INFOBLOX

INFOBLOX STRATEGIC MARKET OPPORTUNITY

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This paper evaluates the causes and effects of widespread network trends driving unprecedented network growth and rapid network change.

Intellectual Property Statement

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Executive summary

This paper evaluates the causes and effects of widespread network trends driving unprecedented network growth and rapid network change. Increased provisioning episodes are directly proportionate with increased financial risks due to inherent down-time risks. Infoblox introduces a novel plan designed to address high risk factors and costly downtime effects, which easily integrates with networks burdened by rapid updates. The capability to provision the network in real-time, calls for a reliable, resilient, never-down, real-time database that is optimized for network infrastructure information. Infoblox® is in a unique position to address this need.

Overview

The adoption of virtualization, cloud computing, and unified communications is driving unprecedented network growth and network change. The natural tension between enabling network change and ensuring network reliability is reaching a breaking point under these new requirements of scale. The time and place of the tipping point may take many organizations by surprise, and new solutions are required to mitigate its effects.[i, ii]

The market needs an effective way to orchestrate the dizzyingly diverse collections of network infrastructure components which are emerging in today's complex and highly dynamic networks. The problem is especially pronounced in Infoblox's core market of large and mid-size enterprises driven by investments in data center virtualization and cloud computing. Infoblox can take advantage of this strategic market opportunity by developing and selling Network Infrastructure Control (NIC).

Introduction

The wide-spread adoption of virtual machines (VM) and other virtualization technology for rapid and cost-effective provisioning, scaling, and de-provisioning of computing infrastructure has opened a market for elastic networks that allow real-time (reactive), automated network configuration change without compromising network reliability.

In the old world, there was no call for dynamic configuration; there are no network mechanisms to dynamically accommodate current fast growth and rate changes. Unprecedented enterprise network growth created sprawling TCP/IP-based networks that serve billions of user accounts worldwide. Along with this growth is a developing technology market space to relocate and renumber virtual computer and storage resources; to automatically re-configure the surrounding physical and virtual network infrastructure that connects and makes the network function.

In the new world of virtualized environments, configuration and provisioning must become a single, real-time act. A new concept, NIC, is just that – a real-time network configuration change solution. NIC, a suite of products, uses real-time distributed database technology. The NIC application suite integrates with the next version of intelligent Grid™ and can be delivered on an appliance or virtually through software. Intelligent Grid is the unrivaled difference Infoblox makes in the market and is the foundation of our success. It is a highly optimized, real-time distributed database and is the reason why we can realistically take legacy management applications and move them into the network with reactive capabilities. Today, Infoblox sells two major configuration change products, yet there is no cohesive coherent system offering management in real-time. However, by leveraging our current product market position, Infoblox is primed to develop NIC, based on a 24x7, real-time, distributed, database system.

Increased provisioning episodes are directly proportionate with increased financial risks due to inherent down-time risks. Nimble network infrastructure management and control becomes a limiting factor in business growth and cost containment. The traditional concept of network management is to buy a server and put it on the side; it is used when it is needed. In contrast, NIC is always on; it always has access to the data path and the control plane, creating a heterogeneous environment.

The financial impact of converting legacy IT infrastructures to real-time networks is negligible when the network investment stays current and fully utilized. NIC provides continuity and cost control by integrating into the current network.

The challenges of virtual network configuration include:

- Managing the constant increase in the rate of change
- Managing capacity and staffing
- Identifying the bottlenecks and performance challenges

NIC is a strategic, scalable solution that tracks and securely manages the network infrastructure for this new market. Infoblox can draw on the relationships we have with our existing customer base. Infoblox is known for focusing on heterogeneous and multi-vendor solutions, and needs to keep this strategy to maintain market expectations.

There are lots of different vendors providing different pieces; new start-ups are considering unique business solutions in this area. Infoblox sells network services appliances for past and present business opportunities. NIC focuses on the emerging problems in virtual networking and cloud. A key assurance in our customer support is in keeping strict adherence to our standards; our customers can have heterogeneous networks and diversity of vendors. This is what Infoblox products do well and they do it without overwhelming complexity. Figure 1 shows the real-time NIC stack; NIC is always on, with access to the data path and the control plane.

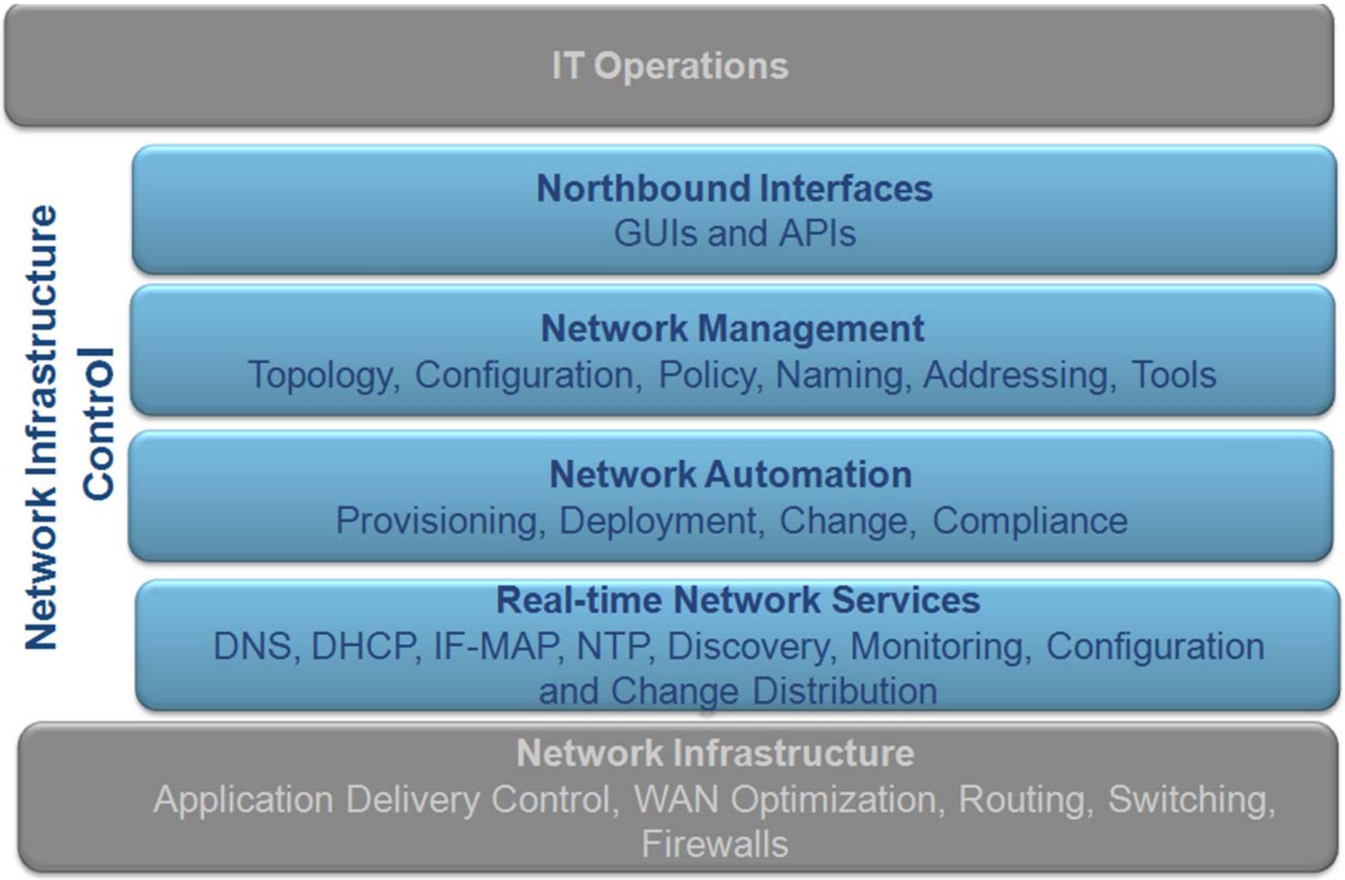


Figure 1: Real-time Network Infrastructure Control stack

History and Future Trends of Networks

Network growth rate has always surprised us and being able to identify an under-optimized trend is an opportunity for a strategic business move. However, it is wise to be cautious when relying on predictions, no matter how expert and renowned the source. It is essential to collect and read real data to get a sense of how the interplay of technology, economics, and human choices plays out. Let's briefly review significant network trends: the growth of the Internet from inception, a map of the Class C network, and the growth of Internet traffic. This data clearly demonstrates how a new Infoblox business opportunity is quickly rising and about to explode broadly into view.

Growth of the Internet 1969 - 1997

In 24 years, TCP/IP networks grew from four hosting computers dedicated to research to 2.1 million nodes encompassing every networkable device you can imagine. No one saw this coming.

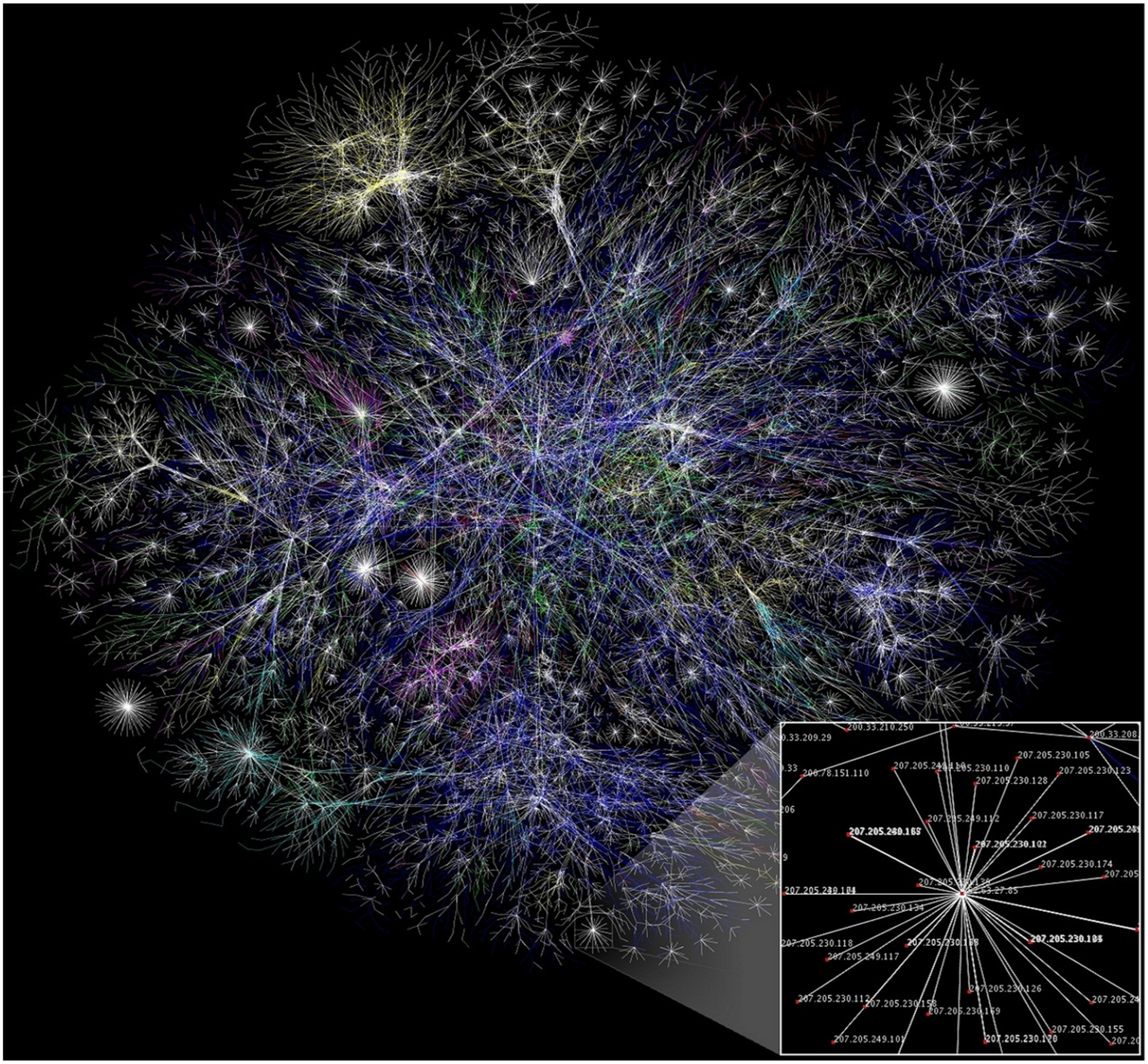
In 1999, Scientific America published, what was then, a shocking predication that by 2005, the Internet would be larger than the traditional telephone network. People didn't see it coming, and hind sight is 20/20. Even as recent as this year, Tech World published IPv4 address depletion is predicted to be as early as December, 2010.[iii] Even though the fact that we are running out of IP addresses has been public for years, 99% of Internet-enabled hosts, world-wide are not incorporating this knowledge into their business models[iv].

This paper focuses on foresight, so the business opportunity for NIC does not fall prey to other sharp-eyed vendors and leave Infoblox in the company of the "not incorporating" percentage ranks.

Growth of Very Large Networks

Today we have over 600 million servers on the public Internet, almost 2 billion users, and the Internet encompasses more than 10,000 networks.[1] Figure 2 shows a portion of the class C network addresses, representing very large public networks. This is an impressive image to see, for its size and complexity. The multifarious image of all private enterprise networks combined, estimated to be at least an order of magnitude *larger* than the public network, is not feasible for this paper. It's much too complex and massive to present visually. Imagine each node shown in Figure 2, as the starting point of a private intranet, with dozens to thousands of end-points. The enterprise market is still growing and is a target for cost effective solutions.

[1] Historical data gathered from betterwhois.com, PBS (1998) History of the Internet, and 2009 Vinton Cerf lectures



Each node represents an IP address. Each line between the IP addesses represents a traffic connection between the nodes. The lengths of the lines indicate the delay between those two nodes.
This graph represents less than 30% of the Class C networks reachable by the data collection program in early 2005. Lines are color-coded according to their corresponding RFC 1918 allocation as follows:
Blue: net, ca, us Green: com, org Red: mil, gov, edu Yellow: jp, cn, tw, au, de Magenta: uk, it, pl, fr Gold: br, kr,nl
White: unknown

Figure 2 Partial map of the Class C networks Internet[v]

Growth of the Internet Traffic

Figure 3 shows Internet traffic growing exponentially over the last 20 years.[vi] Enterprise network traffic, with a well-developed electronic communications infrastructure, is also growing at an exponential rate.[vii, viii]

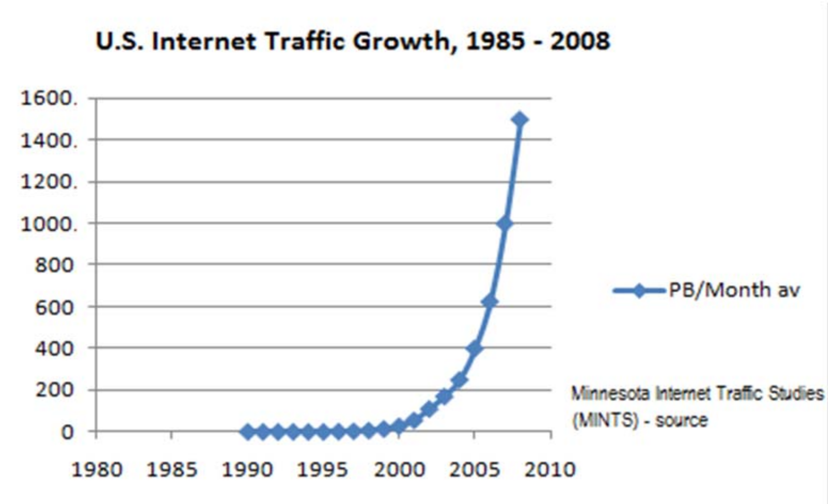


Figure 3: Internet traffic estimates 1985 to 2010

You can infer from Figure 3, that regardless of transmission technical advances, our growing world population is coupled with the growing Internet usage. At times during Internet growth, demand causes network traffic bottlenecks. Eventually, a paradigm shift occurs; the Internet community embraces new technology and moves on with new developments at a faster rate of change, until the growth rate exceeds capacity again, and another shift occurs allowing traffic to speed up. Appreciating the exponential functions is important because time runs out in a hurry towards the end of any exponential growth system, forcing hurried decisions and limited options.[ix]

Three Components of Change in Today's Market

The three components of change driving market growth and business decisions are the following:

- Increasing rate of configuration
- (Virtual) network size
- Amount of mission critical network traffic

The concern is not so much that networks are growing fast and the rate of growth is also increasing; it is that moving more data increases business risks and cost. The driving cause is the changing networks themselves– this change is driven by the explosion of devices and form factors, virtualization and cloud computing.[xvi] NIC addresses networks affected by this growth phenomenon. See Figure 4 Figure 4 for market segments relative to rate of configuration change.

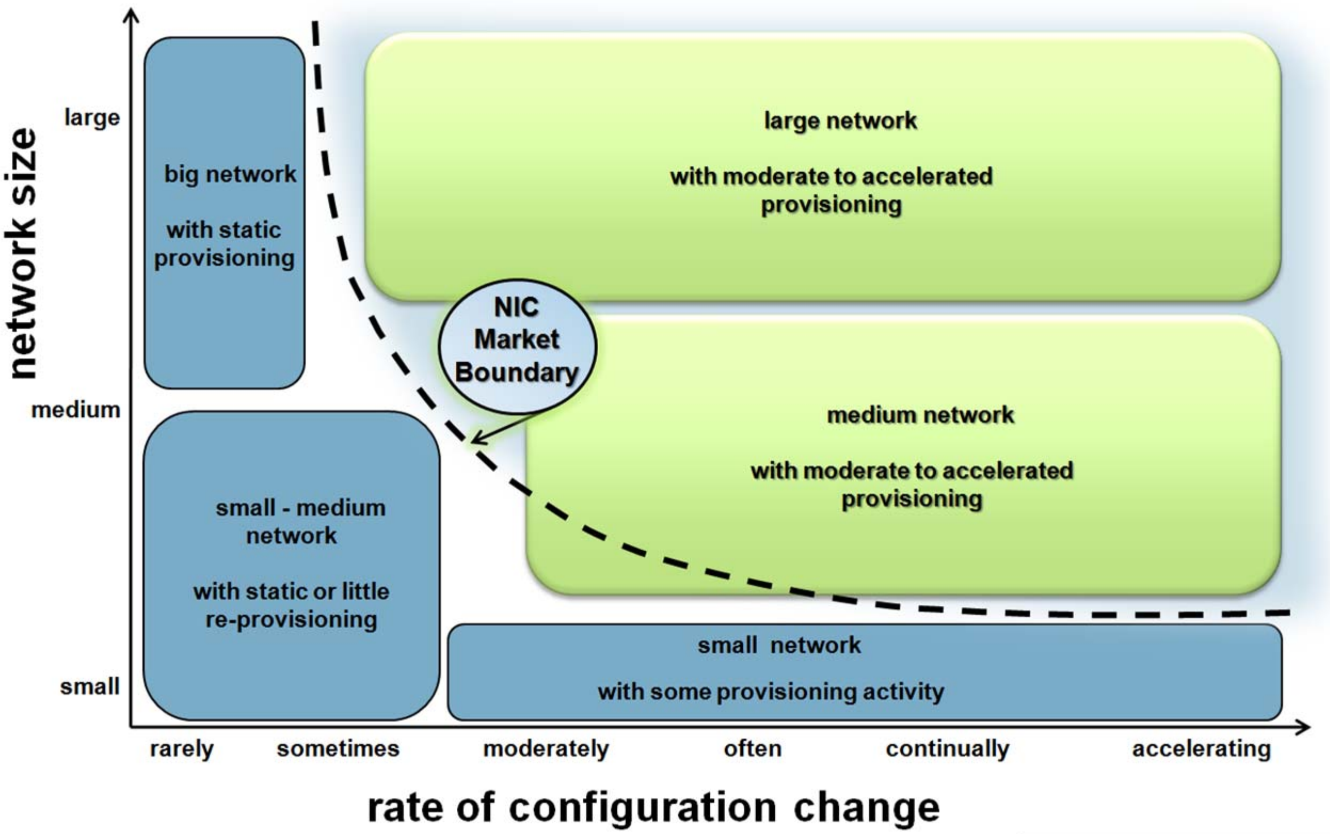


Figure 4: NIC market defined by rate of configuration change in all network sizes

Changes in networks, up until Infoblox solutions, were all done manually. Today, network downtime, with petabytes of data online, is an enormously costly risk factor. This is one of the top potential network management problems to minimize. Even small networks have to change a lot. There is much more mobility, and a resultant higher risk of downtime, if networks are not managed carefully.

Imagine provisioning a new VM; a network engineer may need to:

- Configure
- Create/provision
- Map components, such as a new VLAN, a new VRF (possibly in another virtual firewall context)
- Configure restrictions and rules, such as ACLs and QoS

These tasks need to be done in an end-to-end way, across multiple physical network devices, to create end-to-end connectivity for the new application. Now imagine doing this 4,000 times.

Infoblox Market Position

Gartner puts Infoblox as a market leader in real-time network information services (see Figure 5). Infoblox has sold over 40,000 appliances to more than 4,100 clients across all vertical markets of which 200+ are in the top Fortune 500. Generally speaking, anywhere Cisco Systems® can sell a router or a switch, Infoblox can sell Infoblox gear. The market differentiator of Infoblox is a core competency of real-time distributed information management.

DNS, DHCP, IP Address Management (DDI)

	RATING				
	Strong Negative	Caution	Promising	Positive	Strong Positive
Alcatel-Lucent			x		
Blue Cat				x	
BT Diamond				x	
Efficient IP		x			
Infoblox					x
Men & Mice		x			

Source: Gartner DDI Market Scope (November 2009)

Figure 5: A Gartner market comparison chart showing Infoblox as a clear DDI market leader, with Infoblox network services platforms

Infoblox Grid Manager^{TM} has the functionality and user interface to manage all core network services. Figure 6 shows an example of the Grid Manager which supports sending data to the Grid, through the Grid Master.

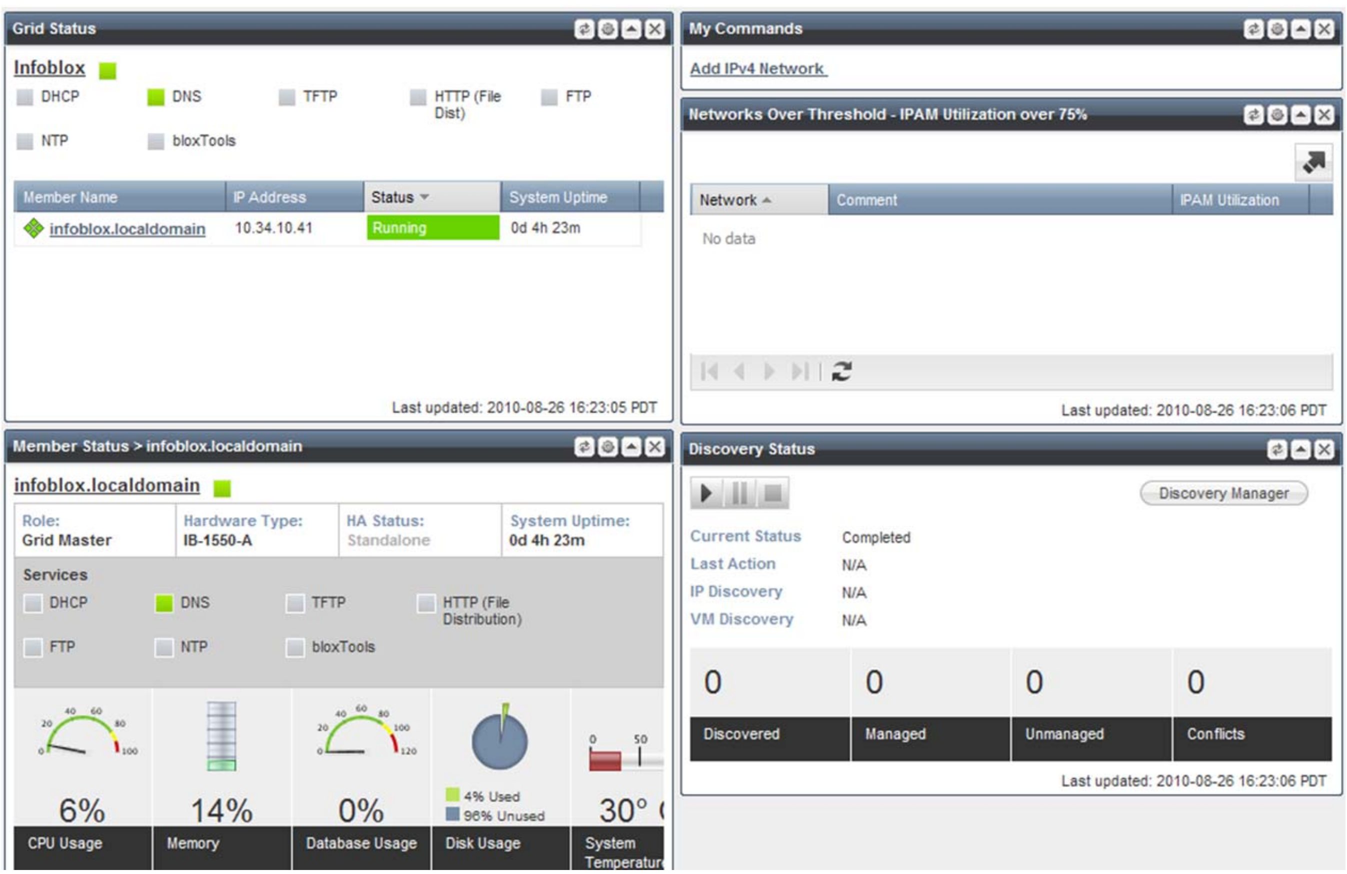


Figure 6: Example of the Infoblox Grid Manager user interface

Specifically, Infoblox is the IPAM (IP address management) appliance market share leader with growing name recognition – Infoblox is on the shortlists of most Gartner clients looking at DNS, DHCP and IPAM (DDI) solutions. Now, more than ever, the mission-critical nature of DNS and DHCP services remains prominent due to network scalability and reliability demands. Downtimes and latency issues, such as secondary DNS resolution or DHCP latency, are incompatible with networks requiring high availability solutions.

In 2009, Gartner named Infoblox as the market leader due to Infoblox pioneering integrated DDI appliances. With the purchase of NetMRI, Infoblox became a challenger in the network configuration and change management (NCCM) market.[x]

Network Configuration Change Management (NCCM)

	RATING				
	Strong Negative	Caution	Promising	Positive	Strong Positive
AlterPoint			x		
BMC Software				x	
Cisco		x			
Dorado Software			x		
EMC					x
HP					x
Intelliden, an IBM company				x	
LogLogic			x		
ManageEngine			x		
Infoblox (formerly Netcordia)				x	
Pari Networks		x			
SolarWinds				x	
Uplogix		x			

As of 29 March 2010

Source: Gartner (March 2010)

Figure 7: A Gartner market comparison chart showing Infoblox as a strong contender in the NCCM market, with NetMRI

The commercial DDI market is expected to increase due to large scale adoption of DNS Security Extensions (DNSSEC) by multiple government mandates and major domain name registries. By extrapolation, in 2014, 30% of all DNS lookups will be signed with DNSSEC. As more enterprises sign their zones, they will move away from BIND and adopt commercial DNS solutions that offer tools that ease the key management and zone signing processes.[xi]

The increased network complexity from virtualized and cloud computing environments will force network managers to embrace more automation, which should put the Infoblox NIC solution in a strong market position.[xi]

Infoblox Network Solutions Today

Infoblox builds products in the DNS, DHCP and IPAM (DDI) and Network Configuration and Change Management (NCCM) market space, namely the Infoblox operating system (NIOS™) and Infoblox NetMRI®.

Infoblox network services appliances provide a platform for delivering reliable, scalable, and secure core network services such as DNS, DNSSEC, DHCP, and IPAM. The integrated Infoblox approach combines the simplicity of appliances with the power of advanced distributed database technology that controls and automates services while achieving availability, manageability, visibility, and control unparalleled by conventional solutions based on legacy technologies.

DNS and DHCP services are available free of charge from several sources. Gartner[x] defines the following reasons why organizations choose to pay for DDI:

- **Centralized control** – many organizations distribute DNS responsibility across two or more teams because they have implemented DNS on multiple platforms.
- **Stability** – commercial DDI solutions help stabilize DNS and DHCP infrastructure with improved reliability and availability features.
- **Operational and internal political issues** – tensions can develop between the team that is responsible for the DNS/DHCP services and the team that owns the underlying platform.
- **IPAM** – a significant shortcoming is the lack of IPAM services in freeware.

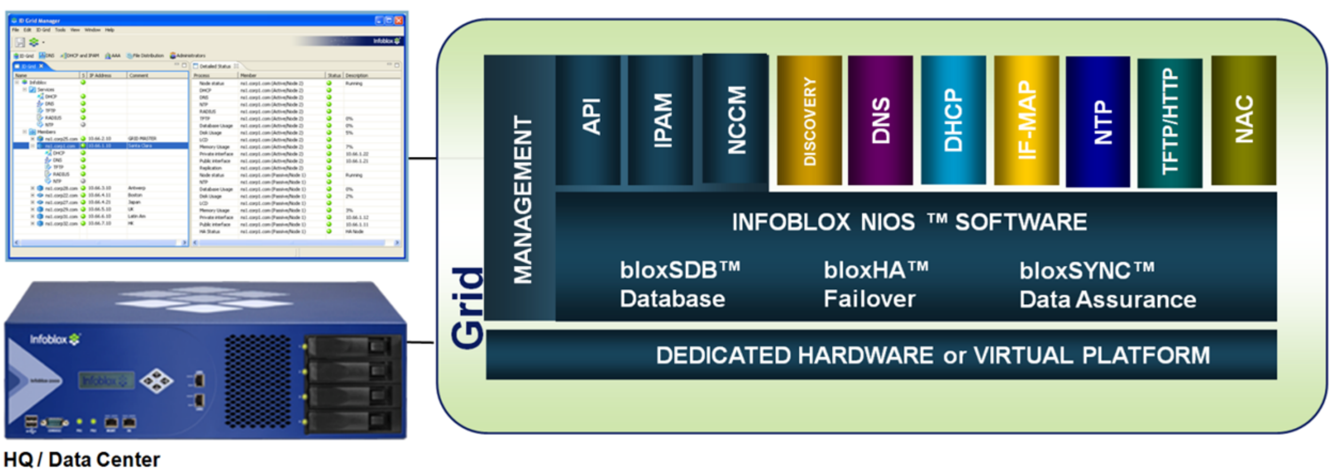


Figure 8: Infoblox Grid components

A recently published case study[xii] of the Edward Donley Computer Center, one of the largest wireless intranet networks in the Midwest, demonstrates a network traffic analysis using old world IT methods on a virtual network.

> "With 60 servers in our virtualized environment and thousands of users constantly accessing our network …troubleshooting problems was difficult and time-consuming. For example, we had a denial of service occur in one of the buildings on campus. It took us hours to identify that the source was a bad printer card." – Tim Chavis, Executive Director, IT Services for the school's Edward Donley Computer Center.

If this network had Infoblox's Grid technology, they would have automatically known the trouble area. Infoblox Grid appliances are linked using sophisticated distributed database technology embedded within each one. This transforms the collection of appliances into a unified system with very unique and beneficial attributes – the Grid enables redundancy. If an appliance fails, then another device in the Grid automatically takes over the role of providing its DNS and DHCP services. The Grid, a differentiator in the market, simplifies several operational tasks.

Current Trends in Enterprise Technology Today

Internet applications and media-rich communication channels are the main drivers in Web application traffic. A common goal in software development is to increase the speed of the application or of the network. Customers in all verticals are transitioning to application acceleration technology to handle high-volume network applications[xiii]

Datacenter Virtualization

Data center virtualization makes computing resources more flexible and efficient, and that reduces costs and accelerates IT processes. Yet, the automation eventually runs into networking troubling issues when a critical mass of high-speed bandwidth servers is reached, due to multiple processes, multi-media content, and more data. To capitalize on the benefits of virtualization, most datacenters make fundamental changes. "The physical network must adapt to the requirements and advantages created by virtualization, specifically higher utilization and higher bandwidth. To do this, forward-thinking network professionals have implemented the End-of-Row or Top-of-Rack topologies in their datacenter networks." [xiv]

A virtualization strategy is more likely to succeed if the datacenter network is also flexible and dynamic. See Figure 9 for a diagrammatic view of where NIC is relative to the other components in a virtualized data center.

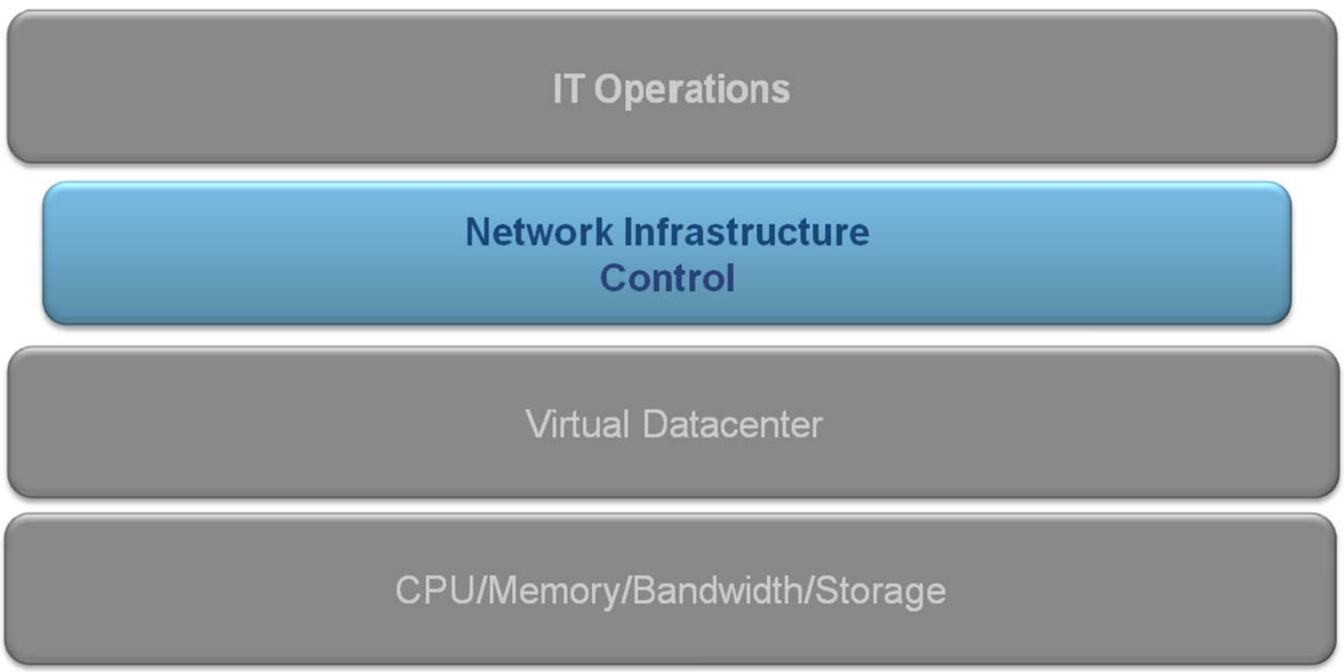


Figure 9: Real-time Network Infrastructure Control stack with a virtual datacenter

Cloud Computing

Virtual network are the underlying technology in cloud infrastructures.[xv] Cloud computing shifts functionality from desktop motherboards to Internet-based computing service networks. It encompasses Software-as-a-Service applications, such as Salesforce.com™, as well as online storage and operating systems platforms.

The term comes from the traditional IT industry use of a cloud icon in a system diagram. The cloud represented the network portion outside the specific network area in discussion. This was true whether or not the cloud was part of the enterprise infrastructure; it simplified the discussion. In this paper, the cloud means shared, just-in-time resources. For a detailed report on the misuse and miscommunication with regard to the term cloud computing, see Gartner's "The What, Why and When of Cloud Computing" 2009 report.[xvi]

Differentiating cloud computing as either public or private (and even hybrid deployment models) is one way to look at cloud computing. Another way to perceive cloud computing is to use a layered model, then introduce a taxonomy for looking at the various layers of cloud computing.[xvi]

In the case of layered services, if a cloud application service provider builds on another provider's cloud computing service, such as Amazon Web Services, they also need to address security, service-level management and performance. It is critical to fully comprehend the supply chain and interdependencies. Over time, as cloud computing matures and providers establish a proven track record for delivery, "trusted" providers will become a less problematic foundation for building higher level services.[xvii]

Gartner identified the strength of public and private cloud computing by using the following characteristic attributes:[xviii]

- **Service-Based**: Consumer concerns are abstracted from provider concerns through service interfaces that are well-defined and reflect the consumer business service.
- **Scalable and Elastic**: The service can scale capacity up or down as the consumer demands, and at the speed of full automation.
- **Metered by Use**: Services are tracked with usage metrics to enable multiple payment models. The service provider has a usage accounting model for measuring the use of the services.
- **Shared**: Services share a pool of resources to build economies of scale. IT resources are used with maximum efficiency.
- **Uses Internet Technologies**: The service is delivered using Internet identifiers, formats and protocols, such as URLs, HTTP, IP and representational state transfer Web-oriented architecture.

By using the five Gartner-defined attributes, you can determine the robustness of a private or public cloud solution.

Gartner proclaimed public and private cloud computing heralds an evolution of business that is no less influential than was e-business. "During the past 15 years, a continuing trend toward IT industrialization has grown in popularity as IT services delivered via hardware, software and people are becoming repeatable and usable by a wide range of customers and service providers," said Daryl Plummer, managing vice president and Gartner Fellow.

Public Cloud

Public cloud computing exists outside the firewall, with software that is architected and managed, so companies do not need to rewrite software for scaling, fault tolerance, geo-replication and security, based on where it is running.[xix] The shift to cloud computing logically follows the shift from mainframe to client–server. Details are abstracted from the users, who no longer have control over the technology infrastructure.[xx] It is a byproduct and consequence of easy access to remote computing sites provided by the Internet.[xxi]

Private Cloud

The enterprise response to cloud computing created new demands for automation and control. A private cloud computing model is formed using the public cloud characteristics and standards. However, there are important differences. Most cloud services don't have the service levels, the security, or the compliance requirements needed by private enterprise systems.

Even so, drawn by cost factors, there is a big trend in the private service markets to move to the cloud even though many best practices services are lacking in the public cloud. Large companies such as Google and Amazon use virtualization to build private cloud computing as a near term solution for a rapid return on investment. It is a business case solution for the migration to a public cloud solution in the future and is an important move to a future public cloud computing business solution.[xxii]

Elastic Networks

Another current trend is elastic virtual computing environments. An elastic network (EN), can run multiple server instances on a variety of operating systems and allow the customer to manage their network permissions using as many or few systems as needed. Cloud services elasticity (CSE) can add flexibility to service providers in capacity planning and service pricing. It is a mechanism for adding and removing capacity in an environment, not necessarily adding and removing load.[xxiii]

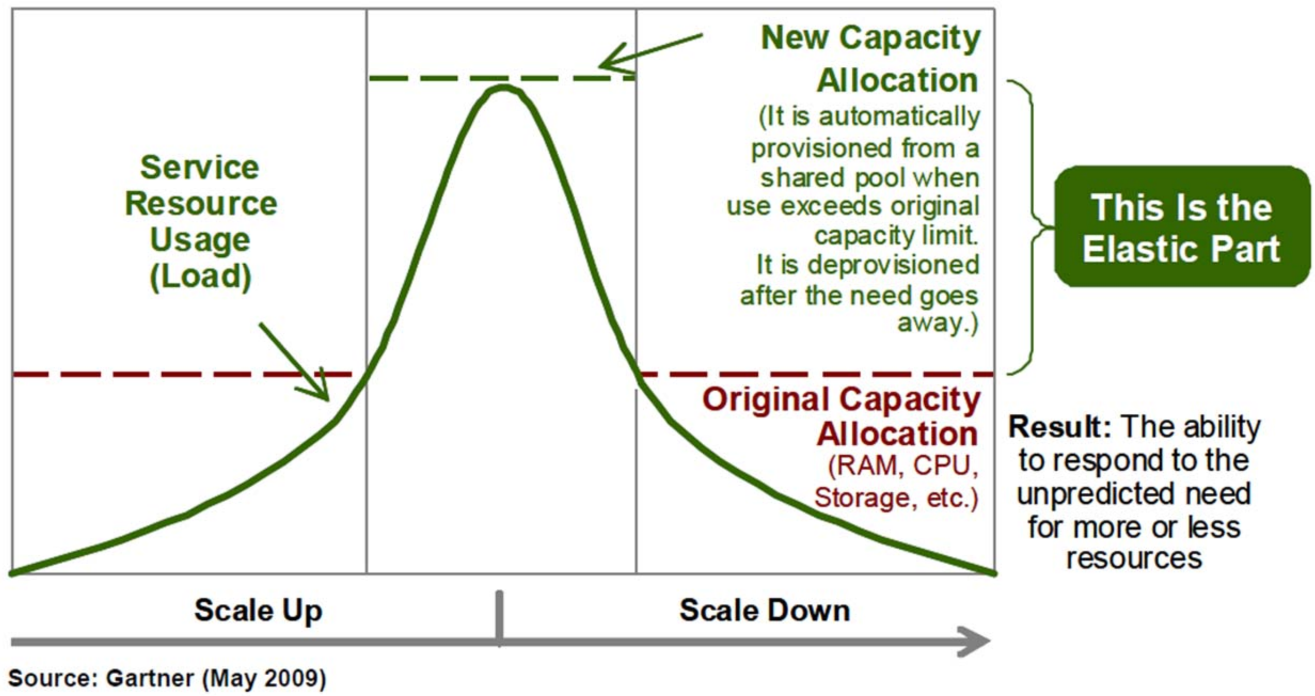


Figure 10: Explains elastic response to scaling up and down, in direct proportion to resources and load.

An EN is a highly automated, very low maintenance, logical network which meets the emerging needs of unified communications, data center enterprise virtualization, desktop virtualization, and cloud computing.

Elasticity is needed when an application or service runs out of space or when it releases space it was using within its current environment. Sometimes, elasticity is the result of the application architecture, such as adding a Web server to the farm, or adding Enterprise JavaBeans (EJB) to the cluster. However, enterprise environments with physical limitations in their network architecture keeping it static, are unable to use the benefits of elastic cloud networks.

"An application designed to work in a static environment may not be able to take advantage of added capacity. Also, certain types of capacity problems may make an elastic capacity change a bad choice. Systems that are bound by shortages in I/O space, or network bandwidth or that simply cannot use a larger memory address space will gain limited benefits It is important to establish solid policies describing when elasticity should be used and what kind of elasticity is needed."[xxiii] See Figure 8.

Future in Virtual Networks

Virtualization is a larger and more immediate driver of cloud computing. Virtualization requires a software infrastructure and management processes. A virtual switch has a new access layer: the virtual network switch resides within physical servers. Each virtual switch, directing network traffic among the various VMs and their virtualized applications, exists on a single physical server. Network activity between co-located VMs does not cross onto the external (physical) network, therefore virtual network traffic is invisible to physical network monitoring tools.

Entering the Virtual Network Market

In the new world of nimble networks, new requirements can increase the risk of downtime. However, NIC is designed to decrease risk. Current network assets cannot meet the new requirements of fast changing networks. NIC also keeps current value in their legacy IT infrastructure. What's called for requires a high level of robustness and capacity, with certainty and security, while managing infrastructure elements, the information running on the routers and switches. Companies do not have to replace their investment in networking; they can add the NIC solution to retain their earlier investment.

We propose entering the market segment of virtual infrastructure with NIC, together with the next version of the Intelligent Grid™ . Then, after penetrating the virtual infrastructure market with real-time management, we will move into managing cloud infrastructures (see Figure 11).

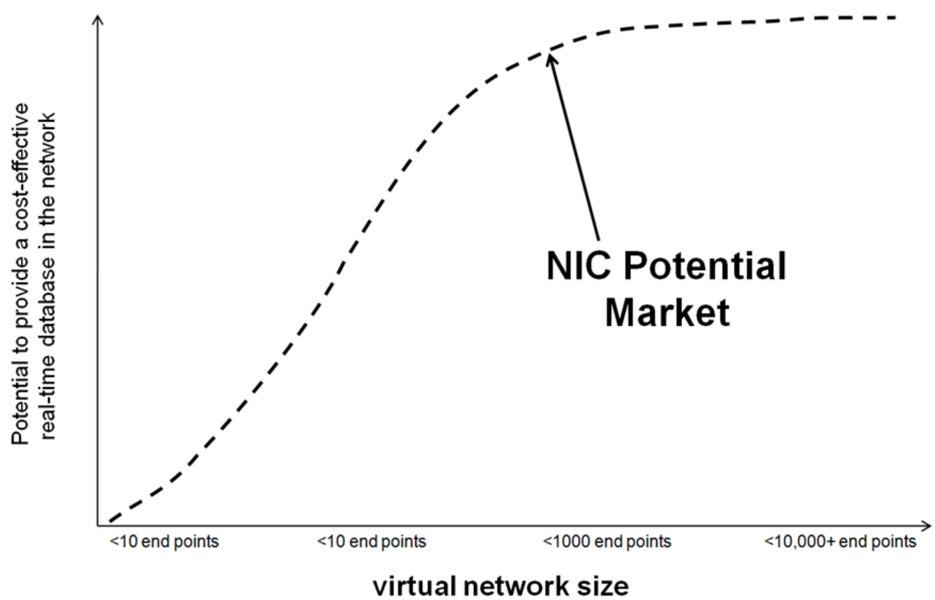


Figure 11: Potential market estimate for optimizing networks with a real-time database

NIC Framework

In the new world of NIC, a real-time service is required. What makes this relevant for Infoblox, is that the Grid can distribute instances of virtual switches during provisioning and configuration; since, in the end, they are just files. Network management configuration changes are made at machine speeds - it is no longer an overlay. By using Grid technology, NIC still delivers real-time network services that will never fail.

Virtual switches are like actual switch components. But they are actually little virtual machines that live in the virtual environment, such as the Cisco 1000v that ships with Vsphere4, acts like a big switch or router, but is just software. Infoblox sells virtual DNS, virtual DHCP servers, virtual load balancers, and virtual firewalls – all regular network components that need to be configured to provide the characteristics that we captured in the management plane.

These tasks need to be done in an end-to-end way across multiple physical network devices, to create end-to-end connectivity for the new application. Network configuration tools, such as NetMRI, can help execute the steps that are in isolation today. What is needed is a meaningful way to orchestrate that process across a complex network topology for an end-to-end solution

Grid Master interfaces with VMware. ESX (a block of serves) is the v-machine layer on potentially hundreds of big servers, and on top of that are a number of VMs. NIOS is the network infrastructure operating system. On top of that are DNS and DHCP, virtual services, network configuration change management, and possibly load balancing (application delivery control), WAN optimization, and firewall security.

The NIC management solution couples the virtual network control plane and the virtual network management plane. NIC users can define high-level abstraction management, automatically configure at the control plane level and have rapidly re-provision end-points.

NIC Network Control and Management Planes

This section places Information Management together with Information Control. You can bind the information management and control planes together in virtual network management. Visualize a hierarchical relationship between the two with a topological view, and define both management and control components in mathematical terms of space. When using NIC, you can define the management plane so that even thousands of components are automatically configured in the Virtual Network control plane (see Figure 12).

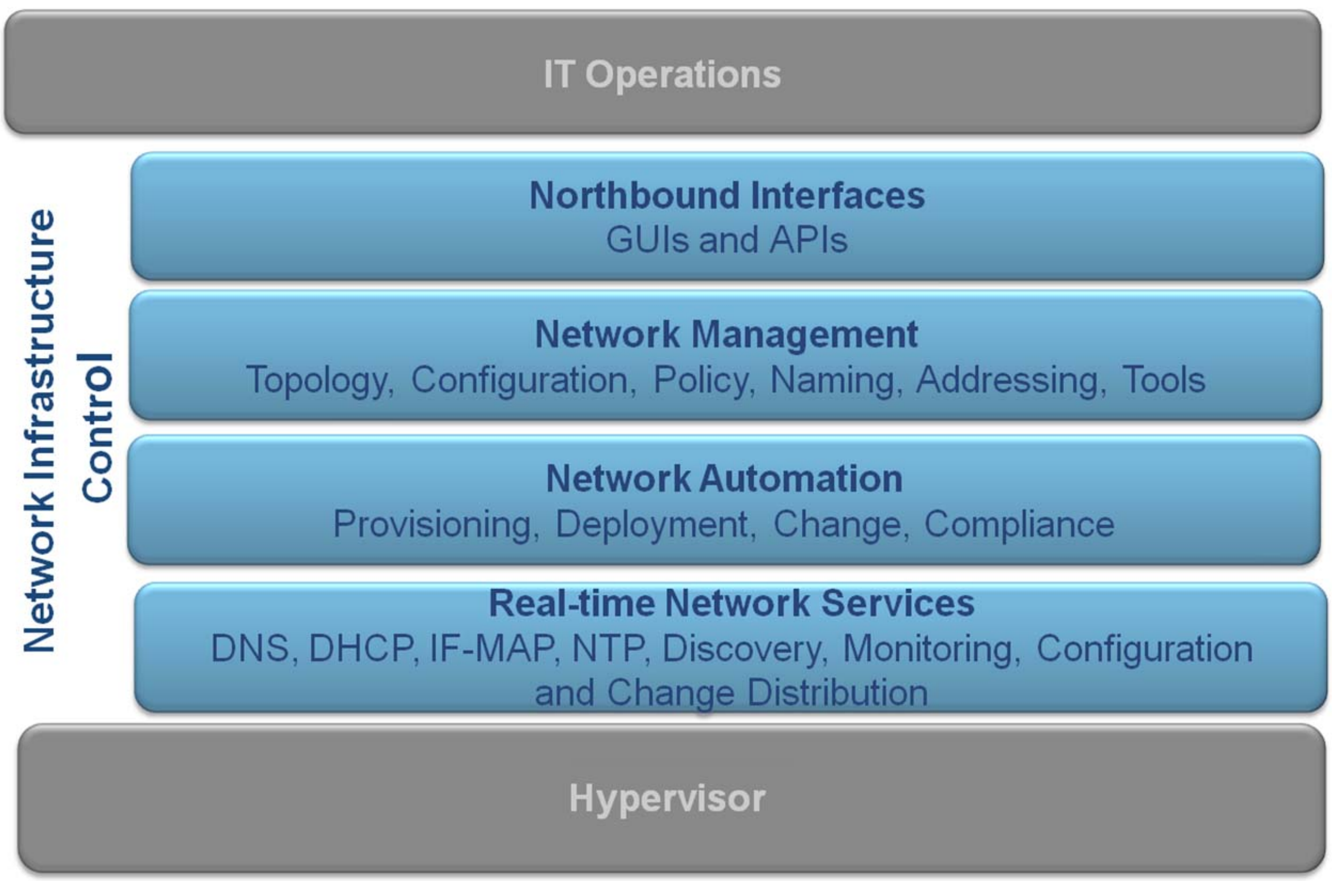


Figure 12: NIC in the virtual network

Elastic Network Management

NIC is a stepping stone for Infoblox to move into the Elastic Network Management (ENM) market. To effectively utilize virtualization, the network must become abstracted[xxiv] and dynamic with two highly abstracted components:

- virtual servers, such as VMware or Microsoft
- infrastructure services from Infoblox

Network administrators using old-world physical network tools cannot effectively troubleshoot virtual network problems. Network management tools monitoring and managing the control plane of individual networking elements, such as switches, would not orchestrate provisioning and configuration across those elements as a real-time service.

Elastic Network Control Plane (ENCP) is a distributed automation platform that transforms your existing networking infrastructure into an EN by providing the provisioning, configuration, and operation of your network infrastructure as a real-time service. ENCP tools review recent activities, inspect VMs for anomalous network behavior, and address near-term demands for audit-ability[xxv].

However, as ENs evolve, many traditional network management tools can remain useful by monitoring and troubleshooting legacy networks and specific elements of the growing Elastic Network Data Plane (ENDP). The ENDP are elements, such as firewalls, routers, switches, and load balancers, orchestrated by an ENCP to meet emerging use cases in unified communication, enterprise virtualization, and cloud computing.

Once a network has new EN elements, legacy network management tools that do not orchestrate provisioning and configuration across those elements as a real-time service also do not provide an ENCP. New tools need to emerge on top of the ENCP to provide ENM. Because ENs are low maintenance, the new ENM tools must focus on different, more elastic and automated use cases than did the traditional network management tools.

A current network can merge seamlessly into an EN. Current investments in physical and virtual networking, including routers, switches, firewalls, and load balancers, can be transformed into an EN network when the ENCP is in place.

Summary

Today's networks grow due to mergers, online business applications, mobile devices, and adding or swapping stationary office machines. Company employees anywhere in the world regularly telecommute and join live voice and video conference meetings. The bottom line is that efficient networks mean additional revenue.

There are three imminent network issues:

- The fast increasing rate of provisioning and de-provisioning
- The tremendous growth of the internet and intranets
- The exponential growth curve of data transmission

Solutions can be developed to address these changes, but they are going to involve a dramatic leap, both in thought and in action, beyond our current methods. Key decision makers must recognize changes in their environment. They must choose to adjust their focus and corporate movements to keep current with market shifts to stay viable in the market.[ii]

This paper proposes that to address these critical issues is to have real-time capabilities by designing and implementing a real-time database for network infrastructure. The company that develops a cost-effective solution such as this, is a company with real-time data management experience. That company is the number one Gartner-rated company[x] Infoblox, and the NIC solution begins with intelligent Grid and NCCM.

Appendix

IP addressing

IP addresses consist of two groups of bits in the address: the most significant part is the network address, which identifies a whole network or subnet, and the least significant portion is the host identifier, which specifies a particular host interface on that network. This division is used as the basis of traffic routing between IP networks and for address allocation policies. Classful network design for IPv4 sized the network address as one or more 8-bit groups, resulting in the blocks of Class A, B, or C addresses. Classless Inter-Domain Routing (CIDR) allocates address space to Internet service providers and end users on any address bit boundary, instead of on 8-bit segments.

Class-based IP addressing is still used, but most networks use the CIDR method, developed in 1993. CIDR is backwards compatible and allows a more efficient allocation of IP addresses than the old Class A, B, and C address scheme.

Network Classes

The original class-based Internet routing scheme was developed in the 1970s. Sites were assigned addresses from one of three classes: Class A, Class B and Class C. The address classes differ in size and number. Internet NIC assigns a class A, B or C address for new networks. NIC would set the Network number to a unique value. The class of an address defines which portion of the address identifies the Network number (N) and which portion identifies the Host numbers (H). The range of values for these classes is as follows. [xxvi]

Class	Range	Allocation
A	1-126	N.H.H.H
B	128-191	N.N.H.H
C	192-223	N.N.N.H
D	224-239	Not applicable

The network administer would then define an IP address for each network host by using the assigned Network number, followed by the Host number. The value of the first IP address number determines the class to which a given IP address belongs.

Class A

Class A IP addresses are reserved for a small number of networks that have a large number of hosts, such as a top research facility. The first octet in a class A IP address has a value in the range of 1 to 126. There are 126 usable addresses, each of which can support 16,777,216 hosts.

Class B

Class B IP addresses are reserved for some networks that have an intermediate number of hosts. The first octet in a class B IP address has a value in the range of 128 to 191. There are 16,320 usable addresses for each Class C IP address, each of which can support 65,536 hosts.

Class C

Class C IP addresses are reserved for a large number of networks that would have a relatively small number of hosts. The first octet in a class C IP address has a value in the range of 192 to 223. There are 2,080,800 networks possible for each Class C IP address, each of which can support 254 hosts.

Class D

Class D IP addresses are used by groups of hosts or routers that share a common characteristic.

Class E

Class E IP addresses exist (240-248), but are reserved for future use.

Exponential Growth

$$\ln 1 = 0$$
$$\ln e = 1$$
$$\ln e^x = x$$

Figure 13: Equation form of exponential function

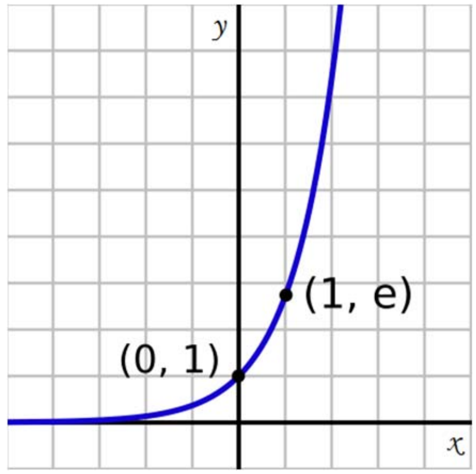


Figure 14: Graphic representation of exponential

The exponential function is used to model phenomena when a constant change in the independent variable (x) gives the same proportional change (increase or decrease) in the dependent variable (y). The function is often written as exp(x) or e^x , especially when the input is an expression too complex to be written as an exponent.

If something is increasing over time on a percentage basis, it is growing exponentially. One form of exponential growth is a doubling rate which can be visualized by asking the question how long would it take to fill Fenway Park with water if you started with a single drop then doubled the drop every minute. That creates a doubling series of 1+2+4+8+16+32 and so on— this doubling series plots out as a hockey stick pattern. At the 45 minute mark, the field is covered with less than 5 feet of water; in 4 more minutes, the field is brimming. In less than 50 minutes, a single drop of water doubling every minute (growing exponentially over time) completely fills Fenway Park[xxvii]. The action of exponential functions only heats up in the last few moments of growth.

The greatest shortcoming of the human race is our inability to understand the exponential function. ~ Dr. Albert Bartlett

The graphical form of the exponential curve sometime looks like a hockey stick. Graphing the human population growth from a few scattered tribes to today's population is one such exponential hockey-stick curve. It took all of human history until 1960 to reach 3 billion and only another 40 years to hit 6 billion.

Population and Internet Growth

Table 1 places the technology and human data in an easy-to-read form, and lists historical growth trend numbers in the total global human and host computer population.

Table 1: History of the Internet

1960	Global population is 3.1 billion
1969	ARPAnet forms for network research. The first official network nodes were UCLA, the Stanford Research Institute, UCSB, and the University of Utah.
1970	Global population is 3.7 billion
1971	Total number of host computers on the network is 15, including Harvard and NASA.
1972	Total number of host computers on the network is 40.
1973	FTP, email, and telnet were developed for better communication.
1974	Data is now transmitted more quickly and efficiently with the design of TCP (Transmission Control Program).
1980	Global population is 4.4 billion
1982	Internet technology protocols are developed as TCP/IP.
1983	Desktop workstations are introduced.
1984	1000 host computers on the network. Domain Name System (DNS) introduced.
1987	10,000 host computers on the network.
1989	100,000 host computers on the network.
1990	Global population is 5.1 billion
1991	World-Wide Web (WWW) released by CERN.
1992	1,000,000 host computers on the network.
1993	Mosaic is launched. InterNIC is created by NSF to provide specific Internet services of DNS tracking
1995	NFS charges $50/year for a DNS registration.
1997	101,803 Name Servers in whois database.
2000	Global population is 6 billion
2010	10 x $10^{\wedge 4}$ Name Servers, 6.2 x $10^{\wedge 6}$ host computers on the network, and 1.8 x $10^{\wedge 9}$ users.

Table 2: Historical Internet Statistics

Total History of Internet Domain Counts & Internet Statistics

Domain Counts | Country IPs | World IPs | DMOZ Listings | Registrar Stats

Domain Tools daily domain statistics page. These stats show how many domains are currently registered and previously registered but are now deleted.

Daily Changes (last 24 hrs) as of July 15, 2010

Active	Deleted	New	Expired	Transferred	TLD
88,474,096	314,873,131	92,878	53,565	115,113	**.Com**
13,191,501	33,852,724	13,985	8,762	14,566	**.Net**
8,567,123	21,077,685	11,617	5,856	12,452	**.Org**
6,663,467	9,910,122	14,224	6,329	14,819	**.Info**
2,132,730	2,165,729	2,589	1,899	1,557	**.Biz**
1,727,806	1,697,651	2,270	1,945	1,425	**.Us**
120,888,557	384,238,620	137,563	78,356	159,932	**Total**

Amount of new domains daily and the amount of domains deleted daily as of July 2010

Table 3: Internet Usage and Population Statistics

World Internet Usage and Population Statistics

World Regions	Population 2009 Est.	Internet Users Dec 2010	Internet Users July 2010	Penetration % Population	Growth 2000-2009	Users % of Table
Africa	991,002,342	4,514,400	86,217,900	8.70%	**1809.80 %**	4.80%
Asia	3,808,070,503	114,304,000	764,435,900	20.10%	**568.80%**	42.40%
Europe	803,850,858	105,096,093	425,773,571	53.00%	**305.10%**	23.60%
Middle East	202,687,005	3,284,800	58,309,546	28.80%	**1675.10 %**	3.20%
North America	340,831,831	108,096,800	259,561,000	76.20%	**140.10%**	14.40%
Latin America/Caribbean	586,662,468	18,068,919	186,922,050	31.90%	**934.50%**	10.40%
Oceania / Australia	34,700,201	7,620,480	21,110,490	60.80%	**177.00%**	1.20%
WORLD TOTAL	6,767,805,208	360,985,492	1,802,330,457	**26.60%**	**399.30%**	100.00%

Year	Hosts
1969	4
1971	15
1972	40
1984	1,000
1987	10,000
1992	1,000,000
2010	6,200,000

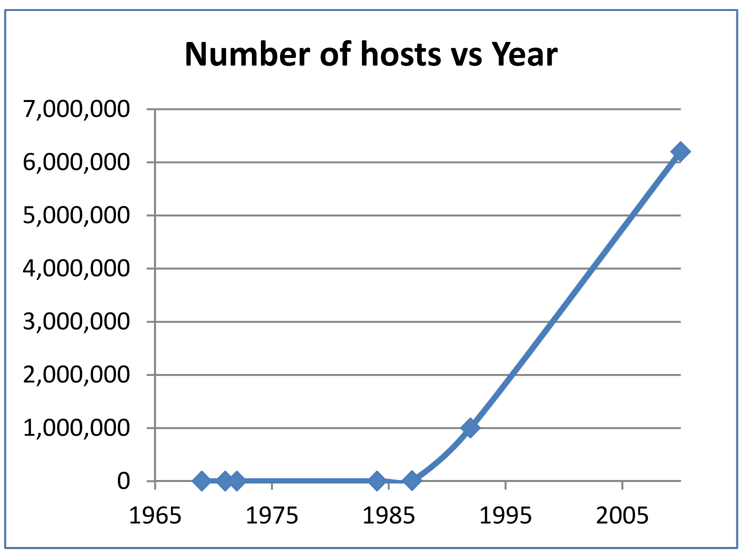


Figure 15: Historical growth of hosts nodes
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