Internet Topics: Matsue Data Center Park Performance and Future Initiatives

■ Matsue Data Center Park Performance

Matsue Data Center Park in Matsue, Shimane Prefecture (henceforth Matsue DCP) is Japan's first container-based data center with an outside-air cooling system, offering high server density and easy scale-out to meet the needs of the age of cloud computing. It has been in stable operation as the infrastructure for the GIO cloud service since operation commenced in April 2011, with containers housing several hundred servers being transported and installed there one after another. As of July 2012 there are 13 containers in operation (Photo 1). If expansion continues at this pace, the maximum capacity of 24 containers will be installed there by the end of this fiscal year.

The "IZmo"*1 (Photo 2) IT modules are containers that do not fall under the buildings subject to the technical advice issued by the Ministry of Land, Infrastructure, Transport and Tourism in March 2011, so they do not require planning permission. This simplifies the process of adding or removing modules. It also used to be necessary to unpack, rack-mount, and wire a large number of servers one-by-one at data centers when constructing systems for providing cloud services. There were issues with amount of time this process required, and with the need to secure a large amount of temporary space to store servers before mounting as well as empty boxes. Container-based data centers drastically reduce the amount of time required to set up servers at a data center, and eliminate the need for storage and work space by mounting several hundred servers in IT modules at the server factory and transporting these by truck for installation.

Another feature of the Matsue DCP is its outside-air cooling system. Because this system is effective at reducing cooling power consumption, which at data centers is second only to the amount consumed by IT equipment, it has been implemented at a large number of data centers in the United States, such as those for Yahoo! and Facebook. On the other hand, it was rarely implemented in Japan because it is difficult to control, and there were design constraints associated with the need to create large openings in buildings to take in outside air. IIJ constructed a proof-of-concept facility comprised of an IT module and a cooling module in central Japan, and ran tests over the course of a year to establish an outside-air cooling control system, before deciding to implement outside-air cooling at the Matsue DCP. At Matsue it is possible to use outside air directly for cooling for about two thirds of the year, achieving a major reduction in power consumption. Because this demonstrated significant energy savings on a commercial level, we believe that more and more data centers will use outside-air cooling systems in Japan in the future.

The cooling module transitions control between three modes according to the temperature and humidity of outside air, keeping the temperature of each server's air inlet in the IT module within the recommended temperature and humidity requirements issued by ASHRAE (The American Society of Heating, Refrigerating and Air-Conditioning Engineers) in 2008. In all outside-air operating mode, outside air is supplied to servers as-is in spring and autumn, and server exhaust heat is also expelled outside as-is. In mixed operating mode, server exhaust is mixed with outside air when the outside air temperature is cold, supplying servers with air at a suitable temperature to prevent condensation. When humidity is low, humidification is also carried out to prevent static electricity. In circulation operating mode, because outside air cannot be used in the summer season when air is hot and humid, server exhaust air is cooled via the direct expansion coils used in standard cooling, and then supplied to servers.

The PUE (Power Usage Effectiveness) metric proposed by The Green Grid is commonly used as an indicator of data center power efficiency, and this is calculated using the following formula. PUE=1 is theoretically the lowest (best) value, when zero power is consumed for cooling, etc.

$$\text{PUE} = \frac{\text{Overall data center power consumption}}{\text{IT equipment power consumption}} = \frac{\text{IT equipment power consumption} + \text{power consumption for cooling, etc.}}{\text{IT equipment power consumption}}$$

Generally, PUE is higher (worse) in the summer season when a large amount of power is consumed for cooling, and lower (better) in other seasons, so it is necessary to assess it as an annual average. Because Matsue DCP is a module-based data center, and IT modules were added in stages, over a year's worth of operational data has been measured for two modules as of July 2012. Figure 1 shows trends in actual values for pPUE (partial PUE, which does not take power loss for shared areas into consideration) over the course of a year for one of these modules. In Figure 1, the pPUE for the summer season at around 1.3 is higher than other seasons. This is due to the use of circulation operating mode, which does not use outside air and consumes more power. In comparison, because outside-air operation mode is used in spring and autumn, employing outside air as-is and reducing power consumption, the pPUE falls below 1.1. Mixed operating mode is used in the winter season, mixing IT module exhaust air and outside air to achieve a suitable temperature, and reducing power consumption to end up with a pPUE below 1.1. This results in an average pPUE of 1.17 for the year. pPUE does not include the loss for shared areas such as lighting and electrical equipment, so the overall PUE for the data center will be higher (worse) than 1.17. However, we estimate

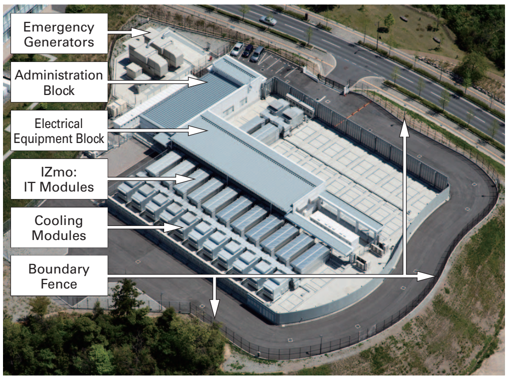

Photo 1: Matsue Data Center Park

Photo 2: IZmo and Cooling Module

*1 "IZmo" IT modules are container-based modules developed by IIJ for constructing data centers optimized for building cloud infrastructure (www.iij.ad.jp/DC/technology/izmo.html) (in Japanese).

that even with this included an annual average value of less than 1.3 is achievable, so we can assert that significant power savings have been made over conventional data centers, which have a PUE of around 2.

■ Reducing PUE from 1.2 to 1.0

In the past it was conventional wisdom that data center temperatures be maintained at around 20 degrees Celsius. However, to promote energy savings ASHRAE relaxed the environmental requirements for data centers drastically in 2011 by raising the acceptable temperature for a server's air inlet to around 40 degrees Celsius. As a result more and more manufacturers are announcing servers guaranteed to operate in high-temperature environments.

When this kind of server is used, an annual average PUE of 1.1 would be achievable. This is because it would allow cooling using only outside air even in the summer season. As can be seen from the pPUE trends in Figure 1, if it were possible to use all outside-air operating mode instead of circulation operating mode in the summer season, the annual average pPUE would fall below 1.1, bringing a PUE of less than 1.2 within reach even when taking power and losses for shared areas into consideration. This would also eliminate the need for direct expansion coils and compressor units in cooling modules, allowing for a simple fan-only configuration, and further reducing the costs associated with cooling devices.

This summer we are planning to conduct proof-of-concept tests at the Matsue Data Center Park through the integrated operation of IT equipment such as servers and facilities that include cooling. In these tests we will aim to achieve higher energy savings by resolving the issue of server fan speed increasing as temperatures rise, consuming more energy. This leads to less reduction in total energy consumption even when cooling energy consumption is lower. We hope to solve this problem through the integrated management and control of IT and facilities.

We believe it will be possible to approach a PUE of 1.0 by further integrating IT and facilities. For example, if we can create sufficient airflow to cool servers via the chimney effect using the heat generated by high-density servers, we can reduce the fans in cooling equipment and servers, eliminating the power required for cooling. There are a number of possible methods for implementing chimney data centers using this system, such as installing containers around a large chimney, or arranging racks around chimneys inside a building (Figure 2).

■ The Future of IT and Facility Integration

Data centers were once "facilities" for housing the "IT equipment" assets of customers, but in the cloud computing era they consist of cloud infrastructure integrating the "IT equipment" and "facilities" of cloud providers. The integrated construction and management of IT and facilities, including operation in high-temperature environments and chimney data centers, has enabled innovation that was not previously possible.

In the future, instead of single data centers, multiple data centers located both home and abroad will be connected via network and operate as one massive computer cluster. Once this becomes a reality, it will be possible to achieve redundancy through software instead of hardware, perhaps reducing the need for individual data center reliability to be as high as up to now. If it is possible to provide a service with data centers implementing mutual backups, it will only be necessary to maintain the battery power required to shut down servers safely when a power outage occurs at a data center, and generators will not be needed. This means that data center equipment configurations will change drastically from how they are now.

We also believe that there will be calls to integrate smart grids into data centers that consume a large amount of power, to utilize a limited amount of power efficiently and grow the IT industry. IIJ will continue to pursue development of technology that goes beyond simple energy savings, such as controlling IT loads between multiple data centers on a network according to the supply of electricity while utilizing volatile renewable energy, to work towards achieving sustainable data centers.

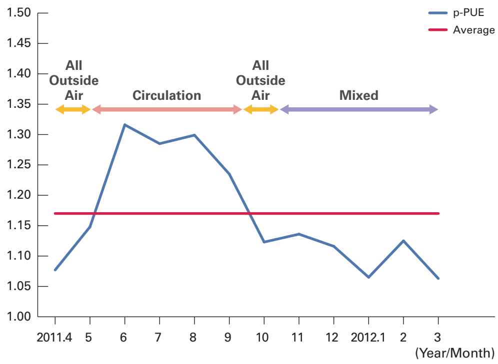

Figure 1: IZmo pPUE Performance

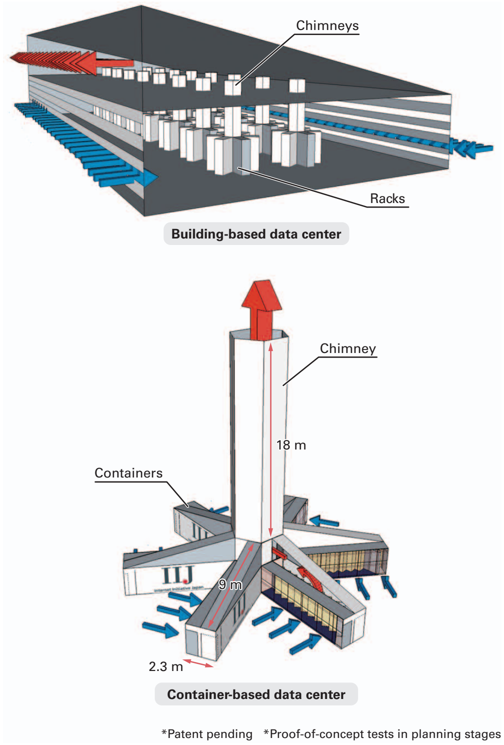

Figure 2: Chimney Data Centers (Concept Art)

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