Speakers

- **Moderator**
  - Dale Sartor – Lawrence Berkeley National Laboratory

- **Presenter/Panelists**
  - John Musilli – Intel Corporation
  - Brandon Hong – Lawrence Livermore National Laboratory
“Imbedded data centers are not a problem, but just an opportunity to re-use an existing infrastructure at an efficiency level equal to new construction or standalone data center designs.”
Embedded Data Center Advantages

Existing Building Envelope Provides

- Building- shell
- Power- building electrical sub-station distribution installed
- Outside plant-water, cooling and power infrastructure connectivity
- Ventilation-make-up air
- Security- walls fence
- Parking
- Logistics- loading docks
Room Level Changes

Air Movement
- Air Segregation
- Flooded Supply Air Design

Space Management
- Densification- “Getting More With Less”

Facility Level Changes

Economizer Opportunity
- Evaporative cooling- Use existing cooling towers posable use of return water loop
- Air Side economizer- Take advantage of climate zone, exterior walls, and roof exhaust
Chimney Cabinet- Flooded Air Design

- 30 kW per Rack
- No Raised Metal Floor
- Flooded Supply Air Design
- Segregated Air
- Chimney cabinets
- Above Ceiling Return Air Plenum
Rack cooling layout to improve capacity without CRAC unit addition or moves

Cooling capacity
Design = 420kW
Actual = 550kW

Flooded Design
All Supply Air delivered to one space.
Cooling units stayed in place.
20kW racks next to 5kW racks

Improved layout
Airflow room level is “N + 1” without any airflow distributions issues
Cooling layout to improve capacity without CRAC unit addition or moves

**Flooded Design**
All Supply Air delivered to one space. Cooling units stayed in place. 20kW racks next to 5kW racks

Large supply air plenum capacity not restricted by raised metal floor depth

**Improved layout**
Airflow room level is “N + 1” without any airflow distribution issues

Cooling capacity
Design = 420kW
Actual = 550kW
Flooded Room Design with “H” Layout

High density and low density rack power mix

This layout provides 40% more rack bays than racks placed as a square perimeter
Segregated Air - No Raised Metal Floor Supply with Above Ceiling Return Air Plenum

Raising the air handlers above the raised metal floor allows a room with poor underfloor distribution or capacity to increase the effective cooling density.

Some facilities use an RMF, raised metal floor, as an access floor for power, cooling and network infrastructure. This does not prohibit a flooded air design—we simply consider the RMF elevation as the slab height, and raise the room air handlers' supply path above the RMF.
Hot Aisle Isolation

IT Distribution on Hot Aisle under floor

Plascore Filler Panel Enclosures

Back-to-Back Cabinets

Egg Crate Ceiling
Hard Panel Hot Aisle Enclosure

- Sliding panels above cabinets to close air gap to create hot aisle enclosure.
- End of rows closed off to create hot aisle enclosure.
- Rear of cabinets.
- Vented ceiling tiles. Return air to ceiling plenum.
- Full height panels for missing cabinets.
- Slab floor
Air Segregation
Various Methods

- Hard wall and soft wall installation in the same room
- Flexible Curtain Hot Aisle Enclosure
- Example of a Floor to Ceiling Filler Panel
- Solid Panel HAE End Caps with Soft Wall over Server Racks
- Moveable Wall Room Dividers
- Chimney cabinets
Air Segregation – No Raised Metal Floor

- Return Air Duct
- Down Draft CRAC Unit
- Stand Mount CRAC No Raised Metal Floor
Space Management
Server Rack Density

Rack Physical Density Intel Vs Industry Today

38% server rack capacity increase in same floor space.

COMPARE: Both footprints are 5,000 sq.ft.

• Intel **Sub 20 inch Rack** Density
  • 240
  • 60U Racks
  • 14,400U Total
  • 43k Servers
  • 1,100 watts/ sq.ft.

• Standard **24 inch Rack** Density
  • 200
  • 52U Racks
  • 10,400U Total
  • 31k Servers
  • 864 watts/ sq.ft.
Compute Modules - 300kW-400kW - 720 RU capacity

- 2 rows of 6 racks = 12 racks total 10' long x 24' wide module footprint including supply air aisle
- 10' wide hot aisle
- 4' deep racks - 720 RU capacity
- 3' cold aisle (split 6' aisle)
- Approximately 1,100 watts/ sq.ft. room density
  1300w/sf. module density
Close Coupled Cooling
Compute Modules 1.1MW

- 2 rows of 24 racks = 48 racks total
- 40’ x 24’ module footprint
- 10’ wide hot aisle
- 4’ deep racks
- 3’ cold aisle (split 6’ aisle)
- Approximately 1,100 watts/ sq.ft.
Larger data center layout 10MW capacity
Outside Air for “N Plus One" Cooling Capacity
Electrical Loss Management

Power Loss and Electrical Efficiency

- 415/240vac rack power distribution for reduced cost per kW and lower transformer and power distribution losses.
- 12kV to 415/240 Substation reduces actual total transformer losses to sub 2%.
- High efficiency transformers reduce electrical losses.
- Utility as second source reduces electrical losses from UPS conversion and max UPS utilization with STS.

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Summary of Efficiency Measures

• **Air Segregation**
  - No Raised Metal Floor reduce construction cost mitigate room hotspots caused by the floor plenum limitations.
  - Air segregation preferred hot aisle solution with ceiling return air plenum or air handling unit in hot aisle.
  - Chimney cabinets raise supply air temperature, raise return air temperature and reduce bypass air.

• **Air Management**
  - Flooded supply air design provides supply air to all racks high density and low density regardless of demand.
  - Variable Frequency Drives energy savings on pump and fan motors.
  - Old airflow volume 160 CFM -200/kW .
  - Current airflow volume 80 CFM -108/kW.

• **Cooling management**
  - Evaporative cooling Wet side economization
  - Free cooling Outside air Dry side economization.
  - Raise Return Air Temperature provides higher efficiency and capacity for heat rejection through cooling coils.
  - Raise Supply Air Temperature to 80°F with conditioned power environments and 80°F to 95°F in utility power environments.
  - Raise Return Chilled Water Temperature increase the efficiency of the chillers.

• **Room Design Efficiency**
  - 1,100 watts/ sq.ft. Power and cooling density.
  - Multi Tier room design takes advantage of N+1 infrastructure stranded capacity through lower tier load sheathing.
  - Densification maximizes power, space and cooling distribution reducing construction cost and improving efficiency.
Wet Side and Dry Side Economization
Evaporative Cooling Wet Side Economizer 1100 watts/sf.
Evaporation type Cooling towers option for Gray Water supply

Plate heat exchangers Used to segregate cooling tower water from data center cooling coils

Data center cooling water main line distribution 3600GPM, 25MW capacity

Data center Hot Aisle flex cooling lines to overhead cooling coils

Close Coupled Cooling overhead cooling coils 330kW cooling capacity per coil system

60U Server racks
Cooling Towers

Servers

Cooling Coils in Top of Hot Aisle

22" Water Lines

Pumps

Plate Heat Exchanger

Plate Heat Exchanger

Close-Coupled Cooling Solution Components

Close Coupled Cooling Design Layout

- Evaporative cooling tower water only solution
- Primary and secondary loop, plate heat exchanger separates the water
- DC air is recirculated, heat rejected through cooling towers only
Close Coupled Cooling

Room level

Modular Build
10ft X 24ft Increments from center cold aisle to center of cold aisle

Server Racking
Sub 20in wide in 30u increment 30u, 60u and 90u elevation

Fit-Up Module
Insert provides on site and offsite compute device fit-up

Close Coupled Cooling
Coil provides 330kW cooling per twelve 60u racks
High Density Compute Modules
• 2 rows of 24 racks = 48 racks total
• 40’ x 24’ module footprint
• 10’ wide hot aisle
• 4’ deep racks
• 3’ cold aisle (split 6’ aisle)
• Approximately 1,100 watts/ sq.ft.
Free Cooling Dry Side Economization
Second Story Space With Outside Walls - Retrofit

- 1,200 sq.ft. vents in wall, exhaust louvers.
- Smaller pressure relief vent in end wall, in case the wind is blowing against the exhaust.
Cooling Management

Outside Air Flow Design

- View of building end.
- Photo shows supply plenum.
- Big recirculating fan to prevent condensation during excessive cold weather 6°F.
- 540,000 cfm at 95°F.
- 400,000 cfm at 80°F.
- PUE Annualized 1.06 at night as low as 1.03
Hot Aisle Exhaust Vents to Outside

- View standing in hot aisle looking up.
- Exhaust vent is just covered by a louver.
- Plastic panel at top of rack, segregates hot from cold aisle.
Outside Air Room Model – Free Cooling Air Side Economizer

Outside Supply Air From Roof Fans

Supply Air

Exhaust Air Vent to Atmosphere

Hot Air Leaves Building through Exterior Wall Mounted Lovers
Power Density – 1,100 watts per net sq.ft.)
Questions
Next Generation Facilities for High Performance Computing (HPC) Embedded Data Center Design Approach

Better Building Summit
May 10, 2016

Brandon Hong, PE
HPC Systems Engineer

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25 Year Facility Master Plan Developed to Meet Next Gen HPC

- HPC Facility Road Map
  - Facilities are 10 to 60 years old
  - Limitations with existing Livermore Computing (LC) facilities
  - Site-wide HPC consolidations
  - Technical Alternatives Analysis
    - “Remodel vs. Build New”
    - Detailed Cost Modeling

- Next Gen HPC = Unique Facility Innovation
  - Liquid Cooling Advances
  - Efficient Electrical Distribution
  - Robust Structural Solutions
  - Sustainable HPC Modular Embedded Solutions
Livermore Computing (LC) Complex Highlights

- 100K SF and 50 MW across the complex in facilities ranging from 10 – 60 years old

- B-453 houses key Top 500 computers
  - Sequoia (20 PF – 9.6MW – 4000SF) and Vulcan (5 PF – 2.4MW – 1000SF)

- Other facilities house smaller less dense systems

- B-453 construction completed in 2004 – Perpetual modifications to scale with technological advances.
B-453 Facility Distribution Challenges - Facility Design Concepts Date to 1998
Next Gen HPC Push Facility Electrical, Mechanical and Structural Infrastructure
Next Gen HPC Pushes Facility Boundaries
B-453 Sequoia Installation Challenges
Future Facility Strategy Plan for Next Gen HPC

- Perform detailed "Technical Alternative Analysis" options
  - Doing nothing is not an option
  - Build new embedded data center facilities scaled to HPC technology
  - Utilize enduring facilities and repurpose non-enduring facilities
  - Implement alternatives as feasible
  - Consolidate and embed HPC services to minimize footprint
Next Gen HPC Sustainable Modular Embedded Design Approach

- Clear, unencumbered space and accommodate increased weights
- Scalable mechanical and electrical infrastructure
- Advanced liquid cooling options with free evaporative cooling
- Build what is needed to scale with current HPC technology
- Repurpose equipment from other LC facilities
First Embedded HPC Modular Approach Nearing Completion

- 6000 SF computer floor space – Scalable to meet next Gen HPC
- Two level computer room without concrete between levels for flexible siting
- Scale to 7.5 MW
- Construction nearly complete
- Awaiting delivery of new HPC systems in June, 2016
Successful Next Gen HPC Requires Embedded Planning and Execution

- Develop a Master Plan, Road Map or Strategic Plan
  - Identify embedded capabilities
  - Identify gaps
  - Retire non enduring solutions
  - Promote enduring embedded solutions
  - Execute consolidations
  - Identify embedded innovative solutions
  - Perform alternative analysis and develop cost models
  - Leverage embedded solutions based on future technologies