



SOLUTION GUIDE

Data Center Solutions

Empowering the Data Driven Network

broadcom.com

The Ever Increasing Demand for Data

The world is becoming hyper-networked as more and more devices are connected to the Internet. From mobile devices to smart appliances, the total number of connected devices is expected to surpass 50 billion units by 2022*. The aggregate amount of data demanded by these devices is enormous. Further, the explosion in user data demand, applications and connected services has a multiplicative effect on the network traffic -- typically 5X or more in machine to machine traffic generated within and between data centers. Not only will the growing number of connected devices increase the demand for data, there are multiple mega trends impacting the data center infrastructure which will further drive the expansion of network bandwidth and storage capacity. These include:

- **Artificial Intelligence (AI)**
- **Intelligent Edge Computing**
- **Software-Defined WAN (SD-WAN)**
- **5G Wireless**
- **Virtual Reality (VR)**
- **Augmented Reality (AR)**



* Juniper Research, June 2018



Empowering **Digital Enterprises** and **Consumers**

Data centers are increasingly important to digital enterprises and consumers. For many enterprises, data centers play a vital role in delivering IT services and providing storage, communications, and networking to support day-to-day business operations. Data centers enable a broad range of business critical applications such as enterprise resource planning (ERP), customer relationship management (CRM), messaging and collaboration, and business analytics. Similarly, consumers through their mobile devices rely on data centers for essential applications such as email, cloud storage, video on demand (VoD), and smart digital assistants. Data centers also empower a growing number of networked devices like wireless sensors, surveillance cameras, and smart light bulbs with analytics and intelligence making daily lives more convenient and comfortable. The impact of data centers on modern digital lifestyles is immeasurable.

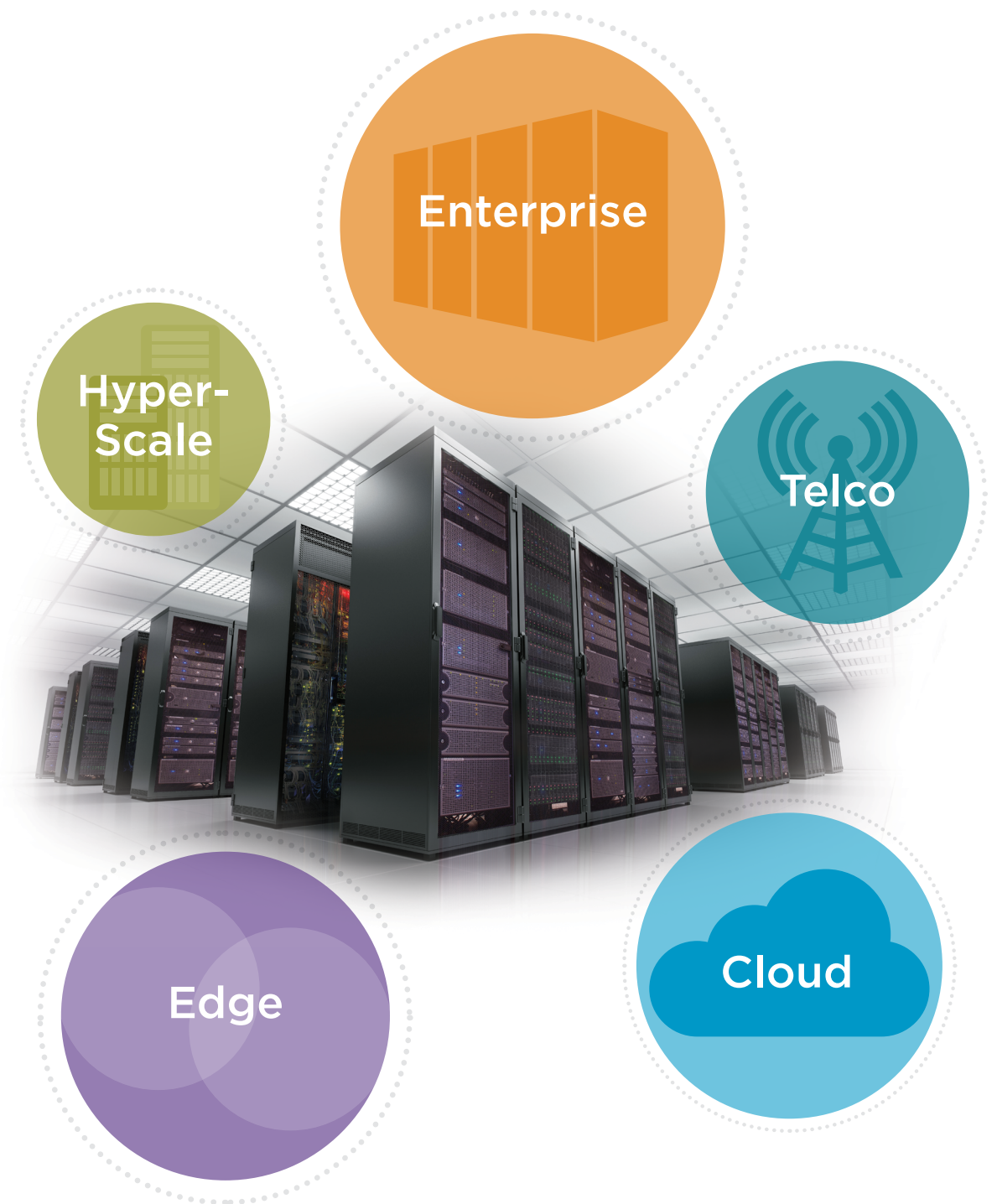
Data centers are an integral part of modern IT infrastructure. Equipped with advanced networking, computing and storage equipment, modern data centers are capable of handling huge volumes of data to and from storage endpoints, server nodes, and network ports. In a cloud environment, hyper-scale data centers are critical resource hubs with massive computational horsepower and storage capacity designed to support a myriad of online applications and services.

The Ever Changing Data Center Landscape

Enterprises and service providers today employ various types of data centers, ranging from privately owned to large-scale public cloud. Recent years have witnessed an increased availability of outsourced data centers trying to get enterprises to move application workloads off premises to reap the benefits of cloud computing. Notable outsourced data center types include content-based, colocation, high performance computing (HPC), shared cloud, and cache-based. In many cases, these purpose-built data centers are effective in handling and managing workloads for enterprises and enabling service providers to deliver services and data faster.

Nevertheless, not all enterprise workloads can be moved off premises to the cloud, especially when applications deal with sensitive data needed for mission-critical operations. For security reasons, many enterprises in critical infrastructure sectors, such as financial services, healthcare, energy, transportation and government, still host their applications on premises. Other important benefits for hosting applications on-premises include single tenancy IT governance and compliance and full control of systems and applications.

As enterprise and consumer needs change and expand over time, data center architecture will evolve to support new requirements. New and emerging applications, such as 4K live streaming, AI, VR and AR, that require high network bandwidth and low latency are expected to drive enterprises and service providers to put more network computing power and storage closer to end user devices or at the edge of the network to improve application performance. As edge computing becomes more prominent in the IT infrastructure, edge data centers will play a greater role in redefining network computing and storage and shaping the data center landscape.

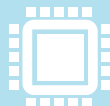


Key Enabling Technologies for Data Center Infrastructure

Expanding data volumes pose many design challenges on the data center infrastructure. The need for higher bandwidth and storage capacity prompts rethinking of the electrical and optical design, as well as the

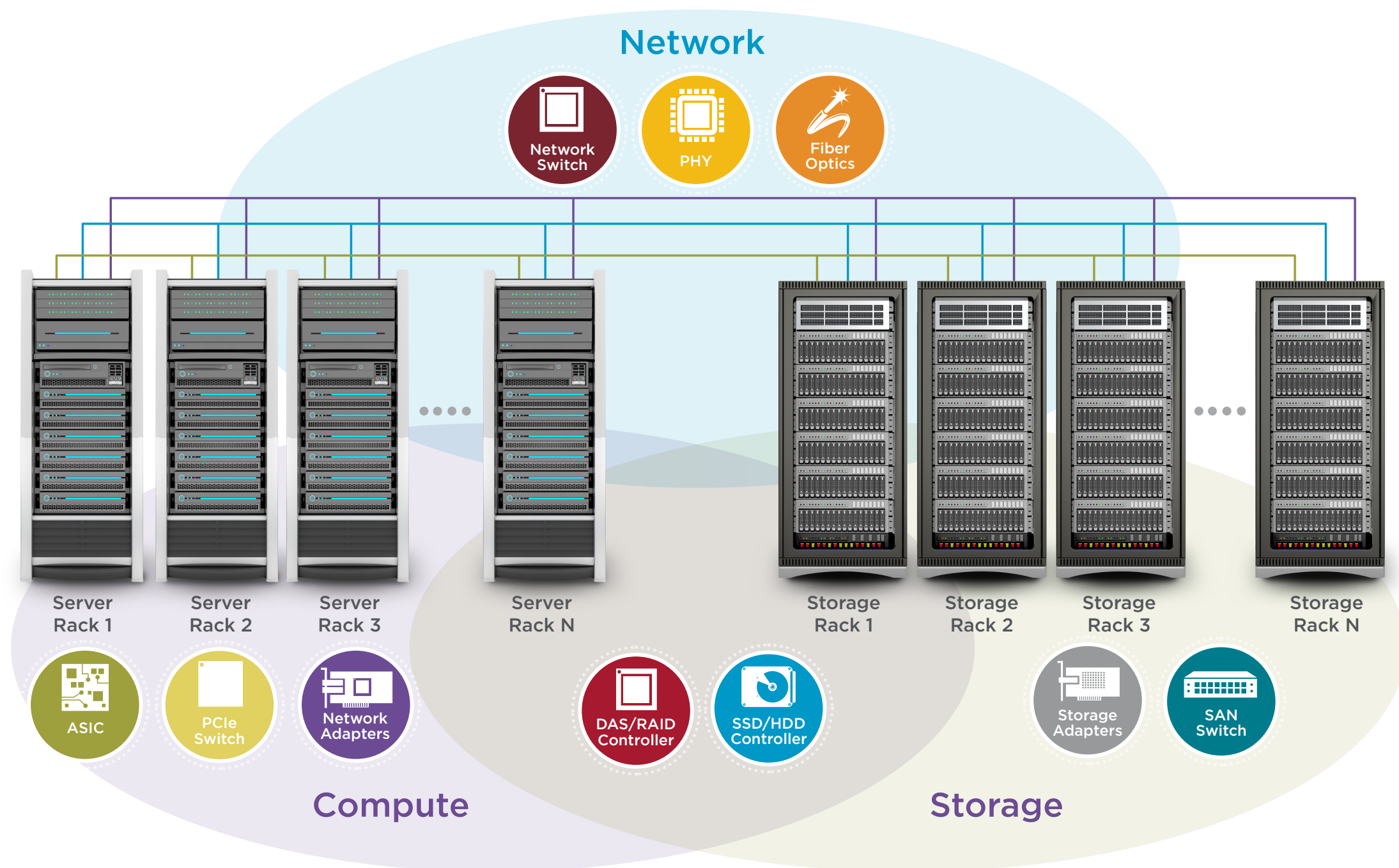
system-level hardware and software design. Furthermore, the ever-changing requirements for the virtualized server and storage fabrics present additional challenges on the network interfaces and storage adapters.

Addressing the needs of modern data centers requires transformational changes across various systems, from the network to the compute and storage. Upgrading bandwidth and eliminating data bottlenecks are essential to supporting next generation data-intensive applications. Equally important is the continuous improvement and optimization of SoC platforms to support diverse use cases as well as future needs. Meeting these technical objectives requires an extensive array of key enabling technologies.

Network	Compute	Storage
 High density terabit LAN switch for large-scale data center network	 ASIC with high density on-die computation & high bandwidth memory supporting HPC and deep learning	 High performance Fibre Channel SAN switch & HBA for mission-critical storage
 High speed SerDes PHY supporting new and emerging Ethernet interfaces	 High performance PCIe switch enabling scale-out compute for HPC and deep learning	 Tri-mode storage adapter extending the capability of SAS/SATA systems to support NVMe SSDs
 High bandwidth optical engines transmitting data over extended reach fiber cabling as the data center expands in size	 High-performance Ethernet network adapters & Smart NIC enabling high-speed networking with CPU offload for compute and storage nodes	 Hybrid SSD/HDD controller addressing high-capacity, high-performance storage needs

Solutions at a Glance

Broadcom is a leading provider of data center solutions with a comprehensive portfolio of network, server and storage connectivity. From Ethernet switch, controller and PHY to custom ASIC, Fibre Channel SAN switch & HBA, SSD/HDD controller, NVMe/SAS/SATA/PCIe storage connectivity and optical transceiver components, Broadcom's highly-differentiated and innovative solutions address the growing needs of modern data centers and empower the data driven network.



Industry Leading Data Center Portfolio

Broadcom provides the industry's most comprehensive portfolio of category leading infrastructure technologies leveraging the breadth and depth of expertise in networking and storage. Broadcom's networking and communication technologies are deeply embedded at various levels of the data center network supporting intra- and inter-network connectivity. From enterprise server racks to large hyper-scale deployments, Broadcom is at the core of data center communications, networking and storage.

Ethernet Switch

Broadcom is the industry leader in merchant Ethernet switch silicon for data center and cloud infrastructure with its proven StrataXGS® and StrataDNX™ switching product lines. The StrataXGS Tomahawk® 3 is the world's fastest switch chip, delivering 12.8 Tb/s of aggregate Ethernet switching bandwidth and dense 100/200/400GbE capacity, optimized for scale-out compute and storage fabrics. The StrataXGS Trident™ 3 family offers flexibility and feature support for enterprise data centers and private clouds migrating to 10/25/100GbE. The StrataDNX Jericho™ 2 combines Broadcom's most feature-rich, programmable packet processor technology ("Elastic Pipe") with carrier-class traffic management and 2.5D HBM integration to deliver 9.6 Tb/s of aggregate routing performance for scalable infrastructure.

Optical/Backplane PHY

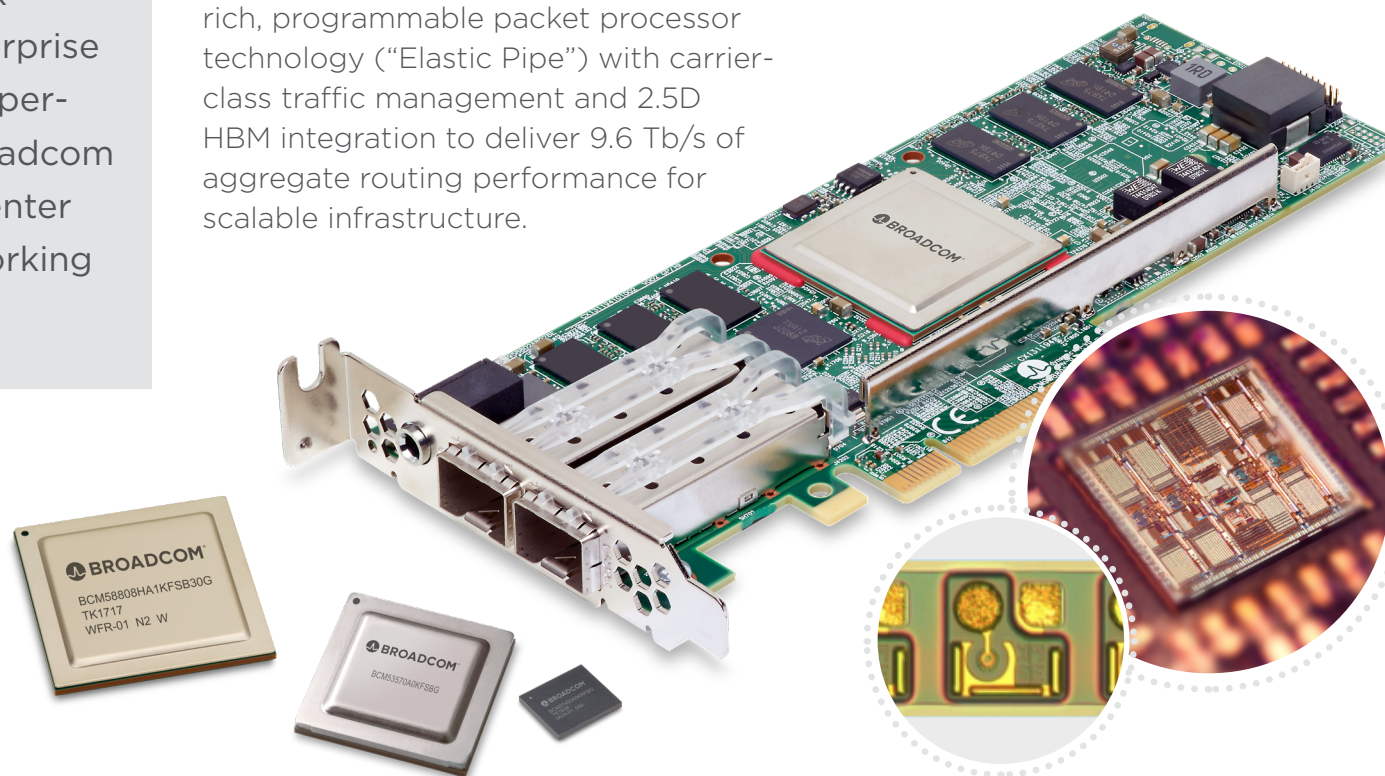
Built upon a proven DSP-based PAM-4 architecture with advanced features, such as time synchronization and Energy Efficient Ethernet, Broadcom's high-speed PHY devices deliver best-in-class metrics for signal integrity and power consumption enabling efficient high-bandwidth transfer of data over fiber optic cabling or copper backplane. Broadcom offers a broad portfolio of Ethernet PHY solutions, including gearbox and MACsec PHY, that support the full gamut of Ethernet interfaces and modulation formats including NRZ and PAM-4 with data rates from 10 to 400 Gb/s.

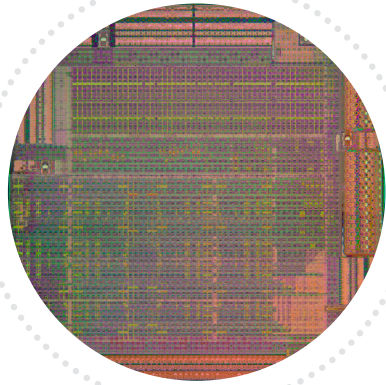
Ethernet Controller

Broadcom's industry leading NetXtreme® Ethernet controllers enable performance-leading, power-optimized network adapters for 10/25/50/100/200GbE networks for the cloud and enterprise data centers. These solutions offer a full range of networking offload features to dramatically reduce server compute load, including the integrated Truflow™ engine which transparently enables virtual switching of packets on the network adapter. The Stingray™ SmartNIC adapters further include a powerful ARM CPU complex designed to run data- and control-plane functions that have historically been implemented on server cores, and are quickly migrating to smart network adapters to achieve better performance with reduced power. Stingray adapters also power a new generation of disaggregated storage nodes using NVMe over Fabrics (NVMe-oF).

Fiber Optic Components

Broadcom is a global technology leader in InP and GaAs-based optical components used in high speed transceiver modules for data center networking and storage applications. Broadcom's extensive selection of optical components, including optics and ICs, support short-reach and long-reach fiber optic communications with data rates up to 400 Gb/s and link distances as long as 10 km.





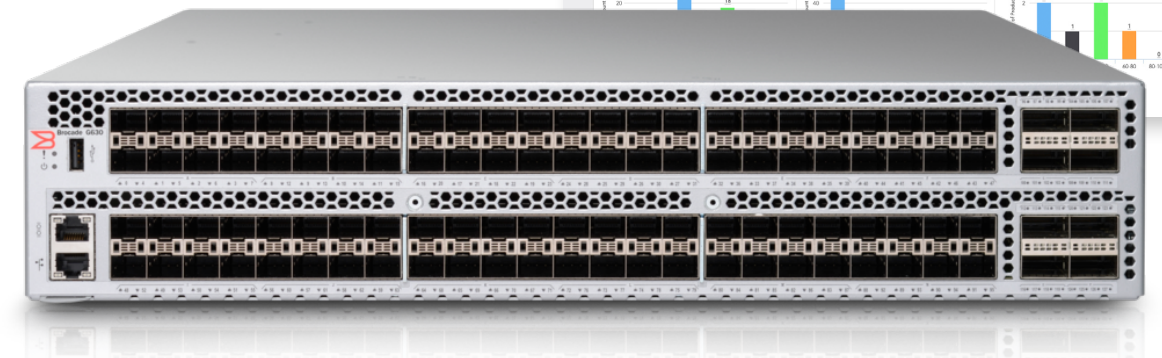
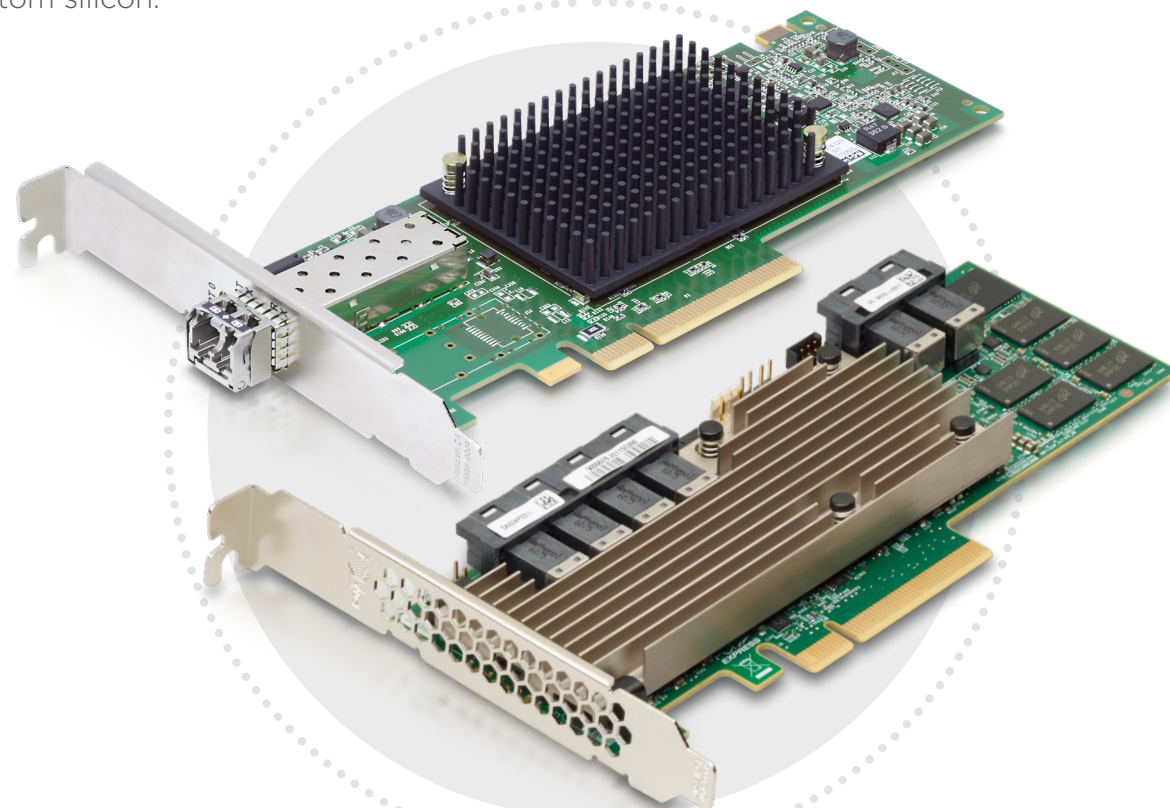
Custom ASIC

With a long-standing history of providing innovative ASIC solutions for data center applications, Broadcom offers a comprehensive ASIC platform in advanced process nodes along with best-in-class IP cores which include high-speed SerDes, HBM PHY, Die2Die PHY and mixed-signal IP. Broadcom ASIC solutions enable end customers such as data center and cloud providers to differentiate in the market place with cutting-edge, early adopter custom silicon.



SSD/HDD Controller & PreAmp

Broadcom provides a broad selection of advanced SSD/HDD SoC and HDD preamplifier solutions addressing high-capacity, high-performance storage needs. Broadcom is a leading provider of data center SSD SoCs. Based on purpose-built SSD IP and flash controller system designs, Broadcom's custom SSD SoCs are leading the industry transition from 12 to 24 Gb/s SAS SSDs and from 8 to 16 Gb/s multi-lane PCIe SSDs.



Direct Attached Storage (DAS) & PCIe Connectivity

Broadcom DAS and PCIe connectivity solutions include NVMe/SAS/SATA storage controller and PCIe switch chips, HBAs, RAID adapters, and NVMe adapters. Broadcom's unique tri-mode SerDes technology enables servers to support any combination of NVMe, SAS and SATA devices. Broadcom offers the industry's broadest portfolio of NVMe storage silicon and software in addition to tri-mode HBAs and RAID adapters. Broadcom's high-performance PCIe Gen4 switch family provides up to 16-GT/s of PCIe connectivity supporting a wide range of compute accelerators for HPC and deep learning applications.

Fibre Channel Switch & HBA

Brocade SAN switching and Emulex HBA solutions for Fibre Channel (FC) storage arrays include switches, HBAs, diagnostic appliances, network analytics and management software, and optical transceivers. Broadcom's Gen 6 FC platforms including FC-NVMe and SAN automation technology are purpose-built for SSD storage and optimized for NVMe-based all flash arrays in modern storage network infrastructure.

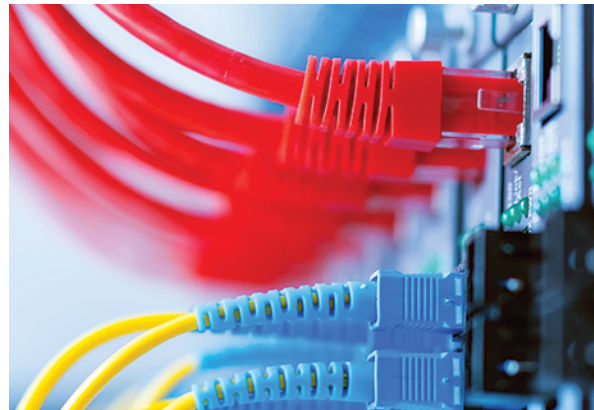
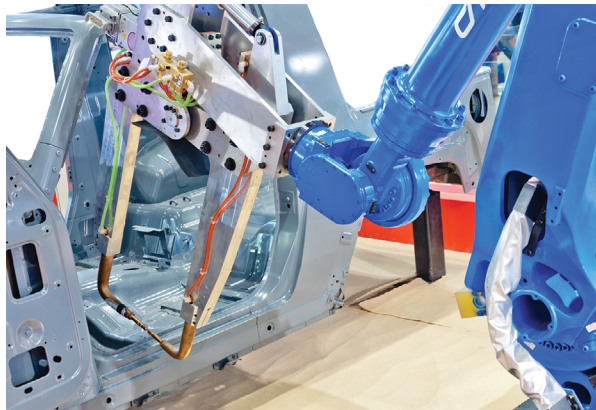
Advancing the Data Driven Future

Global data traffic continues to accelerate with no sign of slowing down. Continued innovation across network, compute and storage domains is critical to sustaining rapid data growth. Driven by the ever increasing demand for data as well as the need to embrace new and emerging applications like AI and 5G, data centers are expanding in size with higher bandwidth capability and greater storage capacity.

Next generation data centers will be equipped with more advanced networking, computing and storage technologies to provide greater IT agility and efficiency, tackling new challenges from the edge to the cloud. Next generation data centers are a vital part of the future network, enabling intelligent automation to allow the network to run on its own with little or no human intervention. In essence, the network will be self-managed and autonomously driven by analytics and intelligence.

As a global infrastructure technology leader, Broadcom is at the core of innovation that empowers the data driven network, and continues to push the envelope with transformative research and developments to advance the digital economy of the future.





Broadcom Inc. is a global infrastructure technology leader built on 50 years of innovation, collaboration and engineering excellence.

Broadcom Inc. (NASDAQ: AVGO) is a global technology leader that designs, develops and supplies a broad range of semiconductor and infrastructure software solutions. Broadcom's category-leading product portfolio serves critical markets including data center, networking, enterprise software, broadband, wireless, storage and industrial. Our solutions include data center networking and storage, enterprise and mainframe software focused on automation, monitoring and security, smartphone components, telecoms and factory automation.