

WHITE PAPER

Introducing the Adaptive Network Vision

Why now?

The networking industry is being disrupted.

There is an explosion in network demand, driven by ultra-mobile users who want the ability to access the cloud and consume high-definition content, video, and applications when and where they choose. This disruption of the network will only be exacerbated by the adoption of the Internet of Things (IoT) and 5G, the use of which involves billions of devices interacting with machines, users, and clouds to drive consumer and business interactions.

For instance, what happens when users want to engage in a 4K-based virtual reality session hosted in the cloud, while traveling at high speed in their driverless cars? What happens when the physical devices currently used to support networking functions become virtual—and so do the user end-points? Network providers are now realizing the level of complexity and variability this type of demand will introduce, and that their current networks are not up to the challenge.

Why? Today's networks are full of legacy systems and protocols, leaving them unable to rapidly scale or adjust. Manual processes are often still required to set up, revise, and tear down even the simplest services. Today's networks are not designed to adjust to these growing and unpredictable demands. When the birth of an overnight sensation can go viral and disrupt the network, how can providers adapt?

In the background is a set of challenging market dynamics. Although everyone wants more from their network providers,

they are not necessarily willing to pay more. This is driving the need for providers to continually lower their cost structures, reduce their operating expenses, accelerate time to revenue (to quickly respond to changing market conditions), and launch and retire new services at unprecedented speeds. In short, providers need their networks to help them achieve better business outcomes in a new world of over-the-top competition and demanding, connected users.

The Adaptive Network vision

To address these challenges, network providers have been looking at a number of technologies to create better cost structures and agility in their networks. Over the last few years, serious exploration and trials around open software, systems, and platforms, the use of APIs, multi-vendor management, analytics, artificial intelligence, and service automation have been critical in helping to understand what is needed to evolve networks.

Why Adaptive Is the Biggest Story
in Networking
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There is universal agreement that whatever technologies are at play, the industry needs a more responsive, automated, and agile self-optimizing network. Network providers believe automation is critical, but maintaining 'control' over their

networks to ensure great customer experiences takes priority. No one vendor can deliver best-in-breed hardware, software, services, and virtual instances for every application. As a result, providers are looking for network technologies that are open, secure, and intelligent. A premium is placed on openness, APIs, and multi-vendor, multi-domain interactions.

Some believe an autonomous network could be the answer. Ciena has a different vision, one that takes the importance of autonomous networking into account, but looks beyond automation to **ensure networks can adapt to change, not just be automated in a reaction to change.**

The Adaptive Network is Ciena’s vision of a new target end-state for network providers. The Adaptive Network utilizes automation, guided by analytics and intent-based policies, to rapidly scale, self-configure, and self-optimize by constantly assessing network pressures and demands.

The Adaptive Network is built on three key foundational elements:

- 1. Analytics and Intelligence:** Collecting network performance data, and analyzing this data using machine learning, provides the ability to more accurately predict potential network problems and anticipate trends by turning mountains of data into actionable insights. Leveraging these insights can help network providers develop smarter, data-driven business policies that enable them to adapt to customer needs securely, and in real time.
- 2. Software Control and Automation:** Multi-Domain Service Orchestration (MDSO) and centralized, software-defined control of individual domains form the basis of adaptive networking. Through the implementation of SDN, NFV, and open APIs, network providers can simplify the end-to-end management and automation of network services across multi-vendor, hybrid networks.
- 3. Programmable Infrastructure:** A programmable packet and optical infrastructure is one that can be accessed and configured via common open interfaces, is highly instrumented, with the ability to export real-time network performance data, and can adjust its resources as needed to meet the demands of the applications running on top of it.

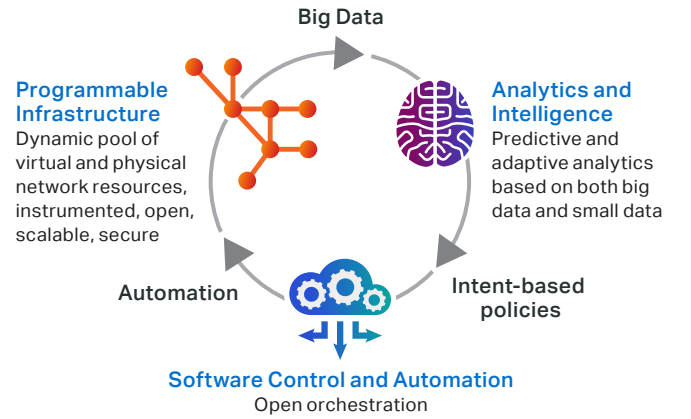


Figure 1. Foundational elements of the Adaptive Network

Realizing the vision

Over our 25-year history, Ciena has worked with over 1,300 customers worldwide—including 80 percent of the world’s largest service providers—as well as Fortune 2000 enterprises, Internet content providers, governments, and other private network providers to build some of the largest networks in the world. By playing a strategic role in our customers’ network strategies, we have developed an understanding of our customers’ needs that is unmatched in the industry. We have harnessed this knowledge and experience to articulate our Adaptive Network vision.

To help our customers begin to understand how this vision can be operationalized within their network environments, Ciena has developed the Adaptive Network Framework (Figure 2). This Framework outlines the key functionality required within each of the foundational elements of the Adaptive Network: Analytics and Intelligence, Software Control and Automation, and Programmable Infrastructure.

Business Operations		
Analytics & Intelligence	Machine Learning & Analytic Apps	
	Big Data Collection & Processing	
Control & Automation	Intent-based Policy	
	SDN Domain Control	Multi-domain Multi-vendor Orchestration
Programmable Infrastructure	Multi-vendor Network Elements & Servers	
	Virtual Network Functions	

Figure 2. Ciena’s Adaptive Network framework

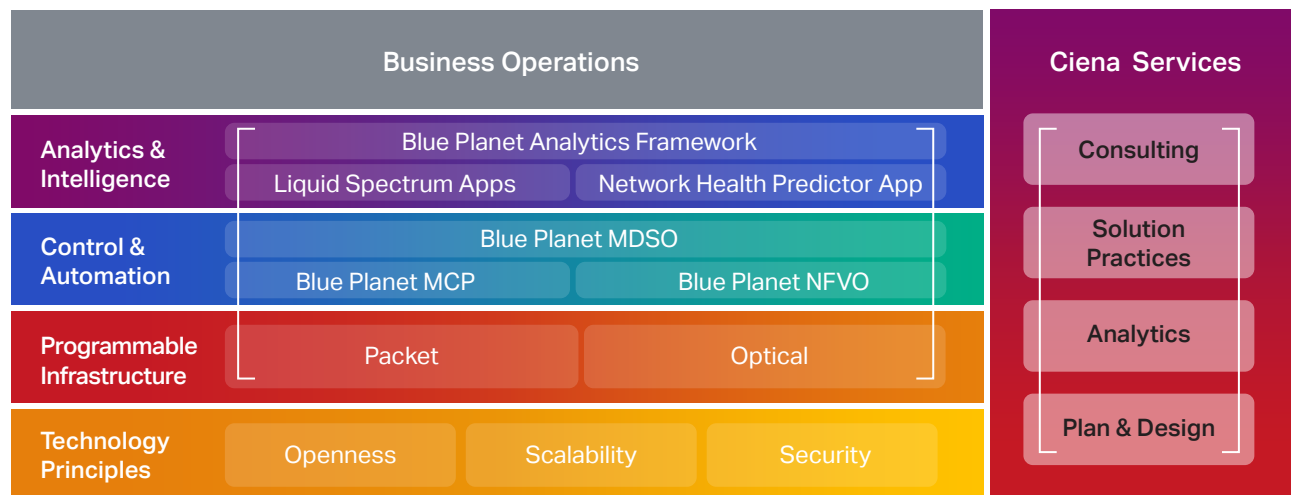


Figure 3. Ciena's products and services enabling the Adaptive Network vision

Realizing the complete functionality of this framework will take time; it will be an evolution of the providers' current network environment. And getting there will be a journey. Each provider will have a different starting point, depending upon their current network infrastructure, market dynamics, and business objectives. Ciena is uniquely positioned to help customers make this journey successful, offering a broad portfolio of products and services uniquely designed to meet the requirements of the Adaptive Network. Figure 3 maps the key products and services within Ciena's portfolio that are critical to enabling the Adaptive Network vision.

The following sections of this paper explain the importance of each of the three foundational elements of the Adaptive Network, and how Ciena has invested in its portfolio to provide solutions that can help customers make this vision a reality.

Analytics and Intelligence

As providers face an explosion of data and demand across their networks, the implications may seem complex. But these challenges also have their benefits, as they grant providers access to a growing wealth of information that, if harnessed effectively, can help them make better decisions to optimize their network performance and deliver a better customer experience. Having easy access to all the information needed to accurately plan and optimize network resources can help providers meet both current and future demand, enabling them to anticipate potential network and service disruptions before they even happen, and even allow them to dynamically adjust network bandwidth requirements based on their customers' needs. These may seem like impossible tasks, but as networks

evolve, such data-driven decision-making will become the table stakes of network providers' survival.

Ciena has developed the Blue Planet® Analytics framework to make possible what previously may have seemed impossible. As providers evolve toward a more adaptive and responsive network, this framework allows providers to leverage powerful analytics and machine learning innovations to mine deep insights from their networks and sharpen their competitive edge.

The following outlines Ciena's portfolio of analytic capabilities, from which we'll continue to build future capabilities:

- **Blue Planet Analytics framework** – an integrated framework for network analytics and machine learning
- **Network Health Predictor application** – an analytics application that enables proactive network assurance in multi-vendor networks by predicting network element failures before they occur
- **Liquid Spectrum™ Performance Meter software applications** – integrated with Blue Planet Manage, Control and Plan (MCP), these provide real-time visibility into network performance, eliminate several lengthy manual processes existing in optical networks today, and allow for proactive system optimization. Liquid Spectrum apps available today include:

Channel Margin Gauge function – gives providers instant visibility into the efficiency of their networks and lets them know if they can run their deployed optics at higher capacities

Planning Tool Calibrator function – accesses real-time fiber characterization data, which then feeds into planning tools to ensure optimal network designs, without all the manual-link engineering and spreadsheet-checking processes currently in use today

Software Control and Automation

The operations environment for network providers is growing increasingly complex. While advancements like Network Functions Virtualization (NFV) and Software-Defined Networking (SDN) enable on-demand services, existing network management and Operational Support Systems (OSSs) lack the scale and flexibility to meet the requirements of these more dynamic network technologies. Simple automation techniques like custom scripting are often used to reduce repetitive manual tasks, but providers must look for more robust automation capabilities to reduce operational complexity and improve efficiency, at scale. To address these requirements, Ciena acquired Cyan in 2015, a leader in multi-vendor control and orchestration. Following the Cyan acquisition, Ciena has continued to invest heavily in these assets, developing an industry-leading automation portfolio. And we have taken automation one step further. By integrating our automation capabilities with Blue Planet Analytics, Ciena enables providers to achieve what we call Intelligent Automation, allowing network providers' businesses to run smarter and much more efficiently.

Deployed at more than 20 of the world's largest network providers, Ciena's automation solutions are field-proven to help customers evolve to a more adaptive network.

The following provides an overview of Ciena's award-winning Blue Planet control and automation portfolio:

- **Blue Planet MDSO** – simplifies the end-to-end management and automation of network services across physical and virtual networks
- **Blue Planet NFV Orchestration (NFVO)** – automates the delivery and lifecycle management of NFV-based network services
- **Blue Planet Manage, Control and Plan (MCP)** – a domain controller for automating the complete service delivery lifecycle across Ciena packet-optical networks

Programmable Infrastructure

Automation and analytics are critical to a more adaptive network, but without the right infrastructure, these capabilities alone will not drive the intended business results. Achieving the level of scale and network responsiveness needed in the Adaptive Network requires a highly programmable infrastructure that can both provide advanced network telemetry and tune to meet changing capacity needs. This is a key differentiator for Ciena, as we continue to lead the market in programmable infrastructure innovation.

Ciena's packet and optical platforms offer the most advanced instrumentation in the industry, providing critical link and network signal performance data, and exposing this information through open APIs to the Blue Planet Analytics framework or any other third-party analytics applications. This allows providers to drive better business decisions based on real-time network insight. Ciena was also the first to deliver a coherent modem that can tune capacity from 100G to 400G in 50G increments, allowing network providers to better match capacity to system margin. And it was Ciena that introduced the market to the concept of Liquid Spectrum. Ciena's Liquid Spectrum apps combine highly instrumented, programmable hardware with advanced software applications to help network providers fundamentally change the way optical networks are designed, built, and managed. These are just some of the innovations Ciena has brought to market to deliver the responsiveness network providers need to evolve to a more adaptive network.

The following provides an overview of Ciena's platforms that are essential to achieving a more programmable infrastructure as part of the Adaptive Network strategy:

- **WaveLogic Ai coherent optics** – enables tunable capacity—from 100G to 400G—in 50G increments
- **WaveLogic Photonics** – a reconfigurable, flexible grid photonic layer that enables dynamic rerouting of wavelengths across the network
- **6500 and Waveserver® platforms** – feature open APIs and modern data models, such as REST and gRPC, for real-time network telemetry and measurement, as well as provisioning at scale
- **Packet Networking products** – provide a broad set of open, purpose-built platforms, the performance of which is

enhanced through end-to-end control and planning using Blue Planet MCP and, in a multi-vendor environment, Blue Planet MDSO. Furthermore, extensive performance metrics allow providers to ensure ongoing optimal network performance (such as latency, QoS, Bit Error-Rate, and loopbacks)

Technology principles that underpin an adaptive network

Evolving toward an adaptive network should not be undertaken without a full understanding of the technology principles that underpin this type of network evolution. Vendors need to prove they are committed to ensuring the operation and customer experience of the Adaptive Network by providing solutions based on openness, security, and scalability.

Openness is critical in the Adaptive Network to allow network providers choices in the products and technologies they can deploy to enable their network evolution. Providers that embrace openness will be able to select the technology solutions that best meet their needs in terms of operational fit, performance, power consumption, and telemetry, resulting in dramatically lower costs, increased agility, simpler scalability, and a network architecture that is highly flexible, to take advantage of future innovations that may not be apparent today.

Ciena's vision of the Adaptive Network is underpinned by its OPn® philosophy to offer customers the greatest degree of choice in how they evolve and execute their network strategies. This philosophy was introduced over five years ago and has defined how the company approaches product development. As a result, through important design principles such as modularity and open APIs for programmability, Ciena can now address the broadest range of openness and consumption models in the market. For example, we have delivered open interfaces that make packet-optical WANs more programmable and interoperable, including open APIs and open line system capabilities.

Ciena offers open tools and environments, like its Emulation Cloud™ and Blue Planet DevOps Toolkit, to enable its customers to add, design, and model services and simplify operations. And Ciena facilitates and participates in an open ecosystem across the industry—among both large and small vendors—to mix and match best-of-breed technology for any given customer architecture.

Security is paramount in the Adaptive Network to ensure it can remain responsive, flexible, and adaptive to changing market

dynamics. Network providers must consider the following security requirements as they evolve their networks:

- Ability to secure and protect the exponential growth in data traffic over the network
- Increased levels of automation and fewer manual processes require greater security measures to detect and mitigate security breaches
- More open, best-of-breed environments must be governed by security protocols to ensure the protection of data across heterogeneous networks

Ciena can help network providers mitigate data security risks through a set of capabilities designed to ensure the confidentiality, integrity, and availability of data in the network. The company provides a highly secure, programmable infrastructure that ensures continuous protection of all in-flight data from unauthorized entities by combining always-on, high-capacity, wire-speed optical encryption with user authentication and intrusion-detection forensics. In addition, Blue Planet MDSO supports fast, seamless deployment of multi-vendor security Virtual Network Functions (VNFs), enabling providers to distribute and manage virtual security network appliances (such as firewalls, IDPS, and proxy services) as needed, ensuring consistent security levels across the network. Blue Planet also provides sophisticated tools for managing network performance, orchestrating data flows, and analyzing network trends, helping network providers identify and react to potential cybersecurity attacks faster to minimize the impact of a security breach. These security capabilities are underpinned by Ciena's commitment to securing its own business by protecting its information assets and those of its partners, and delivering solutions with confidence in the security processes and controls that go into every design, deployment, and operation of a Ciena-enabled network.

Scalability in the Adaptive Network is required, as mobile device proliferation, streaming video, cloud computing, IoT, and the evolution to 5G will all put massive pressure on network capacity. Meeting the demand will require network capacity increases in orders of magnitude, as well as the need to respond to unpredictability in traffic patterns. The Adaptive Network must scale from both capacity and operational perspectives—transporting maximum capacity using minimal equipment to get the most efficiency from fiber assets, and using software-based control to offer the ability to automate

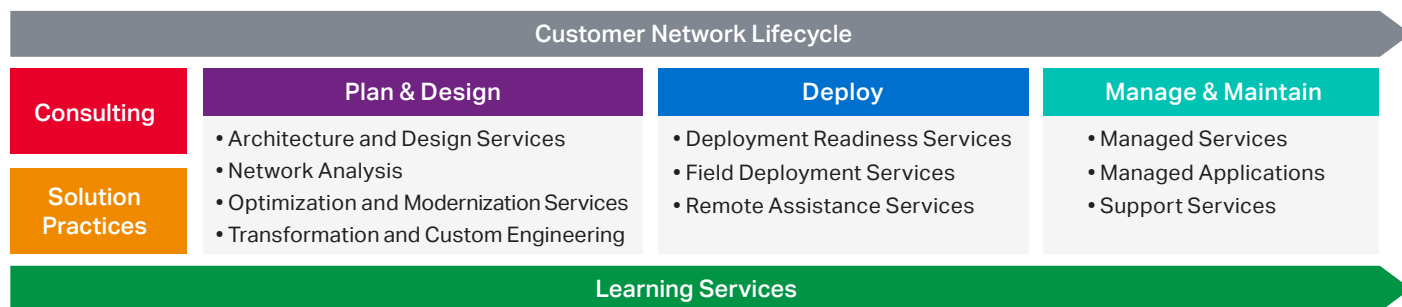


Figure 4. Ciena Services

processes and adjust bandwidth in real time to meet changing customer and traffic requirements.

Ciena has designed its portfolio to meet the scalability required by the Adaptive Network. Ciena's industry-leading, programmable WaveLogic coherent optics allow providers to maximize capacity over existing fiber investments using minimal hardware, and operate alongside a flexible, reconfigurable WaveLogic Photonics layer to flexibly adjust traffic paths as needed. In addition to a highly scalable programmable infrastructure, Ciena's Blue Planet software leverages a modular, micro services-based architecture to help network providers achieve software control and automation with greater scale, agility, and performance.

Navigating the journey

Although technology plays a critical role in any network evolution, network providers also need to partner with vendors who have the know-how and experience to help them traverse this complex journey. A strong professional services partner with the right expertise can foresee challenges and mitigate risks. Ciena Services are designed to do just that. Whether a network provider is taking an initial first leap or planning a larger-scale transformation to realize the Adaptive Network vision, Ciena Services has the insight and proven experience to ensure the journey is successful. Although Ciena provides a complete portfolio of services (Figure 4) extending across the network lifecycle, from business consulting to network planning and design, deployment, learning, and support, the following are the most valuable in the evolution to the Adaptive Network:

- **Consulting Services** – provide customers with customized solutions for their network operations, engineering, and business challenges in moving to the Adaptive Network

- **Blue Planet Solution Practices** – automation-focused, dedicated to helping customers transform their networks to meet specific business objectives. Solution Practices include:

Network Automation Practice – helps network providers accelerate the adoption of automation in their networks to improve capital and operational efficiency

Network Intelligence Practice – helps network providers leverage network analytics and machine learning to more proactively plan, strategize, and better execute on their business goals

Service Monetization Practice – helps network providers evolve their service portfolio to support digital transformation and revenue growth

OSS/IT Modernization Practice – helps network providers modernize their OSS/IT environment to improve operational agility

- **Analytics Services** – A set of proactive services including Network Health, Topology Discovery, and Alarm Correlation, provided as cloud-based services to identify issues in the network before they occur

- **Plan & Design Services**

Architecture and Design Services – end-to-end network architectural and design support for customers moving to new networks

Reconfiguration and Migration Services – deliver a customized set of procedures to reconfigure a live network that can be used to migrate from legacy to new technologies, evolve traffic patterns, or perform node insertions

Network Transformation Services – consultative engagement involving data analysis and business modeling, leading to network optimization and migration to next-generation infrastructure

Custom Solution Engineering – customized solutions and tools to address specific network needs including data extraction, portals, and diagnostics

Navigating Today's Network Evolution.
Does the Journey Have a New Destination?
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Conclusion

Users' ever-increasing expectations—and the technology breakthroughs that continue to feed them—have created an unprecedented level of pressure and complexity for today's network providers. Some strategic approaches suggest that complexity is the enemy, and that a fully automated network is the answer. Ciena takes a broader view. We believe a network, just like the humans who invented it, must grow smarter, more agile, and more responsive every day. We believe network providers must strive to achieve a more adaptive network.

Ciena's Adaptive Network vision has actually been more than five years in the making, starting with OPⁿ and the introduction of WaveLogic 3 programmable coherent optics in 2012,

followed by our WaveLogic Photonics reconfigurable photonic layer in 2014, then the introduction of WaveLogic Ai in 2016. These were followed by a series of key launches in 2017, including Blue Planet MCP, Blue Planet Analytics, Waveserver Ai, and Liquid Spectrum. In 2018, we have continued our focus on the Adaptive Network with the introduction of the Blue Planet Solution Practices, our Intelligent Automation platform, with more to come. This track record of innovation demonstrates Ciena's commitment to helping our customers achieve greater automation, intelligence, and programmability in their networks. We will continue to invest in and evolve our portfolio to deliver on the promise of the Adaptive Network.

We are committed to our customers' success in realizing the Adaptive Network vision. Not only will we stay with our customers on this journey through a constantly changing environment, we will do so with the most open, secure, and scalable architecture in the industry. Because survival of the fittest means survival of the most adaptive.

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