“Chill-Offs” 1&2 confirmed liquid cooling solutions are more efficient than air cooling
Direct to Chip Liquid Cooling

- Lawrence Berkeley National Laboratory Demonstration
- Rack of 38 Cisco UCS C220 M3 Servers Installed in July 2013
- Study confirms:
  - Cooling Power Savings > 50%
  - Savings > 21% of Total data center power
  - Power savings when RackCDU connected to chilled water
LBNL Led Liquid Immersion Demonstration

Project team

Demonstration partner

Naval Research Laboratory
Washington, DC
Open bath liquid immersion cooling

What is missing:

- chillers
- cooling towers
- water use
- raised floors
- computer room air conditioners
- earplugs!
- Server fans
Immersion cooling eliminates compressor based systems

Eliminate:
- Chillers
- CRAC units
- Cooling towers
- Server fans
- Evaporative water loss

Reduce number of pumps

Many hours of “Free cooling”

Simplified controls

Reduced maintenance cost

Cooling systems can be much simpler
Servers installed in immersion bath looking through top glass cover

Note wiring enters bath above fluid level to avoid fluid loss

System is off in this photo

Condenser coils on either side
2-Phase Immersion Cooling
System Evaluation

Data collection plan

Schematic showing monitoring points
NRL Immersion Demonstration Startup Sample Data
4/6/2015 04:20 to 4/6/2015 17:46

Immersed IT Power 14,500 watts

Outside Air Temperature 25°C (77°F)

Dry Cooler Fan Speed 250 RPM (27% of max.) [55 watts]

Zero RPM (off) [15 watts]

Water Supply Temp. Immersion Cooling Coils

29°C (84°F) → 33°C (91.4°F)

Cooling pPUE (includes: pumping, fan, tank systems/controls)

~ 1.048 → ~ 1.015

Time [day of year] (total = ~12 hours)
Energy Performance

Immersion partial PUE (cooling):

IT (in bath) + Tank controls + Dry cooler fan + Loop pump
Learnings

• Contamination can cause failures in 2-phase immersion cooling systems just as in air cooled systems
• The source of contamination in immersion cooled systems is the system itself, not the outside environment. The designer therefore can control contamination.
• Boards for air cooled servers, power supplies etc. have geometries that allow impurities to accumulate eventually causing failures – fix is simple, undercoat and add boiling enhancement coatings
• Contaminants accumulate through distillation when boiling (unique to 2-phase systems).
• Strategies for combatting contamination include; eliminating contaminant, pre-cleaning, in situ scrubbing, coating/under-filling, and control of heat flow.
Future design

• To utilize existing air cooled designs:
  – Removal of fans
  – Add boiling enhanced coatings
  – Under-fill standard boards
  – Sealed disc drives or solid state memory
  – Preclean/scrubb

• To optimize performance:
  – Redesign boards/eliminate possible contamination sites
  – Layout enabling close, high-density equipment, while minimizing fluid required
Back up slides
Completed Immersion Tank - idle

Video of system at idle