THE BUSINESS CASE FOR ADAPTIVE IP

SUMMARY

The original internet was a best-effort IP network, and service was nice to have but not essential. Today, the internet is an essential service for businesses and consumers, but most traffic is still best effort. As 5G networks and services emerge, reliable quality of experience (QoE) and quality of service (QoS) become essential components of IP networks. How can service providers build next-generation IP networks that support growing traffic, diverse devices and services and provide high availability with guaranteed QoS while also decreasing capital expenses (CapEx) and operational expenses (OpEx) to allow for profitable business models? Next-generation IP networks need:

- Software control and automation
- Analytics and intelligence
- Programmable infrastructure

Ciena's Adaptive IP is an example of a next-generation network architecture providing QoS for existing and emerging services while also implementing traffic engineering to optimize network topologies and minimize capacity requirements. Adaptive IP also provides the necessary automation to reduce network OpEx in:

- Engineering and planning
- Service fulfilment
- Service assurance

By optimizing network traffic engineering, implementing strict QoS, and intelligently automating network operations, Adaptive IP provides a next-generation network for emerging services while reducing network total cost of ownership (TCO). ACG has built a TCO model that shows a CapEx reduction of 23%, OpEx decrease of 32%, and a TCO savings of 26%. Adaptive IP provides an agile network to enable fast rollout of new services, which will increase revenue and make network service providers more competitive. Adaptive IP allows service providers to build a next-generation network, from access to metro, while reducing TCO and increasing service velocity and revenue.

Report Highlights

- Next-generation IP networks need to be highly scalable, support strict QoS, and have a high level of availability
- Adaptive IP Solution provides automation and optimization that meets next-generation IP network requirements while reducing TCO
- Adaptive IP CapEx savings up to 23%
- Adaptive IP OpEx savings up to 32%
- Adaptive IP TCO savings up to 26%

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REQUIREMENTS FOR THE NEW IP NETWORK

The demand, scalability, and performance requirements of IP networks from access to metro are increasing at a rapid scale. These requirements are primarily driven by three major industry trends:

- Numbers of devices, diversity of devices, traffic growth, and stringent performance requirements for new services and applications
- The emergence of virtual radio access network (vRAN) and Open RAN (O-RAN) architectures and 5G densification
- The emergence of edge computing

IP traffic and network capacity are continuing to grow quickly and will accelerate with the rollout of 5G services. The number and diversity of IP devices is also increasing significantly. Examples of diverse device types are smartphones, TVs, IoT devices, AR/VR headsets, robots, drones, connected vehicles, and other devices. New device types are also associated with new services that have a diverse set of performance requirements. Some applications require extremely low latency (for example, connected cars), others require high sustained bandwidth (AR-VR), and other applications require only best-effort performance. As a result, the importance of QoS, QoE, and customers' service level agreements (SLA) will continue to grow. The days of best-effort internet service are over.

The emergence of virtual RAN, Open RAN, and 5G densification represents a major network architecture change. In vRAN and O-RAN networks the baseband unit can be centralized or distributed, which drives the requirements for fronthaul, midhaul, and backhaul. In addition to vRAN and O-RAN, there is also a need for 5G densification, which means building out many more cell sites. Densification in combination with 5G fronthaul, midhaul, and backhaul requirements, creates a new and challenging set of requirements for IP networks.

Another driver of IP requirements is the emergence of edge computing. Network operators and enterprises are starting to deploy edge computing nodes for the purpose of:

- Reducing network latency for improved application performance
- Reducing traffic loads in the aggregation and core networks
- Improving security

The deployment of edge computing results in changing network traffic patterns. In legacy networks virtually all network traffic was backhauled to regional data centers where traffic is processed by broadband network gateways or mobile packet core nodes. With the emergence of edge computing and control and user plane separation architectures traffic patterns become highly unpredictable. Some traffic terminates at edge nodes while other traffic is forwarded deeper into the network. Unpredictable traffic patterns change existing network planning rules and increase the requirements for real-time traffic engineering and newer routing technologies such as segment routing.

CHALLENGES WITH LEGACY IP NETWORKS

Legacy IP networks were designed for best-effort internet traffic. Although traffic engineering and QoS have been included in routers for many years these technologies have not been widely implemented because the applications and services did not demand these technologies. As 5G services are rolled out QoS, QoE, and SLAs will become increasingly critical success factors in the design and operation of an IP network; consequently, network designs and operations need to be reengineered.

There are significant challenges in managing networks with unpredictable traffic patterns that require regular changes to network planning rules using legacy IP CLI and scripts. These tools were not designed for real-time network traffic engineering. CLIs and scripts are complex to implement and can also be error prone, resulting in potential network outages if configurations are not correct. A better approach clearly is needed for next-generation IP networks.

ADAPTIVE IP

Adaptive IP was designed to address the requirements and challenges presented by existing networks and future networks, like 5G. It provides scalability, availability, and strict QoS while simultaneously reducing network CapEx and OpEx. Adaptive IP combines disaggregated programmable infrastructure, analytics and intelligence, and software control and automation to optimize transport and automate network design and operations in Figure 1.

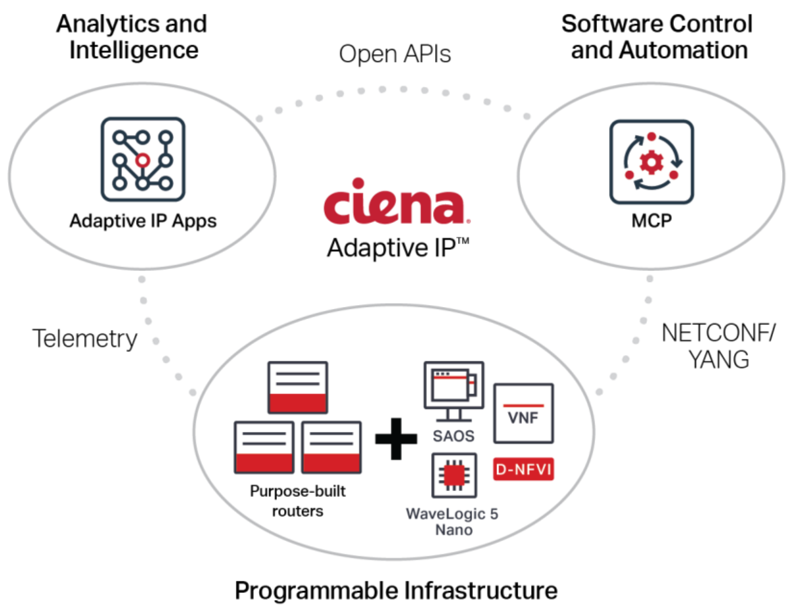

Figure 1. The Ciena Adaptive IP

The key functions in Adaptive IP that address the challenges in 5G networks are:

- **Automation:** Reduces decreases configuration errors, improves fault resolution, and increases service velocity for a reduced time to revenue
- **Segment Routing and Advanced QoS:** Separation of the control and forwarding planes allows for better traffic engineering, link optimization, and QoS, which are necessary for delivering a new generation of IP services
- **Analytics and Intelligence:** Improves network availability, improves existing asset utilization, and reduces network engineering and operations expenses

Adaptive IP provides QoE, QoS, and SLAs in IP networks by using a combination of hard slicing and soft slicing:

- Soft slicing uses software-defined networking, segment routing, and advanced QoS queuing techniques to provide virtual links with QoS

- Hard slicing is provided by FlexEthernet, a technology using TDM channels for specific packet-based traffic that provides improved levels of QoS and latency for certain applications and services

These technologies are critical for latency-sensitive applications such as drones, robots, and connected vehicles, which are expected to grow as 5G networks are deployed.

The Adaptive IP application software performs traffic engineering to optimize network utilization while maintaining strict QoS and SLAs. Real-time streaming data is used with the Constraint-Based Path Computation Engine, segment routing, and advanced QoS to optimize traffic loads on the network while providing QoS for critical applications. The resulting link optimization allows links to run hotter (higher utilization rate) while ensuring latency and jitter requirements are met for specific applications. Link optimization reduces the numbers of transport connections, optics, and router capacity required in the network, which reduces both CapEx and OpEx while providing higher quality service. Adaptive IP uses intelligent closed-loop automation that uses real-time streaming data for continuous optimization and self-healing to eliminate wasted capacity for an optimal return on new and existing network assets.

Adaptive IP automation, analytics, and intelligence provide significant OpEx benefits while also improving network performance, reliability, and availability. There are specific OpEx benefits in the functions of engineering and planning, service fulfilment, and service assurance (Table 1).

	PMO	Adaptive IP	Benefit
Engineering & Planning	Difficult to simulate networks and do what if analyses. Manual efforts use outdated and erroneous information for network planning.	Real-time data used for network simulation and optimization. What if analyses for network planning. Intelligent closed-loop traffic engineering and link optimization. Network availability and survivability analysis.	Up to 70% OpEx reduction,
Service Fulfilment	Network configuration and provisioning is manual, complex, and error prone; it requires use of a CLI, scripts, and significant testing.	Automation of network provisioning and configuration. All plans are intelligently and automatically implemented.	Up to 35% OpEx reduction,

	This requires a rare high level of technical expertise.	No scripts or manual efforts. User friendly interface. Reduced level of technical expertise.	
Service Assurance	Difficult to isolate complex routing problems. Impossible to proactively repair the network before a problem occurs. No visibility into customers, services or applications. Monitoring and troubleshooting VPNs is a major challenge. Difficult to correlate problems across different vendors and no root cause analysis.	Visibility of real-time routing events and traffic flows across the network. Customized alerts. Digital video recorders like replay and forensic analysis. Automation of fault diagnosis and repair. Proactive repair to fix problems before they occur.	Up to 70% OpEx reduction,

Table 1. Benefits of Engineering and Planning, Service Fulfilment, and Service Assurance

In addition to reducing network TCO, Adaptive IP also facilitates faster time to revenue for new services. Data-driven network intelligence and automation reduce the time required to deploy new network services from months to days or weeks. By increasing service velocity, service providers generate revenue quicker and create a fast-fail capability for services that are not successful. These capabilities increase overall revenue and allow service providers to be more competitive to other network operators.

TCO MODEL AND ASSUMPTIONS

ACG Research developed a TCO model Business Analytics Engine (BAE)[1], which is a next-generation economic-simulation platform for networks, data centers, cloud, and network functions virtualization. We use it to compare a network with Adaptive IP to a network without Adaptive IP. The model in this network is representative of a large service provider's network. The BAE model is also adaptable to a specific service provider's network. An overview of the Adaptive IP TCO model is presented in Figure 2.

[1] https://www.acgcc.com/p/bae-software/

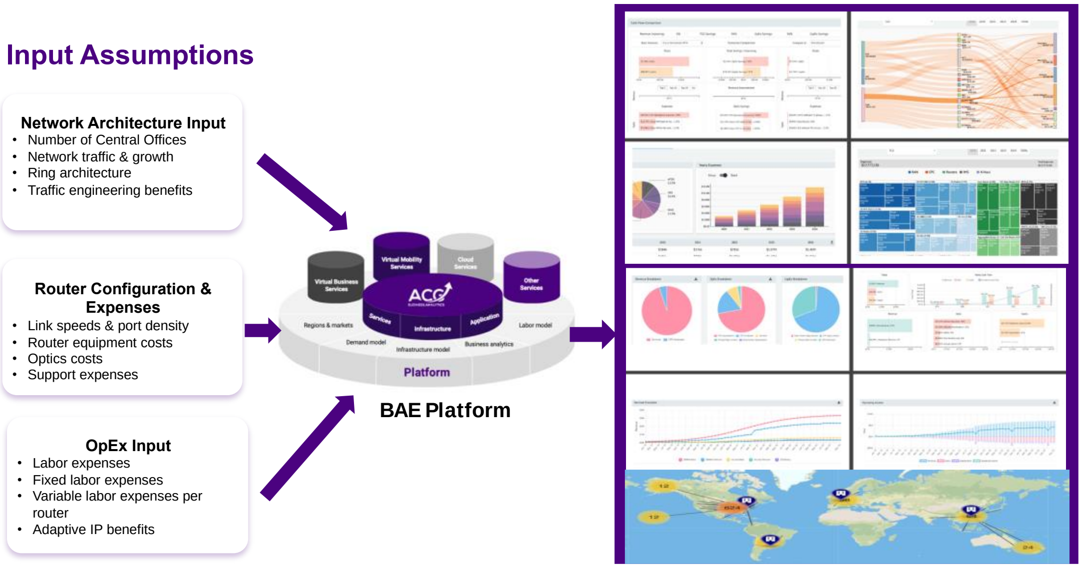

Figure 2. Adaptive IP TCO Model

There are three categories of input data used in the model:

- Network architecture and traffic input
- Router configuration expenses
- OpEx input

The BAE platform using input assumptions in each of these categories runs a five-year simulation of the growth in CapEx and OpEx. Two scenarios are compared in the model:

1. A network evolution solution with Adaptive IP
2. An expansion of the network following the legacy approach

These two scenarios are represented in Figure 3. In the legacy network we assume that routers are operated and managed using standard CLIs and scripts with little automation and no traffic engineering. The Adaptive IP network uses the Ciena routers combined with Adaptive IP Apps and MCP software to automate network operations and implement traffic engineering.

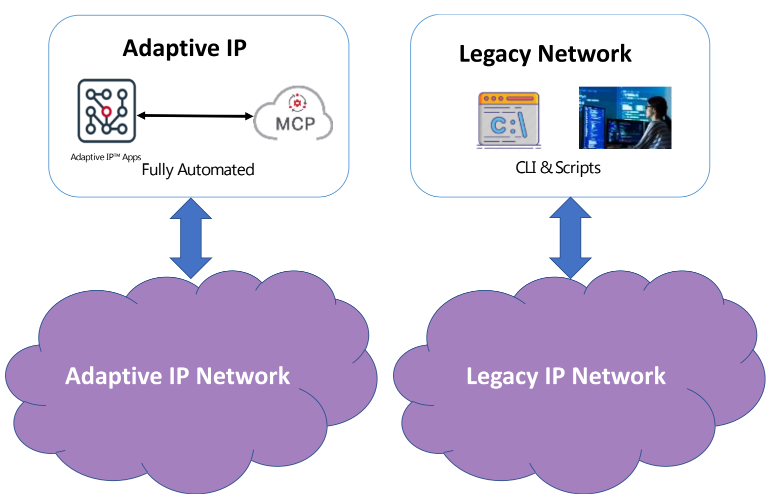

Figure 3. Ciena IP Network Configuration

The network architecture comparison is depicted in Figure 4. We consider a network consisting of access rings, preagg rings, and aggregation nodes. The access rings are 10GE and are designed to support 4G and 5G base stations. The growth in 5G traffic drives the need for 10GE access rings. Access rings connect to 25GE preagg rings that are connected to aggregation nodes. Aggregation links are 100GE. We assume redundant preagg nodes and redundant aggregation nodes. The redundant nodes are engineered to support all traffic in the case of a link or node failure. For the purposes of comparison, we adopted the same network architecture in both scenarios, and no discounts were applied to the costs of the legacy router (the cost of the legacy router and the Adaptive IP routers were identical). All the economic benefits directly result from the Ciena Adaptive IP solution infrastructure and operations optimization.

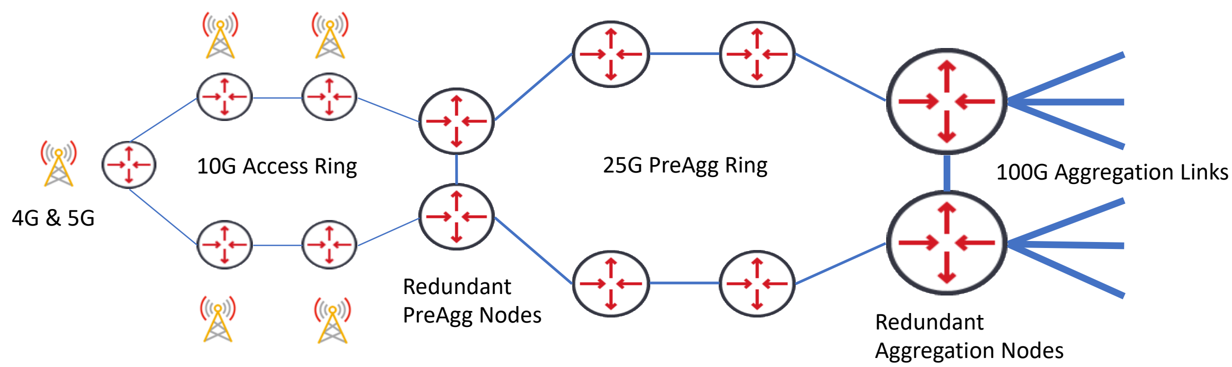

Figure 4. Network Architecture Comparison

There are many detailed assumptions in the TCO model; the key assumptions on the size of the network and traffic growth are shown in Table 2.

Number of Central Offices & Cell Sites	2021	2025
Cell Sites	20,000	26,000
Preagg Central Offices	2,000	2,600
Aggregation Central Offices	250	250

Table 2. Key Assumptions

Another important assumption used in the model is average traffic per cell site. It is expected this traffic will grow significantly over the next five years as 5G, massive multiple-input multiple-output, and millimeter wave technologies are deployed in the mobile network. The traffic assumptions used in the model are depicted in Table 3.

Demand	2021	2025	CAGR
Average Traffic per Access Node	200 Mbps	2 Gbps	58.5%

Table 3. Demand Assumptions

TCO RESULTS

The key results of the TCO model are presented in Table 4 and Figure 5. Table 4 is a summary of Adaptive IP CapEx, OpEx, and TCO savings over five years. Figure 5 presents the total five-year OpEx and CapEx for the base scenario without Adaptive IP and the compare scenario with Adaptive IP. The section in the middle of the chart shows the total savings.

Expense Type	Adaptive IP Savings
CapEx	23%
OpEx	32%
TCO	26%

Table 4. Adaptive IP CapEx, OpEx, and TCO Savings over 5 Years

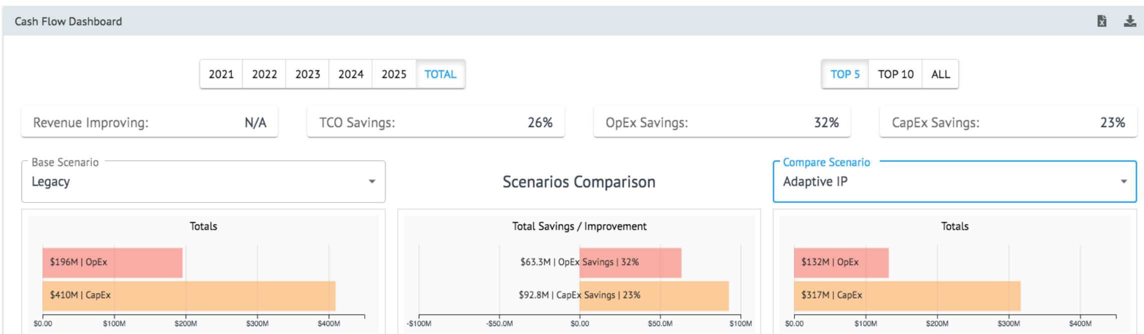

Figure 5. Total Five-Year OpEx and CapEx for Base Scenario without Adaptive IP

The key areas of CapEx and OpEx savings are presented in Figure 6 and Figure 7. Figure 6 shows a total five-year CapEx breakdown in the base scenario without Adaptive IP (left), the comparison scenario with Adaptive IP (right), and the key areas of savings in the middle.

The CapEx savings provided are primarily because of advanced traffic engineering and link optimization. By optimizing traffic loads while maintaining QoS for critical applications, links can be utilized optimally, which reduces the number of routers, links, and optics required in the network. Note that the key savings are in router, interface, and optics acquisition and installation expenses. The cost of delivering these CapEx savings is the Adaptive IP Solution expense.

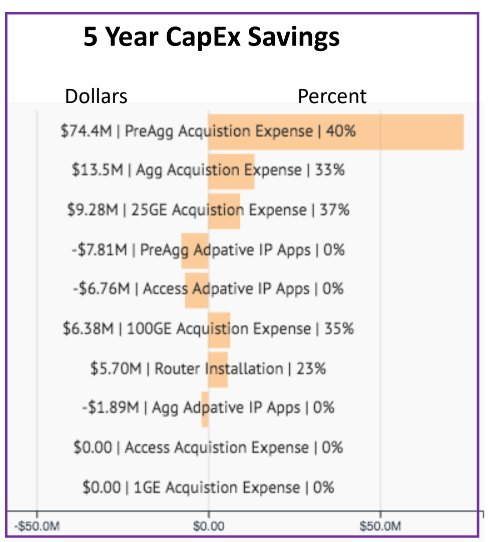

Figure 6. Total Five-Year CapEx Breakdown in the Base Scenario without Adaptive IP

Figure 7 depicts the OpEx savings breakdown. The top OpEx savings is for preagg router vendor support. This decrease in support expenses is also due to enhanced traffic engineering and link optimization, which reduces the number of routers and interfaces and in turn reduces vendors' support expenses. Reducing the number of routers and interfaces also resulted in decreases in power, cooling, and facility expenses. Some of the other key areas of OpEx savings are in:

- Engineering and planning
- Service fulfilment
- Service assurance

The drivers behind these savings are in Table 1.

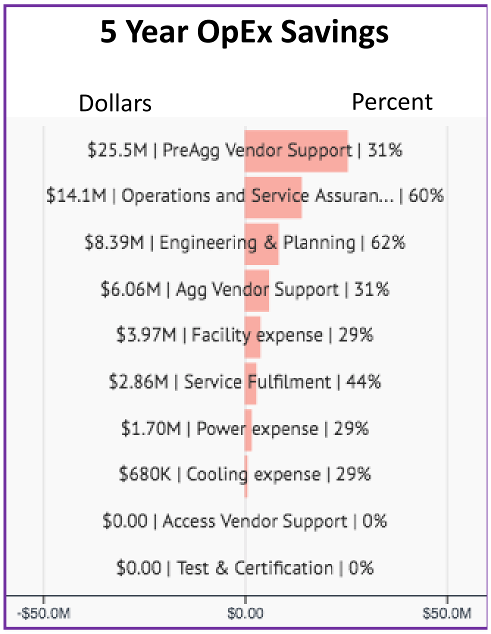

Figure 7. OpEx Savings Breakdown

SERVICE VELOCITY AND NEW REVENUE

Although reducing CapEx and OpEx in networks is a key priority for service providers, increasing top-line revenue is equally important. Service providers need to become more agile to introduce new services quickly and implement a fast-fail mindset if services are not successful. The hyperscalers have perfected this model in the cloud computing space, and network service providers need to replicate this business model as they implement 5G networks. There are many opportunities for new services and revenue:

- 5G services
- Next-generation business services
- Private 5G services
- Edge services
- IoT services
- Cloud gaming
- Connected vehicle services
- Augmented reality and virtual reality services

Agility and time to market is critical for network service providers to stay competitive. We expect significant competition in this space as multiple players move into 5G and edge computing. Adaptive IP provides an automated, agile, and flexible network that enables service agility and faster time to revenue.

CONCLUSION

The internet continues to grow at rapid rates while traffic increases, diverse devices multiply, and services with strict QoS requirements become essential. This paper presents key requirements of next-generation IP networks and explains how the Ciena Adaptive IP solution addresses these requirements while at the same time reducing network TCO. It provides intelligent analytics-driven automation and traffic engineering to allow service providers to build reliable next-generation IP networks, from access to metro, while reducing network TCO. The ACG TCO model BAE demonstrates that service providers can reduce network TCO by 26% using Adaptive IP while providing the agility to rapidly deploy new services and generate new revenue.