

SUMMARY

According to a first aspect of the present invention, there is provided a server cooling system comprising: a first space defined by a floor, one or more lateral walls, and a roof; one or more openings located on the roof and the one or more lateral walls, wherein ~~at least one~~ a first opening of the one or more openings is located on a first lateral wall of the one or more lateral walls to allow outside natural air to enter and ~~at least one~~ a second opening of the one or more openings is located on the roof, wherein ~~the second opening is higher than the first opening~~ to allow air in the server cooling system to be heated and rise via natural convection and exit the server cooling system via the second opening; an enclosure installed within the first space and defining a second space that is sealed from the first space; one or more air-handling units configured to draw external air into the first space through the ~~at least one~~ first opening of the one or more openings located on the first lateral wall; and a rack installed in the first space and engaging the enclosure in a sealed manner, wherein one or more rack-mounted units can be installed in the rack such that front faces of the rack-mounted units interface with the first space, and that back faces of the rack-mounted units interface with the second space, and one or more cooling fans in the rack are operable to draw air from the first space through the front faces of the one or more rack-mounted units and expel heated air through the back faces of the one or more rack-mounted units to the second space.

According to a second aspect of the present invention, there is provided a server cooling system comprising a first space defined by a floor, one or more lateral walls, and a ceiling; a third space defined by the ceiling and a roof; one or more openings located on the ceiling and one of the one or more lateral walls, wherein ~~at least one~~ a first opening of the one or more openings is located on a first lateral wall of the one or more lateral walls to allow outside natural air to enter, ~~at least one~~ a second opening of the one or more openings is located on a second lateral wall of the one or more lateral walls, wherein ~~the second opening is higher than the first opening~~ to allow air in the server cooling system to be heated and rise via natural convection and exit the server cooling system via the second opening, and at least one of the one or more openings is located on the ceiling to allow air exchange between the first space and the third space; an enclosure installed within the first space and defining a second space operably connected to the one or more openings and the third space; one or more air-handling units configured to draw external air into the first space through ~~at least one~~ the first opening of the one or more openings located on the first lateral wall; and a rack installed in the first space and

engaging the enclosure in a sealed manner, wherein one or more rack-mounted units can be installed in the rack such that front faces of the rack-mounted units interface with the first space, and that back faces of the rack-mounted units interface with the second space, and one or more cooling fans in the rack are operable to draw air from the first space through the front faces of the one or more rack-mounted units and expel heated air through the back faces of the one or more rack-mounted units to the second space.

According to a third aspect of the present invention, there is provided a server cooling system comprising a first space defined by a floor, one or more lateral walls, and a ceiling; a third space defined by the ceiling and a roof; one or more openings located on the ceiling and at least one of the one or more lateral walls, wherein ~~at least one~~ a first opening of the one or more openings is located on a first lateral wall of the one or more lateral walls to allow outside natural air to enter, ~~at least one~~ a second opening of the one or more openings is located on a second lateral wall of the one or more lateral walls, wherein the second opening is higher than the first opening to allow air in the server cooling system to be heated and rise via natural convection and exit the server cooling system via the second opening, and at least one of the one or more openings is located on the ceiling to allow air exchange between the first space and the third space; a first enclosure installed within the first space and defining a fourth space operably connected to the one or more openings; a second enclosure installed within the first space and defining a fifth space operably connected to the third space; one or more air-handling units configured to draw external air into the first space through ~~at least one~~ the first opening of the one or more openings located on the first lateral wall; and a rack installed in the first space and engaging the first enclosure and the second enclosure in a sealed manner, wherein one or more rack-mounted units can be installed in the rack such that front faces of the rack-mounted units interface with the fourth space, and that back faces of the rack-mounted units interface with the fifth space, and one or more cooling fans in the rack are operable to draw air from the fourth space through the front faces of the one or more rack-mounted units and expel heated air through the back faces of the one or more rack-mounted units to the fifth space.

Embodiments of the present invention provide systems and methods directed to an integrated, building-based air handling system for efficient cooling of data centers. In a particular embodiment, the present invention provides an enclosure comprising at least one server rack port

configured to interface with one or more server racks. The server rack ports are configured to engage the server racks such that a back face of a rack-mounted unit installed in the server racks interface with the interior space defined by the enclosure. One or more fans draw cooling air from a front face of the rack-mounted unit and expel heated air to the interior space. In some embodiments, the server racks ports and the server racks are engaged in a substantially sealed manner to reduce air leakage into and out of the enclosure.

In other embodiments of the present invention, the systems and methods involve utilizing natural cool air to cool the servers. In one embodiment, valved openings on the lateral walls of a data center may be connected to a control system which is operable to open up the valved openings when the difference in temperature inside and outside the data center reaches certain threshold values. External cool air enters the data center through the valved openings. One or more fans draw the cool air from a front face of the rack-mounted unit and expel heated air through the back face of the rack-mounted unit to the interior space defined by the enclosure. The enclosure is operably connected to the valved openings on the roof of the data center and the heated air inside the enclosure is exhausted out of the data center through the valved openings. In some embodiments, one or more evaporative cooling units are used to cool external air coming from the valved openings on the lateral walls of the data center. In other embodiments, a ceiling may be used in a data center. The roof and the ceiling define an attic space. The enclosure is operably connected to the attic space. Heated air is expelled to the attic space and exhausted out of the data center through valved openings coupled to the roof.

In some embodiments, both a hot row enclosure and a cold row enclosure are used. Air cooled by one or more cooling units enters the cold row enclosure. One or more fans draw cold air from the cold row enclosure through the rack-mounted units to cool the servers and eject heated air to the hot row enclosure. In some embodiments, the cooling fans mounted internally within the rack-mounted units

CLAIMS

1. A server cooling system comprising:
 - a first space defined by a floor, one or more lateral walls, and a roof;
 - one or more openings located on the roof and the one or more lateral walls, wherein
 - a first opening at least one of the one or more openings is located on a first lateral wall of the one or more lateral walls to allow outside natural air to enter, and
 - a second opening at least one of the one or more openings is located on the roof, wherein the second opening is higher than the first opening to allow air in the server cooling system to be heated and rise via natural convection and exit the server cooling system via the second opening;
 - an enclosure installed within the first space and defining a second space that is sealed from the first space;
 - one or more air-handling units configured to draw external air into the first space through the first opening at least one of the one or more openings located on the first lateral wall; and
 - a rack installed in the first space and engaging the enclosure in a sealed manner, wherein
 - one or more rack-mounted units can be installed in the rack such that front faces of the rack-mounted units interface with the first space, and that back faces of the rack-mounted units interface with the second space, and
 - one or more cooling fans in the rack are operable to draw air from the first space through the front faces of the one or more rack-mounted units and expel heated air through the back faces of the one or more rack-mounted units to the second space.
2. The server cooling system of claim 1, wherein each of the one or more cooling fans is mounted internally within a corresponding rack-mounted unit.
3. The server cooling system of claim 1, further comprising one or more cooling units operable to cool air in the first space.
4. The server cooling system of claim 1, wherein the enclosure comprises at least one server rack port allowing the rack to be removably installed in the enclosure.

5. The server cooling system of claim 1, further comprising a control system operably connected to the one or more openings to selectively activate the one or more openings based on temperatures observed within and outside the first space.

6. The server cooling system of claim 5, further comprising one or more openings coupled to the enclosure and operably connected to the control system.

7. The server cooling system of claim 3, wherein at least one of the cooling units is an evaporative cooler.

8. The server cooling system of claim 1, wherein the roof comprises a single-sloped roof.

9. A server cooling system comprising
a first space defined by a floor, one or more lateral walls, and a ceiling;
a third space defined by the ceiling and a roof;
one or more openings located on the ceiling and the one or more lateral walls, wherein
a first opening at least one of the one or more openings is located on a first lateral wall of the one or more lateral walls to allow outside natural air to enter,
a second opening at least one of the one or more openings is located on a second lateral wall of the one or more lateral walls, wherein the second opening is higher than the first opening to allow air in the server cooling system to be heated and rise via natural convection and exit the server cooling system via the second opening, and
at least one of the one or more openings is located on the ceiling to allow air exchange between the first space and the third space;
an enclosure installed within the first space and defining a second space operably connected to the one or more openings and the third space;
one or more air-handling units configured to draw external air into the first space through the first opening at least one of the one or more openings located on the first lateral wall; and
a rack installed in the first space and engaging the enclosure in a substantially sealed manner, wherein

one or more rack-mounted units can be installed in the rack such that front faces of the rack-mounted units interface with the first space, and that back faces of the rack-mounted units interface with the second space, and

one or more cooling fans in the rack are operable to draw air from the first space through the front faces of the one or more rack-mounted units and expel heated air through the back faces of the one or more rack-mounted units to the second space.

10. The server cooling system of claim 9, wherein each of the one or more cooling fans is mounted internally within a corresponding rack-mounted unit.

11. The server cooling system of claim 9, further comprising one or more cooling units operable to cool air in the first space.

12. The server cooling system of claim 9, wherein the enclosure comprises at least one server rack port allowing the rack to be removably installed in the enclosure.

13. The server cooling system of claim 9, further comprising a control system operably connected to the one or more openings to selectively activate the one or more openings based on temperatures observed within and outside the first space.

14. The server cooling system of claim 9, wherein the control system is operably connected to the one or more ceiling openings and is operable to selectively activate the one or more ceiling openings based on temperatures observed within the first space and the third space.

15. The server cooling system of claim 11, wherein at least one of the cooling units is an evaporative cooler.

16. The server cooling system of claim 9, wherein the roof comprises a single-sloped roof.

17.A server cooling system comprising

- a first space defined by a floor, one or more lateral walls, and a ceiling;
- a third space defined by the ceiling and a roof;
- one or more openings located on the ceiling and the one or more lateral walls, wherein
 - a first opening at least one of the one or more openings is located on a first lateral wall of the one or more lateral walls to allow outside natural air to enter,
 - a second opening at least one of the one or more openings is located on a second lateral wall of the one or more lateral walls, wherein the second opening is higher than the first opening to allow air in the server cooling system to be heated and rise via natural convection and exit the server cooling system via the second opening, and
 - at least one of the one or more openings is located on the ceiling to allow air exchange between the first space and the third space;
- a first enclosure installed within the first space and defining a fourth space operably connected to the one or more openings;
- a second enclosure installed within the first space and defining a fifth space operably connected to the third space;
- one or more air-handling units configured to draw external air into the first space through the first opening at least one of the one or more openings located on the first lateral wall; and
- a rack installed in the first space and engaging the first enclosure and the second enclosure in a substantially sealed manner, wherein
 - one or more rack-mounted units can be installed in the rack such that front faces of the rack-mounted units interface with the fourth space, and that back faces of the rack-mounted units interface with the fifth space, and
 - one or more cooling fans in the rack are operable to draw air from the fourth space through the front faces of the one or more rack-mounted units and expel heated air through the back faces of the one or more rack-mounted units to fifth space.

18. The server cooling system of claim 17, wherein each of the one or more cooling fans is mounted internally within a corresponding rack-mounted unit.

19. The server cooling system of claim 17, further comprising one or more cooling units operable to cool air in the first space.

20. The server cooling system of claim 17, wherein each of the first enclosure and the second enclosure comprises at least one server rack port allowing the rack to be removably installed in the respective enclosure.

21. The server cooling system of claim 17, further comprising a control system operably connected to the one or more openings to selectively activate the one or more openings based on temperatures observed within and outside the first space.

22. The server cooling system of claim 17, wherein the control system is operably connected to the one or more ceiling openings and is operable to selectively activate the one or more ceiling openings based on temperatures observed within the first space and the third space.

23. The server cooling system of claim 19, wherein at least one of the cooling units is an evaporative cooler.

24. The server cooling system of claim 17, wherein the roof comprises a single-sloped roof.