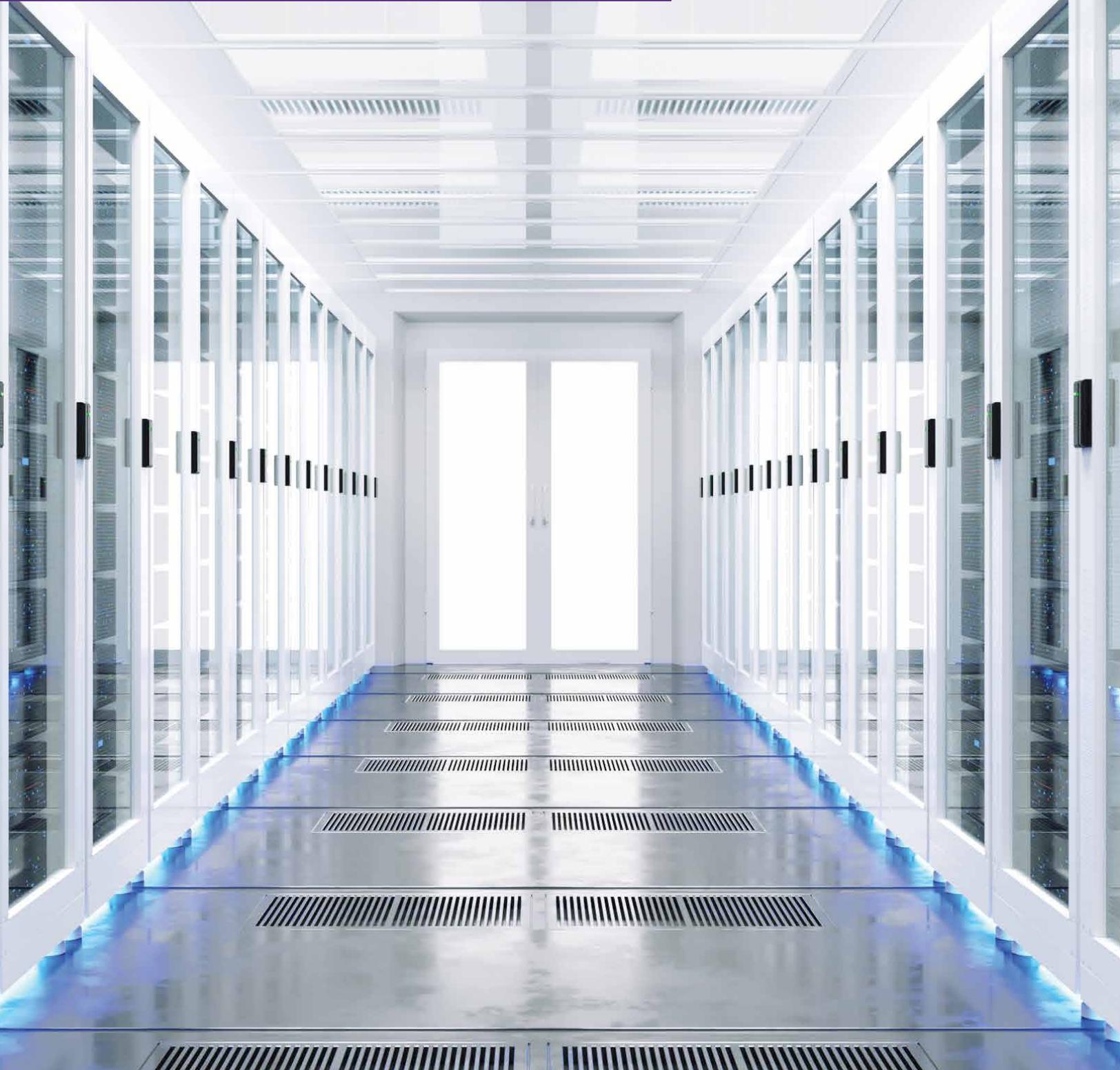


DesignWare IP for Cloud Computing SoCs

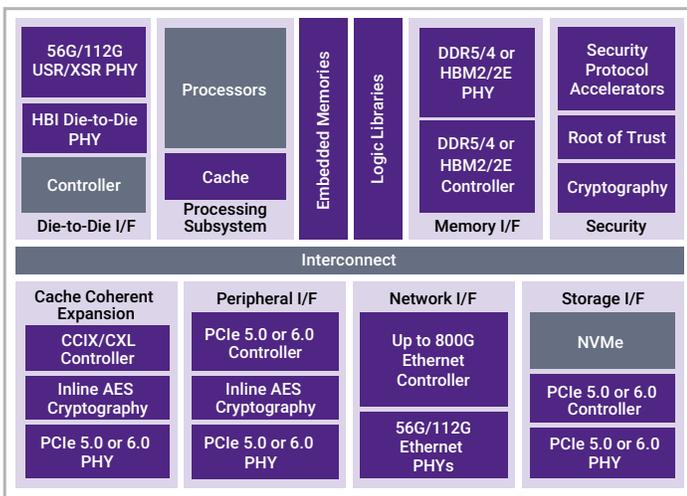


Overview

Hyperscale cloud data centers continue to evolve due to tremendous Internet traffic growth from online collaboration, smartphones and other IoT devices, video streaming, augmented and virtual reality (AR/VR) applications, and connected AI devices. This is driving the need for new architectures for compute, storage, and networking such as AI accelerators, Software Defined Networks (SDNs), communications network processors, and solid state drives (SSDs) to improve cloud data center efficiency and performance. Re-architecting the cloud data center for these latest applications is driving the next generation of semiconductor SoCs to support new high-speed protocols to optimize data processing, networking, and storage in the cloud. Designers building system-on-chips (SoCs) for cloud and high performance computing (HPC) applications need a combination of high-performance and low-latency IP solutions to help deliver total system throughput. Synopsys provides a comprehensive portfolio of high-quality, silicon-proven IP that enables designers to develop SoCs for high-end cloud computing, including AI accelerators, edge computing, visual computing, compute/application servers, networking, and storage applications. Synopsys' DesignWare® Foundation IP, Interface IP, Security IP, and Processor IP are optimized for high performance, low latency, and low power, while supporting advanced process technologies from 16-nm to 5-nm FinFET and future process nodes.

High-Performance Computing

Today's high-performance computing (HPC) solutions provide detailed insights into the world around us and improve our quality of life. HPC solutions deliver the data processing power for massive workloads required for genome sequencing, weather modeling, video rendering, engineering modeling and simulation, medical research, big data analytics, and many other applications. Whether deployed in the cloud or on-premise, these solutions require high performance and low-latency compute, networking, and storage resources, as well as leading edge artificial intelligence capabilities. Synopsys provides a comprehensive portfolio of high-quality, silicon-proven IP that enables designers to develop HPC SoCs for AI accelerators, networking, and storage systems.



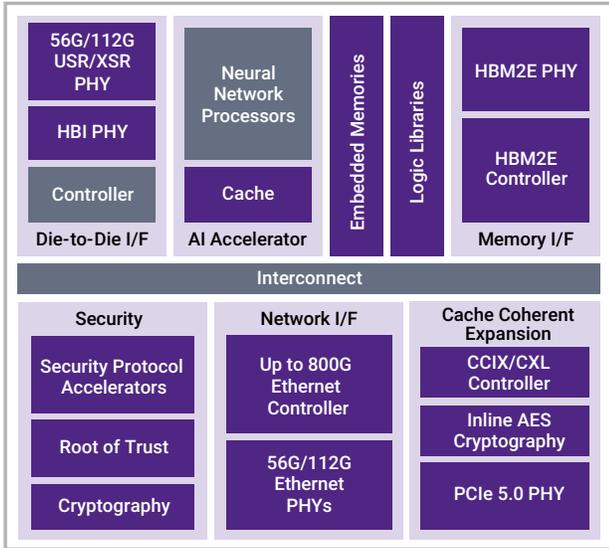
IP for HPC SoCs in Cloud Computing

Benefits of Synopsys DesignWare IP for HPC

- Industry's widest selection of high-performance interface IP, including DDR, PCI Express, CXL, CCIX, Ethernet, and HBM, offers high bandwidth and low latency to meet HPC requirements
- Highly integrated, standards-based security IP solutions enable the most efficient silicon design and highest levels of data protection
- Low latency embedded memories with standard and ultra-low leakage libraries, optimized for a range of cloud processors, provide a power- and performance-efficient foundation for SoCs

Artificial Intelligence (AI) Accelerators

AI accelerators process tremendous amounts of data for deep learning workloads including training and inference which require large memory capacity, high bandwidth, and cache coherency within the overall system. AI accelerator SoC designs have myriad requirements, including high performance, low power, cache coherency, integrated high bandwidth interfaces that are scalable to many cores, heterogeneous processing hardware accelerators, Reliability-Availability-Serviceability (RAS), and massively parallel deep learning neural network processing. Synopsys offers a portfolio of DesignWare IP in advanced FinFET processes that address the specialized processing, acceleration, and memory performance requirements of AI accelerators.



IP for Core AI Accelerator

Benefits of Synopsys DesignWare IP for AI Accelerators

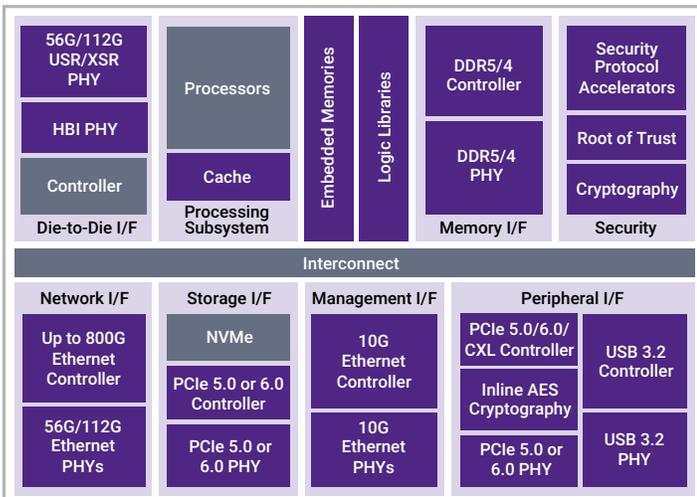
- Industry's widest selection of high-performance interface IP, including DDR, USB, PCI Express (PCIe), CXL, CCIX, Ethernet, and HBM, offers high bandwidth and low latency to meet the high-performance requirements of AI servers
- Highly integrated, standards-based security IP solutions enable the most efficient silicon design and highest levels of data protection
- Low latency embedded memories with standard and ultra-low leakage libraries, optimized for a range of cloud processors, provide a power- and performance-efficient foundation for SoCs

Edge Computing

The convergence of cloud and edge is bringing cloud services closer to the end-user for richer, higher performance, and lower latency experiences. At the same time, it is creating new business opportunities for cloud service providers and telecom providers alike as they deliver localized, highly responsive services that enable new online applications.

These applications include information security, traffic and materials flow management, autonomous vehicle control, augmented and virtual reality, and many others that depend on rapid response. For control systems in particular, data must be delivered reliably and with little time for change between data collection and issuing of commands based on that data.

To minimize application latency, service providers are moving the data collection, storage, and processing infrastructure closer to the point of use—that is, to the network edge. To create the edge computing infrastructure, cloud service providers are partnering with telecommunications companies to deliver cloud services on power- and performance-optimized infrastructure at the network edge.



IP for Edge Server SoC

Benefits of Synopsys DesignWare IP for Edge Computing

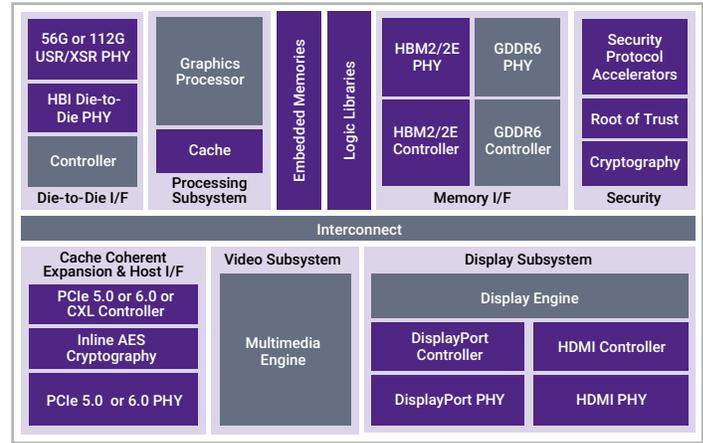
- Industry's widest selection of high-performance interface IP, including DDR, USB, PCI Express, CXL, CCIX, Ethernet, and HBM, offers high bandwidth and low latency to meet the high-performance requirements of edge computing servers
- Highly integrated, standards-based security IP solutions enable the most efficient silicon design and highest levels of data protection
- Low latency embedded memories with standard and ultra-low leakage libraries, optimized for a range of edge systems, provide a power- and performance-efficient foundation for SoCs

Visual Computing

As cloud applications evolve to include more visual content, support for visual computing has emerged as an additional function of cloud infrastructure. Applications for visual computing include streaming video for business applications, online collaboration, on-demand movies, online gaming, and image analysis for ADAS, security, and other systems that require real-time image recognition. The proliferation of visual computing as a cloud service has led to the integration of high-performance GPUs into cloud servers, connected to the host CPU infrastructure via high-speed accelerator interfaces.

Benefits of Synopsys DesignWare IP for Visual Computing

- Silicon-proven PCIe 5.0 IP is used by 90% of leading semiconductor companies
- CXL IP is built on silicon-proven DesignWare PCI Express 5.0 IP for reduced integration risk and provides cache coherency to minimize data copying within the system
- HBM2/2E IP is optimized for power efficiency, using 80% less power than competitive solutions



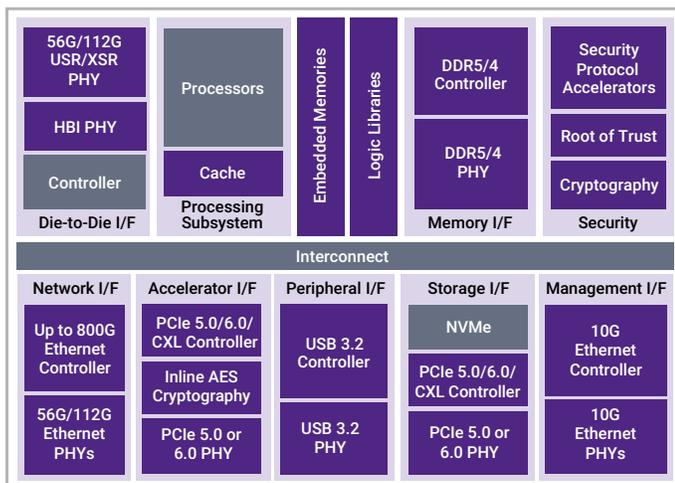
Server-based graphics accelerator block diagram

Servers

The growth of cloud data is driving an increase in compute density within both centrally located hyperscale data centers and remote facilities at the network edge. The increase in compute density is leading to demand for more energy-efficient CPUs to enable increased compute capability within the power and thermal budget of existing data center facilities. The demand for more energy-efficient CPUs has led to a new generation of server CPUs optimized for performance/watt.

This same increase in data volume is also driving demand for faster server interfaces to move data within and between servers. Movement of data within the server can be a major bottleneck and source of latency. Minimizing data movement as much as possible and providing high-bandwidth, low-latency interfaces for moving data when required are key to maximizing performance and minimizing both latency and power consumption for cloud and HPC applications. To improve performance, all internal server interfaces are getting upgrades:

- DDR5 interfaces are moving to 6400 MBps
- Doubling the bandwidth of PCIe interfaces as they move from PCIe 4.0 at 16GT/s to PCIe 5.0 at 32GT/s and PCIe 6.0 at 64GT/s
- Compute Express Link (CXL) provides a cache coherent interface that runs over the PCIe electrical interface and reduces the amount of data movement required in a system by allowing multiple processors/accelerators to share data and memory efficiently
- New high-speed SerDes technology at 56Gbps and 112Gbps using PAM4 encoding and supporting protocols enable faster interfaces between devices including die, chips, accelerators, and backplanes



Cloud server block diagram

Benefits of Synopsys DesignWare IP for Cloud Compute Servers

- Silicon-proven PCIe 5.0 IP is used by 90% of leading semiconductor companies
- CXL IP is built on silicon-proven DesignWare PCI Express 5.0 IP for reduced integration risk and supports storage class memory (also referred to as persistent memory) for speed approaching that of DRAM with SSD-like capacity and cost
- 112Gbps XSR/USR SerDes supports a wide range of data rates (2.5 to 112 Gbps) with area-optimized RX

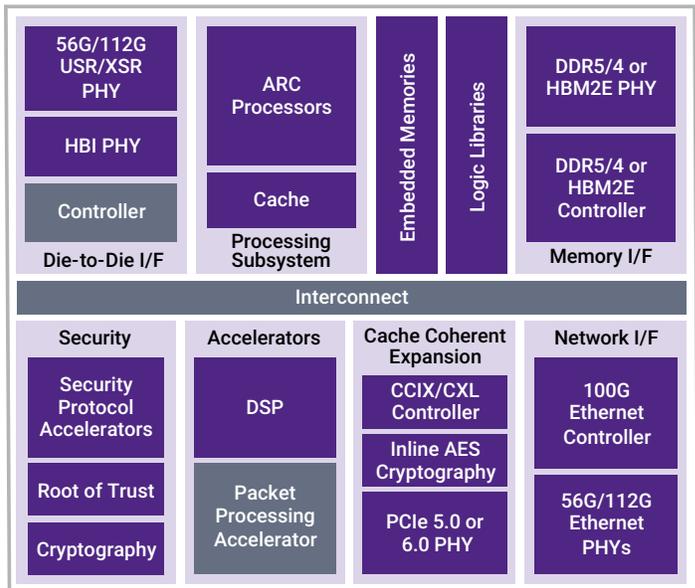
Networking

Traditional data centers use a tiered network topology consisting of switched Ethernet with VLAN tagging. This topology only defines one path to the network, which has traditionally handled north-south data traffic. The transition to a flat, two-tier leaf-spine hyperscale data center network using up to 800G Ethernet links enables virtualized servers to distribute workflows among many virtual machines, creating a faster, more scalable cloud data center environment.

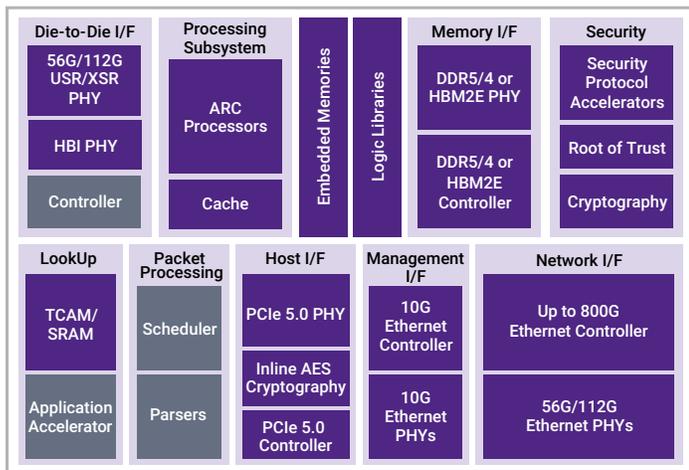
Smart network interface cards (NICs) combine hardware, programmable AI acceleration, and security resources to offload server processors, freeing the processors to run applications. Integrated security, including a root of trust, protects coefficient and biometric data as it moves to and from local memories. Smart NICs accelerate embedded virtual switch, transport offloads, and protocol overlay encapsulation/decapsulation such as NVGRE, VXLAN and MPLS. By offering dedicated hardware offloads including NVMe-over-Fabric (NVMeoF) protocols, Smart NICs free the server CPU to focus compute cycles on cloud application software and enable efficient data sharing across nodes for HPC workloads.

Network switch SoCs enable cloud data center top-of-rack and end-of-row switches and routers to scale port densities and speeds to quickly adapt to changing cloud application workloads. By scaling port speeds from 10Gb Ethernet to 400/800G Ethernet and extending port densities from dozens to hundreds of ports, the latest generation Ethernet switch SoCs must scale to provide lowest latency and highest throughput flow control and traffic management. Synopsys' DesignWare Interface IP portfolio supports high-performance protocols such as Ethernet, PCI Express, CXL, CCIX, USB, DDR, and HBM. DesignWare Interface IP is optimized to help designers meet the high-throughput, low-latency connectivity needs of cloud computing networking applications. Synopsys' Foundation IP offers configurable embedded memories for performance, power, and area, as well as high-speed logic libraries for all processor cores.

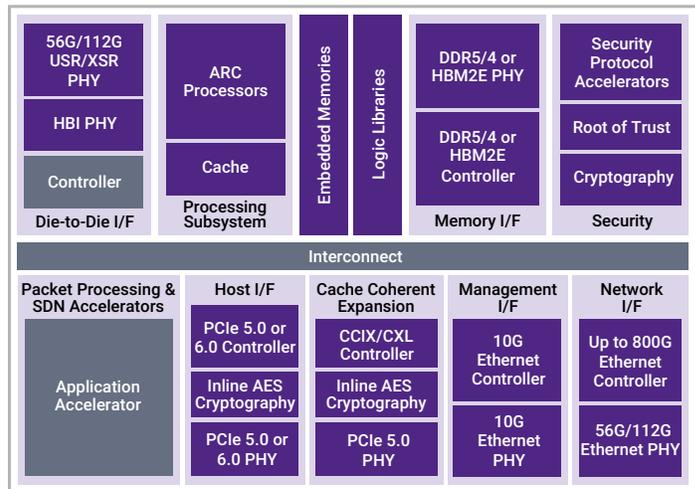
Communication service providers are turning towards server virtualization to increase efficiency, flexibility, and agility to optimize network packet processing. The latest communications architecture uses Open vSwitch Offloads (OVS), OVS over Data Plane Development Kits (DPDK), network overlay virtualization, SR-IOV, and RDMA to enable software defined data center and Network Function Virtualization (NFV), accelerating communications infrastructure. To achieve higher performance, communications network processors can accelerate OVS offloads for efficiency and security. Synopsys provides a portfolio of high-speed interface IP including DDR, HBM, Ethernet for up to 800G links, CXL for cache coherency, and PCI Express for up to 64GT/s data rates. DesignWare Security IP enables the highest levels of security encryption, and embedded ARC processors offer fast, energy-efficient solutions to meet throughput and QoS requirements. Synopsys' Foundation IP delivers low-latency embedded memories with standard and ultra-low leakage libraries for a range of cloud processors.



IP for Smart NIC in cloud computing network



IP for cloud computing network switch



IP for communication network processors

Benefits of Synopsys DesignWare IP for Cloud Computing Networking

- Synopsys’ portfolio of IP in advanced foundry processes, supporting high-speed protocols such as DDR, HBM, Ethernet, USB, CCIX, CXL, and PCI Express, are optimized to meet the high-throughput, low-latency connectivity needs of hyperscale data center networking and cloud communications network processor applications
- Low latency embedded memories with standard and ultra-low leakage libraries, optimized for a range of cloud processors, provide a power- and performance- efficient foundation for SoCs
- Configurable AMBA interconnects with a library of peripheral components deliver SoC design flexibility and minimize design complexity
- Highly integrated, standards-based security IP solutions enable the most efficient silicon design and highest levels of security encryption
- ARC processors, supported by a broad spectrum of 3rd-party tools, operating systems and middleware from leading industry vendors, offer high-speed, energy-efficient IP to meet throughput and QoS

Storage

NVMe-based Solid-State Drives (SSDs) can utilize a PCIe interface to directly connect to the server CPU and function as a cache accelerator allowing frequently accessed data, or “hot” data, to be cached extremely fast. High-performance PCIe-based NVMe SSDs with extremely efficient input/output operation and low-read latency improve server efficiency and avoid having to access the data through an external storage device. NVMe SSD server acceleration is ideal for high transaction applications such as AI acceleration or database queries queries, as well as HPC workloads that require high-performance, low-latency access to large data sets. PCIe-based NVMe SSDs not only reduce power and cost but also minimize area compared to hard disk drives (HDDs). Synopsys’ portfolio of DesignWare Interface IP for advanced foundry processes, supporting high-speed protocols such as PCI Express, USB, and DDR, are optimized to help designers meet their high-throughput, low-power, and low-latency connectivity for cloud computing storage applications. Synopsys’ Foundation IP offers configurable embedded memories for performance, power, and area, as well as high-speed logic libraries for all processor cores. Synopsys also provides processor IP ideally suited for flash SSDs.

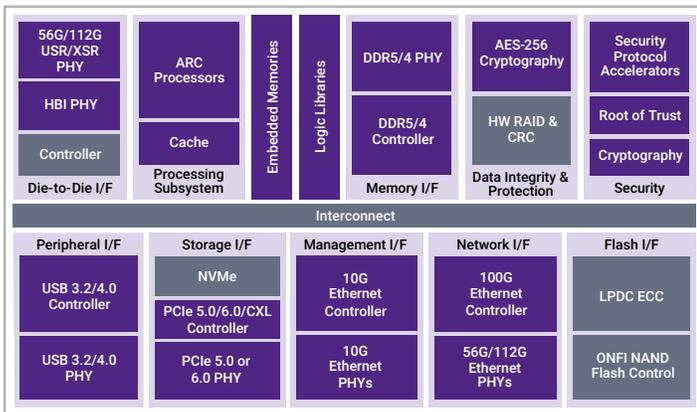


Figure 6: IP for cloud computing storage

Benefits of Synopsys DesignWare IP for Cloud Storage

- High-performance, low-latency PCI Express controllers and PHYs supporting data rates up to 64GT/s enable NVMe-based SSDs
- High-performance, low-power ARC processors support fast read/write speeds for NVMe-based SSDs
- Portfolio of interface IP including Ethernet, USB, PCI Express, and DDR provides low latency and fast read/write operations

Interface IP	
Ethernet Controller and PHY	NRZ and PAM-4 112G and 56G Ethernet PHYs and configurable controllers for up to 800G hyperscale data center SoCs
DDR5/4 Controller and PHY	DDR memory interface controllers and PHYs supporting system performance up to 6400 Mbps, share main memory with compute offload engines plus network and storage I/O resources
HBM2/2E PHY	HBM2/2E IP allows high memory throughput with minimal power consumption
USB Controller and PHY	Complete USB IP solution reduces engineering effort while reducing area
PCI Express Controller and PHY	High-performance, low-latency PCI Express controllers and PHYs supporting data rates up to 64GT/s enables real-time data connectivity and NVMe SSDs and SD Express cards
Compute Express Link (CXL) Controller and PCIe 5.0 PHY	Very high-bandwidth with extremely low latency IP supporting all three CXL protocols (CXL.io, CXL.cache, CXL.mem) and device types
CCIX Controller and PHY	CCIX IP solutions support data transfer speeds up to 32 Gbps and cache coherency for faster data access
Security IP	
Security IP	Highly integrated, standards-based security IP solutions enable the most efficient silicon design and highest levels of security
Foundation IP	
Embedded Memories and Logic Libraries	Low latency embedded memories with standard and ultra-low leakage libraries provide a power- and performance-efficient foundation for SoCs
Processor IP	
ARC HS Processors	Highly scalable ARC HS processors provide the high performance and energy efficiency required for network control plane processing, computational storage, AI co-processing, and other embedded processor applications in the cloud

About DesignWare IP

Synopsys is a leading provider of high-quality, silicon-proven IP solutions for SoC designs. The broad DesignWare IP portfolio includes [logic libraries](#), [embedded memories](#), [PVT sensors](#), [embedded test](#), [analog IP](#), [wired and wireless interface IP](#), [security IP](#), [embedded processors](#), and [subsystems](#). To accelerate prototyping, software development and integration of IP into SoCs, Synopsys' [IP Accelerated initiative](#) offers [IP prototyping kits](#), IP software development kits, and [IP subsystems](#). Synopsys' extensive investment in IP quality, comprehensive technical support and robust IP development methodology enable designers to reduce integration risk and accelerate time-to-market.

For more information on DesignWare IP, visit synopsys.com/designware.