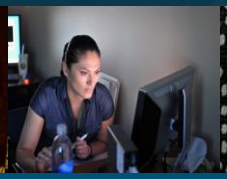
SC 2019



David J. Martinez

Sandia National Laboratories

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Liquid Cooling Close Coupled Systems

400 watt CPUs and 2000 watt servers are coming, air can't do it (at 5000 ft), and liquid is more efficient.

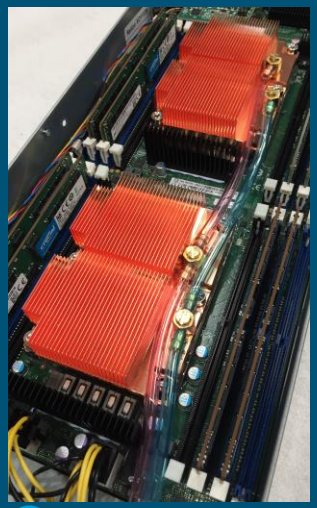
Liquid cold plate on the chip negative pressure hybrid~70% heat capture to liquid

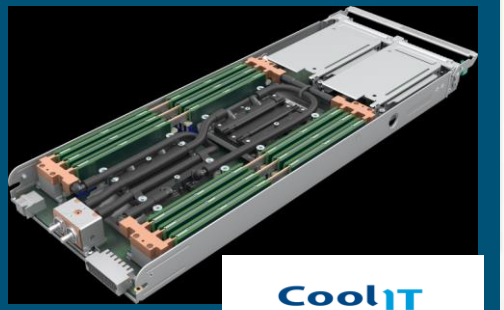
Liquid cold plate on the chip positive pressure ~65% heat captured to liquid

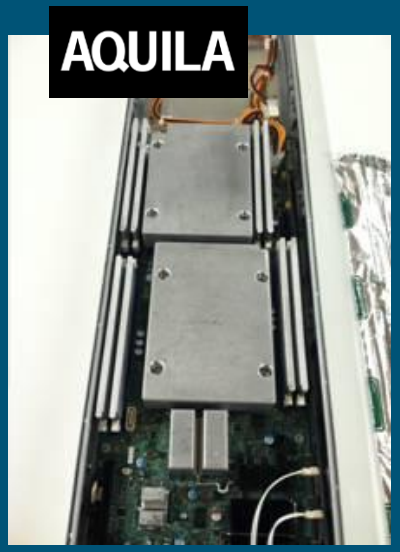
Plate cooling technology indirect cooling with thermal interface 90% heat capture to liquid

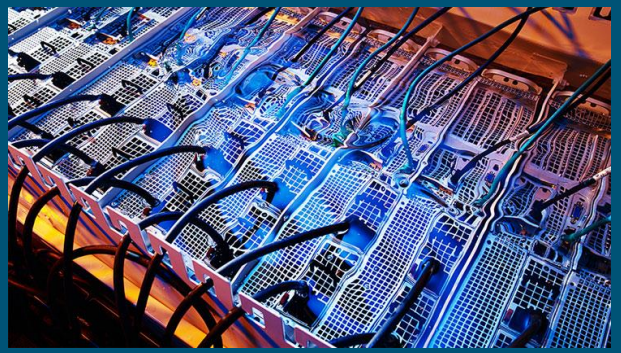
Immersion cooling – dielectric fluid with total board submerged with ~100% heat capture liquid

All good solutions with warm water some are less maintenance and less initial infrastructure cost ,several advantages vs disadvantages all solutions are more effective in heat capture than current air solutions along with less OPEX.







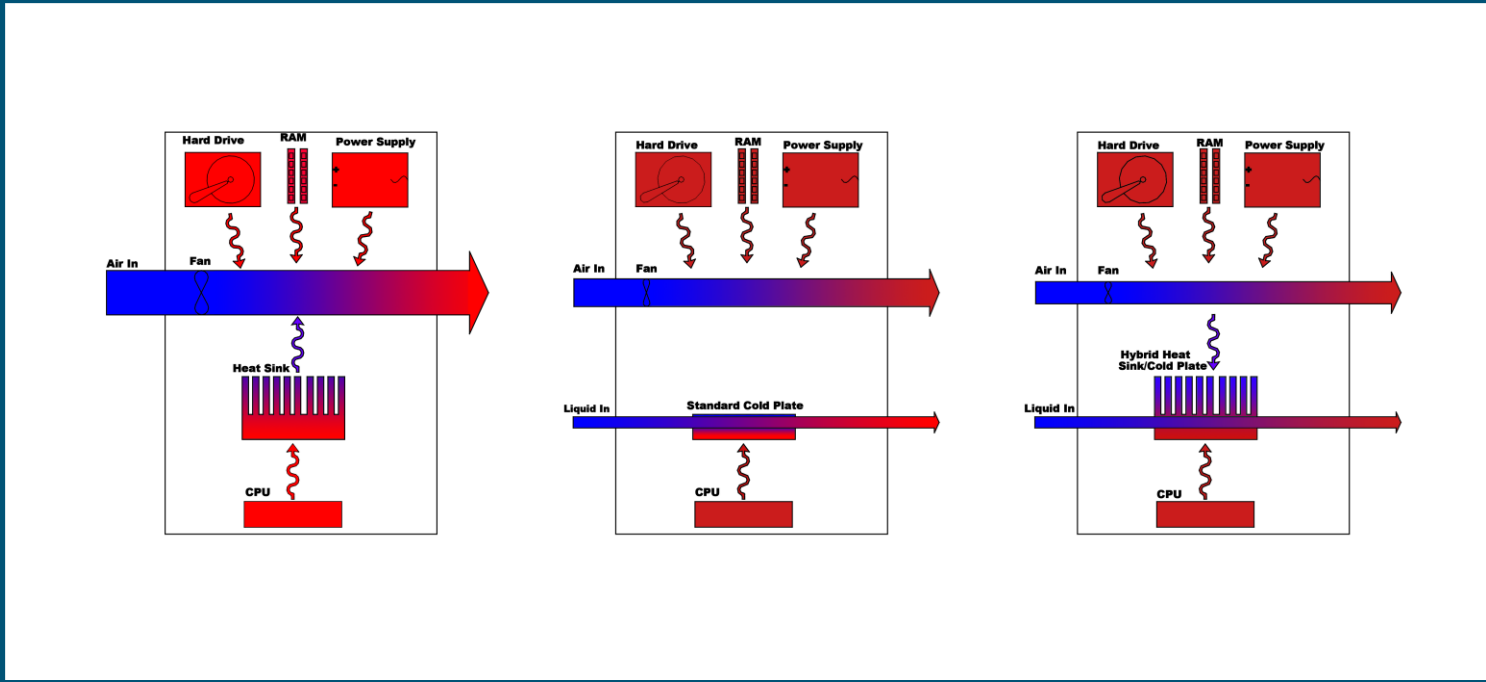


Liquid Cooling Close Coupled Systems

Air Cooled 0%

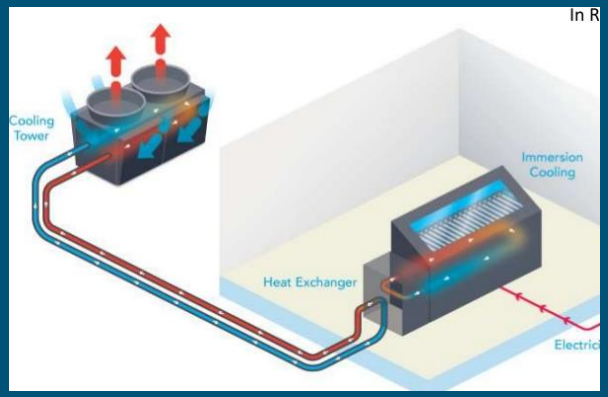
Water Cooled 60%

Hybrid Cooled 70%

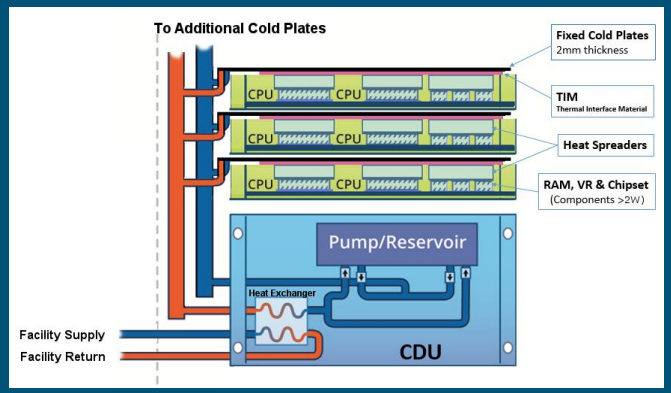


Immersion 100%

Contact Cooled 90%



<- Warranty ? ->



ATTAWAY COMPUTER SYSTEM

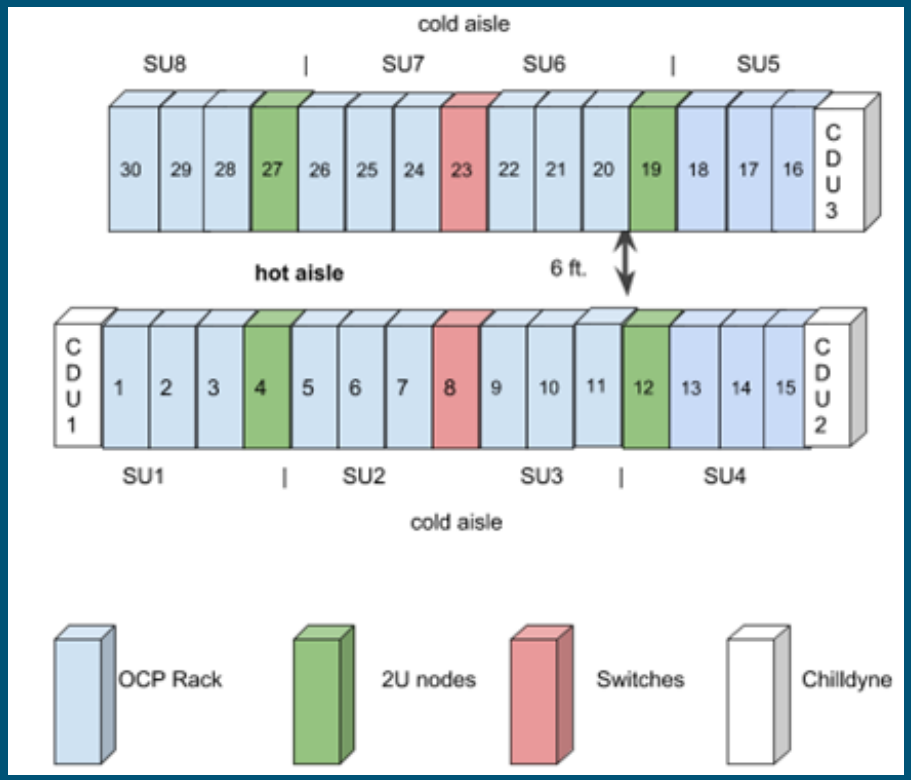
1,488 compute nodes (8 scalable units)
- 1.93 PFLOPs fastest cluster at Sandia

2.3 GHz processors
- Nodes have dual sockets with 18 cores each
- Intel Xeon Gold 6140 "Skylake"
- ~1.3 TFLOPs per node!

192 GB RAM per node (5.3 GB per core)

Intel Omni-Path high speed interconnect
- 2:1 oversubscription
- Mellanox ConnectX4 HCA's in IO nodes

Penguin Tundra™ hardware platform
- Open Compute (OC) 21" racks
- 3 nodes compute nodes slotted in 1 Open Unit (OU)

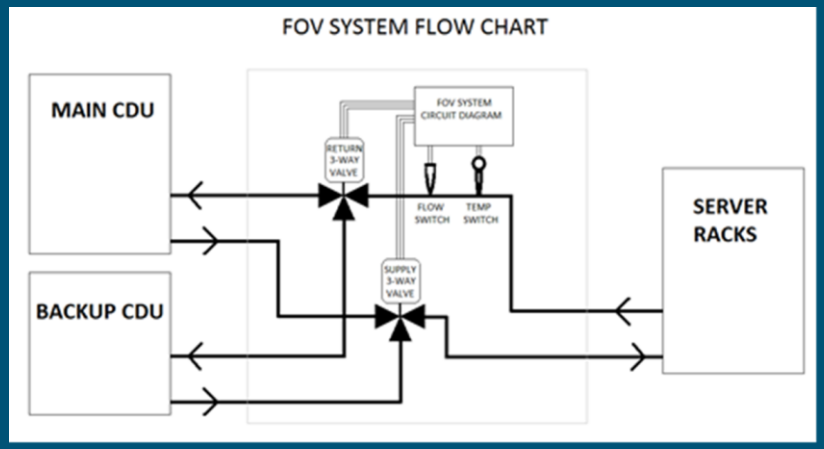


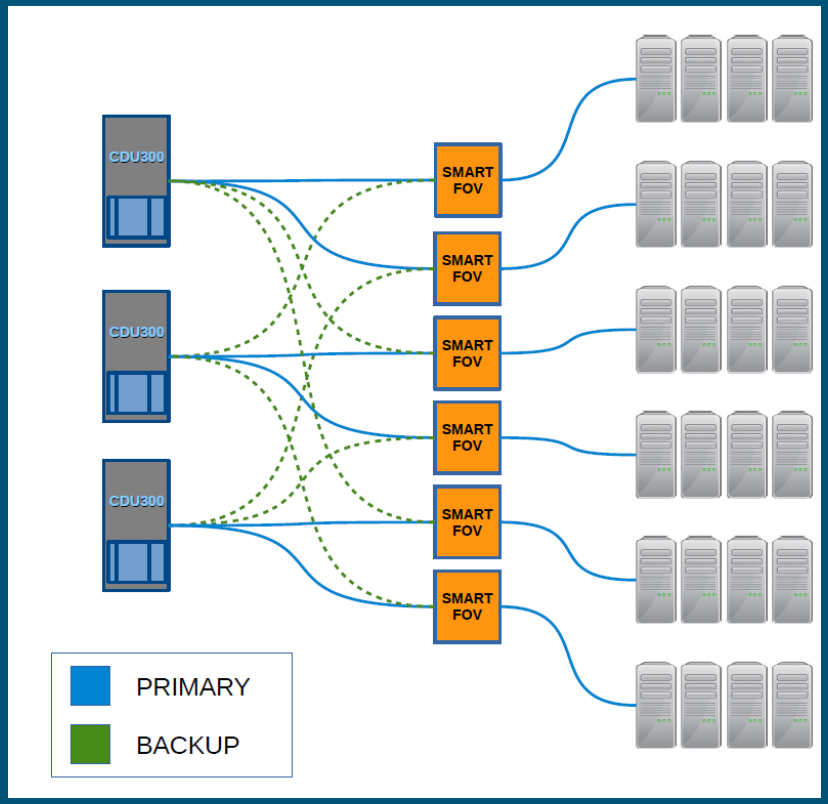
Next generation water cooling:
- Processors are directly cooled by hybrid cold plate. Fins provide additional air cooling/heat exchange
- Floor based CDU's provide negative pressure to prevent leaks and improve resilience.
- Automatic fail over valves deliver N+1 redundancy so any CDU failure will not cause downtime

ATTAWAY Redundant Liquid Cooling

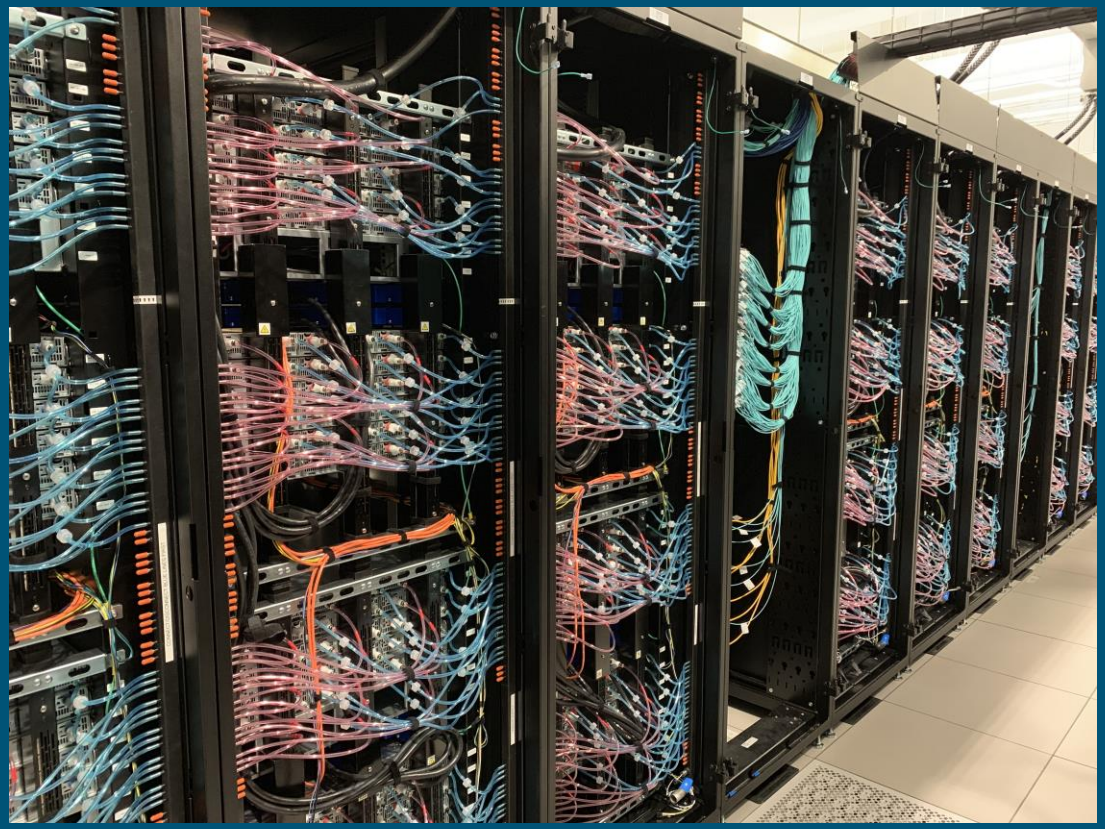
24 racks in 6 sets of 4 racks, cooled by 3 CDUs.

- Each CDU cools 8 racks under normal conditions, 12 racks if fail over occurs.
- 6 fail over valves each connected to 2 CDUs, primary and backup.
- If the temperature is too high or the flow is too low, the valve switches its set of racks from main to back up
- Valves are controlled and monitored via SNMP, and stores data retrieved via FTP.
- Valves can be reset via SNMP or by power cycling.





Attaway Computer System



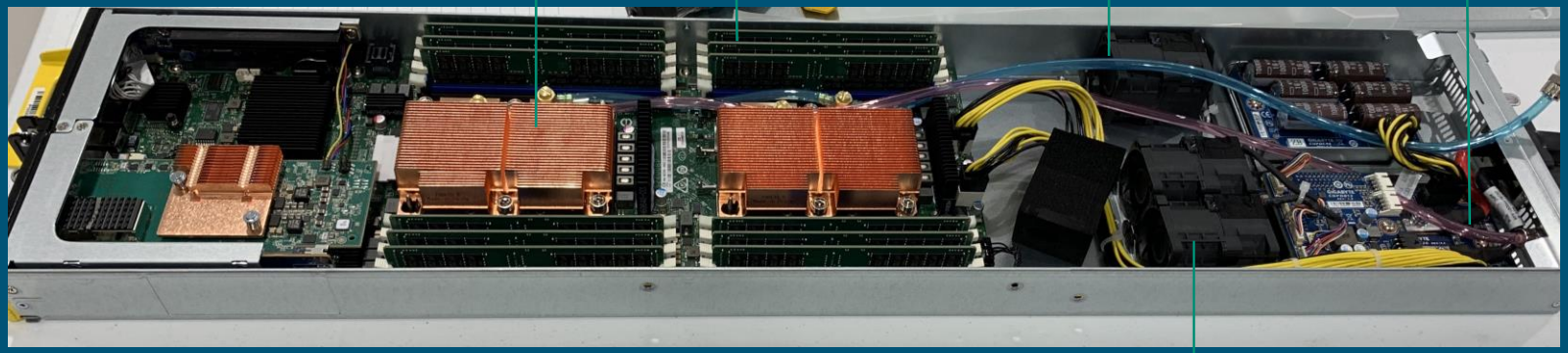
24 OCP compute racks 6 sys administrative racks

480 volt 60 amp per rack ~30 kW per rack 12 volt DC

70% liquid cooled medium temp supply water 70 F return water ~90 F entering air temp 78 F

Reverse Osmosis (RO) process water with rust inhibitor and biocides Automatic water quality monitoring. Automatic fill and drain when racks are connected or disconnected.

Node For New Attaway Computer



Works air cooled if liquid cooling is not connected. Finned cold plates can capture heat from air in addition to heat from CPUs.

CDU

The CDU is a negative pressure chamber pump system, similar to a pneumatic ejector.

1. Pump Chambers

Pump consists of Auxiliary Reservoir and Main pumping chambers. The system pulls sever water into the main or auxiliary chamber under vacuum in turn. Reservoir under low negative pressure supplies servers.

2. Heat Exchanger (2x)

Transfers the heat created by the servers to the facility water typical 1 C approach at 150 KW.

3. Liquid Ring Pump (LRP)

LRP uses water as a seal to provide the vacuum necessary to propel the coolant. The water seal does not wear out.

4. Microprocessor Control

The temperature is controlled to maintain the coolant above the dew point in the data center. Control and Monitoring is via SNMP, get data via FTP.

5. Water Quality Control + Automation

The water quality is monitored and controlled to maintain corrosion and bacterial protection. Automatic fill, drain, air purge and leak test are included and coolant additive is stored on board.

6. Coolant Handling Manifold

4-6 cooling loops exiting bottom of CDU. Optional single feed coolant supply at either bottom or top.

Chilldyne Negative Pressure CDU

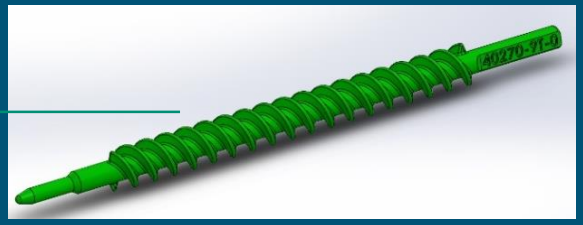
- Three CDU's share cooling load that two CDU's can handle
- CDUs report KW heat pumped, process and facility water flow and temperature, includes software for failure tolerance and resilience to failed sensors.
- 480V power + stainless steel chamber + SNMP new for Sandia
- UP to 65 GPM primary water with controlled return temperature for efficient operation with Sandia's advanced facility water system

Chilldyne Hybrid Liquid Air Cooled Cold Plate

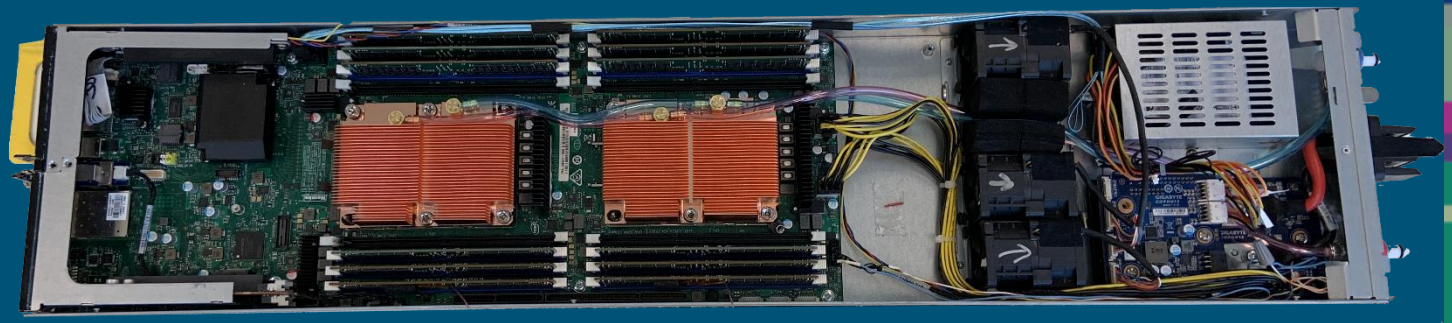
Robust Cold plate design

Includes fins for back up air cooling

Turbulator with large flow passage for corrosion and contamination tolerance



Finned cold plates installed with no changes to server assembly or test procedures



Sandia Server Side design

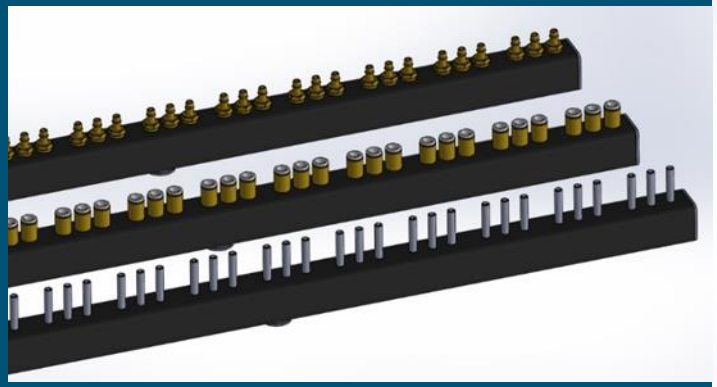
Low cost Manifold design for negative pressure

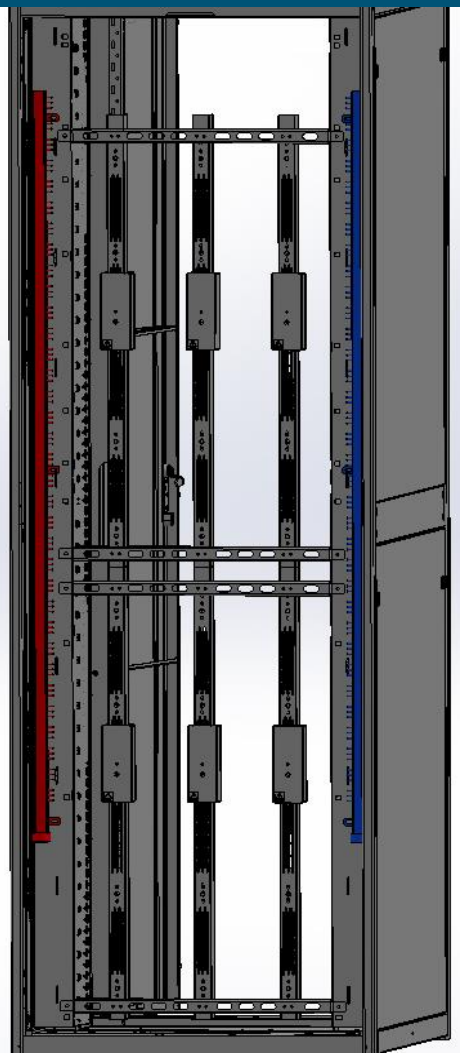
Straight barbs because vacuum means tubes fall on, not off

Temperature and pressure sensors in each rack

Includes flow limiting valves to limit air leakage in case server tubing is open to air.

Room for additional servers (up to 102 possible)





Conclusion (two different like systems)

Each system have different characteristic's however some systems have a few common points:

- Some systems are noninvasive to the system administrator (can service nodes without having a mechanical engineering degree or plumber background)
- Some systems have great heat transfer and are flexible when adding additional systems
- Some systems can utilize warm water cooling with a possibility of capturing reheat use
- Some systems are designed with further enhancement capabilities
- Some systems are designed with ease of accessibility while servicing
- Some systems utilize simplistic chemistry in the water composition
- Some systems facility interface connections are standard to the industry

Contact

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