Keysight AI Data Center Builder

Design, validate and benchmark AI data center infrastructure with emulated AI workloads

Introduction

The Keysight AI Data Center Builder (KAI DC Builder) is a robust evaluation and benchmarking solution that helps you improve interconnect performance in AI / ML systems. Designed for fast deployment and streamlined operations, it provides deep insights into performance characteristics of backend network fabrics to identify bottlenecks, increase throughput, and optimize the overall efficiency of your AI systems.

To accelerate AI / ML network design, the KAI DC Builder:

- **Emulates realistic high-scale AI workloads** — Reduce dependency on large GPU clusters for infrastructure experimentation and validation.
- **Simplifies the benchmarking process** — Validate AI network fabric with pre-packaged benchmark applications and dataset analysis tools.
- **Offers a choice of Test Platforms** — Choose between (1) RoCEv2 endpoint emulation on high-density AresONE traffic load appliances, (2) software endpoints on servers equipped with RDMA NICs, or (3) real AI accelerators.

The solution can complement, minimize or even replace GPU usage in AI cluster infrastructure performance testing, enabling AI operators to reduce the spending they would otherwise allocate entirely to GPU-based benchmarking systems.

KEYSIGHT

Highlights

- Run Collective Benchmarks application to evaluate AI cluster communication performance
- Tune RDMA network and NIC performance using workload and host emulation controls
- Test collective operations including:
  - AllReduce, AllGather, ReduceScatter, AlltoAll, Broadcast, Gather
  - Unidirectional and Bidirectional Ring, Halving-Doubling AllReduce algorithms
  - Parallel and PXN AlltoAll algorithms
- Emulate multi-GPU host environments with scale-up interconnects
- Simulate RDMA endpoints with Keysight AresONE hardware for realistic traffic generation
  - RoCEv2 RC mode
  - 100GE, 200GE, 400GE, 800GE interface speeds
  - NRZ, PAM4 53GE and 106GE serdes
- Include RDMA NICs as part of the system under test

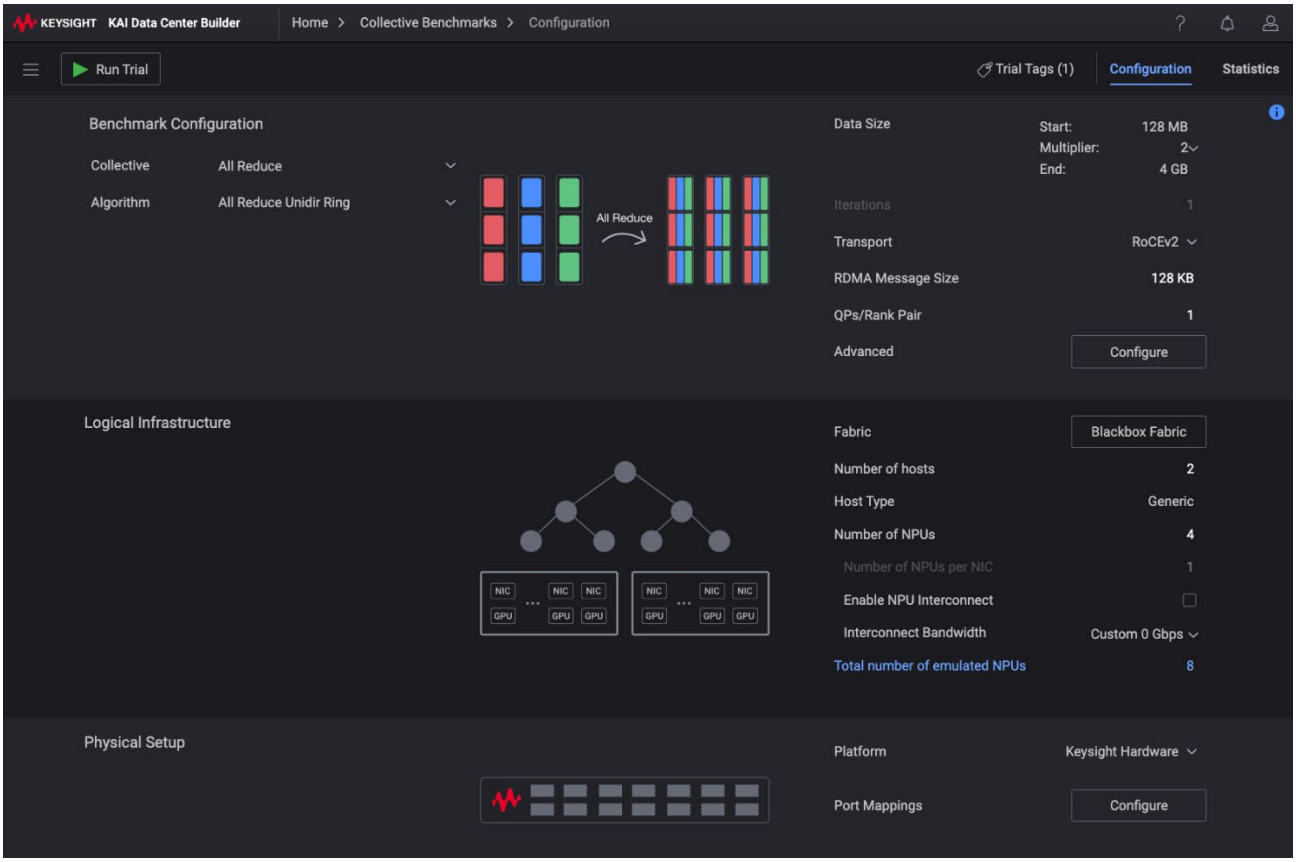

Figure 1. Collective benchmarks application configuration

Topologies

KAI DC Builder supports emulation of AI hosts connected to a scale-out (backend) network fabric to benchmark and validate performance of:

1. Network fabric — when using Keysight hardware test ports
2. Network fabric and NICs — when using Keysight software test ports

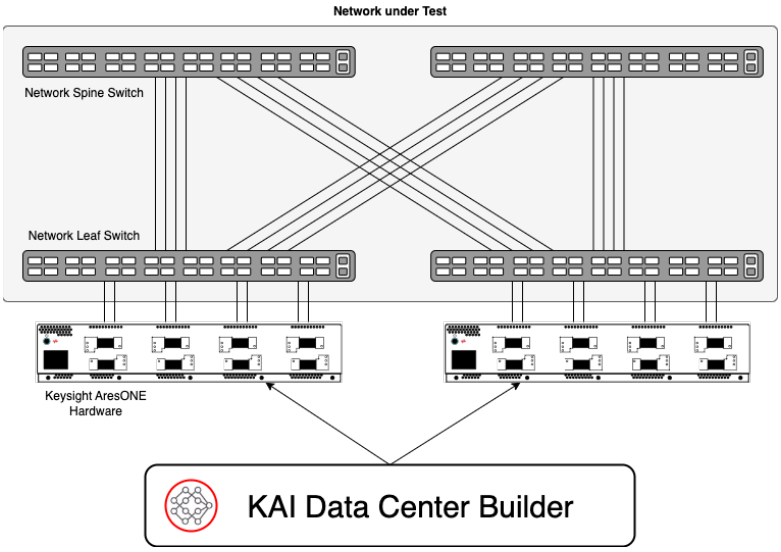

Figure 2. Network under Test Topology with Keysight hardware

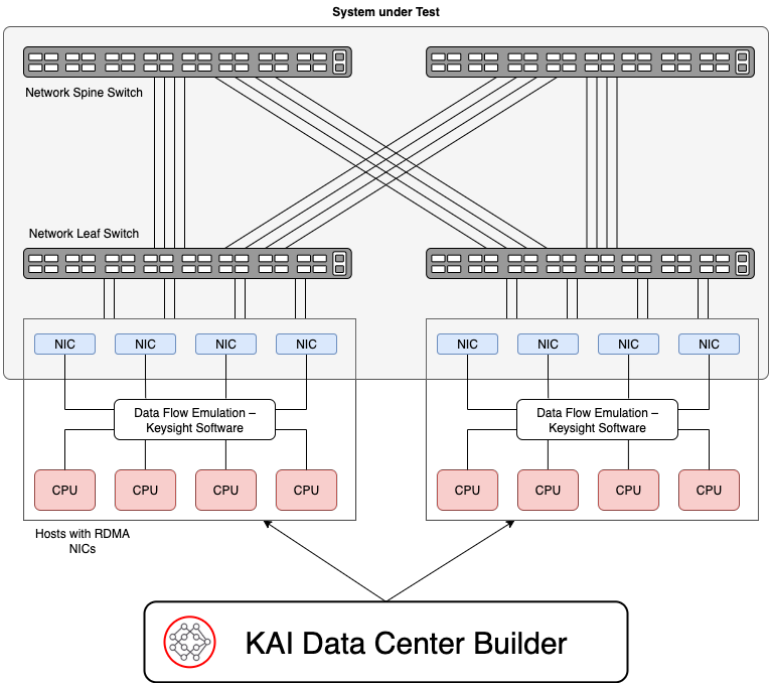

Figure 3. System Under Test Topology with Keysight software

Applications

The KAI DC Builder enables users to run applications that specialize in measuring or analyzing various aspects of the AI infrastructure.

KAI DC builder applications

Application	Function	Description
Collective Benchmarks	Single collective operation micro-benchmark	Benchmark collective operations — distributed communication algorithms commonly used in scaled-out AI and HPC systems. The typical objective of using the Collective Benchmarks app is to ensure the network can provide the optimal and consistent bandwidth for a range of data exchanges expected from the distributed AI jobs.

Index	Data Size	Collective	Completion Time (ms)	Algbw (GB/s)	Busbw (GB/s)	Ideal (%)	PFC Rx	ECN CE Rx	Frames ReTx	Min FCT (ms)	P50 FCT (ms)	P95 FCT (ms)	Max FCT (ms)
1	128.00 MB	ALL_TO_ALL-1	7.936	16.91	14.80	30.05	0	1458	0	7.220	7.720	7.910	7.936
2	256.00 MB	ALL_TO_ALL-2	15.362	17.47	15.29	31.05	2	1982	0	14.858	15.150	15.300	15.362
3	512.00 MB	ALL_TO_ALL-3	30.103	17.83	15.61	31.69	0	1787	0	28.978	29.582	29.799	30.103
4	1,024.00 MB	ALL_TO_ALL-4	58.697	18.29	16.01	32.50	0	2154	0	55.448	57.516	58.650	58.697
5	2,048.00 MB	ALL_TO_ALL-5	113.709	18.89	16.53	33.55	2	2720	0	105.642	109.996	112.258	113.708
6	4,096.00 MB	ALL_TO_ALL-6	221.121	19.42	17.00	34.51	0	3371	0	189.554	208.750	218.249	221.121

Figure 4. Collective benchmarks results summary table

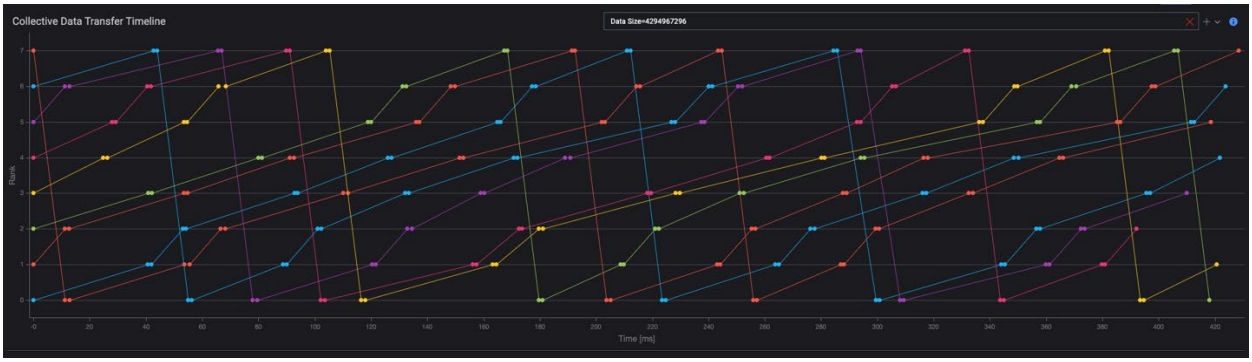

Figure 5. AllReduce data chunk timeline

Users, controller, UI, API

Users interact with the KAI DC Builder through a Web UI to define and control a trial. The KAI DC Builder's DSE Controller provides the Web UI. Test automation programs interact with the DSE Controller via the northbound API. The DSE Controller coordinates execution of the test by the test platforms, saves the measured metrics into storage and after the trial is finished reports to metrics back to the user or the test program. The APIs exposed by the Controller are universal among all types of test platforms and provide common user experience independent of the type used.

Test platforms

The KAI DC Builder can execute its applications using one of the test platforms.

KAI DC builder test platforms

Test platform	Function	Description
Data Flow Emulation — Keysight hardware	Emulates RDMA transport protocol	Keysight traffic load appliances emulate network protocols and generate synthetic traffic.
Data Flow Emulation — Keysight software	Operates on top of 3rd party RDMA NICs to generate RDMA traffic	General purpose computers with RDMA NICs.
Data Flow Emulation — NCCL™ tests*	Runs nccl-tests software to exercise collective operation micro-benchmarks	Computers with GPUs and RDMA NICs that run NCCL™ library and nccl-tests software.

NOTE: NCCL™ and nccl-tests are developed and maintained by NVIDIA Corporation.*

Product Specifications

Collective benchmarks application

Feature	Specification
Benchmarks	**Supported Parameters**
Workload	A single collective operation at a time, with capability to iterate over multiple data sizes
Workload Configuration	Collective operation type and algorithm
Data Size Configuration	List of data sizes Start and end data size, multiplier
Statistics	**Supported Parameters**
Summary Stats	Collective Completion Time Algorithm bandwidth (algbw) Bus bandwidth (busbw) Ideal % – not supported with NCCL-tests PFC Rx Frames ECN-CE Rx frames Retransmitted (ReTx) Frames – only with Keysight hardware Min/Max/P50/P95 Flow Completion Time (FCT) – not supported with NCCL-tests
Drill Down Stats	Data Chunks table, CDF and timeline plots Flow Stats for Keysight hardware test platform Port Stats

General capabilities

General capabilities of the KAI DC Builder are available across any of its applications and test platforms.

Feature	Specification
Collective operations	**Supported parameters**
Collectives operation types and algorithms	Broadcast Parallel AlltoAll Parallel AlltoAll PXN AllReduce Unidirectional ring AllReduce Bidirectional ring AllReduce Halving foubling AllGather Unidirectional ring Reduce scatter Unidirectional ring Gather Parallel
Collective configuration	Data size 1 KB to 4 TB RDMA message size 1 KB to 256 MB QPs/Rank pair 1 to 16 RDMA verb Write or Send

Feature	Specification	
Logical infrastructure emulation	**Supported parameters**	
Host configuration – Generic type	Number of emulated hosts	Limited by total number of NPUs
	Number of NPUs per emulated host	1 to 8
	Number of NICs per NPU	1
	NPU Interconnect	Enabled or Disabled
	NPU Interconnect bandwidth	User provided value

Data Flow Emulation — Keysight Hardware

Feature	Specification	
Ethernet speeds	800GE PAM4 (106G) 400GE PAM4 (106G, 53G) 200GE PAM4 (106G, 53G) 100GE PAM4 (106G, 53G) 100GE NRZ (25G)	
RDMA transports	RoCEv2 RC Mode	
Layer 1 Settings parameters	Forward Error Correction (FEC) Auto-negotiation Link Training IEEE Defaults	
Ethernet parameters	Ethernet MTU – from 1500 to 9000 MAC Address – auto or manual VLAN ID, 802.1p Priority	
IP Interface parameters	Local IPv4 or IPv6 address (dual stack is not currently supported) Gateway IPv4 or IPv6 address Subnet Prefix (Network mask)	
RDMA Transport parameters	Data DSCP ACK DSCP NACK DSCP	
Congestion control parameters	PFC Enable/Disable PFC Priority for RDMA Traffic Data ECN bits, Control ECN bits, CNP ECN bits, CNP DSCP DCQCN Enable/Disable DCQCN parameters	
RoCEv2 RC mode parameters	Retransmission Timer (ms)	1 to 5,369
	Retransmission Retry Count	1 to 254
	Retransmission on RNR NACK	0 (Infinite), 1 to 1021
	ACK Request:	0 (ACK on last packet only), 1 to 128
Statistics	**Supported parameters**	
QP-level statistics	Bytes Tx/Rx Frames Tx/Rx, Delta RDMA message Tx/Rx, Failed RoCEv2 RC ACK/NACK Tx/Rx ECN CE Rx, CNP Tx/Rx Frame Sequence error	

Data Flow Emulation — NCCL-Tests Engine

Feature	Specification
NCCL parameters	Standard NCCL environmental parameters are configurable

Controller

Feature	Specification
Northbound APIs	API with protobuf data model — configuration, control, metrics
Graphical user interface	Web UI
Session concurrency	Single concurrent trial session per DSE Controller.
Trial concurrency	To execute multiple parallel trials, run multiple copies of the DSE Controller – one per trial.
Controller form factor	Docker container(s). Multiple DSE Controllers can be run in parallel on the same host or VM, using dedicated container namespaces.
Client concurrency	Multiple concurrent clients per single DSE Controller are supported (with limitations). Changes in the configuration made by one user will propagate to all other users. Trial operations (Run, Abort) would be visible to all users.
Trial state ownership	The DSE Controller keeps the state of the test execution, the client shall act in a stateless manner.
Test port ownership	Test ports are reserved by a DSE Controller based on the list of ports specified in its current configuration.
Concurrent trials	Number of concurrently running trials across multiple KAI DC Builder controllers is limited by • available Data Flow Emulation endpoint licenses required across all the trials • available Keysight hardware test ports required across all the trials • available RDMA NICs required across all the trials

Prerequisites and Compatibility

System requirements

System resource	Distributed system emulation controller	Data flow emulation — Keysight software	Data flow emulation — NCCL-Tests
CPU architecture	x86-64	x86-64	x86-64
Operating system	Linux — see documentation for more details	Linux — see documentation for more details	Linux — see documentation for more details
Runtime	Docker CE	N/A	N/A
Recommended CPU	8 cores	16 cores	16 cores, or more if required by NCCL
Recommended GPU	N/A	N/A	One or more hosts with two or more GPUs each: NVIDIA A100 NVIDIA H100 NVIDIA H200
Recommended RAM	8 GB	32 GB	32 GB, or more if required by NCCL
Recommended disk storage	80 GB	16GB	16GB, or more if required by NCCL
RDMA NIC cards	N/A	Broadcom BCM57508 Broadcom BCM57608 NVIDIA ConnectX-5 NVIDIA ConnectX-6 NVIDIA ConnectX-6 Dx NVIDIA ConnectX-7	Broadcom BCM57508 Broadcom BCM57608 NVIDIA ConnectX-5 NVIDIA ConnectX-6 NVIDIA ConnectX-6 Dx NVIDIA ConnectX-7
Software libraries	N/A	Libibverbs — see product documentation for more details	NCCL — see product documentation for more details

Keysight hardware requirements

Requirement	Part numbers
One or more of: AresONE-M 800GE OSFP 8-port full performance fixed chassis model AresONE-M 800GE OSFP 4-port full performance fixed chassis model AresONE-M 800GE QSFP-DD800 8-port full performance fixed chassis model AresONE-M 800GE QSFP-DD800 4-port full performance fixed chassis model AresONE-S 400GE QSFP-DD 16-port full performance fixed chassis model AresONE-S 400GE QSFP-DD 8-port full performance fixed chassis model Reduced performance AresONE models are not supported. Other AresONE generations and configurations of are not supported.	Consult with AresONE hardware data sheets.
Keysight RoCEv2 Lossless Ethernet Enablement	905-1092 (factory installed) or 905-1093 (field upgrade)
An alternative to the above is to use **Keysight AI Fabric Test Solution bundles** to purchase compatible AresONE hardware with factory installed RoCEv2 Lossless Ethernet Enablement	Consult with **Keysight AI Fabric Test Solution** data sheet.
Optional: Keysight IxNetwork RoCEv2 Lossless Ethernet Test Package for AresONE-S 400GE and AresONE-M 800GE fixed chassis models	930-2208

Ordering Information

Licensing

Feature	Licenses required	Quantity
Run Collective Benchmarks App trial	Collective Benchmarks App	Uncounted
Emulate RDMA NICs with Data Flow Emulation — Keysight Hardware	Data Flow Emulation — Universal Transport Endpoints	Number of concurrent endpoints (NICs)
Use RDMA NICs with Data Flow Emulation — Keysight Software	Data Flow Emulation — Universal Transport Endpoints	Number of concurrent endpoints (NICs)
Run NCCL-Tests with Data Flow Emulation — Keysight Software	Data Flow Emulation — Universal Transport Endpoints	Number of concurrent endpoints (NICs)

Demo mode: KAI DC Builder applications can be used to view the results of the previous trials, without a valid license.

Part numbers

P/N	Description	Includes
	Bundles	
950-2001	KAI Data Center Builder Start bundle - Collective Benchmarks application, uncounted license; Data Flow Emulation plugin, 16 universal transport endpoints. (12-Months Floating Worldwide License, Keysight software support subscription). Requires license term to be specified (must be purchased in multiples of years, list price is per unit per year). TAA Compliant.	Collective Benchmarks App, uncounted license* Data Flow Emulation — Universal Transport Endpoints, Qty 16
	Individual licenses	
950-2101	KAI Data Center Builder - Collective Benchmarks application, uncounted license. (12-Months Floating Worldwide License, Keysight software support subscription). Requires license term to be specified (must be purchased in multiples of years, list price is per unit per year). TAA Compliant.	Collective Benchmarks App, uncounted license*
950-2201	KAI Data Center Builder - Data Flow Emulation plugin, 16 universal transport endpoints. (12-Months Floating Worldwide License, Keysight software support subscription). Requires license term to be specified (must be purchased in multiples of years, list price is per unit per year). TAA Compliant.	Data Flow Emulation — Universal Transport Endpoints, Qty 16

*) **Uncounted license** applies to the licensed capabilities for which consumption is **uncounted** — only presence of the license on a license server is checked, without counting how many are currently in use or consumed. The uncounted licenses require activation on a license server prior to use to make them available to KAI Data Center Builder instances. It is the customer's responsibility to provide network connectivity between the KAI Data Center Builder instances and the license server with the activated licenses for license validation. If such connectivity cannot be provided for certain users in the customer environment, a customer must deploy additional license server(s) and purchase additional uncounted license(s) to activate them on such license server(s).

Further Information

Product page: https://www.keysight.com/us/en/products/network-test/protocol-load-test/kai-data-center-builder.html

Downloads and documentation: https://support.ixiacom.com/kai-data-center-builder

Keysight AI Fabric RoCEv2 Test Solution: https://www.keysight.com/us/en/assets/3124-1126/data-sheets/Keysight-AI-Fabric-Test-Solution.pdf