40Kw WHITE PAPER

CLOSED LOOP COOLING VALIDATION TESTING

R.A.S.E.R. H.D.

PAPER Commissioning by;

http://ellipticalmobilesolutions.com/

Testing and Data

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R.A.S.E.R. HD Alpha Testing Validation

Background

Gkkworks has been contracted to act as third party agents in a validation study for new products created for the Data Center by Elliptical Mobile Solutions (EMS).

EMS is a manufacturer of Micro-Modular Containers for the Data Center Industry. The company is located in Chandler, Arizona and has been in operation for the past six years. The company has developed a number of different patented Micro-Modular Data Centers. These solutions are part of a line of patented products that use a method for heat rejection called “Closed Loop Cooling”. These products can be configured with IT equipment and will handle loads from 6Kw to 40Kw redundant.

Gkkworks continues this testing within this paper with a higher capacity unit within the design of the R.A.S.E.R. H.D. We spent several days in Minnesota at a cabinet manufacture’s facility testing a higher density solution with the same cabinet used for the initial Alpha white paper.

The R.A.S.E.R. HD is a third product in a line of units created by EMS over the past few years. This unit uses closed loop heat rejection that close couples rejection of heat from the server source using a low flow, low power fan, coil, and exchanger developed and manufactured by a company called Schroff which is part of the Pentair Corporation.

The R.A.S.E.R. HD is built of the same components and materials that exist in Data Centers today. Considerations in the engineering of this product have taken into perspective the need to create a fault tolerant separation between the water rejection system and the electrical and IT loads, thus protecting the IT equipment from any failure in the heat exchanger.

The ability to make 100% utilization of the fans and coils associated with this product has produced a configuration that allows for direct closed coupled rejection of the heat produced from the CPU and other computer components in the most efficient manner available on the market today.

The unit has options for active fire detection/suppression as well as an electronic security system that is HIPPA/SOX compliant. It also has on board monitoring for all environmental elements associated with the operation of the unit. Shock and vibration isolation is inherent to the cabinet so fully populated IT loads can be shipped directly from supplier to the Data Center. This provides a unique opportunity to configure data center solutions in a true lean construct and allow IT assets to move with a company in a non-capital intense environment.

Definition of Designed Components

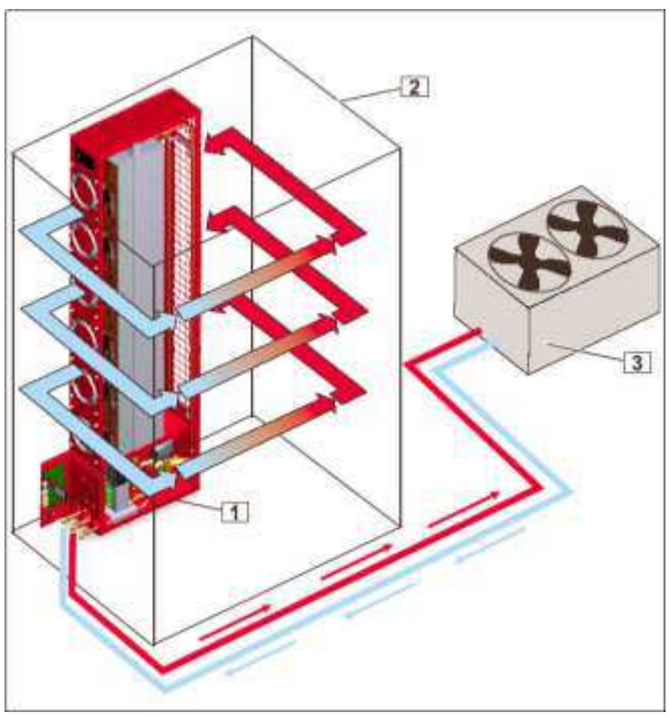
Closed-Loop Configuration:

Closed-loop cooling addresses the compute load independent of the room in which it's installed. The rack and heat exchanger work exclusively with one another, creating a microclimate within the enclosure. Those not familiar with containment strategies can think of close-coupled, closed loop as containment fully evolved: both hot aisle and cold aisle in the same rack footprint using the same components you would use in a traditional Data Center environment but reconfigured to maximize the rejection of heat.

Close-Coupled Cooling Solution

The cooling system consists of an air and a water loop. The fans of the cooling unit (1) draw warm air from the rear section of the cabinet into an air/water heat exchanger (2). The air is cooled and then blown into the front area of the cabinet.

Inside the air/water heat exchanger the heat energy of the warm air is transferred to the medium of water. The air/water heat exchanger is connected to an external reciprocal chiller unit (depending on the water temperature being used and not supplied with the module) (3), where the water is cooled again.



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Close-Coupled Cooling Efficiencies

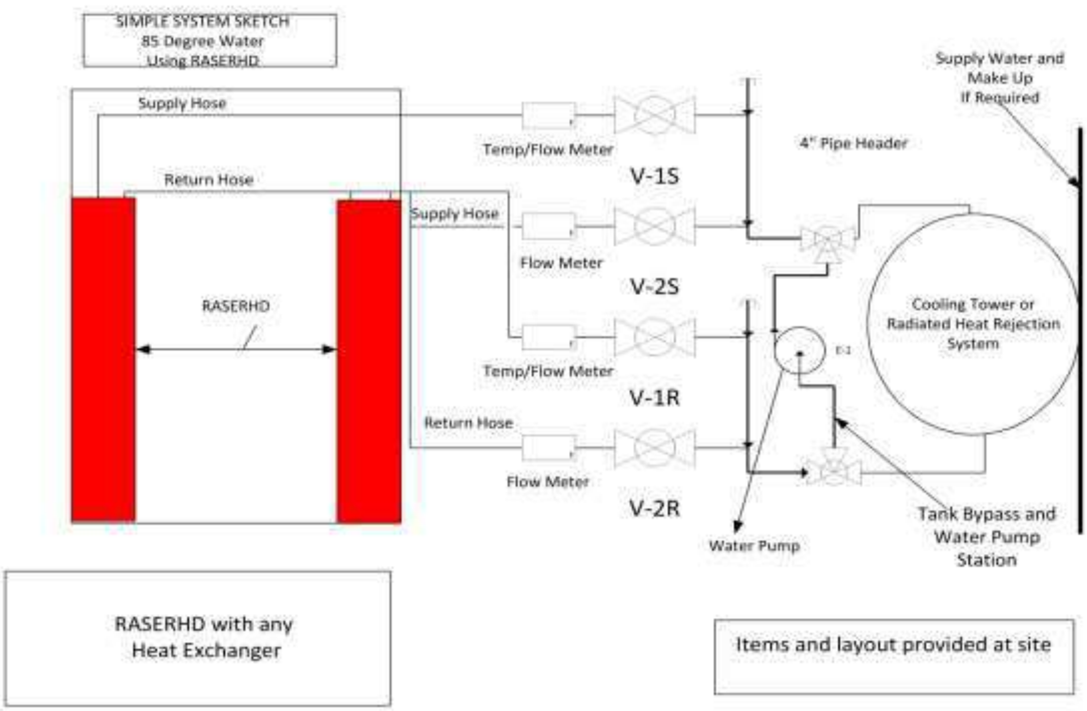
As in previous testing, the 40Kw configuration of the R.A.S.E.R. HD was set into a configuration as depicted bellow using a water storage tank that could be used as a constant supply of water blended at varying temperatures for the duration of the tests.

The intent of this testing was to simulate the actual conditions of the data center environment in a lab facility using water temperature from 55 degree F to 85 degree F. The results of these tests are included in this report.

In general it is noted that the opportunity to use these units for the purpose of warmer water heat rejection at varying loads in the unit is substantial to ensuring constant and reliable rejection of heat from the CPU chip or storage array without having to directly couple the water source to the computer components.

Test Configuration

The following diagram shows the configuration used to provide constant water temperature for each of the tests performed.



Testing Criteria and Results

As part of product and testing, the following criteria were established for the 40Kw R.A.S.E.R.HD testing. As this is a new product, EMS was looking to establish the following data.

1. Ease of transport and installation to an evaporative cooler system
2. Ability to run the unit under load at varying water temperatures
3. Ability to simulate in rush of a full load and capture time to recover operating temperature (chip instant on)
4. Ability to run the unit under load to determine unit capacity at higher water temperatures, up to 85 degrees.

All of the testing was completed in an indoor lab environment.

The R.A.S.E.R. HD unit configuration during testing was such that the exchangers were installed in separate compartments (40Kw each) from the IT load. Air was circulated in a closed loop vortex through the servers; water was isolated from the main electrical distribution. The unit itself was welded to rails that kept the unit off the floor by six inches. This also allowed for ease of transportation as the unit was delivered with a pallet jack off of a truck.

As the R.A.S.E.R. HD was tested water was discharged from an alternate location in the Lab.

No water entered the unit as seen in this photo due to the fact that the unit components were 6" off the ground.

The R.A.S.E.R. HD exchangers are equipped with an array of power, temperature sensors, and an auto shut off valve. In the event of power loss the valve will remain open. This serves as a well-engineered solution between water and electrical in the data center. For these tests additional sensors were installed in locations throughout the unit. Charts provided in this report of the load and heat rejection performance denote the additional sensors.

The R.A.S.E.R. HD was fitted with load bank simulators for the test. The units used were provided by Com-Rent and were of the type STC 6 Rack Mount Load Banks, Quantity (4) Units at 11Kw each.

Testing Criteria / Results

Product Configuration

R.A.S.E.R. HD
44Kw of Load Bank

Exchangers located in separate chambers right and left of the load banks

R.A.S.E.R. HD additional sensors, load-banks and one exchanger

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Testing Criteria / Results

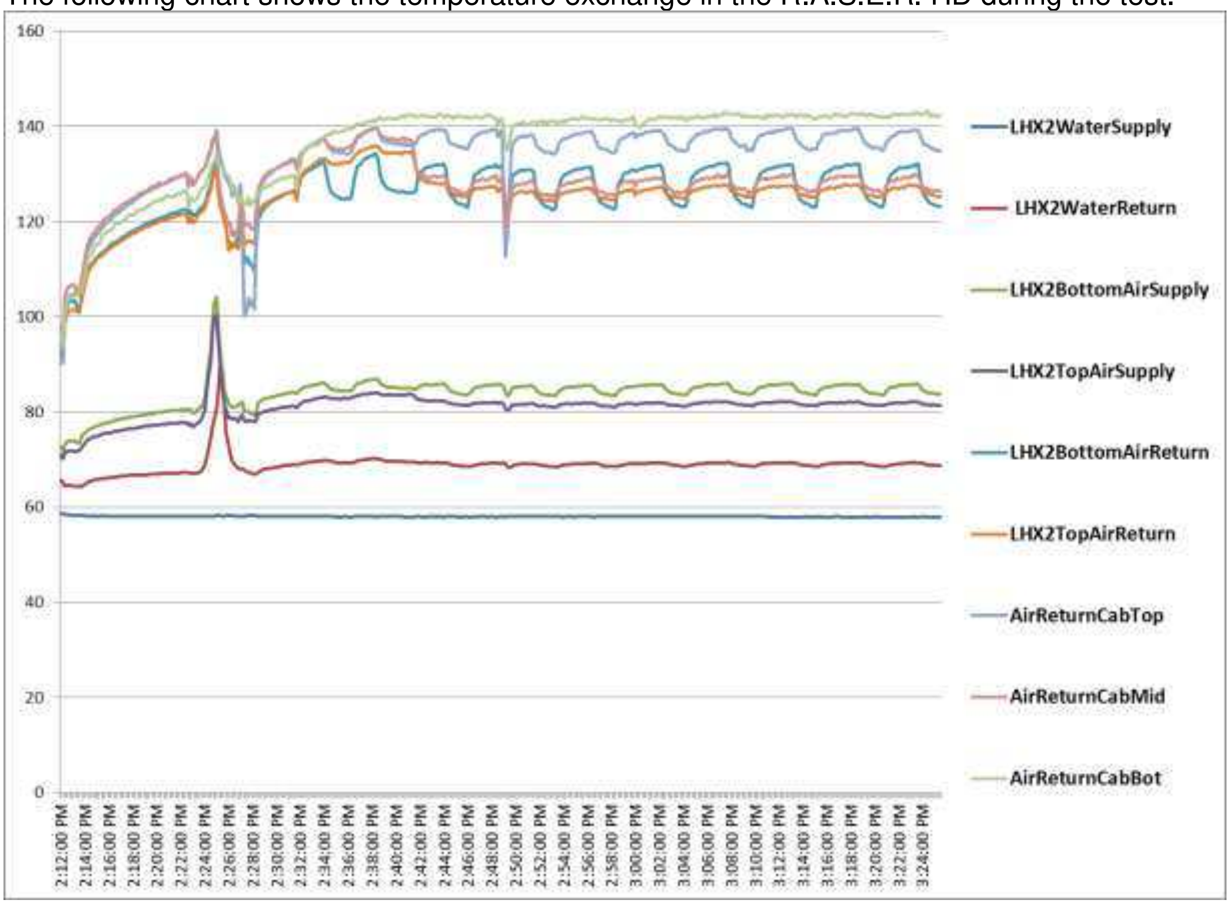
General Note Humidification

During all of the following tests the humidity dew point level in the unit never changed. There was a constant dew point well within the ASHRAE range. It is noted that under normal conditions the unit is sealed from the outside environment. Therefore humidification will maintain a constant in the R.A.S.E.R. HD without much variation. The opening of doors on a live environment could produce some condensation on the coil of the exchanger but operating at higher water temperatures this would be minimal or nonexistent. A c~~C~~ondensate removal nozzle is provided in such a case.

Test One (Lab air temperature 65º F (23.8ºC) Same on all tests

The R.A.S.E.R. HD unit was installed with 44Kw of load banks operating at 230V single phase protected with four 50 amp breakers. Fans were powered with 230v 15 amp breakers total and power to the fans was provided through an onboard rectifier that steps power to the fans from AC to DC. Four water hoses were installed to the distribution lines in the units that provided supply and return to two exchangers in the R.A.S.E.R. HD. through one exchanger at 12 gpm ea. and fans running at 80%. The exchanger will vary fans between 80% and 100% depending on air return temperature. The water temperature was set at 57º F (13.8º C).

The following chart shows the temperature exchange in the R.A.S.E.R. HD during the test.



Test One Cont.

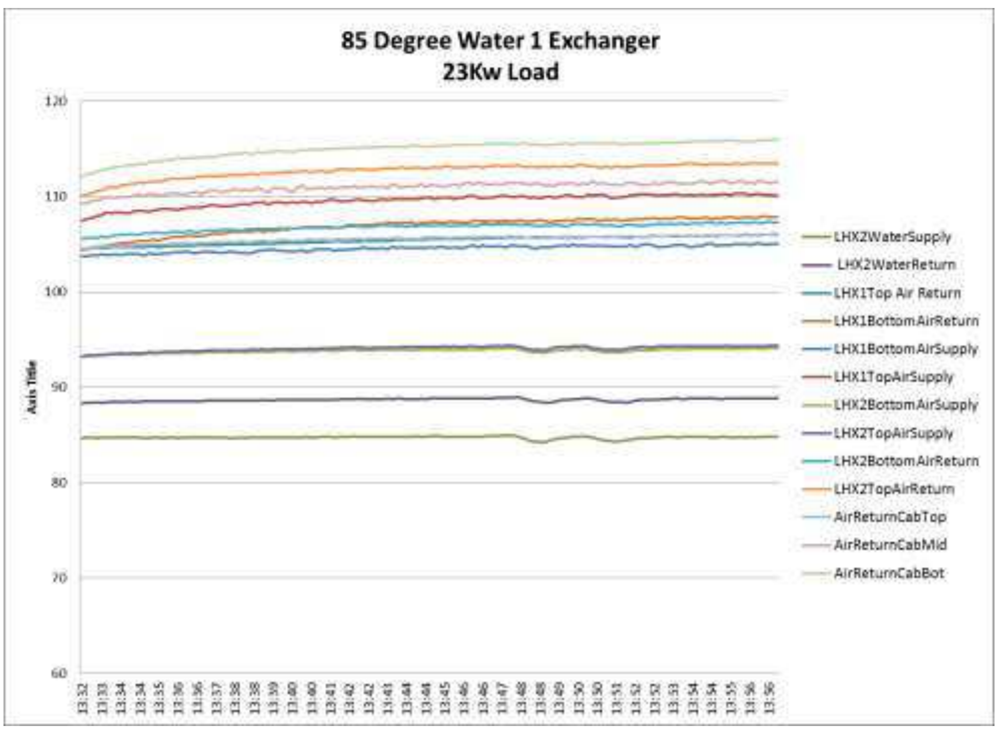
During the test a spike was seen that was caused when the manual valves for the exchanger on the outside of the unit were adjusted to re-verify water flow. As the flow was adjusted the temperature directly reacted in sync. This shows a direct correlation between the load and the high efficiency of the fans and coil assembly to react to temperature.

Test Two

In this test the Load Banks were set to 23Kw. The R.A.S.E.R. HD was run with one exchanger off line and one exchanger running. The water temperature was set to 85º F (29.4º C). The fans on the unit ran at 80% for the entire time of testing. The following chart notes the results of temperature readings taken during this test.

Temp. (ºC)

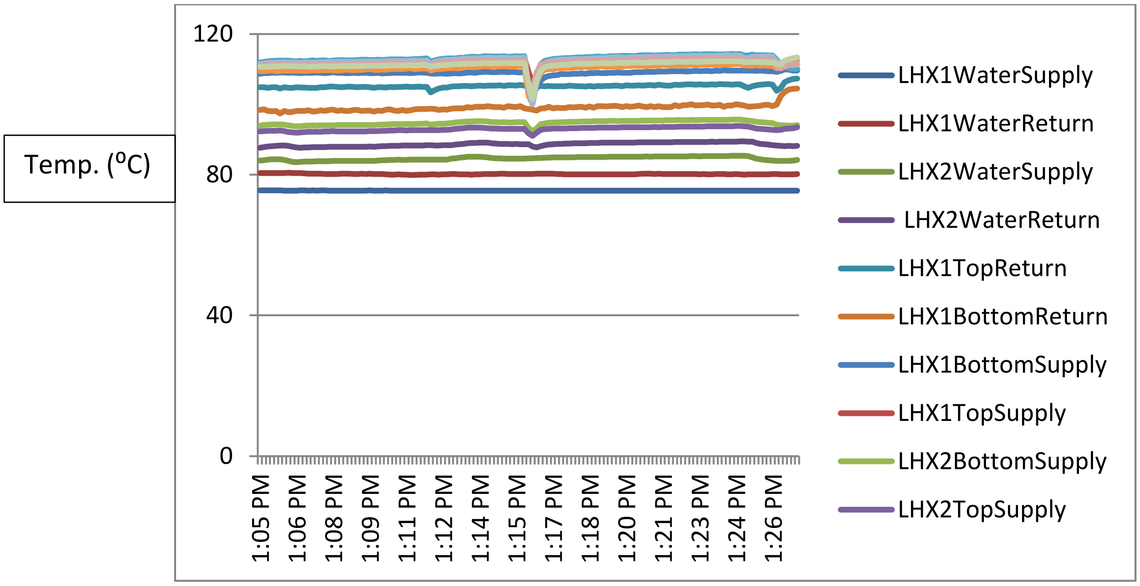
Graph lines are showing Water supply Temp at bottom of graph to Air return at the top of the graph



At 85º F (29.4º C) water and one exchanger running, the R.A.S.E.R. HD maintained a constant 23Kw of heat rejection.

Test Three

During this test, the EMS Technician set both exchangers to run through the automated power and controls located on the R.A.S.E.R. HD and then set the load banks at full running at 44Kw. The chart below shows the result of these tests.



As indicated in the previous alpha paper we believe that given an opportunity to true Data Center testing of various IT loads and configurations that there is ability for this type of design (Warmer water closed loop cooling) to achieve PUE's in the realm of 1.03. Actual PUE's will be determined by actual IT configuration.

What This Design Type Provides for Data Center Designs

Based on our testing and the results outlined in these white papers, Gkkworks has developed a design metric that allows for the IT and facility to grow in a new and unique way. We now have various design configurations that can easily be created by this type of a solution. As part to this paper we are providing this information as a guide to understand the value of adopting this type of a solution for new and existing Data Center designs.

As an organization, gkk works remains agnostic to the multitude of data center solutions that exist in the industry today. Gkkworks offers this information as specialists in the design, performance, procurement, and cost simulations for data center design and construction.

This paper will allow for further study and analysis of these design types and offer a guideline to utilization of these designs.

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Analysis of Major Design Components

Real Estate

The number one capital consideration for any data center is the real-estate. The numerous financial options available today to the data center industry vary from wholesale solutions to cloud, to actual build and own your own. The real estate industry has access to any and all aspects of these opportunities and provides a number of solutions for procuring, leasing, owning, and renting space for IT deployment. The limiting factor in this phase of the design process is that the strategy to procure has always been created around the concept of buying all the real estate you need up front due to the time frames associated with making Data Center space available for IT. The need to have this model is required in order to ensure a complete commitment to utility and tax incentives that are negotiated at the time of this procurement. The only set back is that the initial consideration for the RE procurement is set against a small window of IT density that will be needed to accommodate growth. The sizing for this is anywhere from 5Kw to 10Kw per rack or 150 to 200 watts per square foot.

There is an opportunity here to design a data center with more flexible growth using a closed loop system. Having the capability to design for this flexibility using components that can be switched out from 10Kw to 20Kw and potentially 40Kw gives you the ability to achieve greater longevity for your RE investment through density. This density and configuration can also be maximized through energy efficiency by using warmer water temperatures to reject heat across the chip as shown in the white paper.

Innovative alternatives to this type of development are starting to make way to the industry in modular design, not just from a building perspective but from an actual manufacturing one. If all of the components needed to create a data center were manufactured as plug in modules installed by a single contract entity, the cost variables in the procurement process would be more cost effective from concept through operation.

Modular Manufactured Development

Creating Data Centers "Just in Time" (JIT) to satisfy IT growth has yet to be perfected in this industry from a proactive approach. Since its inception, the Data Center has always been reactive to the needs of IT. Designs today are developed to make space readily available ahead of the business need and at a great expense to any one industry. Currently companies like HP, IO Data Centers, and Elliptical Mobile Solutions are driving designs in a manner that are equal to the standardization process that Henry Ford introduced to the car manufacturing industry. Developing entire Data Center solutions can now be packaged into standardized deliverable systems. These systems are coupled together on site and brought online, pre commissioned, and burned in from a software readiness standpoint. Other organizations like Dell, IBM, and Schneider Electric are also developing solutions at the modular component level. All are driving solutions to data center development from a bricks and mortar to "JIT" delivered solutions.

Based on a micro modular design, facilities can be sized, manufactured, constructed and operating in as little as 3 to 5 months ~~.~~and IT expansions can be deliverd in a~~s~~ few ~~as two~~ weeks. This allows for infrastructure to be fabricated in a sizing metric equal to the IT hardware that will use it. The real estate would equate to use of a landing pad with site utility ready to plug in and or existing shell (warehouse) facilities that could be reapportioned for data center use.

Micro modular units constructed to withstand the same impacts as those created for a traditional data center would allow units to be distributed across an open slab. These units, as in the design for container units, can be constructed against a distribution and utility spline. The difference between the container and the micro modular design is in the efficiency,~~ and the~~ scalability and use of space. With the latter, ~~Between the two~~ there is an ability to ebb and flow capacity from 10Kw to 400Kw at a time.

The Hardware Side of the Cloud

In the micro modular design there is the ability to re-asses the Data Center design as a whole from the IT aspect of the layout. In tradition designs today, the enterprise, wholesale, and some colocation layouts dictate a need to segment installations as a means to distribute platforms uniformly across the data center floor between hardware components. This type of design was primarily created in the mainframe era and has changed little over the years. In creating this design it was necessary to buss and tag components across a data center footprint tying to transfer heat evenly to CRAC units. Mainframes were in one location, DASD was a few aisles over, and Tape drives and storage were in another area. The network systems were also in a row of their own. This works for the distribution of load and heat but creates another issue for the IT folks and that is one of latency. Today, Data Centers are set in somewhat the same fashion -- Servers, Storage, and Network are all in neat hot and cold aisles with load spread across the floor. This is because the traditional facility is set to only handle upwards of 8Kw and in some denser areas, 12Kw.

In the denser micro modular and container design there is now an opportunity to create a tighter combination of systems all within the same frame. Having the capability to size a system of IT components to actual software application across virtualized systems could drive a greater ability to drive latency out of the equation. You could couple servers, storage, and network in a software application and system array either in the same 42-52U frame or in units sitting right next to each other. Heat loading would no longer be a concern in the Data Center ~~There would no longer be concern from a heat loading perspective in any area of the Data Center~~ because your configurations would not be constrained by a per Kw cabinet size. Distribution is easier because you no longer have to worry about hot and cold aisle configurations.

Network

L~~It is l~~ast-mile packet loss ~~which~~ has the biggest impact on the customer's/user's experience – NOT bandwidth or congestion. The Internet (TCP/IP) is designed so that packet loss is used as a signaling tool to reduce packet throughput. Regardless of where the packet loss occurs, the Internet is designed to slow down any data stream that is affected by a lost packet. However the rate to which a data stream is slowed down is greatly dependent on distance. ~~This is why~~Network Perfomance is accelerated by moving caching boxes as close as possible to the user. This affects end-to- end throughput, particularly if there is ongoing packet loss.

In a micro modular and container design, as stated previous, this could be eliminated by re-design of IT hardware configurations to software applications,~~.~~

The long haul, too, could be better managed by adopting a denser server and storage configuration between delivery points. An overlay on long haul network topology configured in a paralleling fashion to IP distribute would allow capacity across a larger frame work, enhancing Content Delivery Networks (CDN) and other distributed network topologies' performance..~~.~~

Conclusion

The considerations for close-coupled designs are many. Product selection depends largely on the individual installation and requires input from a number of groups including IT, facilities staff, consulting engineers, and vendor representatives. Yet, the end result of this concerted effort can be considerable.

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The costs to develop facilities around a manufactured concept are just beginning to be realized. As volume drives solutions in the Data Center using these types of manufactured systems, there is a greater opportunity for IT to continue on a track that will allow for tighter control of cost without having to spare innovation.

As the ~~"~~manufacturing of Data Center capacity "J~~j~~ust I~~i~~n T~~t~~ime" (JIT) to meet the business need~~"~~ is more widely adopted, ~~the benefits will be seen in greater~~ efficiencies in energy utilization, space optimization, and operational longevity will be seen throughout the industry. ~~The need for~~ G~~g~~eographic dependency for solutions around free cooling, hydro power and larger footprint (acres) for data centers become~~s~~ less dependent on Total Cost of Ownership for the Data Center

Cloud utilization and development of a secure Data Center platform are dependent in the near future on the ability to innovate every aspect of the data center from the Utility to the Hardware. The process and benefits realized in manufacturing solutions to meet the need will drive greater alignment and ability to create micro modular solutions from the end user to the enterprise provider at a more cost effective and beneficial rate to the industry.

The befit of developing Data Centers in a manufactured environment will allow for quicker adoption of solutions that eliminate CO_2. Data Centers can now to be manufactured and operate using an organic approach rather than the traditional fossil fuel methodology.