with Bailey in 2012, Prof. Grossman suggested a data-mining approach would be useful in discovering the information required. In particular, he suggested that the h-index,[5] a general form of a calculation used to measure the productivity of scholars, could provide the right metric.

As the pair explored the idea further, they soon became aware their final method might have applications beyond their initial focus on IT networks, and might prove useful for researchers studying naturally occurring interactions such as those between genes in the human body, or between members of a social network.

The formula that resulted from their discussions, the "Bailey-Grossman equation," is fundamentally concerned with the complexity of sets of things, and how these things interact. It provides a single number, the Network Complexity Index (NCI), which is the balance point between the number of groups that are interacting and the size of those groups.

The Bailey-Grossman Equation

$$B(N) = Max\ j,\ X[j] \geq j$$

Details at *http://flowforwarding.org/nci-article*.

By way of example, the Bailey-Grossman equation could be applied to a record of every phone number that called every other phone number at some point, including conference calls with multiple numbers connected, and would be totalled into a single figure. This figure—the NCI—would reflect the complexity of the network in question, in this case a network of phones with people talking to each other.

To explore this further, if you were to compare the NCI of a town's phone network with that of a comparatively sized corporation, the town's NCI is likely to be higher than that of the corporation. Although they may have a similar number of endpoints, their general uniformity of purpose would mean that the corporation's phones would lead to a less-complex network. By keeping this in mind, a phone network provider would be able to scale accordingly, knowing that its customers—both consumer and corporate—are provided for, now and in the future.

For Bailey's purpose, the equation could be used to reveal the NCI of a business IT network by measuring the interactions between the network's endpoints—its users, devices, sensors, and apps—using the Domain Name Systems (DNS) as a data source.

The challenge though, was how to access this critical DNS data from inside a business. Companies hold no historical record of the required interactions, so for the equation to work it would need to be implemented within a piece of software that was able to access and capture this data in real time.

Tapestry

Freely available as a download from FlowForwarding.org (*http://www.flowforwarding.org*), Tapestry is an open-source software application designed to capture data from a network's DNS servers and process it through the embedded Bailey-Grossman equation to generate a Network Complexity Index (NCI) figure.

Running on the network control plane, Tapestry can be installed on one or more software-defined networking (SDN) white boxes, and, fully monitoring a company's network, extract the complexity data from the DNS requests made on the network, then pull these different threads together to provide an instantaneous measurement—the NCI.

What's the Solution?

Tapestry—with the Bailey-Grossman equation at its heart—is a tool for measuring network complexity and improving awareness of an increasingly important issue.

The ultimate aim of uncovering a business's NCI is to better understand the change in the level of reliance that a business has on its network: how intertwined the network is with all of the core functions of the business.

By taking regular measurements of its NCI, a business can gain information to understand just how fast its network complexity is growing. This rate of growth is the true value of Tapestry, rather than a single NCI measurement in isolation.

An increased focus on how the speed at which a business's network complexity is growing is needed to allow network managers and IT directors to better manage that growth. It can provide additional data to allow them to consider the cost implications and the available solutions—not only to keep these costs down, but also to avoid the network becoming overwhelmed by the functions that inherently rely on it.

After all, as we've already said, if the network goes down, you go home.

Reducing Complexity with Technology

Following years of viewing the network as plumbing, knowing a network's NCI should encourage IT professionals to see the network differently, providing them with a new perspective on solutions available today such as automation, and those of the future, namely software-defined networking (SDN).

Through automated network management, for example, a business can better maintain control of its network infrastructure.

By making use of sophisticated, affordable software and data analytics within the control plane, automation allows network managers to carry out more tasks, offloading their mundane day-to-day actions and focusing on those which can add value to their organization. This, in turn, can immediately make the IT operation more efficient and more cost-effective. In this way, automation can help businesses cope with growing complexity and enable them to scale while keeping costs down, even as the network grows.

SDN is an especially hot topic in the networking space right now. By mixing commodity hardware controlled centrally through an intelligent software layer, SDN introduces programmability to the network.

If you consider the majority of the existing networking landscape as hardware-defined networking (HDN), an entire industry organized along box function lines—switches, routers, load balancers, and the like—you'll notice that, under the hood, the boxes are actually much the same.

SDN allows companies to use open standards to program remotely in real time and turn a single white-box device into a switch, a firewall, a router, or a load balancer. This can then be quickly reprogrammed to perform some other role as needed.

It's hard to predict when SDN will break into the mainstream, but when it does, it has the potential to reduce both network complexity and associated cost. The market correction that SDN promises could occur overnight, and those businesses which have planned for its arrival are the ones that will gain a competitive edge. Calculating the network's NCI should be the first step in that plan.

Summary

As more users join a network, with more devices, each with more sensors and apps, and all sharing more information with each other, so the network's complexity increases. And as the Internet of Things becomes a reality, this complexity looks likely to continue growing.

As the network grows, so too can the cost of managing its complexity. And as more core business functions become entwined within the network, there's a growing risk of it not being able to deliver as required or even being overwhelmed entirely. For the first time in history, it is becoming clear that complexity rather than bandwidth could be the barrier to network growth.

By using Tapestry to extract complexity data from DNS requests within its network, and running this information through the Bailey-Grossman equation, a business can determine its Network Complexity Index (NCI).

This measurement will enable the business to monitor the rate of growth of its network complexity, providing IT decision makers with the perspective necessary to consider the implications of growth, to rethink network expense models, and to focus on the actions required to manage the associated costs and risks.

Measuring and managing complexity has potential to help businesses run highly scalable, adaptable, automated, software-defined networks.

The future belongs to the organizations and people that embrace the complexity, beauty, and value that the real network has to offer.

Footnotes

[1] *http://en.wikipedia.org/wiki/Moore's_law*
[2] *http://www.theguardian.com/business/2013/aug/29/nasdaq-crash-report-nyse*
[3] *http://www.bbc.co.uk/news/technology-18801300*
[4] *http://en.wikipedia.org/wiki/National_Center_for_Data_Mining*
[5] *http://en.wikipedia.org/wiki/H-index#Definition_and_purpose*

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