

IC Manage Holodeck Enables Microsoft Azure for Semiconductor Design

Abstract

The great expansion of data for semiconductor design poses great challenges for project management and IT Infrastructure. Design teams will need to leverage cloud compute resources to meet project schedules and optimize infrastructure costs.

This paper covers how to use IC Manage Holodeck for accelerating Electronic Design Automation (EDA) jobs on Microsoft Azure while reducing IT infrastructure and cloud computing costs with instant hybrid cloud bursting.

Specifically, solutions will be presented for:

- Running EDA jobs in Azure in minutes without data migration or workflow modification
- Minimizing the cost of cloud storage while maximizing EDA application performance
- Hybrid cloud customer examples with IC Manage Holodeck and its unique scale out storage caching architecture

Challenges Created by Data Explosion (Source Data, Derived Data and Metadata)

- Managing the data mobility of EDA databases approaching petabyte
- Increasing cost of IT infrastructure for compute and storage

Technology Trends Providing Opportunities to Address Broken EDA Paradigm

- HPC architectures with 100+ threaded CPUs and massive CPU cycles/second
- Access to near infinite cloud CPUs across the globe
- High speed, commodity NVMe storage with reduced latency and input/output (I/O) scale out

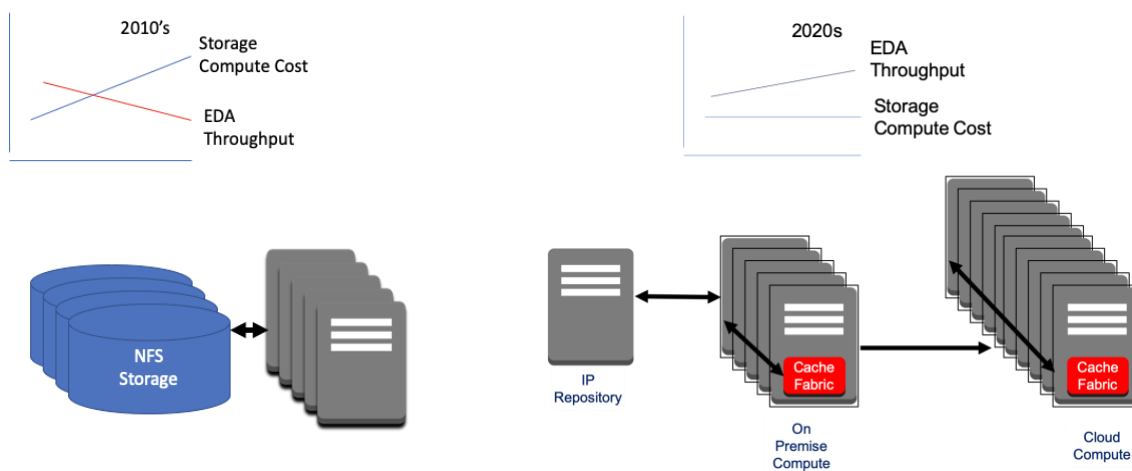
Introduction

Over the past decade, IC and system designs have grown multifold in complexity, from size of the chips and impact of physical phenomena on their performance to the sheer number of engineers involved in bringing the design to production. It is not uncommon to find hardware design teams, each with 100s of engineers spread across multiple companies and continents working on a complex system project. Source data, derived data and metadata (process, status, analytics) have caused data explosions to petabyte size as designs move toward 7nm and below.

Limitations of EDA workflows based on a limited set of tools, proprietary flows and shared storage with complex dependencies are creating major challenges to improve or evolve the IT infrastructure. The high cost of capital acquisition and insufficient IT infrastructure are creating major challenges for semiconductor companies to progress.

These trends will continue to have a significant impact on how design teams effectively manage their projects.

Microsoft Azure has deployed the latest High Performance Computing (HPC) architectures with massive CPU cycles/second, access to latest CPU available in large pool, across many geographical regions and provided high speed storage such as NVMe with reduced latency. IC Manage has worked close with Azure to integrate these capabilities with IC Manage's Holodeck software defined solution to improve the EDA paradigm centered on shared NFS-based environments. Augmenting the large pool compute capacity provided by Azure, Holodeck provides an integrated data orchestration platform that efficiently brings data closer to compute across Azure clusters, regions and countries.



EDA Job Acceleration – Extending IT Infrastructure with Microsoft Azure

Traditionally, IC design methodology uses compute farms to access shared data on large NFS file servers. However, this approach imposes high capital costs for fixed storage assets and data I/O bottlenecks that dramatically reduce compute efficiency. Storage I/O bottlenecks also result in higher cost of running EDA tools.

Why Costs of Running EDA Tools and NFS Storage is Rising

- Compute farms accessing shared data on large NFS filers results in data I/O bottlenecks, dramatically reducing compute efficiency
- Workspaces of source and generated data is approaching multiple terabytes to petabyte, resulting in significant capital costs for NFS storage systems
- Sheer size of workspace data prevents parallelizing EDA workflows, forcing EDA jobs to run serially

IC design workspaces contain both source data and data generated from EDA workflows. Nearly 90 percent of the workspace data is derived from multiple stages of the design process such as functional verification, layout, place and route, timing and power analysis, optimization, and regressions. The combined workspace for a full System on Chip (SoC) can approach 100s of terabytes and will continue to grow exponentially with each technology node. The sheer size of workspace data prevents us from easily parallelizing EDA jobs, since there are not enough on-premise compute resources nor excess storage to enable parallelization. Azure compute resources enable parallelization by making 1000s of compute nodes available for as long as needed and IC Manage Holodeck virtualizes cloud storage for jobs to run in as many parallel workspaces as needed.

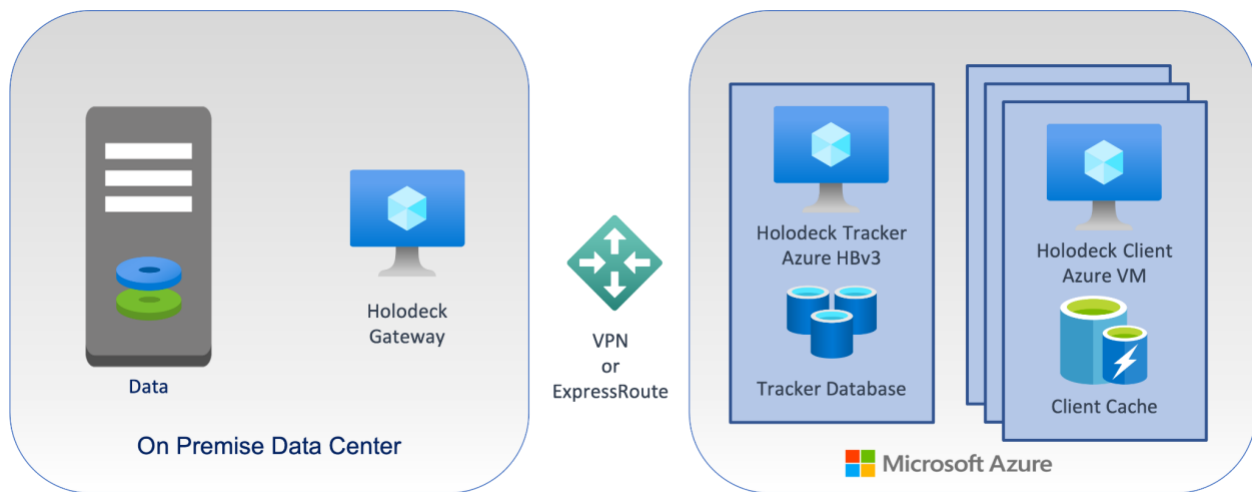
Available cloud caching solutions provide some storage efficiency, but limited I/O read and especially I/O write performance that is needed to keep up as compute capacity is scaled out. IC Manage Holodeck uses the NVMe storage available on Azure compute instances as high-speed local file caches along with peer-to-peer network communication to achieve higher read and write performance. The Holodeck Peer-to-Peer networked cache allows all nodes in the Azure region to dynamically share data as compute capacity is added.

Faster I/O Performance and Lower IT Infrastructure Cost with Azure and Holodeck

- Holodeck/s scale out storage architecture leverages Azure's large network of inexpensive local NVMe to deliver 100s of GB/sec I/O performance
- Peer-to-peer network communication along with high-speed local file caches improves aggregate read/write performance and eliminates duplicate NFS storage cost

On-Demand Azure Hybrid Cloud Bursting with IC Manage Holodeck

The capacity of on-premise compute alone is not sufficient in keeping up with the demands of today's designs and aggressive project schedules. Increasing on-premise capacity can be a very time consuming and expensive proposition, sometimes taking up to 6 months to bring needed compute capacity online. Design teams want to run 100s to 1,000s of jobs immediately, creating a pent-up demand for elastic compute power. IC Manage and Azure's engineering teams have collaborated to enable design teams to take advantage of Azure's large pool of compute resources, state of the art servers and networking to enable high performance elastic compute and instantly add compute resources. However, moving a design workspace with up to 100s of terabytes to Azure is not a trivial task.



Chip design and verification workflows are very complex with multiple, interdependent NFS environments, usually comprising 10s of millions of files, spanning 100+ terabytes to petabytes of storage when we include all the EDA tools and scripts, foundry PDKs, design data. Enabling Azure to run all the workflows and jobs can be daunting without a means to easily and efficiently synchronize these 10s of millions of interdependent on-premises files across domains. Using software such as rsync or ftp can be very slow and costly to move 100s of terabytes of data to the cloud, essentially eliminating any ability to gain fast access to Azure's compute resources. While very large NFS storage is available in Azure, the cost of storage adds up quickly, especially if duplicate copies of the design are maintained on both on-premise and in Azure. Trying to determine the correct subset of design data to copy to Azure is extremely hard due to all the interdependencies between the data and legacy workflow scripts. More importantly, on-premise EDA tools and workflows are built on an NFS-based shared storage model, where large numbers of compute nodes share the same data. Just like on-premise NFS, scaling shared cloud storage to support 1000s of compute nodes is very challenging.

Challenges of Running EDA Workflows in the Cloud

- Complex workflows with interconnected NFS environments comprising 10s of millions of files across 100s of terabytes of storage with no means to easily and efficiently synchronize across domains
- Maintaining duplicate copies of the design on both on-premise and cloud environments resulting in significant cloud storage cost
- Infrastructure disparity between on-premise EDA tools and workflows built on NFS-based shared storage model and the cloud's local block storage model

The combination of IC Manage Holodeck and Azure compute nodes provides a cost effective and time efficient solution for on-demand hybrid cloud bursting of existing on-premises workflows which run identically in the cloud, enabling elastic high-performance compute by taking advantage of Azure’s compute power with local NVMe storage. The ability to automatically run jobs in the cloud using unmodified on-premise workflows helps preserve millions of dollars and person-hours already invested in on-premise EDA tools, scripts, and methodologies. Engineering jobs can ‘cloud burst’ to Azure during times of peak demand, providing capacity in a transparent fashion.

CUSTOMER EXAMPLE: STATIC TIMING ANALYSIS

Metric	Holodeck	Without Holodeck	Holodeck Reduction
Time to Start 1 st Job	10 min	19 days	99.9%
CPU	35 hours*	60 hours	41%
Storage	2TB	200TB	99%

IC Manage Holodeck peer-to-peer cache fabric scales out I/O performance by simply adding more compute nodes as peers. Storing the needed portions of the design workspace in the cache fabric eliminates the need for duplicate NFS storage in the cloud. Once caches in the Azure are hot, they can be fully decoupled from the on-premise environment, reducing storage cost and minimizing NFS filer performance bottlenecks. Since Holodeck works at the file extent level, data is transferred with ultra-fine granularity, delivering low latency bursting. **Only bytes that are accessed by the are forwarded to Azure compute nodes** and selectively filtered design data deltas are written back to on-premises storage for post processing, if necessary. Not having to duplicate all on-premise data significantly reduces the cloud data storage costs, sometimes by as much as 99%. By using temporary cache storage, all data disappears leaving no trace, at the moment that the Azure environment is shut down after jobs are completed. Azure compute nodes can also be shut down upon job completion to ensure that there are no bills for idle CPUs.

SCALE OUT EXAMPLE: VERILOG SIMULATION - 2,015 Regression Tests

Metric	Holodeck (50 Nodes*)	Without Holodeck (1 Node on Premise, Upload Time to Cloud)	Holodeck Reduction
Time to Start 1 st Job	8 sec	19 min	99%
Runtime	6.5min	210 minutes	98%
Storage	74MB	1.3GB	94%

Conclusion

A scale out architecture utilizing Azure compute instances with local NVMe as a peer-to-peer cache network enables high performance elastic computing for EDA tool acceleration. IC Manage Holodeck hybrid cloud bursting provides immediate and transparent access to Azure's compute capacity. Virtually projecting on-premise storage to the cloud enables instant bursting, reducing cloud storage cost as well as eliminating NFS filer bottlenecks.

The combination of IC Manage Holodeck and Microsoft Azure provides a unique solution for semiconductor design teams to extend their compute resources quickly and transparently to overcome the complexities presented by design, verification and integration.

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