

[0006] Some computer servers can now produce outputs in excess of 35 kW similar to the IBM Blue Jean Server. The rear-door heat exchangers and other similar cooling products on the market cannot handle the cooling requirements of these high-density computer servers.

[0007] Many existing data centers have been constructed with in-row rack cooling systems and integral hot and cold aisle containment. These data centers, however, waste a significant amount of space. Also, it is difficult to increase the cooling capacity of the in-row rack cooling systems when servers are added to the server racks or existing servers are replaced with servers requiring more cooling capacity. Furthermore, it is difficult for many existing data centers to upgrade their cooling systems to comply with future government regulations that require reductions in energy consumption. Thus, the data center industry has been seeking energy efficient modular cooling solutions for new and existing white space in data centers, as well as “just-in-time” and modular cooling expansion capabilities both at the server level as well as at the overall rack level.

SUMMARY

[0007a] According to a first aspect of the present invention, there is provided a modular server rack cooling structure for cooling at least one server in at least one rack of a data center, the modular server rack cooling structure comprising: a first supporting member including a first plurality of beam members, wherein the first plurality of beam members are directly coupled to each other to form a substantially U-shaped configuration; a second supporting member including a second plurality of beam members, wherein the second plurality of beam members are directly coupled to each other to form a substantially U-shaped configuration, wherein the first and second supporting members are disposed in a diametrically opposed orientation; a third supporting member including a third plurality of beam members, wherein the third plurality of beam members are directly coupled to an upper end of each of the first and second plurality of beam members; a first heat exchanger directly coupled to the first plurality of beam members of the first supporting member such that the first heat exchanger is positioned in heat transfer relationship with a first plurality of servers, wherein the first heat exchanger is not attached to the at least one rack; a second heat exchanger coupled to the second plurality of beam members of the second supporting member such that the second heat exchanger is positioned in heat transfer relationship with a second plurality of servers, wherein the second heat exchanger is not attached to the at least one rack; a third heat exchanger coupled to the third plurality of beam members of the third supporting member, the third heat exchanger positioned at a right angle with respect to the first heat exchanger and the second heat exchanger; and a fourth heat exchanger coupled to the third plurality of beam members of the third supporting member and extending upward from the third plurality of beam members at an acute angle with respect to the third plurality of beam members.

[0007b] According to a second aspect of the present invention, there is provided a modular data center system, comprising: at least a first rack and at least a second rack

disposed opposite one another to form a hot aisle or a cold aisle between the at least a first rack and the at least a second rack, each rack supporting at least one server; a modular server rack cooling structure comprising: a first supporting member including a first plurality of beam members, wherein the first plurality of beam members are directly coupled to each other to form a substantially U-shaped configuration, wherein the first supporting member is disposed adjacent the at least a first rack; a second supporting member including a second plurality of beam members, wherein the second plurality of beam members are directly coupled to each other to form a substantially U-shaped configuration, wherein the second supporting member is disposed adjacent the at least a second rack such that the first and second supporting members are disposed in a diametrically opposed orientation; a third supporting member including a third plurality of beam members, wherein the third plurality of beam members are directly coupled to an upper end of each of the first and second plurality of beam members; a first heat exchanger coupled to the first plurality of beam members of the first supporting member such that the first heat exchanger is positioned in heat transfer relationship with at least one server of the at least a first rack, wherein the first heat exchanger is not attached to the at least a first rack; a second heat exchanger coupled to the second plurality of beam members of the second supporting member such that the second heat exchanger is in heat transfer relationship with at least one server of the at least a second rack, wherein the second heat exchanger is not attached to the at least a second rack; a third heat exchanger coupled to the third plurality of beam members of the third supporting member, the third heat exchanger positioned at a right angle with respect to the first heat exchanger and the second heat exchanger; and a fourth heat exchanger coupled to the third plurality of beam members of the third supporting member and extending upward from the third plurality of beam members at an acute angle with respect to the third plurality of beam members.

[0007c] According to a third aspect of the present invention, there is provided a method of installing a modular server rack cooling structure for cooling at least a first server installed in at least a first rack and at least a second server installed in at least a second rack, the at least a first rack and the at least a second rack disposed opposite from each other to form at least a portion of a hot aisle or a cold aisle, the method comprising: positioning at least a portion of a modular support structure in the hot aisle or the cold aisle, the modular support structure comprising at least a first supporting member including a first plurality of beam members directly coupled to each other to form a substantially U-shaped configuration, a second supporting member including a second plurality of beams members directly coupled to each other to form a substantially U-shaped configuration, and a third supporting member including a third plurality of beam members directly coupled to an upper end of each of the first and second plurality of beam members; coupling a first heat exchanger to the first plurality of beam members of the first supporting member so that the first heat exchanger is positioned adjacent to the at least a first server of the at least a first rack; coupling a second heat exchanger to the second plurality of beam members of the second supporting member so that the second heat exchanger is positioned adjacent to the at least a second server of the at least a second rack; coupling a third heat exchanger to the third plurality of beam members of the third supporting member so that the third heat exchanger is positioned at a right angle with respect to the first heat exchanger and the second heat exchanger; and coupling a fourth heat exchanger to the third plurality of beam members of the third supporting member and extending upward from the third plurality of beam members at an acute angle with respect to the third plurality of beam members.

[0008] ~~There is also disclosed~~In one aspect, the present disclosure features a modular server rack cooling structure for cooling at least one server in at least one rack of a data center. The modular server rack cooling structure for cooling at least one server in at least one rack of a data center includes at least a first supporting member and at least a first heat exchanger that are coupled to each other. The first supporting member is configured to position the first heat exchanger in heat transfer relationship with the server, where the first heat exchanger is not attached to the rack.

[0013] In some embodiments, the data center further includes at least a second rack for supporting at least one server, where the first rack and the second rack are disposed opposite one another to form a hot aisle or a cold aisle between the first rack and the second rack. The modular server rack cooling structure may further include at least a second supporting member and at least a second heat exchanger coupled to each other. The second supporting member is configured to position the second heat exchanger in heat transfer relationship with the server of the second rack, where the second heat exchanger is not attached to the second rack. In some embodiments, the modular server rack cooling structure further includes at least one forced fluid-flow device configured and disposed with respect to the first heat exchanger to provide a flow of fluid between the server and the first heat exchanger.

[0014] ~~There is also disclosed~~In another aspect, the present disclosure features a modular data center system including at least a first rack and at least a second rack disposed opposite one another to form a hot aisle or a cold aisle between the first rack and the second rack, each of which supports at least one server. The modular data center system also includes a modular server rack cooling structure including at least a first supporting member and at least a first heat exchanger coupled to each other. The first supporting member is configured to position the first heat exchanger in heat transfer relationship with at least one server of first rack so that the first heat exchanger is not attached to the first rack. The modular data center system also includes at least a second supporting member and at least a second heat exchanger coupled to each other. The second supporting member is configured to position the second heat exchanger in heat transfer relationship with at least

member of the third supporting member. In some embodiments, the second heat exchanger is disposed vertically, horizontally or diagonally.

[0019] In some embodiments, the modular data center system further includes at least one forced fluid-flow device configured to provide a flow of fluid between the servers and the heat exchangers, at least a fourth supporting member, and at least a fourth heat exchanger in which the third heat exchanger is coupled to the fourth supporting member and the fourth supporting member is configured to position the fourth heat exchanger adjacent to the forced fluid-flow device.

[0020] ~~There is further disclosed~~In yet another aspect, the present disclosure features a method of installing a modular server rack cooling structure for cooling at least a first server installed in at least a first rack and at least a second server installed in at least a second rack in which the first rack and the second rack are disposed opposite from each other to form at least a portion of a hot aisle or a cold aisle. The method includes positioning at least a portion of a modular support structure in the hot aisle or the cold aisle where the modular support structure including at least a first support member, a second support member, and a third support member. The method also includes coupling at least a first heat exchanger to the first supporting member so that the first heat exchanger is positioned adjacent to the first server of the first rack. The method also includes coupling at least a second heat exchanger to the second supporting member so that the second heat exchanger is positioned adjacent to the second server of the second rack and coupling at least a third heat exchanger to the third supporting member so that the third heat exchanger is positioned within the hot aisle or the cold aisle, where coupling the third heat exchanger

CLAIMS

What is claimed is:

1. A modular server rack cooling structure for cooling at least one server in at least one rack of a data center, the modular server rack cooling structure comprising:
at least a first supporting member; and
at least a first heat exchanger, the at least a first heat exchanger coupled to the at least a first supporting member, the at least a first supporting member configured to position the at least a first heat exchanger in heat transfer relationship with the at least one server, wherein the at least a first heat exchanger is not attached to the at least one rack.
2. The modular server rack cooling structure according to claim 1, wherein the at least a first supporting member comprises a beam member, and wherein the at least a first heat exchanger has a dimension defining an edge of the at least a first heat exchanger and wherein the edge of the at least a first heat exchanger is rotatably coupled to the beam member.
3. The modular server rack cooling structure according to claim 2, wherein the beam member is a horizontal beam member or a vertical beam member.
4. The modular server rack cooling structure according to claim 1, wherein the at least a first supporting member comprises at least first, second and third beam members, the first beam member substantially orthogonally coupled to the second beam member

and the third beam member substantially orthogonally coupled to the second beam member to form a substantially U-shaped configuration, and wherein the at least a first heat exchanger has a dimension defining an edge of the at least a first heat exchanger and wherein the edge of the at least a first heat exchanger is rotatably coupled to the first beam member, the second beam member, or the third beam member.

5. The modular server rack cooling structure according to claim 4, wherein the dimension defining the edge of the at least a first heat exchanger has a substantially longitudinal dimension defining a longitudinal edge of the at least a first heat exchanger and wherein the longitudinal edge of the at least a first heat exchanger is rotatably coupled to the first beam member or the third beam member.

6. The modular server rack cooling structure according to claim 5, wherein the at least a second supporting member comprises a beam member, and wherein the at least a second heat exchanger has a dimension defining an edge of the at least a second heat exchanger and wherein the edge of the at least a second heat exchanger is rotatably coupled to the beam member of the at least a second supporting member.

7. The modular server rack cooling structure according to claim 6, wherein the at least a second heat exchanger is disposed vertically, horizontally or diagonally.

8. The modular server rack cooling structure according to claim 5, wherein the at least a second supporting member comprises a beam member, and wherein the at least a

second heat exchanger is coupled to the beam member of the at least a second supporting member.

9. The modular server rack cooling structure according to claim 1, wherein the data center further includes at least a second rack for supporting at least one server, wherein the at least a first rack and the at least a second rack are disposed opposite one another to form a hot aisle or a cold aisle between the at least a first rack and the at least a second rack, the modular server rack cooling structure further comprising:

at least a second supporting member; and

at least a second heat exchanger, the at least a second heat exchanger coupled to the at least a second supporting member, the at least a second supporting member configured to position the at least a second heat exchanger in heat transfer relationship with the at least one server of the at least a second rack, wherein the at least a second heat exchanger is not attached to the at least a second rack.

10. The modular server rack cooling structure according to claim 1, further comprising at least one forced fluid-flow device configured and disposed with respect to the at least a first heat exchanger to provide a flow of fluid between the at least one server and the at least a first heat exchanger.

11. A modular data center system, comprising:

at least a first rack and at least a second rack disposed opposite one another to form a hot aisle or a cold aisle between the at least a first rack and the at least a second rack, each rack supporting at least one server;

a modular server rack cooling structure comprising:

at least a first supporting member; and

at least a first heat exchanger, the at least a first heat exchanger coupled to the at least a first supporting member, the at least a first supporting member configured to position the at least a first heat exchanger in heat transfer relationship with at least one server of the at least a first rack, wherein the at least a first heat exchanger is not attached to the at least a first rack;

at least a second supporting member; and

at least a second heat exchanger, the at least a second heat exchanger coupled to the at least a second supporting member, the at least a second supporting member configured to position the at least a second heat exchanger in heat transfer relationship with at least one server of the at least a second rack, wherein the at least a second heat exchanger is not attached to the at least a second rack.

12. The modular data center system according to claim 11, wherein the at least a first supporting member comprises a beam member, the at least a first heat exchanger has a dimension defining an edge of the at least a first heat exchanger, the edge of the at least a first heat exchanger is rotatably coupled to the beam member of the at least a first supporting member, the at least a second supporting member comprises a beam member,

the at least a second heat exchanger has a dimension defining an edge of the at least a second heat exchanger, and the edge of the at least a second heat exchanger is rotatably coupled to the beam member of the at least a second supporting member.

13. The modular data center system according to claim 12, further comprising at least one forced fluid-flow device configured to provide a flow of fluid between the servers and the heat exchangers.

14. The modular data center system according to claim 12, wherein the beam members are vertical beam members disposed adjacent to the at least a first rack and the at least a second rack.

15. The modular data center system according to claim 12, further comprising:
at least a third supporting member; and
at least a third heat exchanger, the at least a third heat exchanger coupled to the at least a third supporting member, the at least a third supporting member configured to position the at least a third heat exchanger in heat transfer relationship with the at least one server of the at least a first rack or the at least one server of the at least a second rack.

16. The modular data center system according to claim 15, wherein the at least a third supporting member comprises a beam member, and wherein the at least a third heat exchanger has a dimension defining an edge of the at least a third heat exchanger and

wherein the edge of the at least a third heat exchanger is rotatably coupled to the beam member of the at least a third supporting member.

17. The modular data center system according to claim 15, wherein the at least a third supporting member comprises a beam member, and wherein the at least a third heat exchanger is coupled to the beam member of the at least a third supporting member.

18. The modular data center system according to claim 17, wherein the at least a second heat exchanger is disposed vertically, horizontally or diagonally.

19. The modular data center system according to claim 15, further comprising:
at least one forced fluid-flow device configured to provide a flow of fluid between the servers and the heat exchangers;
at least a fourth supporting member; and
at least a fourth heat exchanger, the at least a third heat exchanger coupled to the at least a fourth supporting member, the at least a fourth supporting member configured to position the at least a fourth heat exchanger adjacent to the at least one forced fluid-flow device.

20. A method of installing a modular server rack cooling structure for cooling at least a first server installed in at least a first rack and at least a second server installed in at least a second rack, the at least a first rack and the at least a second rack disposed

opposite from each other to form at least a portion of a hot aisle or a cold aisle, the method comprising:

positioning at least a portion of a modular support structure in the hot aisle or the cold aisle, the modular support structure comprising at least a first support member, a second support member, and a third support member;

coupling at least a first heat exchanger to the at least a first supporting member so that the at least a first heat exchanger is positioned adjacent to the at least a first server of the at least a first rack;

coupling at least a second heat exchanger to the at least a second supporting member so that the at least a second heat exchanger is positioned adjacent to the at least a second server of the at least a second rack; and

coupling at least a third heat exchanger to the at least a third supporting member so that the at least a third heat exchanger is positioned within the hot aisle or the cold aisle, wherein the coupling at least a third heat exchanger to the at least a third supporting member is performed after at least a third server is installed in the at least a first rack or the at least a second rack.

Claims

1. A modular server rack cooling structure for cooling at least one server in at least one rack of a data center, the modular server rack cooling structure comprising:

a first supporting member including a first plurality of beam members, wherein the first plurality of beam members are directly coupled to each other to form a substantially U-shaped configuration;

a second supporting member including a second plurality of beam members, wherein the second plurality of beam members are directly coupled to each other to form a substantially U-shaped configuration, wherein the first and second supporting members are disposed in a diametrically opposed orientation;

a third supporting member including a third plurality of beam members, wherein the third plurality of beam members are directly coupled to an upper end of each of the first and second plurality of beam members;

a first heat exchanger directly coupled to the first plurality of beam members of the first supporting member such that the first heat exchanger is positioned in heat transfer relationship with a first plurality of servers, wherein the first heat exchanger is not attached to the at least one rack;

a second heat exchanger coupled to the second plurality of beam members of the second supporting member such that the second heat exchanger is positioned in heat transfer relationship with a second plurality of servers, wherein the second heat exchanger is not attached to the at least one rack;

a third heat exchanger coupled to the third plurality of beam members of the third supporting member, the third heat exchanger positioned at a right angle with respect to the first heat exchanger and the second heat exchanger; and

a fourth heat exchanger coupled to the third plurality of beam members of the third

supporting member and extending upward from the third plurality of beam members at an acute angle with respect to the third plurality of beam members.

2. The modular server rack cooling structure according to claim 1, wherein the first heat exchanger has a dimension defining an edge that is rotatably coupled to a beam member of the first plurality of beam members.

3. The modular server rack cooling structure according to claim 2, wherein at least one of the first and second plurality of beam members is a horizontal beam member or a vertical beam member.

4. The modular server rack cooling structure according to claim 1, wherein the first plurality of beam members comprises at least first, second and third beam members, the first beam member substantially orthogonally coupled to the second beam member and the third beam member substantially orthogonally coupled to the second beam member to form a substantially U-shaped configuration, and wherein the first heat exchanger has a dimension defining an edge that is rotatably coupled to the first beam member, the second beam member, or the third beam member.

5. The modular server rack cooling structure according to claim 4, wherein the dimension defining the edge of the first heat exchanger has a substantially longitudinal dimension defining a longitudinal edge of the first heat exchanger and wherein the longitudinal edge of the first heat exchanger is rotatably coupled to the first beam member or the third beam member.

6. The modular server rack cooling structure according to claim 5, wherein the second

plurality of beam members comprises at least first, second, and third beam members, the first beam member substantially orthogonally coupled to the second beam member and the third beam member substantially orthogonally coupled to the second beam member to form a substantially U-shaped configuration.

7. The modular server rack cooling structure according to claim 6, wherein the second heat exchanger is disposed vertically, horizontally or diagonally.

8. The modular server rack cooling structure according to claim 1, wherein the at least one rack is at least a first rack and the data center further includes at least a second rack for supporting at least one server, wherein the at least a first rack and the at least a second rack are disposed opposite one another to form a hot aisle or a cold aisle between the at least a first rack and the at least a second rack, wherein the at least a second rack is disposed adjacent the second plurality of beam members of the second supporting member.

9. The modular server rack cooling structure according to claim 1, further comprising at least one forced fluid-flow device configured and disposed with respect to the first heat exchanger to provide a flow of fluid between the at least one server and the first heat exchanger.

10. A modular data center system, comprising:

at least a first rack and at least a second rack disposed opposite one another to form a hot aisle or a cold aisle between the at least a first rack and the at least a second rack, each rack supporting at least one server;

a modular server rack cooling structure comprising:

a first supporting member including a first plurality of beam members,

wherein the first plurality of beam members are directly coupled to each other to form a substantially U-shaped configuration, wherein the first supporting member is disposed adjacent the at least a first rack;

a second supporting member including a second plurality of beam members, wherein the second plurality of beam members are directly coupled to each other to form a substantially U-shaped configuration, wherein the second supporting member is disposed adjacent the at least a second rack such that the first and second supporting members are disposed in a diametrically opposed orientation;

a third supporting member including a third plurality of beam members, wherein the third plurality of beam members are directly coupled to an upper end of each of the first and second plurality of beam members;

a first heat exchanger coupled to the first plurality of beam members of the first supporting member such that the first heat exchanger is positioned in heat transfer relationship with at least one server of the at least a first rack, wherein the first heat exchanger is not attached to the at least a first rack,;

a second heat exchanger coupled to the second plurality of beam members of the second supporting member such that the second heat exchanger is in heat transfer relationship with at least one server of the at least a second rack, wherein the second heat exchanger is not attached to the at least a second rack;

a third heat exchanger coupled to the third plurality of beam members of the third supporting member, the third heat exchanger positioned at a right angle with respect to the first heat exchanger and the second heat exchanger; and

a fourth heat exchanger coupled to the third plurality of beam members of the third supporting member and extending upward from the third plurality of beam members at an acute angle with respect to the third plurality of beam members.

11. The modular data center system according to claim 10, wherein the first heat exchanger has a dimension defining an edge that is rotatably coupled to a beam member of the first plurality of beam members, and the second heat exchanger has a dimension defining an edge that is rotatably coupled to a beam member of the second plurality of beam members.

12. The modular data center system according to claim 11, further comprising at least one forced fluid-flow device configured to provide a flow of fluid between the servers and the heat exchangers.

13. The modular data center system according to claim 11, wherein at least one of the plurality of beam members are vertical beam members disposed adjacent to the at least a first rack and the at least a second rack.

14. The modular data center system according to claim 11, wherein the fourth heat exchanger is in heat transfer relationship with the at least one server of the at least a first rack or the at least one server of the at least a second rack.

15. The modular data center system according to claim 14, wherein the fourth heat exchanger has a dimension defining an edge that is rotatably coupled to a beam member of the third plurality of beam members.

16. The modular data center system according to claim 14, wherein the second heat exchanger is disposed vertically, horizontally or diagonally.

17. A method of installing a modular server rack cooling structure for cooling at least a first server installed in at least a first rack and at least a second server installed in at least a second rack, the at least a first rack and the at least a second rack disposed opposite from each other to form at least a portion of a hot aisle or a cold aisle, the method comprising:

positioning at least a portion of a modular support structure in the hot aisle or the cold aisle, the modular support structure comprising at least a first supporting member including a first plurality of beam members directly coupled to each other to form a substantially U-shaped configuration, a second supporting member including a second plurality of beams members directly coupled to each other to form a substantially U-shaped configuration, and a third supporting member including a third plurality of beam members directly coupled to an upper end of each of the first and second plurality of beam members;

coupling a first heat exchanger to the first plurality of beam members of the first supporting member so that the first heat exchanger is positioned adjacent to the at least a first server of the at least a first rack;

coupling a second heat exchanger to the second plurality of beam members of the second supporting member so that the second heat exchanger is positioned adjacent to the at least a second server of the at least a second rack;

coupling a third heat exchanger to the third plurality of beam members of the third supporting member so that the third heat exchanger is positioned at a right angle with respect to the first heat exchanger and the second heat exchanger; and

coupling a fourth heat exchanger to the third plurality of beam members of the third supporting member and extending upward from the third plurality of beam members at an acute angle with respect to the third plurality of beam members.

18. The modular server rack cooling structure according to claim 6, wherein the third

plurality of beam members comprises at least first and second beam members extending from the first supporting member to the second supporting member, wherein the third heat exchanger has a dimension defining an edge that is rotatably coupled to the first beam member or the second beam member of the third plurality of beam members.