The Self-Driving Network

Part II: Appetite for Disruption

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Executive Summary

This white paper, the second in a two-part series, articulates the economic imperative behind the Self-Driving Network™, the technology progression from automation to autonomy, and the organizational and skills transformation required. Part I: A Bolder Vision for the Industry introduced the Juniper Networks vision for the future of autonomous networking, tracing the history of innovation in the automobile industry to envision how the Self-Driving Network will evolve.

Introduction: A Holistic Approach

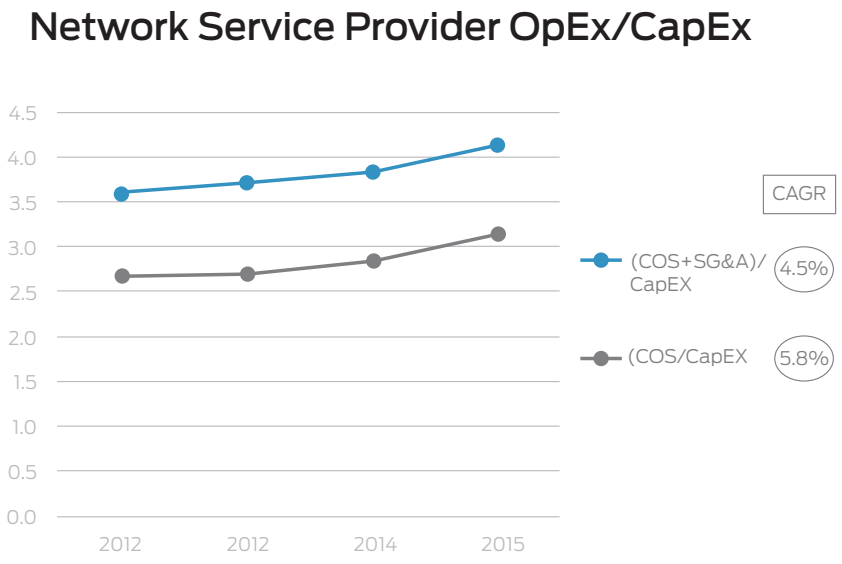
To fulfill our vision of the Self-Driving Network, it is critical that we not only think about our technology roadmap but also consider the economic forces pressuring our industry and the larger human ramifications that autonomous networks may introduce. Disruptive innovation typically occurs not through technical breakthroughs alone, but through a serendipitous confluence of technological, economic, and sociological factors.

It often takes an outsider to disrupt an industry. Incumbents within an industry ecosystem are rarely motivated to change because they are so invested in the status quo. This blindness to potential disruption creates a potential opportunity for an industry outsider, such as a nimble "digital native," to disrupt the networking industry. A number of factors indicate that this outcome is a legitimate possibility. Web services companies, which possess deep capabilities in automation and other hyperscale cloud technologies, operate much faster than incumbents who are weighed down by legacy business models. However, steep barriers to entry exist in telecommunications, including regulation and massive capital requirements. Although Google Fiber may have pushed incumbent network operators to accelerate broadband investments, it does not appear that it will fundamentally displace traditional network operators. In fact, after several years of significant effort and investment, Google Fiber has paused further expansion.

The Economic Imperative

While an imminent, external threat to the traditional service provider business may not exist, there is a creeping threat from within. Juniper believes that there is an economic imperative for traditional service providers to radically change the way they operate their networks. Disrupt yourself or, eventually, others will.

The primary cost for traditional telecommunications service providers lies in their operating expenses, not capital expenditures. The annual cost to operate a network is much higher than the cost to initially buy the equipment. As networks become bigger, more complex, and tougher to manage, these operating costs skyrocket (Figure 1).



Weighted average for Verizon, AT&T, CenturyLink, Sprint
COS (cost of service/sales) includes network operations, customer service, leases energy, handsets/phones, inter-carrier costs SG&A includes sales, marketing, and general/adminstrative expenses
Source: Company reports, Juniper analysis

Figure 1: Network operating expenses vs. capital expenditures

The pattern here is clear and troubling. To get these costs under control, network operators must fully embrace automation and work toward autonomy: The Self-Driving Network.

Automation allows network designers to tackle the never-ending, relentless trade-off between performance and agility, where "agility" is defined as the speed at which you can get infrastructure to do something that you did not anticipate, while "performance" refers to traditional "speeds and feeds." Automation and autonomy allow us to "push out" these curves to make the trade-offs less painful (Figure 2).

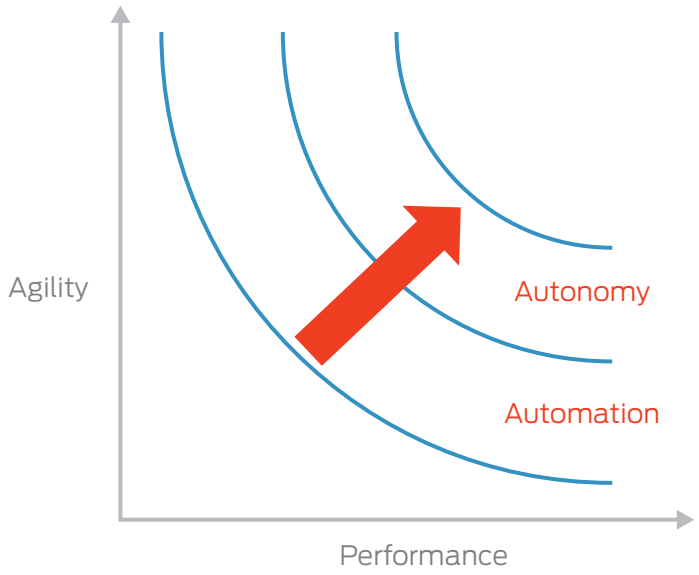


Figure 2: Network agility vs. performance

The Technologies Required

To address the increasingly difficult network economics, first we need to more aggressively adopt automation techniques and then push toward networks that operate autonomously (Figure 3). The path to the Self-Driving Network begins with Juniper's automation strategy, which includes three elements:

1. Reduce operational complexity by **simplifying** and **abstracting the network**.
2. Enable customers to deploy new network services **faster**.
3. Improve capacity utilization and network resiliency through **deep telemetry**.

To help our customers execute on this strategy, Juniper has constructed an automation framework that consists of the Juniper Networks® Junos® operating system, plus a comprehensive suite of tools, extension kits, and programmatic interfaces (https://www.juniper.net/us/en/solutions/automation/). With this foundation, Juniper customers, as well as pre-sales and post-sales professionals, are developing and deploying approaches aimed at reducing operational expenses (OpEx). Juniper has provided advanced automation capabilities for many years but to truly unleash the power of "digital cohesion," where service providers and enterprises will provision numerous services instantly to deliver a frictionless customer experience, we need to go beyond mere automation.

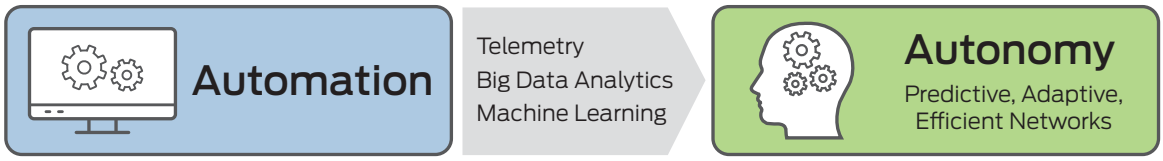


Figure 3: The Self-Driving Network

This next stage is where the Self-Driving Network, where networks are predictive and adaptive to their environments, emerges. Coverage is ubiquitous and pervasive, and the quality of the customer experience is optimized and customized for the individual. These future networks are inexpensive to operate—possibly even free to end users. With minimal guidance from a network operator, a Self-Driving Network will:

- Self-discover its constituent parts
- Configure itself
- Self-monitor using probes and other techniques
- Self-defend from external and internal threats
- Self-correct
- Auto-detect when a new service is needed and then auto-enable that service
- Automatically monitor and update services to optimize service delivery
- Self-analyze through the use of machine learning for introspection
- Self-report periodically or when an unexpected situation arises

We are inching toward autonomous networks as we infuse automation frameworks with machine learning and big data analytics. The path to these "zero touch" networks relies on telemetry, automation, machine learning, and programming with declarative intent:

- **Telemetry**: SNMP, streaming telemetry, and deep packet inspection (DPI) are beginning to show limitations. We need telemetry based on push semantics and anomaly detection based on machine learning. Much more information will be gathered and processed on-box. Telemetry will be active, "zooming in" as needed and "zooming out" again. To act in the most efficient and effective way, service providers must correlate data across time, geography, and network layers. And finally, deep telemetry is needed to determine device state, customer state, and packet state. Juniper's OpenNTI is an example of a simple, open-source tool for collecting, normalizing, and visualizing key performance indicators (KPIs) using standard telemetry, analytics, and a hierarchical design.
- **Automation**: Today, we automate topology discovery, path computation, and path installation. We have bandwidth reservation that is responsive to traffic changes, but we need smarter auto-bandwidth—e.g., is that traffic spike due to downloading the latest Beyonce song or a DDoS attack? When networks are self-driving, we will have automatic service placement and service motion; specific upgrades based on configured services; and inductive network response based on machine learning.
- **Declarative intent**: Tell the network what you want it to accomplish, not exactly what to do. With the Juniper Networks NorthStar Controller, service providers can install network paths based on provided constraints such as bandwidth, diversity, and inter-virtual network policies. Autonomous networks will operate based on hints and suggestions rather than constraints. Services will self-assemble to form a cohesive customer experience, and the network will make decisions based on knowledge of the most valued customers, application priorities, or peering costs. Your car should be able to read your calendar and know where to go, including figuring out the best route. Juniper is building intent-based systems into our Contrail Policy Framework and Security Policy Enforcer.
- **Decision making**: Today's rules-based systems involve simple programming (for instance, if X happens, then do Y) that, although giving the impression you are in control, is actually quite cumbersome. Machine learning, on the other hand, is creative—you don't necessarily know how it's going to learn. Machine learning will help us move from static programming of the network to algorithms that learn from data inputs, make predictions, and take appropriate actions. The more data fed into training algorithms, the smarter the networks will become.
- **Local views and global views**: Network management and control are becoming more centralized as part of software-defined networking (SDN). While local awareness will remain essential, increased global awareness will usher in the Self-Driving Network featuring root cause analysis via supervised learning; time-based trending to establish and adapt baselines; correlation of information across geographies, layers, and peers; and optimal local decisions based on global state.

Significant barriers do exist to developing fully autonomous networks, but they should motivate us, not deter us. Juniper is helping industry participants experiment with, and learn about, these tools and technologies through our OpenLab locations and a variety of hackathons and throw downs.

Augmented Intelligence, Not Artificial Intelligence

It is important to take a step back and think about the larger societal ramifications of technological progress while we are still in the early stages of development. As discussed in Part 1 of this white paper series, with self-driving cars, DARPA probably was not thinking beyond technology with its first few challenges. Fortunately, with the Self-Driving Network, the associated sociological and industry ecosystem issues do not appear to be quite as wide-ranging, powerful, and threatening. But they do exist, and primarily in the form of networking employment.

While the philosophical debate about whether automation will cause massive unemployment has brewed for decades, it has heated up recently as computerization creeps into virtually every industry. A study by Carl Benedikt Frey and Michael A. Osborne in 2013 concluded that "about 47 percent of total U.S. employment is at risk."

In 2003, MIT Economist David Autor first categorized labor based on two dimensions: routine vs. non-routine and cognitive vs. non-cognitive. This division continues to be a helpful framework for understanding the future of labor.

- Routine/manual positions often exist in construction, transportation, production, and repair.
- Routine/cognitive usually involves structured work, but can include highly skilled positions such as accountants and radiologists.
- Non-routine/manual includes occupations that require non-repetitive dexterity (such as hair stylists and caregivers).
- Non-routine/cognitive includes management and professional occupations requiring analytical thinking, creativity, and relationship skills.

The trends are clear: technology is placing enormous pressure on "routine" jobs, both "manual" and "cognitive." The future of network operations employment should be viewed through this same lens. Routine tasks involving configuration, monitoring, and reporting will be increasingly automated, while less routine, more cognitive tasks will continue to require humans, at least for the foreseeable future. Juniper views this positively, as it frees up workers from mundane activities so that they can focus on higher level, strategic initiatives such as conceiving and developing new services.

Skills transformation in the networking industry is already underway. SDN, which has exposed the physical infrastructure to be programmed through APIs, has been a wake-up call to network engineers and system administrators who have not previously needed programming skills to perform their jobs. The need to speed up the creation and deployment of services has created the DevOps movement, which is the confluence of roles and responsibilities among network operations, IT, and software development.

The forward-looking network operators understand that to fully realize the benefits of virtualization and software-defined infrastructure, they must transform their organizations as well as their network architecture. This means taking the offensive with their human resource strategies. Incumbents must not only re-engineer operational and service delivery processes, but also update their organizational and individual skill sets. Over time, network know-how will slowly move from relatively static operations to programming. Ultimately, in a self-driving world, the network experts will provide oversight and algorithmic tweaking. Eventually, everyone in the network organization will be as good as the best person in the industry. Some will shift to service design roles as the network essentially "gets out of the way."

Too many people in our industry are fearful of automation and the "robots taking our jobs." Elon Musk has warned that "with artificial intelligence, we're summoning the demon," but we view the future much more optimistically. In the past, technology has always ended up creating more jobs than it destroys. While many speak of artificial intelligence, we prefer to think in terms of augmented intelligence.

Innovation requires resources. How can we continue to innovate if most of our IT and networking resources are devoted to just keeping the lights on? To free up capacity to innovate, service providers must replace old work with new work. Yes, some jobs will disappear, but many others will evolve, and new jobs will be created. Automation reduces costs and improves service; overall customer demand, and therefore revenue opportunities, will increase. When networks are better defended from threats; when networks are more reliable and resilient, more adaptive and responsive, and easier to manage; then the network becomes an even bigger part of everyone's lives. And the industry wins.

Conclusion: A Vision to Pursue the Self-Driving Network

Network complexity is increasing exponentially as traffic levels continue to grow and new devices proliferate. This manifests itself as rising operational costs and slower time to revenue, squeezing margins for traditional service providers. Abstracting, simplifying, and obscuring this complexity are major challenges for the industry going forward. While the industry has been making modest, incremental progress in the areas of automation and virtualization, Juniper is not content: we want disruptive innovation. Automation is a great first step, but we need much more. Service providers are telling us that the economics of the network is unsustainable, yet we all know that we cannot live without it.

We need a compelling vision in networking, one really worth pursuing. Current thought reflects the networking industry's fear of bold ideas. Incremental changes are fine, but the future can be more rewarding and exciting depending on the work we all do to get there. A world in which technology further disappears into the fabric of our lives makes us more productive, healthier, and freer to do more of what makes each of us happy. We need to stop being so fearful and reticent: we need to build the Self-Driving Network.

About Juniper Networks

Juniper Networks challenges the status quo with products, solutions and services that transform the economics of networking. Our team co-innovates with customers and partners to deliver automated, scalable and secure networks with agility, performance and value. Additional information can be found at Juniper Networks or connect with Juniper on Twitter and Facebook.

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