Fujitsu Cool-Central® Liquid Cooling Technology
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Efficient cooling of large PRIMERGY CX400 M1 HPC or cluster solutions

Fujitsu Cool-Central® Liquid Cooling Technology helps to reduce data center cooling costs by over 50 % and allows for 2.5-5x higher data center server density.
Why On-Chip Liquid Cooling?

<table>
<thead>
<tr>
<th>Maximum rack density</th>
<th>Less cooling power and costs</th>
<th>Lower investment needed for building new data centers</th>
<th>Lower overall energy consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Extreme dense</strong></td>
<td>Liquid cooling allows for up to 50% <strong>less cooling power and costs</strong> through high efficient coolers with low operating costs</td>
<td>A hot water based liquid cooling infrastructure requires <strong>a way lower investment</strong> than traditional air cooled infrastructure</td>
<td>Hot water based liquid cooling enables the easy <strong>usage of waste heat</strong> for heating homes, green houses, or swimming pools</td>
</tr>
</tbody>
</table>
Water as a Medium for Heat Transfer

Removing the waste heat
For 1000 W, 10 K temperature difference:
- 325 m³/h of air
- 0.09 m³/h water
⇒ Small water tubes can transport more heat than a room full of air!

Heat transfer
- Heat transfer from water-to-water is better by a factor of 1,000 than water-to-air
- Cold plate and pump units are the same size or even smaller than regular heat sinks
Fujitsu’s Liquid Cooling Offering

- Future-proofing the Fujitsu PRIMERGY portfolio
  - KW per rack will further rise and traditional air cooling will not be sufficient for future developments
  - Liquid Cooling will allow for higher-performant, denser and more energy efficient PRIMERGY servers per rack

- The liquid cooling solution out of one hand
  - Cool-Central® Liquid Cooling Technology offers professional liquid cooling tested and designed for Fujitsu Server PRIMERGY CX400 M1 systems
  - Liquid cooling equipment already pre-installed ex factory
  - Easy management: integration of the cooling solution into Fujitsu’s ServerView management software
  - Professional services to evaluate the customers cooling infrastructure
Fujitsu PRIMERGY Server for Liquid Cooling

Fujitsu PRIMERGY CX400 M1

- Condensed 4-in-2U density
  - Features up to 4 half-wide dual socket server nodes plus up to 24 storage drives
  - 50% less rack space in comparison with standard rack servers for highest performance per rack unit

- Server nodes for every scenario
  - Different dual socket server nodes featuring latest Intel® Xeon® processor E5-2600 v3 product family to best match particular scale-out solution stacks
  - PRIMERGY CX2550 M1: Standard server node, 16 DIMMs (1U)
  - PRIMERGY CX2570 M1: Enhanced HPC node with up to two GPGPU or co-processor cards, 16 DIMMs (2U)

Usage Scenarios

- Scale-out cloud infrastructure
- Hyper-converged computing
- HPC server farms
Air Cooled Data Center

Chiller Plant: 974 kW
CRAC: 226 kW
IT Power: 2.0 MW
Cooling Power: 1.2 MW
Other: 0.4 MW
Total Energy: 3.6 MW

PUE: 1.8
74% of overhead power used for cooling
Cool-Central® LCT Cooled Data Center

- **Dry Cooler**: 60 kW
- **IT Power**: 1.9 MW
- **Recovery Potential**: 1.52 MW

**Chiller Plant**: 390 kW

- **CRAC**: 90 kW

**Cooling Power**: 0.54 MW (55%)

**Other**: 0.4 MW

**Total Energy**: 2.84 MW (21%)

**PUE**: 1.49

57% of overhead power used for cooling

- **IT Power**: 1.9 MW (5%)
- **Cooling Power**: 0.54 MW
- **Other**: 0.4 MW

**Temperature**:
- 10 °C (50 °F)
- 15 °C (59 °F)
- 40 °C (104 °F)
- 58.9 °C (138 °F)

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Cool-Central® LCT: How it Works

Heat exchanger
Liquid-to-liquid heat exchanger between facilities liquid loop and server liquid loops. Facilities and server liquids are kept separate and never mix.

Coolant reservoir and control
Tubes move cooling liquid to and from RackCDU to servers

Pump/cold plate units
Atop CPUs, GPUs and RAM circulate liquid through server and RackCDU, collecting heat and returning to RackCDU for exchange with facilities liquid

Facility water requirement
- Maximum water temperature
- Facility supply: 40 °C
- Facility Return: 59 °C
- Water pressure
  - Max: 100 PSI
  - Min: 10 PSI

Leak Detection Panel
(not shown)
Cool-Central® LCT: How it Works

Dual in-series pumps
- Provide redundancy
- Pumps / motors hot swappable for serviceability
- Pumps / cold plate units replace air heat sinks and circulate cooling liquid

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Quick Connectors
From / to RackCDU

Server loops and tubes
- Fully tested, filled and ready to install
- IT staff never has to handle liquids
- Low pressure, factory sealed design eliminates risk of leaks

Memory Coolers

Wide range of compatible components
- Intel Xeon and Xeon Phi
- Nvidia Tesla, Grid
- Memory modules

Picture does not show Fujitsu node
Cool-Central® LCT: Monitoring and DC Integration

- Monitoring, readouts and user controlled alarming for items such as temperatures, flow, pressures and leak detection
- Surveillance/alarm system is web accessible by operations management
- System supports integration into data center management suites/DCIM via SNMP
Customer Pain Points, Usage Scenarios
Data Center Cooling: Customer Pain Points

Higher density in existing DC required
Equipping an existing data center with additional servers leads to cooling and density challenges.

Challenge:
- Air cooling capability: traditional air cooled data centers support max 15 kW per rack
- 15 kW per rack means that a fully equipped 42 U rack just supports servers with max wattage of 350 W
- Alternatively a rack can be populated with just 30x 500 W servers

Advantages of Liquid Cooling Technology:
- No real max wattage limit per rack as up to 80 % of heat is dissipated through water
- Racks can be fully equipped with servers
- Furthermore: the Liquid Cooling Technology does not occupy height units in the rack or precious floor space in the data center
Data Center Cooling: Customer Pain Points

To high cooling costs in existing data center

Operating costs for the traditional air cooled data center are too high.

Challenge:
- Air cooling has a low efficiency due to losses in exchanging the heat from air to water and back to air (CRAH / chiller) or with cooling compressors (CRAC).
- CRAH units require water cooled down to ~10 °C by chillers which is energy and cost intensive.
- Hotspots in the rack / data center are hard to cool as the stream of cold air is tricky to route to the needed place.

Advantages of Liquid Cooling Technology:
- Liquid cooling allows to collect the waste heat directly at its source.
- Exchanging the heat with water is highly efficient.
- Hot water based cooling simply relies on dry coolers which have high efficiencies and low operating costs.
- Water just has to be cooled down to 40 °C, which maximizes the number of hours in which “free cooling” is possible.
Save money when building a new data center
The cooling equipment of a newly built data center can easily amount for 20% of the total investment.

Challenge:
- Air cooling equipment like computer room air handlers (CRAH) + chillers or computer room air conditioners (CRAC) are expensive and take up lots of floor space

Advantages of Liquid Cooling Technology:
- A hot water based liquid cooling infrastructure requires a way lower investment than traditional air cooled infrastructure
- Dry coolers have a by factors higher cooling capacity and can thus replace several CRAC+chiller / CRAH units
- As dry coolers for the liquid cooling infrastructure are placed outside the data center precious floor space can be saved
Data Center Cooling: Customer Pain Points

**Lower the overall energy consumption of the company**
Why is energy and money spend on the cooling of the data center and on heating the offices at the same time?

**Challenge:**
- Especially in the temperate zones offices have to be heated for a large part of the year, while at the same time a lot of effort is put into the removal of the heat produced in the data center. Is there a way to use this waste heat?

**Advantages of Liquid Cooling Technology:**
- The Cool-Central Liquid Cooling Technology just needs cool water of around 40 °C. The returning water is around 60 °C.
- The excess heat can be used to heat offices, homes, green houses, or swimming pools

**Pay once, use twice**

\[
1 \text{ kW} = 1 \text{ kW} + 0.8 \text{ kW}
\]

1 kW of IT power delivers up to 0.8 kW of easy reusable waste heat energy
Maximum achievable data center density

Data center density

- Maximum servers per rack
  - The max number of servers per rack is determined through the maximum heat dissipation rate
  - Only with direct to chip liquid cooling the heat dissipation is high enough to support a rack full of high performance servers

- Available floor space
  - In-row cooling in traditional air cooled data centers takes up a lot of floor space which could be used for further racks
  - A data center cooled partly with liquid cooling needs less than half the in-row CRACs offering more available floor space

Number of racks required for 1000x PRIMERGY CX2550 M1 LCT nodes

- Air Conditioning: 111
- In-row: 33
- Rear door: 17
- Liquid Cooling: 12

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# Liquid Cooling: Possible TCO Savings

Power consumption and costs of 1,000x PRIMERGY CX2550 M1 (dual socket server)

<table>
<thead>
<tr>
<th></th>
<th>Air Cooling</th>
<th>Liquid Cooling</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Power consumption (Cooling infrastructure + servers)</strong></td>
<td>956.3kW</td>
<td>696.4kW</td>
</tr>
<tr>
<td><strong>Initial cost for cooling infrastructure</strong></td>
<td>$2,186.4k</td>
<td>$972.0k</td>
</tr>
<tr>
<td></td>
<td>Not realistic because 21x air conditioner required</td>
<td>Realistic</td>
</tr>
<tr>
<td><strong>Cooling capability is too low (max 30 kW per rack)</strong></td>
<td>$934.4k</td>
<td></td>
</tr>
<tr>
<td><strong>Total cost of ownership</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In-Row</td>
<td>Liquid</td>
<td>0 Y</td>
</tr>
<tr>
<td>TCO $M</td>
<td>In-Row</td>
<td>Liquid</td>
</tr>
<tr>
<td>Electricity cost is calculated as 50% power load</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In 5 years Cool-Central LCT can save up to $0.55M!
Calculating the cooling infrastructure

<table>
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<tr>
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<th>Air (In-row)</th>
<th>Liquid + Air</th>
</tr>
</thead>
<tbody>
<tr>
<td>Server heat dissipation</td>
<td>566 kW (Air)</td>
<td>216 kW (Air)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>358 kW (Liquid)</td>
</tr>
<tr>
<td>Cooling infrastructure for air cooled parts</td>
<td>#In-row 14x 41 kW</td>
<td>#Chiller 5x 118 kW</td>
</tr>
<tr>
<td></td>
<td>6x 41 kW</td>
<td>2x 118 kW</td>
</tr>
<tr>
<td>Cooling infra for liquid cooled parts</td>
<td>#Dry cooler -</td>
<td>1x 422 kW</td>
</tr>
</tbody>
</table>

The heat dissipation of the servers is separated by components cooled by air (HDDs, mainboard) and by liquid (CPU, memory). The resulting kW have to be removed by the corresponding cooling infrastructure.

In-row cooler remove the heat of the data center and need additional chiller plants outside the building.

The dry cooler removing the heat from the liquid cooled parts features a high capacity.

With additional liquid cooling the cooling infrastructure of the data center can be designed way slimmer or with the same energy level a higher server density. The needed dry cooler has a high cooling capacity and at the same time a very low energy consumption.