Best Practice of Alibaba Datacenter

Immersion Cooling Escorts Cloud Computing

Hedy, Ren
Datacenter Growing with IT

Datacenter has become a Production Center from an Auxiliary Facility.
Key Points of Alibaba Green Datacenter

1. Forward-Thinking on IT Strategy
2. Site Selection and Critical Facility Design
3. Immersion-Cooling Combined with Datacenter
4. Intelligent Operation
Datacenter As Multi-Layer System

- Application Layer
- Operation Layer
- IT Hardware Infrastructure
- Site Facility
- Space, Cooling, Power
- Flexible Migration Capacity of Software
- Private Cloud
- Virtualization
- Automation
- Resource Schedule
- Servers
- Storage
- Network

Infrastructure and Facility
Datacenters serve for IT, so forward-thinking on IT planning is very important.

**Forward-Thinking on IT Strategy**

**Begin With IT Planning**

- **IT Planning**
  - Coordination with Each Stake-Holder
    - IT Hardware Infrastructure
    - Disaster Recovery
    - Site Facility
    - DC Factors
  - DC Operation
    - Flexible Scalability
    - Strategy & Finance
    - Other Factors

**Decision-Making**

- Priority and Balance
  - Sustainable Development
  - Easy Operation
  - Adaption with different cloud-service

**Datacenter Strategy**

- Capacity
- Cost/Income
- Scalability
Key Points of Alibaba Green Datacenter

1. Forward-Thinking on IT Planning
2. Site Selection, Critical Facility Design
3. Cooling Combination with IT Equipments
4. Intelligent Operation
Site Selection—Why Zhangbei?
Critical Facility Design—Space and Architecture
Critical Facility Design—Power Supply System

Dual UPS
Efficiency: $88\% \times 94\% = 83\%$

AC direct supply & HVDC
Efficiency: \[
\frac{(94\% + 94\% \times 94\%)}{2} = 91\%
\]

Dual AC direct supply
Efficiency: 94\%

Widely used
Small-scaled used
Critical Facility Design—Cooling System

Climatic Parameter Analysis
Air Corrosion Levels

<table>
<thead>
<tr>
<th>Level</th>
<th>Copper/Silver Corrosion Rate</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1</td>
<td>300 Å/month</td>
<td>Corrosion is controlled not to affect the reliability of equipments。</td>
</tr>
<tr>
<td>G2</td>
<td>300-1000 Å/month</td>
<td>Corrosion can be measured, and it possibly affects the reliability of equipment.</td>
</tr>
<tr>
<td>G3</td>
<td>1000-2000 Å/month</td>
<td>High Possibility of corrosion.</td>
</tr>
<tr>
<td>GX</td>
<td>&gt;2000 Å/month</td>
<td>Only special designed and packaged equiments can be installed.</td>
</tr>
</tbody>
</table>

ASHRAE “Gaseous and Particulate Contamination Guidelines for Data Centers” defines four levels of corrosion.
➢ Average dry bulb temperature is 3.7°C in latest 5 years.

➢ Air is clean enough for direct cooling in 320 days a year.

➢ Water-side free cooling time is about 96%, air-side free cooling time is about 88%.

➢ Direct air-side economizer is fit for Zhangbei area.

➢ Considering special weather such as sand storm, water-side economizer is also furnished.

➢ Water resources are not rich.

➢ PUE is 1.25.
Free Cooling Depends on Climate

Free Cooling—When outdoor temperature and humidity is appropriate, no need for running mechanical refrigeration.
Key Points of Alibaba Green Datacenter

1. Forward-Thinking on IT Planning
2. Site Selection, Critical Facility Design,
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4. Intelligent Operation
### New Challenges on Datacenter Cooling Solution

<table>
<thead>
<tr>
<th>Power Consumption</th>
<th>Case Temperature</th>
<th>Merom</th>
<th>Penryn</th>
<th>Nehalem</th>
<th>Westmere</th>
<th>Sandy Bridge</th>
<th>Ivy Bridge</th>
<th>Haswell</th>
<th>Broadwell</th>
<th>Skylake</th>
<th>Future</th>
</tr>
</thead>
<tbody>
<tr>
<td>35W</td>
<td>Tc=72</td>
<td>65nm</td>
<td>45nm</td>
<td>45nm</td>
<td>32nm</td>
<td>32nm</td>
<td>22nm</td>
<td>22nm</td>
<td>14nm</td>
<td>14nm</td>
<td></td>
</tr>
<tr>
<td>40W</td>
<td>Tc=72</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>80W</td>
<td>Tc=76</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>95W</td>
<td>Tc=74</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>135W</td>
<td>Tc=72</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>155W</td>
<td>Tc=77</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>165W</td>
<td>Tc=79</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>165W</td>
<td>Tc=52</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>255W</td>
<td>?</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

1. Computing drives CPU into higher power consumption.
2. Air-Cooling cannot meet the heat dissipation demand any more.
3. Datacenters in all climate zones need to lower PUE and optimize TCO.
New Challenges on Datacenter Cooling Solution

**Rack power density is growing rapidly**

**Issues:**
- How to resolve high density racks’ cooling?
- How to lower cooling cost and TCO?
- How to achieve low PUE in every climate zone?

**Power and cooling cost is increasing rapidly**

**Alibaba Rack Density**

<table>
<thead>
<tr>
<th>Alibaba DC Situation</th>
<th>Past</th>
<th>Now</th>
<th>Future</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Density</td>
<td>3-5 kw/rack</td>
<td>7~19 kw/rack</td>
<td>20~90 kw/rack  (partial)</td>
</tr>
</tbody>
</table>

**Green Data Center Revenue by Technology Sector, World Markets: 2009-2015**

- Monitoring and Management
- IT equipment
- Power & cooling infrastructure
<table>
<thead>
<tr>
<th></th>
<th>Air Cooling</th>
<th>Cold Plate</th>
<th>Immersion Cooling</th>
<th>0 means “Base Line”</th>
<th>+ means “Better”</th>
<th>- means “Worse”</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cooling Capacity</strong></td>
<td>0</td>
<td>+</td>
<td>++</td>
<td>Immersion Cooling is the best.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Hardware Integration</strong></td>
<td>0</td>
<td>+</td>
<td>++</td>
<td>No fans in immersion Cooling.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Maintenance</strong></td>
<td>0</td>
<td>--</td>
<td>-</td>
<td>New design of hardware.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Hardware Reliability</strong></td>
<td>0</td>
<td>-</td>
<td>+</td>
<td>Unaffected by dust, humidity and vibration.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Hardware Performance</strong></td>
<td>0</td>
<td>+</td>
<td>++</td>
<td>Cooling helps improving performance.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Energy Efficiency</strong></td>
<td>0</td>
<td>+</td>
<td>++</td>
<td>No fans, chillers, CRAHs.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Heat Recovery</strong></td>
<td>0</td>
<td>+</td>
<td>++</td>
<td>Easy to be recovered from liquid.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Noise</strong></td>
<td>0</td>
<td>+</td>
<td>++</td>
<td>No fans, no noise.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Corrosion</strong></td>
<td>0</td>
<td>+</td>
<td>++</td>
<td>Isolation from air, no corrosion.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Material Compatibility</strong></td>
<td>0</td>
<td>0</td>
<td>?</td>
<td>Material compatibility needs to be tested.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Initial Capex</strong></td>
<td>0</td>
<td>-</td>
<td>--</td>
<td>Liquid cost is temporarily high.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Opex</strong></td>
<td>0</td>
<td>+</td>
<td>++</td>
<td>No fans, chillers, CRAHs. Low PUE.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td>0</td>
<td>-</td>
<td>--</td>
<td>Liquid is heavy.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Why immersion-cooling?**

We have to solve material compatibility, maintenance, hardware re-design & cost for immersion-cooling.
Immersion-Cooling Combined with Datacenter

➢ Simple Cooling System: No chillers, no CRAHs, no server fans, zero WUE.

➢ Low PUE in any climate zone.

➢ New monitor and control system.
Benefits From Immersion-Cooling

**Density**
- No limitation for rack power density.
- No need to worry about heat dissipation when designing hardware.

**Efficiency**
- Low PUE in every place even in hot climate zone.
- Lower chip temperature, faster data-processing.

**Simplicity**
- No server fans, no screws, no CRAHs, no chillers.
- No need for special thermal design of high performance hardware and easy hardware update.
- Unaffected by vibration, air dust and air humidity.

**Scalability**
- Easy to expand rack density from 20 kW to about 120 kW by replacing the server.
- Modular construction is easier for immersion-cooling solution.
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4. Intelligent Operation
Datacenter Need Intelligent Operation

- Costs
- Guy with a wrench
- Design
- Training
- Cabling
- High capacity CRAC units
- Fire
- Data center redundancy
- High-speed pipes
- Terrorism
- Liquid cooling
- Special localized cooling
- Applications, Migration
- Virtualization
- Natural Disasters
- Redundant power grids
- Backup power
- Power distribution
- Security
- Governance
- Operations Center
- Operations Center
- Natural Disasters

- Datacenter Need Intelligent Operation
✓ Complicated system and many kinds of equipment

✓ 7×24X365 uninterruptible running

✓ Continuous Cooling is usually must to have

✓ On-demand cooling capacity

✓ Seamless transition between economizer and mechanical cooling
Full Air-Side Free Cooling

- Open Fresh Air Dampers
- Close Return Air Dampers
- Open Exhaust Air Dampers
Partial Air-Side Free Cooling

- Modulate Fresh Air Damper
- Modulate Return Air Damper
- Modulate Exhaust Air Damper
No Air-Side Free Cooling

- Close Fresh Air Damper
- Open Return Air Damper
- Close Exhaust Air Damper
Datacenter Facility Management Platform

EPMS

BMS

Fire and Security Control

ITSM

Data Acquisition & Visualization

- Generators, fuel supply system, city electricity, Battery, UPS, PDU&PUE.

Data Acquisition & Visualization

- Chillers, CRAHs, Temperature and Humidity Monitor of cold aisles, Free Cooling Status, PUE&WUE.

Fire and Security Alarm

Configuration, Event Change, Process, Problem, knowledge, Service Management
Datacenter—Base of Cloud Computing

IT Equipment

MDC

IDC

Medium-cycle

Large-cycle

micro-cycle

IT service

Intelligent Operation

Dynamic Infrastructure

Resource Pool (Standardized, Standardized)

Finance

Third-party Cloud

Resources Automated Scheduling

E-commerce

Cloud Computing

Big Data