The Self-Driving Network

Part 1: A Bolder Vision for the Industry

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Executive Summary

The development of self-driving cars is a case study in industry innovation and disruption that has implications well beyond the automobile. This white paper, the first in a two-part series titled *The Self-Driving Network*, introduces Juniper's vision for the future of autonomous networking. By tracing the history of innovation in the automobile industry—specifically, and more recently, the self-driving car—it is possible to envision how the Self-Driving Network™ will evolve. It is important 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. The second part of this white paper series articulates the benefits of the Self-Driving Network, the technology progression from automation to autonomy, and the organizational and skills transformation required.

Introduction: A Vision for the Network of the Future

As an industry, networking has been far too timid. While technologies such as software-defined networking (SDN) and Network Functions Virtualization (NFV) are critical elements of the network and have served the industry well for the last five years, they have crowded out other important thinking and development. What's needed is a sharper and more complete vision. For instance, what if we could apply recent advances in artificial intelligence technologies to build a vastly improved network? Specifically, what if the concept of self-driving cars could be applied to networking? After all, self-driving cars are making considerable progress, operating autonomously on roadways from Silicon Valley to Pittsburgh and Miami. Sure, they have humans behind the wheel just in case, but they are out there on the road today.

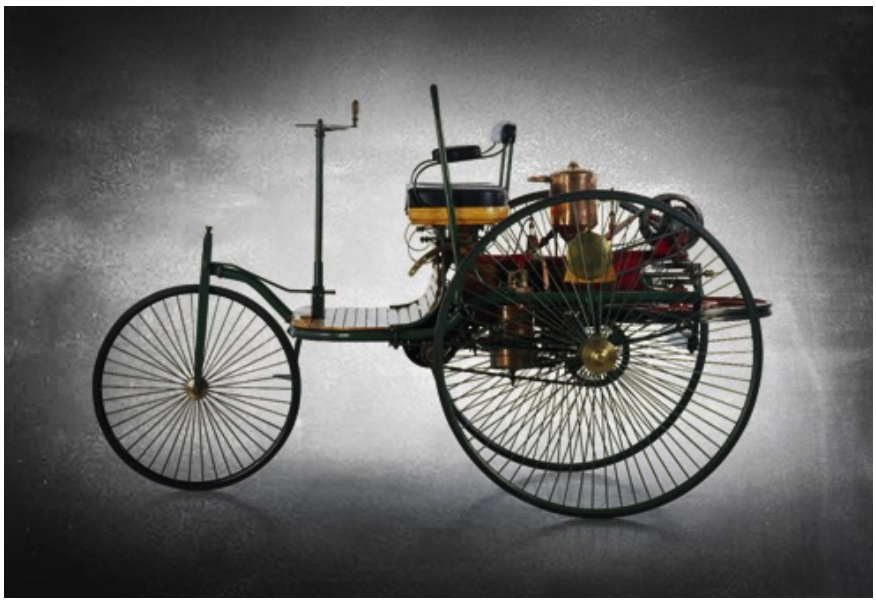
Similar machine learning technologies are permeating countless other industries, from medical diagnostics and legal discovery to financial asset trading. Yet we don't hear anything about self-driving networks that can configure, monitor, and maintain themselves, adapting to their operating environments with little or no human intervention.

Juniper Networks is aiming to change that. Just as self-driving cars free drivers up to work, read, or even sleep during their commutes, Juniper's Self-Driving Network™ will liberate operators from the tedium of day-to-day management, allowing them to apply their limited resources to higher value activities.

Rather than merely jumping on the machine learning hype train, however, Juniper intends to disrupt the industry by helping customers build autonomous networks. The journey will be long and potentially tumultuous; while some fledgling automation tools do currently exist, they are not yet being used to their full potential, and many of the necessary artificial intelligence technologies have yet to be developed. The transformation will impose cultural shifts and require significant technological breakthroughs. But sometimes, upheaval is necessary. Juniper is not satisfied with the incremental improvements the networking industry has been making year after year. What's needed is truly disruptive innovation.

A Brief History of the Car

To help us better understand the concept of the Self-Driving Network, it is instructive to first trace the evolution of the automobile. The modern car has been around for 130 years; the first "production" gasoline powered automobiles were developed by Karl Benz in the 1880s (see Figure 1).



Source: www.mercedes.com

Figure 1: Benz Patent-Motorwagen (circa 1886)

In the decades that followed, cars continued to evolve, although they were highly manual machines compared to what we drive today. Over time, however, more and more automation was gradually introduced. Up until recently, these enhancements were mere conveniences, making driving easier and safer for more people, in more situations (Figure 2).

- Manual starting with a crank -> Electronic starter (1920s)
- Manual transmission -> Automatic transmission (1939)
- Manual control of the engine -> Cruise control (1950s) -> Adaptive cruise control (1997)
- Manual steering -> power steering (1951) -> Active steering (2003)
- Manual braking -> Anti-lock braking, ABS (1970)
- Manual parking -> Autonomous parking (2003)

Source: Wikipedia

Figure 2: Incremental evolution of automobile automation

In many cases, when these automated enhancements were introduced, they were actually lower performance than the manual version. It typically took a few design iterations to not only make the feature simpler and more convenient, but also superior in terms of overall performance. Eventually, drivers became more comfortable and adept with the new features. Interestingly, Juniper observes similar design/user dynamics with respect to network automation tools.

While these innovations made driving easier, safer, and more convenient, they were all incremental. There is nothing radical here; none of these new features resulted in dramatic improvements by themselves, or even taken in the aggregate.

By way of contrast, the self-driving car phenomenon is not only truly disruptive, it is also very recent and evolving rapidly. No steering wheel, no pedals; the driver essentially becomes a passenger. We are now extremely close to what science fiction movies have been predicting for decades.

Revolutionary Impact of the Self-Driving Car

The origin of the self-driving car can be traced back to the DARPA Grand Challenge, a competition established in 2004 to spur the development of autonomous vehicles. The first event took place in the Mojave Desert in Southern California, along a 150-mile route. None of the vehicles finished the course; in fact, the winning vehicle traveled only seven miles. The next year, on a similar course, five teams completed the entire trip. At the third challenge, which took place in 2007 on a much tougher urban course, six teams finished. These results demonstrate substantial progress in a very short amount of time, particularly compared to the pace of innovation and automation in vehicles over the previous 100 years.

The self-driving car is not just another step in a long line of incremental industrial improvements, it is truly revolutionary. It will spawn dramatic changes not only to the automobile value chain, but also to the larger industry ecosystem. While we have visibility into some of these changes, other changes are less clear and many questions remain, among them:

- Transport-as-a-Service: As services such as Uber become more reliable, are rental cars really needed? Do we even need to own cars? What do we do with parking lots?
- Legal/insurance: Which parties need insurance? Where does liability lie? Who do the ambulance chasers chase?
- Law enforcement: Do you need as much highway patrol if you can monitor and manage traffic remotely and centrally?
- Design for ethics: Does your car swerve right with a 17% chance of hitting a pedestrian, or swerve left and potentially injure you?
- Professional drivers: Does this occupation essentially disappear?

Stephen Hawking has warned that "the development of full artificial intelligence could spell the end of the human race." Yes, there are unknown consequences and winners and losers, but surely the benefits of self-driving cars will outweigh the negatives. Traffic flow will be optimized and congestion alleviated. Highway capacity could nearly triple according to a study by Columbia University. Commutes will no longer be something to dread. Employment will shift in some areas, as new programmers, developers, and other support functions are required. Finally, and perhaps most importantly, automobile deaths should plummet. Currently, 1.3 million people worldwide die in car accidents every year. Machines can probably do a better job, since there will no longer be any drunk, tired, and/or distracted drivers on the road.

Why Are We Not There with Networks?

Why is Juniper thinking so much about the evolution of self-driving cars? This evolution provides critical insights into the journey required to realize fully autonomous networks, as well as the obstacles the industry may encounter along the way. We must be cognizant of and prepared for the far-reaching effects of the technological disruption, in addition to the broader impacts of the Self-Driving Network as we build them with our customers. But we cannot be afraid of progress or timid about disrupting the industry.

Unfortunately, while we are almost there with cars, it feels like we have a long way to go with networks. So we must look at the forces that influence progress, and how and why industries transform. Juniper views the path to the Self-Driving Network through three lenses: economics, technology, and society.

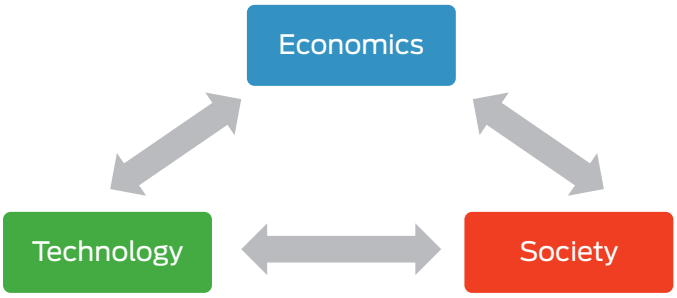


Figure 3: Influences on industry disruption and self-driving networks

Analyzing the evolution of the automobile and the development of the self-driving car through these three lenses reveals both similarities to and differences in the way autonomous networks may evolve. Let's look at the forces behind the self-driving car.

Economics

The typically powerful force of economics is surprisingly muted with respect to self-driving cars. Auto manufacturing is a tough business; it suffers from chronic over capacity, and self-driving cars do not solve this problem. It is not readily apparent that cars "need" to be automated. Quality has been improving for decades, while prices continue to drop.

However, looking at it from a different value chain perspective, there is an economic motivation behind Google's pioneering work in self-driving car development. If they can relieve everyone from an hour of commuting every day, that's more time people can spend on the Internet, which ultimately generates revenue for Google.

But the more compelling economic benefits lie with companies such as Uber. With Uber, drivers receive approximately 75% of each fare. For most companies, the idea of reducing cost of goods sold (COGS) by 75% is nothing more than a fairy tale. But this is a potential reality for Uber and others. As a result, we have seen increasing autonomous vehicle activity with these companies recently, and this activity is expected to continue.

In the end, powerful incentives to reduce costs, increase safety, and improve overall performance will influence how other transportation and logistics companies approach self-driving vehicles.

Technology

Technology has been the most powerful force influencing the development of self-driving cars. Since an economic imperative to produce self-driving cars did not appear to exist within the auto industry, it took an outsider like Google to spur the disruption. Google's founding mission is essentially to monetize big data; the Google self-driving car is just another project that is a part of this mission. Interestingly, the autonomous vehicle emerged out of the confluence of three other unrelated technology megatrends—cloud computing, mobile networks, and big data analytics.

Society

Industry outsiders have harnessed a few massive technological developments to make the fully autonomous vehicle a (near) reality. In an article titled "The Massive Economic Benefits of Self-Driving Cars," Forbes estimates the societal benefits of self-driving cars could be $642 billion per year in the U.S. alone based on "extremely conservative back of the envelope calculations" for lives, injuries, and time saved. However, a variety of social and psychological factors, combined with an overall fear of the unknown, may pump the brakes on the wide-scale rollout and adoption of self-driving cars in the coming years.

Conclusion—Self-Driving Cars Without the Self-Driving Network

It is ironic that self-driving cars are not possible without robust networks:

- Networks are required within cars to connect local telemetry to local intelligence and control.
- Networks are required between cars on the road for safety and amplified intelligence, which comes with the interconnectedness.
- The macro network to the cloud is required for centralized intelligence, analytics, management, and control.

In other words, the self-driving cars operating today are completely dependent on networks, yet the networks on which they run are largely manually configured and managed. In *The Self-Driving Network Part II: Appetite for Disruption*, we will explore why we believe this situation will soon change.

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.

Corporate and Sales Headquarters
Juniper Networks, Inc.
1133 Innovation Way
Sunnyvale, CA 94089 USA
Phone: 888.JUNIPER (888.586.4737)
or +1.408.745.2000
Fax: +1.408.745.2100
www.juniper.net

APAC and EMEA Headquarters
Juniper Networks International B.V.
Boeing Avenue 240
1119 PZ Schiphol-Rijk
Amsterdam, The Netherlands
Phone: +31.0.207.125.700
Fax: +31.0.207.125.701

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