having a power consumption capacity of 1 MW. Further, the traditional chiller plant is typically designed to cool the entire data center, as opposed to a few selected areas within the data center. As a result, the traditional chiller plant spends a considerable amount of energy on areas that do not need to be cooled. Further, one of the design constraints used to implement the traditional chiller plant is the power consumption capacity of the entire data center. For that reason, if the data center does not run at its power consumption capacity due to load fluctuation, the efficiency of the traditionally chiller plant drops significantly.

[0004] Currently, several cooling systems exist in the market having a more modular design approach compared to the traditional, large, oversized cooling electrical infrastructures that allow them to treat selected areas of a large data center at a reduced cost. For instance, an air-cooled "free cooling" system (also referred to as a straight air-cooled system) uses ambient air as a medium to cool server racks or containers of server racks in a large data center. However, one of the drawbacks of the air-cooled "free cooling" system is that it operates only in a cool, dry-climate environment thereby restricting its use to limited geographical areas in the world.

[0005] An adiabatic-assisted system is another cooling system that rivals the traditional, large, oversized cooling electrical infrastructures. The adiabatic-assisted system is a cooling system assisted by adiabatic water, having a more expanded geographical reach than the air-cooled "free cooling" system. However, the adiabatic-assisted system has certain cooling tolerance limitations and is incapable of providing sufficient cooling to high density data centers, e.g., data centers having IT rack loads of 40 kW per IT rack.

SUMMARY

[0006] The examples of the modular data pod systems and the associated cooling systems of the present disclosure provide significant improvements over traditional data centers and their cooling systems including, for example, (1) a lower cost per kilowatt (kW) to build, deploy, and operate a data center, (2) faster deployment than stick-built construction, (3) more easily restacked and redeployed to allow the data center to keep up with new technological advances in server technology, (4)

expandability, (5) compatibility with very high efficiency systems to gain the highest power use efficiency

(PUE) factor, (6) space saving and efficient in its space requirements allowing higher density capabilities (i.e., more kilowatts per square foot), (7) scalability, (8) efficiency in mechanical cooling, (9) multi-use characteristics for single deployment, large indoor warehousing, or large outdoor applications, such as data center farms, (10) energy-efficiency in the containment of hot and cold aisles, (11) flexibility in its use of different types of cooling systems, and (12) capability of being modified to meet data center tier requirements for redundancy.

[0007] There is disclosed a modular data center. In one example, the modular data center includes a first cooling circuit that has a primary cooling device and a plurality of modular data pods. Each modular data pod includes a plurality of servers, a heat exchange member coupled to the first cooling circuit, and a second cooling circuit coupled to the heat exchange member. The second cooling circuit is configured to cool the plurality of servers. The second cooling circuit includes a secondary cooling device configured to cool fluid flowing through the second cooling circuit.

[0008] There is disclosed a modular data pod. The modular data pod includes a plurality of servers, at least one heat exchange member and a second cooling circuit. The at least one heat exchange member is configured to couple to a first cooling circuit which includes a free-cooling device. The second cooling circuit is coupled to the heat exchange member. Further, the second cooling circuit is in thermal communication with the plurality of servers. The second cooling circuit includes a mechanical cooling device.

[0009] According to an aspect of the present invention, there is provided a modular data center includes a central cooling system and a plurality of modular data pods. Each modular data pod includes a plurality of servers, a heat exchange assembly coupled to the central cooling system, and a distributed cooling system coupled to the heat exchange assembly. The heat exchange assembly is configured to cool the plurality of servers.

[0010] According to a further aspect of the present invention, there is provided a modular data pod includes an enclosure, a plurality of computer racks arranged within the enclosure. The enclosure includes wall members

contiguously joined to one another along at least one edge of each wall member. The wall members are formed in the shape of a polygon. The enclosure also

includes a data pod covering member. The plurality of computer racks forms a first volume formed between the inner surface of the wall members and first sides of the computer racks. The plurality of racks also forms a second volume formed between the inner surface of the wall members and second sides of the computer racks. The modular data pod further includes a computer rack covering member which is configured to enclose the second volume. The computer rack covering member and the data pod covering member form a third volume. The third volume couples the first volume to the second volume. The modular data pod may also include an air circulator which is configured to continuously circulate air through the first, second, and third volumes.

[0011] According to a further aspect of the present invention, there is provided a modular data center includes a central fluid and electrical circuit, a chain of modular data pods and a central cooling device. Each modular data pod in the chain of modular data pods includes a shared cooling fluid circuit section and an unshared cooling fluid circuit. The unshared cooling fluid circuit is coupled to the shared fluid and electrical circuit section. The shared fluid and electrical circuit section form a part of a shared fluid and electrical circuit. The shared fluid and electrical circuit are coupled at one end to the central fluid and electrical circuit. The central cooling device is coupled to the central cooling fluid circuit. The central cooling device is configured to support at least a portion of the cooling requirements of the first chain of modular data pods.

[0012] There is disclosed a cooling system for a modular data center. The cooling system includes a first cooling circuit which includes a primary cooling device. The cooling system also includes a plurality of modular data pods. Each modular data pod includes an enclosure that includes a plurality of server racks, a heat exchange member coupled to the first cooling circuit, and a second cooling circuit coupled to the heat exchange member. The second cooling circuit is configured to cool the enclosure. The second cooling circuit includes a secondary cooling device configured to cool fluid flowing through the second cooling circuit.

[0013] According to a further aspect of the present invention, there is provided a system for cooling electronic

equipment. The system includes a free-cooling system and a mechanical sub-cooling system. The free-cooling system is configured to cool a first fluid in thermal communication with electronic equipment using atmospheric air. The mechanical sub-

cooling system is coupled to the free-cooling system. The mechanical system is configured to cool a second fluid flowing in the free-cooling system as a function of an amount by which the free-cooling system has exceeded its maximum cooling capacity.

[0014] According to a further aspect of the present invention, there is provided a cooling system for cooling electronic equipment. The cooling system includes a first fluid circuit, a second fluid circuit and a third fluid circuit. The first fluid circuit is configured to cool electronic equipment using a first fluid flowing through the first fluid circuit. The second fluid circuit is configured to free cool a second fluid flowing through the second fluid circuit. Further, the second fluid circuit is configured to cool the first fluid using the free-cooled second fluid. The third fluid circuit is configured to mechanically cool the second fluid as a function of the difference between the wet bulb temperature of atmospheric air and a first predetermined wet bulb temperature when the wet bulb temperature exceeds the first predetermined wet bulb temperature.

[0014a] According to a further aspect of the present invention, there is provided a method of cooling electronic equipment, comprising: cooling electronic equipment using a first fluid; free cooling the first fluid by enabling heat transfer from the first fluid to a second fluid that has been cooled using atmospheric air; and mechanically cooling the second fluid to the extent that free cooling the first fluid is insufficient to cool the first fluid.

[0014b] According to a further aspect of the present invention, there is provided a method of cooling a plurality of computer racks, comprising: arranging a plurality of computer racks within an enclosure having the shape of a polygon to form a first volume between the wall members of the enclosure and first sides of the plurality of computer racks and to form a second volume between second sides of the computer racks; and enclosing the second volume to form a third volume coupling the first volume to the second volume; and circulating air between the first volume and the second volume via the third volume and the computer racks.

[0014c] According to a further aspect of the present invention, there is provided a method of deploying a plurality modular data pods to form a data center, comprising: coupling a plurality of shared fluid and electrical circuit sections of a respective plurality

of modular data pods in series to form a shared fluid and electrical circuit having a first end and a second end; coupling an unshared fluid and electrical circuit of each modular data pod of the plurality of modular data pods to a respective shared fluid and electrical circuit section; and coupling a shared fluid and electrical circuit section at the first end of the shared fluid and electrical circuit to a central fluid and electrical circuit.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] Various embodiments of the present disclosure are described with reference to the accompanying drawings wherein:

[0016] FIG. 1 is a schematic diagram of a modular data center according to embodiments of the present disclosure;

[0017] FIG. 2A is an illustration of a modular data pod having a pentagonal wall configuration according to one embodiment of the present disclosure;

[0018] FIG. 2B is an illustration of a modular data pod having a hexagonal wall configuration according to another embodiment of the present disclosure;

[0019] FIG. 2C is an illustration of a modular data pod having a heptagonal wall configuration according to yet another embodiment of the present disclosure;

[0020] FIG. 2D is an illustration of a modular data pod having an octagonal wall configuration according to one embodiment of the present disclosure;

[0021] FIG. 2E is an illustration of a modular data pod having a nonagonal wall configuration according to one embodiment of the present disclosure;

[0022] FIG. 2F is an illustration of a modular data pod having a decagonal wall configuration according to yet another embodiment of the present disclosure;