CLAIMS

1. A fluid flow manifold system for cooling a plurality of pluggable sub-systems selected from at least servers, network line cards, server sleds, server blades, optical pluggable modules, and other hardware equipment requiring thermal management used in the ICT (Information & Communication Technology) industry, comprising:

an overhead condenser that exchanges heat outside of the system with a flow line connection to an accumulator which manages fluid in a rack;

manifold units fluidly connected to the accumulator and the condenser, which include:

riser flow conduits and riser ports that convey two-phase fluid from the pluggable sub-systems to the condenser,

downcomer flow conduits and downcomer ports which convey single-phase fluid to the pluggable sub-systems; and

sloped branch junction connectors, wherein the manifold system distributes fluid flow due at an elevated pressure source to multiple manifold units that supply multiple evaporators in the plurality of the pluggable sub-systems in the system, and the pluggable sub-systems are cooled in parallel,

wherein the elevated pressure source is formed from gravity or a pump;

flow line connection between two or more downcomer lines at a lowest elevation of the system to balance downcomer liquid level; and

server by-pass flow line with restricted flow CSA (cross section area) between a downcomer and riser at the lowest elevation of the system.

2. The manifold system of claim 1, wherein the manifold units are fluidically connected to the accumulator and the condenser via sloped branch junctions to balance flow distribution via gravity on a downcomer side of the manifold system.

3. The manifold system of claim 2, further comprising:

a minimal length between a condenser refrigerant inlet and the sloped branch junctions on a riser side to reduce pressure drop as two-phase flow returns to the condenser.

4. The manifold system of claim 2, further comprising:

redundant ports with isolation valves on the sloped branch junctions connecting to the downcomer and riser flow conduits in the manifold units to facilitate the replacement of manifold units during system operation.

5. The manifold system of claim 2, further comprising:

progressive variation of flow tube CSA (cross section area) along a length of each manifold riser and downcomer.

6. The manifold system of claim 1, further comprising:

coolant sensor modules installed on selected locations on the manifold system to detect leaks to provide real-time continuous anomaly detection.

7. The manifold system of claim 6, wherein the coolant sensor modules are selected from at least one of: infrared-based sensors, electrochemical based sensors,

MEMS (microelectromechanical systems) based sensors, and photodiode-based sensors.

8. A fluid flow manifold system for cooling a plurality of pluggable sub-systems selected from at least servers, network line cards, server sleds, server blades, optical pluggable modules, and other hardware equipment requiring thermal management used in the ICT (Information & Communication Technology) industry, comprising:

an overhead condenser that exchanges heat outside of the system with a flow line connection to an accumulator which manages fluid in a rack;

manifold units fluidly connected to the accumulator and the condenser, which include:

riser flow conduits and riser ports that convey two-phase fluid from the pluggable sub-systems to the condenser,

downcomer flow conduits and downcomer ports which convey single-phase fluid to the pluggable sub-systems; and

sloped branch junction connectors, wherein the manifold system distributes fluid flow due at an elevated pressure source to multiple manifold units that supply multiple evaporators in the plurality of the pluggable sub-systems in the system, and the pluggable sub-systems are cooled in parallel,

wherein the elevated pressure source is formed from gravity or a pump; and

material selectively removed between a riser and downcomer manifold to achieve controlled heat conduction between the riser and downcomer manifold, while retaining structural integrity of the manifold system.

9. A fluid flow manifold system for cooling a plurality of pluggable sub-systems selected from at least servers, network line cards, server sleds, server blades, optical pluggable modules, and other hardware equipment requiring thermal management used in the ICT (Information & Communication Technology) industry, comprising:

an overhead condenser that exchanges heat outside of the system with a flow line connection to an accumulator which manages fluid in a rack;

manifold units fluidly connected to the accumulator and the condenser, which include:

riser flow conduits and riser ports that convey two-phase fluid from the pluggable sub-systems to the condenser,

downcomer flow conduits and downcomer ports which convey single-phase fluid to the pluggable sub-systems; and

sloped branch junction connectors, wherein the manifold system distributes fluid flow due at an elevated pressure source to multiple manifold units that supply multiple evaporators in the plurality of the pluggable sub-systems in the system, and the pluggable sub-systems are cooled in parallel, wherein the elevated pressure source is formed from gravity or a pump; and

flow restrictors inserted into the downcomer flow conduits and the downcomer ports of the manifold units to manage excess static pressure developed in the downcomer.

10. A fluid flow manifold system for cooling a plurality of pluggable sub-systems selected from at least servers, network line cards, server sleds, server blades, optical pluggable modules, and other hardware equipment requiring thermal management used in the ICT (Information & Communication Technology) industry, comprising:

an overhead condenser that exchanges heat outside of the system with a flow line connection to an accumulator which manages fluid in a rack;

manifold units fluidly connected to the accumulator and the condenser, which include:

riser flow conduits and riser ports that convey two-phase fluid from the pluggable sub-systems to the condenser,

downcomer flow conduits and downcomer ports which convey single-phase fluid to the pluggable sub-systems; and

sloped branch junction connectors, wherein the manifold system distributes fluid flow due at an elevated pressure source to multiple manifold units that supply multiple evaporators in the plurality of the pluggable sub-systems in the system, and the pluggable sub-systems are cooled in parallel, wherein the elevated pressure source is formed from gravity or a pump; and

smooth flow transition incorporated into the manifold units on entrances to the downcomer ports to guide passive fluid flow and on entrances to the riser ports to minimize pressure drop while maintaining riser and downcomer port alignment to the pluggable sub-systems.

11. A fluid flow manifold system for cooling a plurality of pluggable sub-systems selected from at least servers, network line cards, server sleds, server blades, optical pluggable modules, and other hardware equipment requiring thermal management used in the ICT (Information & Communication Technology) industry, comprising:

an overhead condenser that exchanges heat outside of the system with a flow line connection to an accumulator which manages fluid in a rack;

manifold units fluidly connected to the accumulator and the condenser, which include: riser flow conduits and riser ports that convey two-phase fluid from the pluggable sub-systems to the condenser,

downcomer flow conduits and downcomer ports which convey single-phase fluid to the pluggable sub-systems; and

sloped branch junction connectors, wherein the manifold system distributes fluid flow due at an elevated pressure source to multiple manifold units that supply multiple evaporators in the plurality of the pluggable sub-systems in the system, and the pluggable sub-systems are cooled in parallel,

wherein the elevated pressure source is formed from gravity or a pump; and

offset riser and downcomer flow conduits to optimize space occupied by the manifold units with ports sized substantially different to further manage space and minimize pressure drop.

12. A fluid flow manifold system for cooling a plurality of pluggable sub-systems selected from at least servers, network line cards, server sleds, server blades, optical pluggable modules, and other hardware equipment requiring thermal management used in the ICT (Information & Communication Technology) industry, comprising:

an overhead condenser that exchanges heat outside of the system with a flow line connection to an accumulator which manages fluid in a rack;

manifold units fluidly connected to the accumulator and the condenser, which include: riser flow conduits and riser ports that convey two-phase fluid from the pluggable sub-systems to the condenser,

downcomer flow conduits and downcomer ports which convey single-phase fluid to the pluggable sub-systems; and

sloped branch junction connectors, wherein the manifold system distributes fluid flow due at an elevated pressure source to multiple manifold units that supply multiple evaporators in the plurality

of the pluggable sub-systems in the system, and the pluggable sub-systems are cooled in parallel, wherein the elevated pressure source is formed from gravity or a pump; and

a by-pass downcomer flow conduit to aid in the effective distribution of a coolant.

13. A fluid flow manifold system for cooling a plurality of pluggable sub-systems selected from at least servers, network line cards, server sleds, server blades, optical pluggable modules, and other hardware equipment requiring thermal management used in the ICT (Information & Communication Technology) industry, comprising:

an overhead condenser that exchanges heat outside of the system with a flow line connection to an accumulator which manages fluid in a rack;

manifold units fluidly connected to the accumulator and the condenser, which include:

riser flow conduits and riser ports that convey two-phase fluid from the pluggable sub-systems to the condenser,

downcomer flow conduits and downcomer ports which convey single-phase fluid to the pluggable sub-systems; and

sloped branch junction connectors, wherein the manifold system distributes fluid flow due at an elevated pressure source to multiple manifold units that supply multiple evaporators in the plurality of the pluggable sub-systems in the system, and the pluggable sub-systems are cooled in parallel, wherein the elevated pressure source is formed from gravity or a pump; and

temperature probes strategically positioned around the system for coolant gross leak detection based on anomalous temperature variations, wherein the temperature

probes are selected from at least one of: a thermocouple, thermistor, a RTD (resistance temperature device), and diode and are strategically positioned around the system at points of risk to mechanical failure, and therefore most probable refrigerant leak points.

14. A fluid flow manifold system for cooling a plurality of pluggable sub-systems selected from at least servers, network line cards, server sleds, server blades, optical pluggable modules, and other hardware equipment requiring thermal management used in the ICT (Information & Communication Technology) industry, comprising:

an overhead condenser that exchanges heat outside of the system with a flow line connection to an accumulator which manages fluid in a rack;

manifold units fluidly connected to the accumulator and the condenser, which include:

riser flow conduits and riser ports that convey two-phase fluid from the pluggable sub-systems to the condenser,

downcomer flow conduits and downcomer ports which convey single-phase fluid to the pluggable sub-systems; and

sloped branch junction connectors, wherein the manifold system distributes fluid flow due at an elevated pressure source to multiple manifold units that supply multiple evaporators in the plurality of the pluggable sub-systems in the system, and the pluggable sub-systems are cooled in parallel, wherein the elevated pressure source is formed from gravity or a pump; and

resistive heating elements on manifold risers to provide precise amounts of heat into a cooling loop for start-up control and during system operation.

15. The manifold system of claim 14, wherein the resistive heating elements provide localized or distributed heat input into the cooling loop.