Fujitsu Virtuora® Ecosystem

A Critical Piece of the SDN Enabled Network

EXECUTIVE SUMMARY

Fujitsu Network Communications, the North American information and communication technology vendor arm of Fujitsu Limited, is transforming the solutions it provides and the way it engages communication service providers. Fujitsu might best be known for its vertically integrated optical networking equipment like the FLASHWAVE® 9500 Packet Optical Networking Platform. Although still selling and supporting the FLASHWAVE products, Fujitsu is undergoing significant transformation; the company is embarking on a four-part journey to revolutionize its products and customer engagement:

- Embracing network disaggregation. Today, it offers the 1FINITY™ series, a suite of open, disaggregated and programmatic optical transport and switching appliances.
- Embracing modular, disaggregated software for network control. Virtuora® Ecosystem includes applications and a path computation element that directs Fujitsu and third-party products. The multi-layer, multi-domain, multi-vendor approach gives Virtuora the ability to extend and control broad portions of the network. Open interfaces enable Virtuora to interface northbound for hierarchical control and orchestration with simplified OSS/BSS integration.
- Embracing containerized, microapplications utilizing an open-source framework to enable rapid, customized software in a makerspace-like collaborative environment.
- Changing the way it does business. Fujitsu is using Agile development and a customer co-creation engagement model to accelerate innovation. User stories and epics replace lengthy requirements documents. Software is iterated via multi-week sprints with intermediate revisions handed to customers for testing and rapid feedback.

Collectively, Fujitsu is transforming itself as well as its customers.

Key Insights

- Fujitsu is embracing change and transforming:
  - Disaggregated network elements with 1FINITY
  - Disaggregated, modular software, including Virtuora software
  - Containerized microservices and microapplications
  - Co-creation customer engagement
- Customers are benefiting from the changes:
  - Tier-1 CSP integrated solutions easier and faster with custom features for its network
  - Tier-1 CSP solving an automation request via microapplication in weeks instead of months

INTRODUCTION

Today, optical networks are delivering multi-terabit transmission over a single fiber pair via 100G, 200G, 400G and most recently 600G wavelengths with advanced coherent dense wave division multiplexing (DWDM) technology. Although such transmission speeds are impressive, the future deployment of 5G mobile services, augmented/virtual reality and on-demand 4k streaming video means that bandwidth demand will not abate any time soon. Overall IP traffic is expected to grow at 26% CAGR through 2022[1]. Global cloud IP traffic is growing even faster at 27% CAGR through 2021[2]. ACG Research's optical port tracker reports that the number of 100G+ coherent DWDM ports deployed in 2017 exceeded 350,000 units or a 39% increase versus 2016[3]. ACG's forecast anticipates 100G+ ports approaching one million annual shipments by 2021.

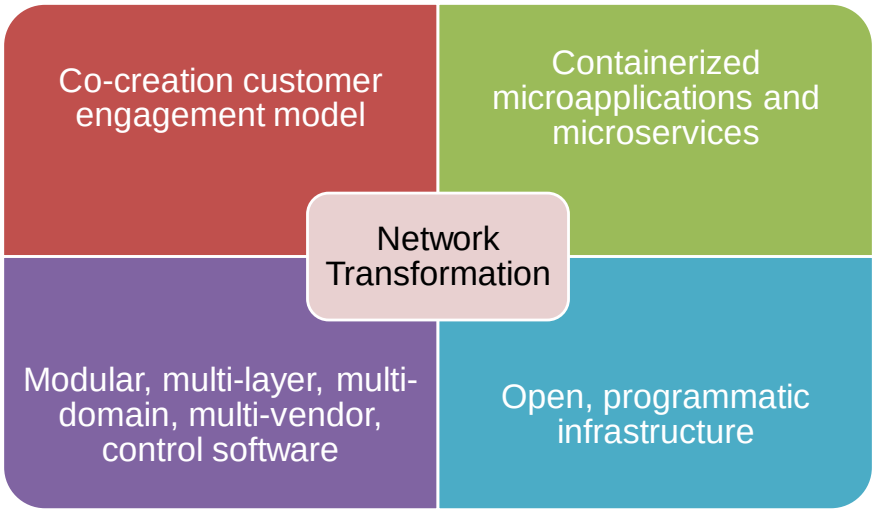

Figure 1. Fujitsu's Network Transformation Approach

Increasing bandwidth demands, changing traffic patterns driven by the migration of applications and workloads to the cloud, and competitive pricing pressures are driving service providers toward cost-optimized, disaggregated, programmable optical infrastructure like the Fujitsu 1FINITY family of disaggregated appliances. Service providers are also working to reduce operational costs and manual activities by embracing software-defined networking (SDN). With SDN, network elements and functions are abstracted utilizing data models and open, programmatic interfaces. Combined with real-time data collection, performance monitoring and intelligent analytics, SDN can simplify network operations and enable closed-loop automation. Fujitsu launched the Virtuora Ecosystem in 2015 to address the need for intelligent, automated, multi-layer, multi-domain, multi-vendor control and automation.

The relationship between communication service providers (CSP) and vendors is also changing. CSPs cannot rely solely on outsourcing innovation to their vendors. Leading CSPs are seeking active participation in a continuous and cooperative development process. Fujitsu is embracing this relationship change with participation in open-source development communities, including Open ROADM, Open Daylight and ONAP, and by enhancing its Agile development processes that enable iterative software to

[1] 2018 Cisco Visual Networking Index.

[2] 2018 Cisco Global Cloud Index.

[3] Q3-2017 ACG Research Optical Network Report.

be delivered to customers as needed. With Fujitsu's co-creation, service providers can guide new features and functionalities and facilitate rapid course corrections and modifications long before the final release. With extensive experience building networks, disaggregated programmatic infrastructure, intelligent software control, containerized microservices/microapplications and a collaborative co-creation customer engagement process, Fujitsu is transforming itself as well as its customers' networks.

OPEN, DISAGGREGATED, PROGRAMMATIC INFRASTRUCTURE

In launching the 1FINITY line, Fujitsu has been an early industry leader in optical infrastructure disaggregation. Consistent with the system-on-a-blade approach, 1FINITY includes a family of 1RU, DWDM transponders, muxponders, ROADMs, line amplifiers and switches. To simplify rack installations, Fujitsu also offers multi-slot mechanical housing to organize and power any combination of the 1FINITY stand-alone appliances. In October 2018, Fujitsu demonstrated its next-generation transponder platform, the 1FINITY T600. The T600 supports 64QAM modulation at 69Gbaud and 75GHz channel spacing to deliver 600 Gb/s transmission performance and is expected to be commercially available in 2019.

Figure 2. Fujitsu 1FINITY™ Disaggregated Optical Infrastructure Portfolio

All Fujitsu 1FINITY products are powered by the Fujitsu System Software Version 2 (FSS2) operating system, resulting in consistent configuration, management, control and behavior. FSS2 supports YANG data models, configuration management with NETCONF and OpenConfig and performance monitoring with gRPC based streaming telemetry. FSS2 also supports zero-touch provisioning to enable rapid installation and reduced operational costs. Open interfaces and Fujitsu's broad industry collaboration provides flexibility for CSPs, enabling the 1FINITY portfolio to be managed by Fujitsu's Virtuora Network Controller or a third-party controller that also leverages open interfaces.

Open ROADM and Open Line Systems

Fujitsu has been an active member of the Open ROADM Multi-Source Agreement since it was announced by AT&T at the 2016 OFC conference. The Open ROADM initiative consists of service providers and vendors working collaboratively to define interoperability specifications to enable a multi-vendor, mix-and-match approach to building optical networks. As the name implies, much of the focus is on defining the behavior for an open reconfigurable optical add drop multiplexer (ROADM). Open in this case means that any vendor's DWDM wavelength can be multiplexed onto a common fiber pair and optically transported and switched with another vendor's ROADM and optical line system (OLS). The goal is to enable a multiplexed collection of wavelengths to originate (typically from a disaggregated transponder like the 1FINITY T100 or T600) from multiple independent vendors, be transported and switched over another vendor's OLS/ROADM and terminated at the destination. To facilitate multi-vendor

interoperability, manageability and control, Open ROADM has ongoing efforts to develop common YANG models, REST APIs and southbound networking protocols like NETCONF.

Fujitsu has been a leading Open ROADM vendor with its disaggregated 1FINITY series, which includes the 1FINITY L100 Series appliances that provide ROADM and muxponder/add-drop capabilities. The Virtuora Ecosystem has also played a significant role with SDN control and automation. Multiple successful field trials have occurred since 2016; these have included Fujitsu Virtuora SDN controller for both Fujitsu 1FINITY elements and third-party vendor hardware. Leveraging its open, northbound REST APIs, Virtuora has also been integrated with the Linux Foundation's ONAP orchestration solution. In March 2018, AT&T announced that it would begin to move Open ROADM hardware and multi-layer SDN control software from trials to commercial deployment in all metro regions.

VIRTUORA ECOSYSTEM AND ARCHITECTURE

The Virtuora Ecosystem was designed for the era of open and disaggregated networking. Fujitsu is an active participant in the Linux Foundation's Open Daylight (ODL) open-source development community where Fujitsu makes regular contributions and benefits from the contributions of a broad community of participants. Built on ODL, the Virtuora microservices-based software architecture enables service providers to mix-n-match the software functions and applications needed for their unique network. Based upon the software modules deployed, Virtuora can play many roles: optical controller, packet controller, and network controller.

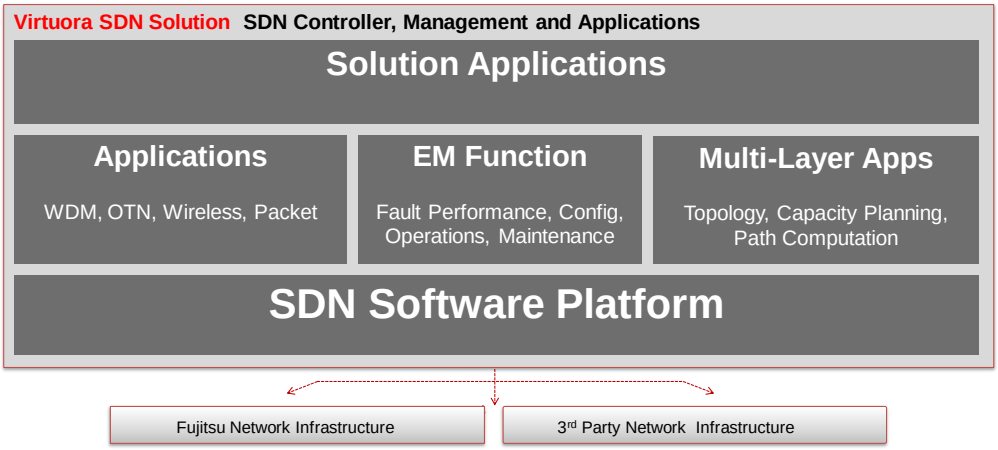

Figure 3. Virtuora Modular Design Components

Open, Standard Interfaces

Open interfaces, including NETCONF and REST APIs, are supported to enable maximum flexibility. Fujitsu leverages the Virtuora northbound interfaces by creating applications to ride on top of the controller platform, including a multi-layer path computation element (PCE) to instantiate, continuously monitor and modify the best path as determined by intent-based parameters. Service providers can also leverage the Virtuora open NBIs to create their own applications and services beyond those provided by Fujitsu.

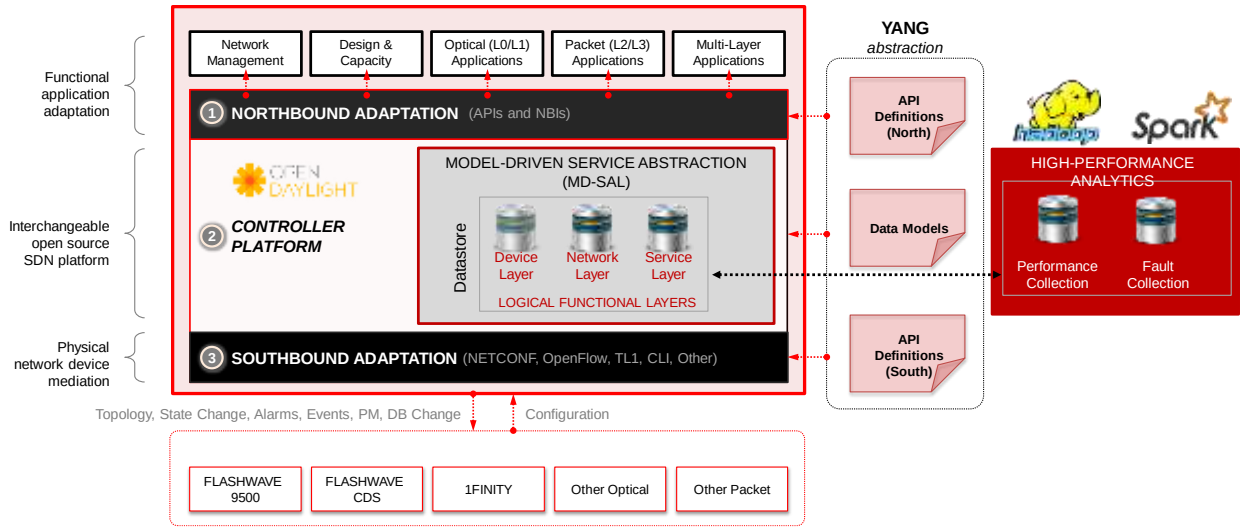

Figure 4. Virtuora Ecosystem Open Interfaces and Modeling

Built for Telemetry, Analytics and Intelligence

The Virtuora Ecosystem was architected with modern big-data analytics in mind. One of the key aspects of the architecture is a store-once, use-many philosophy. As an example, network performance and fault management data is stored in an Apache Hadoop cluster. The Apache Spark compute engine is then used to analyze and correlate the Hadoop data. The stored data is accessible for analysis by any authorized application, including the high-performance analytics engine of Virtuora. Fujitsu's initial focus is in the area of network health and predictive analytics. The analytics engine is utilizing the combined performance and fault management data to anticipate potential networking issues and outages before they occur. If the analytics engine identifies an issue, the service provider is informed, and a recommendation provided for corrective action; for example, replacement of a degraded component like a network amplifier. Alternatively, in those cases where Virtuora can independently perform the corrective action based upon policies or intent parameters, it can provide additional input to the PCE about the cost/weight of a particular path resulting in traffic being rerouted around a potential networking issue.

MICROAPPLICATIONS ENABLING RAPID CUSTOMIZATION

When Fujitsu began working to disaggregate software components that were previously embedded in network elements or monolithic network management software, it quickly realized that containers were lighter, more scalable and more efficient than virtual machines. Wanting to remain both open and industry-leading, Fujitsu embraced the use of Docker for its container engine and Kubernetes for container orchestration and management. Fujitsu's microservices and microapplications are built on Docker/Kubernetes today.

What is a microapplication? A microapplication is a prepackaged collection of microservices with a human-friendly user interface used to manage service behavior, input variables and output results. By contrast, a microservice is a stand-alone, container-based, single-function module communicating via a lightweight mechanism like an API. A microservice typically involves machine-to-machine communication but not an interactive GUI to manage input/output as an example. Fujitsu has developed a collection of microapplications for CSPs to utilize for all types of networking and operational tasks. Operational tasks

that were commonly executed via a scripting language have been turned into microapplications. Examples include circuit inventory requests, IP circuit modifications and automated bill-of-material creation based upon existing networking design and operation. If there is a task that an operations team needs automated, there is usually a microapplication or there will be one shortly.

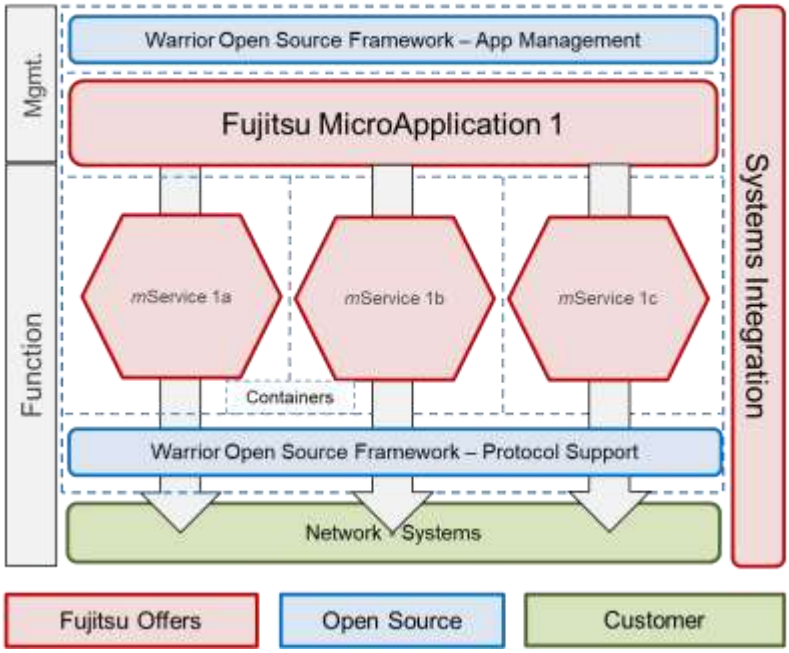

Figure 5. Microapplications Framework

Once Fujitsu developed microapplications, it soon realized that all microapplications had similar needs: common protocol and API support to access network information, common configuration and life-cycle management to enable microapplication instantiation and resource allocation and a common, flexible system integration and test automation environment to enable the outputs of one microapplication to serve as inputs for others. That is why three years ago Fujitsu started developing a microservices framework. The idea was to create an open software automation framework to enable microapplication configuration and administration, access to a rich set of network protocols and test automation that simplifies functional, performance and solution testing. Fujitsu committed the framework into open source with Apache v2.0 license in late 2017 to enable others, including Fujitsu's CSP customers, to generate new microapplications or customize existing ones.

Figure 6. Microapplication Desktop View

Beyond enabling CSPs to develop their own microapplications, in October 2018 Fujitsu also announced the launch of its MicroApplications Practice. The goal of the practice is to help CSPs cost-effectively transform their networking challenges through precision, automated solutions. Fujitsu collaborates with each customer to deliver the most effective microservice-based solution for each unique challenge, blending business expertise with the most advanced digital technologies.

EMBRACING CO-CREATION FOR CUSTOMER ENGAGEMENT

In addition to evolving its portfolio, Fujitsu is embarking on a journey to change the way it develops products and engages customers. Fujitsu utilizes an Agile development process known as Scrumban that is a hybrid of Scrum and Kanban methodologies. Software engineers are organized into a collection of scrum teams (that can be specialized), which execute two-week sprints, analyze the backlog and repeat the process. Test engineers are active members of each scrum team, developing test cases throughout the sprint cycle. Regression testing is continuous and fully automated. Software changes that break test cases are identified and resolved in near real time, thus avoiding the massive and highly variable system integration test cycles that used to befall classic waterfall developments.

Although embracing an Agile development methodology enables the team to be nimbler and more responsive to customer requests and changing market conditions, Fujitsu is also embracing a co-creation customer engagement model. Co-creation requires continuous and active customer involvement from the development of the initial user stories to the testing of intermediate software loads and to the final software delivery. By embracing Agile and co-creation, service providers become collaborators in the innovation process, resulting in tailored solutions to fit their specific needs.

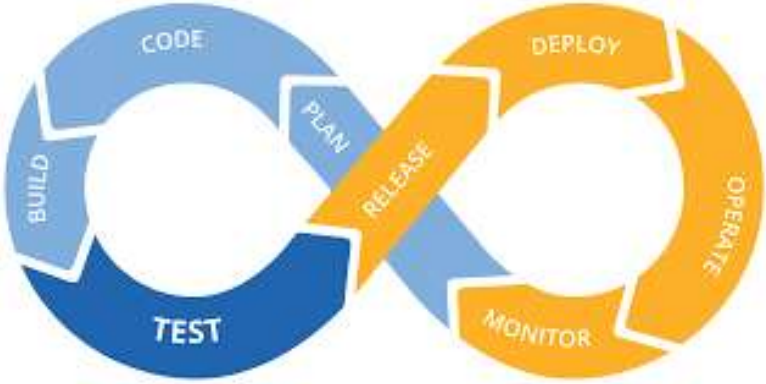

Figure 7. Continuous Development and Deployment Model

Global Tier-1 Service Provider

The Virtuora Ecosystem and microapplications have been deployed globally by more than 25 service providers. We talked with members of Fujitsu's customer engagement team regarding an ongoing Virtuora engagement with a global Tier-1 service provider. During the discussion we focused on how the engagement process was different (and better) than previously. Although the process required the customer to be more actively involved in the testing and the development process, once both sides identified and aligned on their respective responsibilities the process went smoothly and the customer obtaining a tailored SDN control solution to meet its unique networking needs.

Key highlights from the discussion:

- The fixed-mobile converged (FMC) service provider was looking for a multi-layer, multi-vendor, multi-domain SDN controller solution to provide a "single pane of glass" to manage its programmable optical and IP/MPLS network. Phase 1 was a multi-vendor metro DWDM use-case. Phase II expanded Virtuora's scope to include control and management of IP/MPLS (Layer 3) infrastructure from multiple vendors.
- Fujitsu brought the 1FINITY T100 transponder, Virtuora Ecosystem and existing microservices and microapplications to initial customer testing.
- Fujitsu utilized its Agile development process to rapidly iterate and enhance the software to accommodate unique aspects of the customer's network. The customer requested new software deliveries every few months to help it manage its on-site test and lab resources.
- Customer testing of the new functionality provided rapid feedback that Fujitsu then iterated in subsequent sprints. In the past with classic waterfall developments, customers would submit a feature request and wait 12 to 18 months before the feature was available. If the feature needed to be modified, the delivery could take an additional six months.
- Because the third-party metro DWDM infrastructure was not fully Open ROADM compliant, Fujitsu adapted its Open ROADM YANG models and southbound NETCONF protocol to support the third-party infrastructure. Following the adaptations, the third-party equipment was fully managed by the Virtuora Ecosystem.
- Fujitsu's MicroApplication Practice team delivered a microservice for the customer in less than three months. The customer wanted to operationalize additional pieces of the multi-vendor SDN environment. With the microservice and utilization of existing open APIs, Fujitsu delivered the solution without needing to touch other pieces of software or the network.
- Within a matter of months, the customer had a proven, multi-vendor, multi-layer SDN controller solution with "single pane of glass" visibility and programmable operational support. The customer was pleased with the capabilities of the solution and the timeliness of the delivery.

Second Global Tier-1 Service Provider

We also caught up with a member of Fujitsu's MicroApplications Practice team to discuss a recent Tier-1 service provider engagement. The service provider had requested its internal IT organization to automate a network preplanning tool. The internal IT team estimated that it needed a total of 12 weeks to deliver a demo and final version of the automated software. In contrast, Fujitsu's MicroApplication Practice team went from concept to delivery of the final microapplication in two weeks. By having the software disaggregated into containers and microservices, there were no dependencies with other parts of the solution, including the network infrastructure. The solution reduced the amount of time the service provider spent on network planning activities and enhanced the accuracy of the planning results.

CONCLUSION

Fujitsu is embracing disaggregated, modularized SDN control software with open interfaces with the launch of the Virtuora Ecosystem. However, the changes at Fujitsu are far more extensive than the delivery of an SDN controller. Fujitsu is embracing disaggregated, programmatic infrastructure with the launch of 1FINITY. Fujitsu is adopting containerized microservices and microapplications for delivering custom solutions and automation without impacting other parts of the network or the solution. Fujitsu is

also utilizing Agile development processes with co-creation to offer CSPs the opportunity to become collaborators in the innovation process. The combination adds up to a company on a mission to transform itself and its customers' networks.

Analyst Biography: Tim Doiron is Principal Analyst at ACG Research, leading the firm's Intelligent Networking practice. Doiron's work is focused on network innovations and transformations in the areas of packet optical networking, data center inter-connect, transport/multi-layer software-defined networking, network orchestration, mobile anyhaul and enterprise services virtualization with network function virtualization and vCPE/SD-WAN. Tim has ongoing collaborations in areas of open source software, network programmability, visibility, telemetry and automation.

Tim has more than 25 years of networking and telecommunications experience across business and technical organizations. He has served in executive and managerial roles: VP/general manager, VP of product management, director of marketing, product manager, business development and software engineering manager at vendor and service provider companies Coriant, Tellabs, ARRIS, Cadant, Ericsson and AT&T Mobility. Tim has extensive experience bringing new products to market.

Tim is a frequent speaker at industry conferences and has authored numerous articles. He holds a Master of Business Administration, Webster University; a Master of Science in electrical engineering, Virginia Polytechnic Institute and State University; and a Bachelor of Science degree in electrical engineering, Southern Illinois University. Doiron also holds eight patents and is a member of IEEE and the Optical Society (OSA). He is an active member of the Electrical and Computer Engineering Industrial Advisory Board at Southern Illinois University where he serves as an advisor to the department chair.

Authorship: This paper was authored by ACG Research, which is solely responsible for its contents.

Sponsorship: Fujitsu Network Communications, Inc., is a trusted partner to a broad spectrum of customers across all industries, enabling them to realize the maximum value from their communications networks. We are a market-leading U.S.-based manufacturer of network equipment and a top U.S. patent holder in optical networking. Our solutions combine the best wireline, wireless, and software technology with extensive multivendor services expertise to deliver custom, end-to-end network integration and management solutions. For more information, see http://us.fujitsu.com/telecom.