



Redfish for Thermal Equipment

WORK IN PROGRESS

DMTF Redfish Forum

February 2022

V0.8



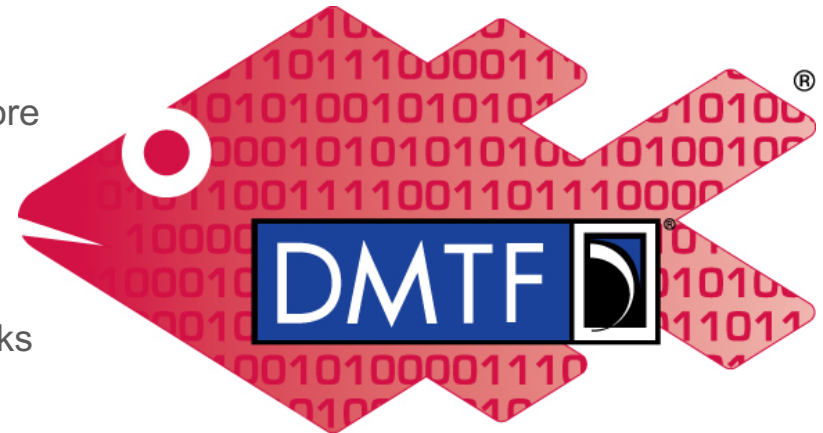
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- This information is subject to change without notice. The standard specifications remain the normative reference for all information.
- For additional information, see the DMTF website: www.dmtf.org



Getting involved in Redfish

- Redfish Standards page
 - Schemas, Specs, Mockups, White Papers & more
 - <http://www.dmtf.org/standards/redfish>
- Redfish Developer Portal
 - Redfish Interactive Resource Explorer
 - Educational material, documentation & other links
 - <http://redfish.dmtf.org>
- Redfish User Forum
 - User forum for questions, suggestions and discussion
 - <http://www.redfishforum.com>
- DMTF Feedback Portal
 - Provide feedback or submit proposals for Redfish standards
 - <https://www.dmtf.org/standards/feedback>
- DMTF Redfish Forum
 - Join the DMTF to get involved in future work
 - <http://www.dmtf.org/standards/spmf>



Redfish



Introduction

- Proposal to extend Redfish DCIM models to incorporate cooling units
 - Support for rack-based Cooling Distribution Units (CDUs)
 - Support for immersion cooling units
 - Models should apply generally to other liquid cooling gear
 - Heat exchangers, air conditioners, etc.
 - Expect the model to also cover air-cooling systems
 - Explicit coverage is not shown in this proposal, but some notes are mentioned
- Leverages existing Redfish DCIM models and style
 - Adapts the Power Distribution Unit concepts, schemas and properties
 - Controls – several instances of valves for liquid flow
 - Sensors – New types for pressure, flow rates, etc.



THERMAL EQUIPMENT MODEL

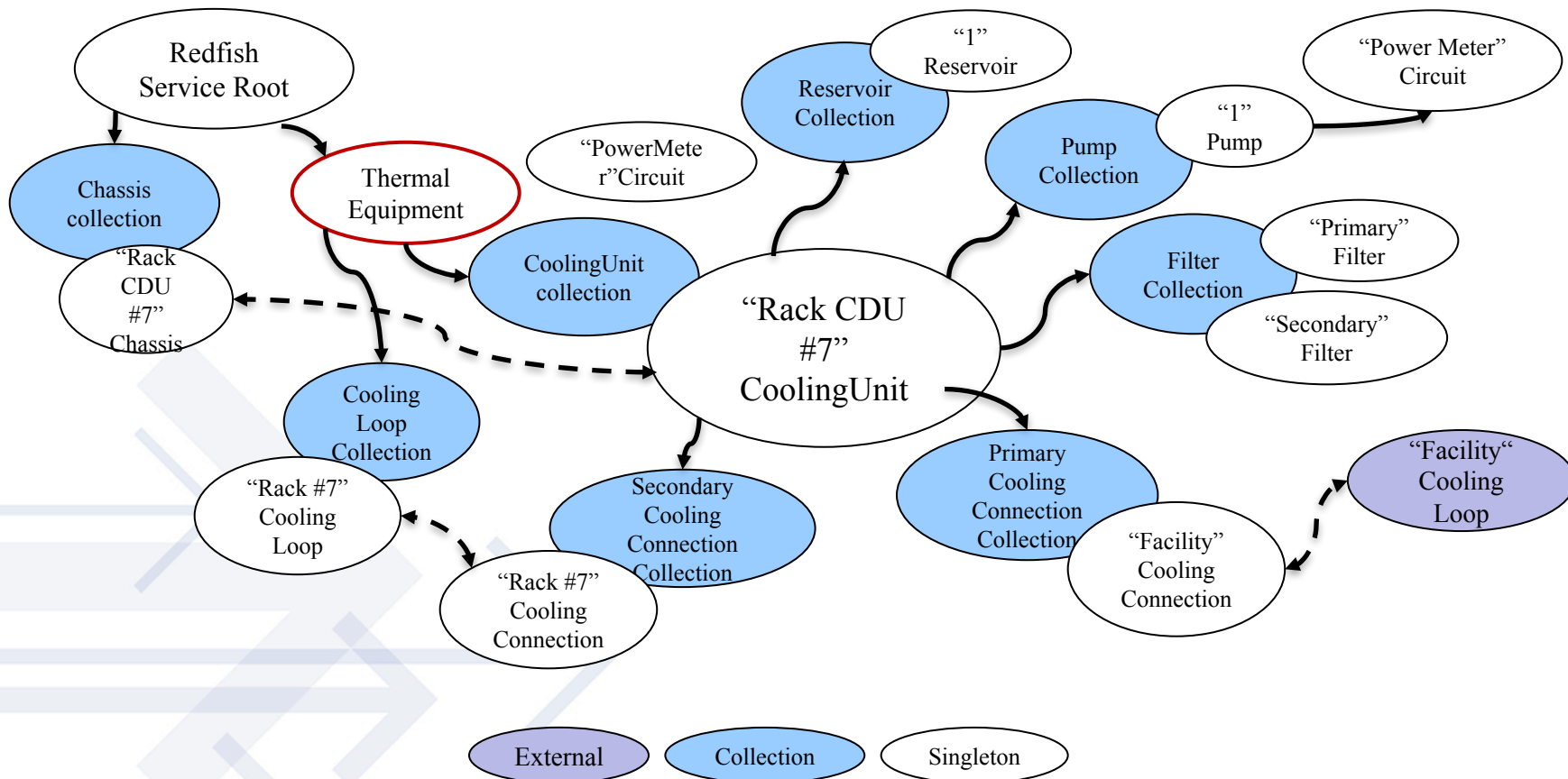


NEW ThermalEquipment resource

- Single resource under **ServiceRoot**
 - Follows design pattern used for **PowerEquipment**
 - Contains links to all cooling systems and related equipment
 - Used primarily for discovery of managed equipment
- **Links to Resource Collections of:**
 - Cooling Distribution Units (CDU's)
 - Immersion cooling units
 - Air Handler (CRAH) units
 - Air Conditioners (CRAC) units
 - Cooling Loops
 - Other cooling equipment?



Thermal Equipment / Cooling Unit Model





COOLING LOOP MODEL

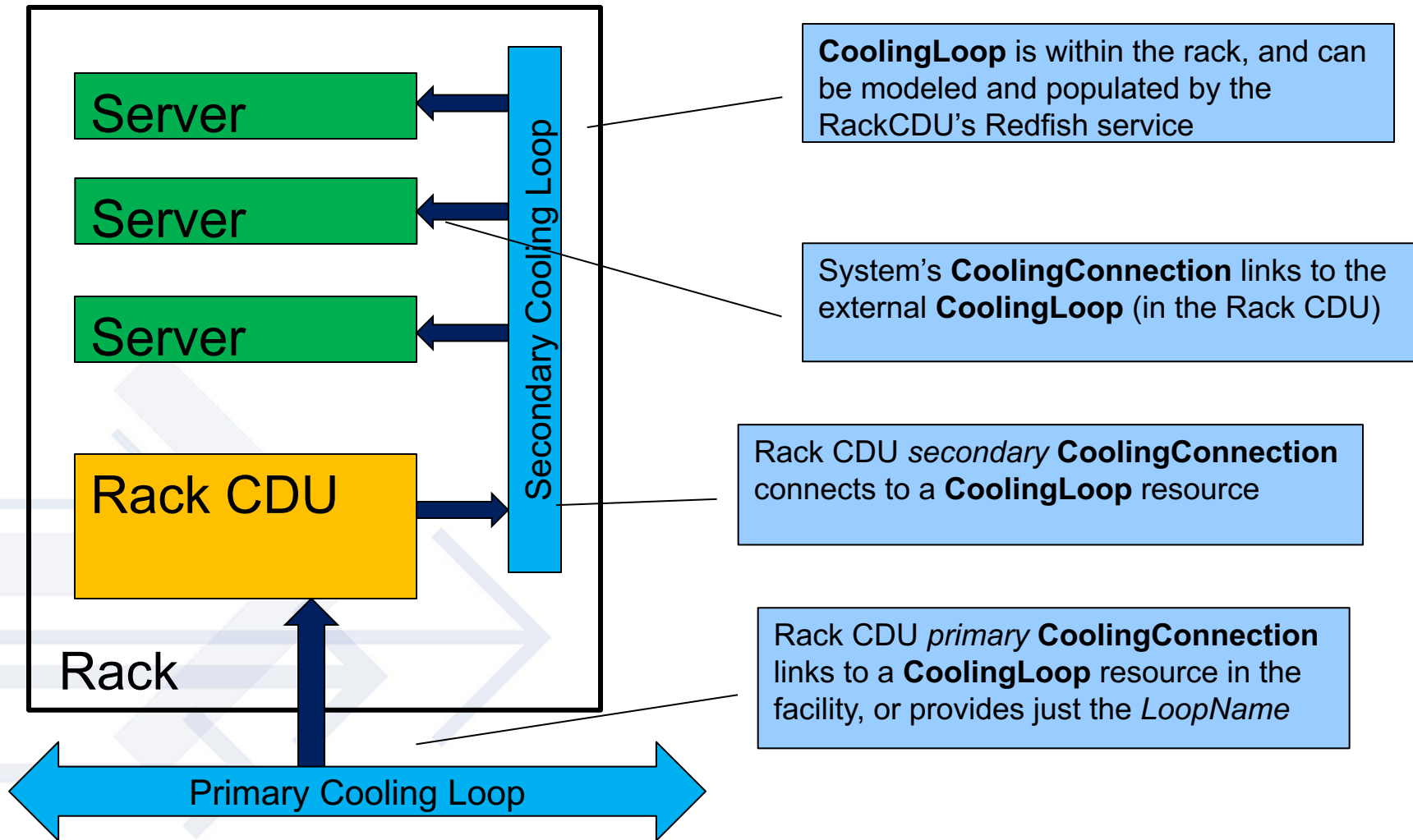


Cooling Loop Model

- Large-scale cooling equipment connects through “loops”
 - Loop can be self-contained (within a rack or group of racks)
 - Or can be facility-wide (primary loops from external chillers, etc.)
 - The concepts for cooling loops came from Circuit models
- Create a **CoolingConnection** that connects to **CoolingLoop**
 - Models both the “supply” and “return” side of the managed equipment
 - Metrics are gathered at these connection points
 - Can be different for each piece of equipment connected to the loop
 - Provide information about the connected loop if available
 - User-entered “loop name” provides a connection path through the infrastructure



Cooling Loop – Rack-level self-contained example



CoolingLoop is within the rack, and can be modeled and populated by the RackCDU's Redfish service

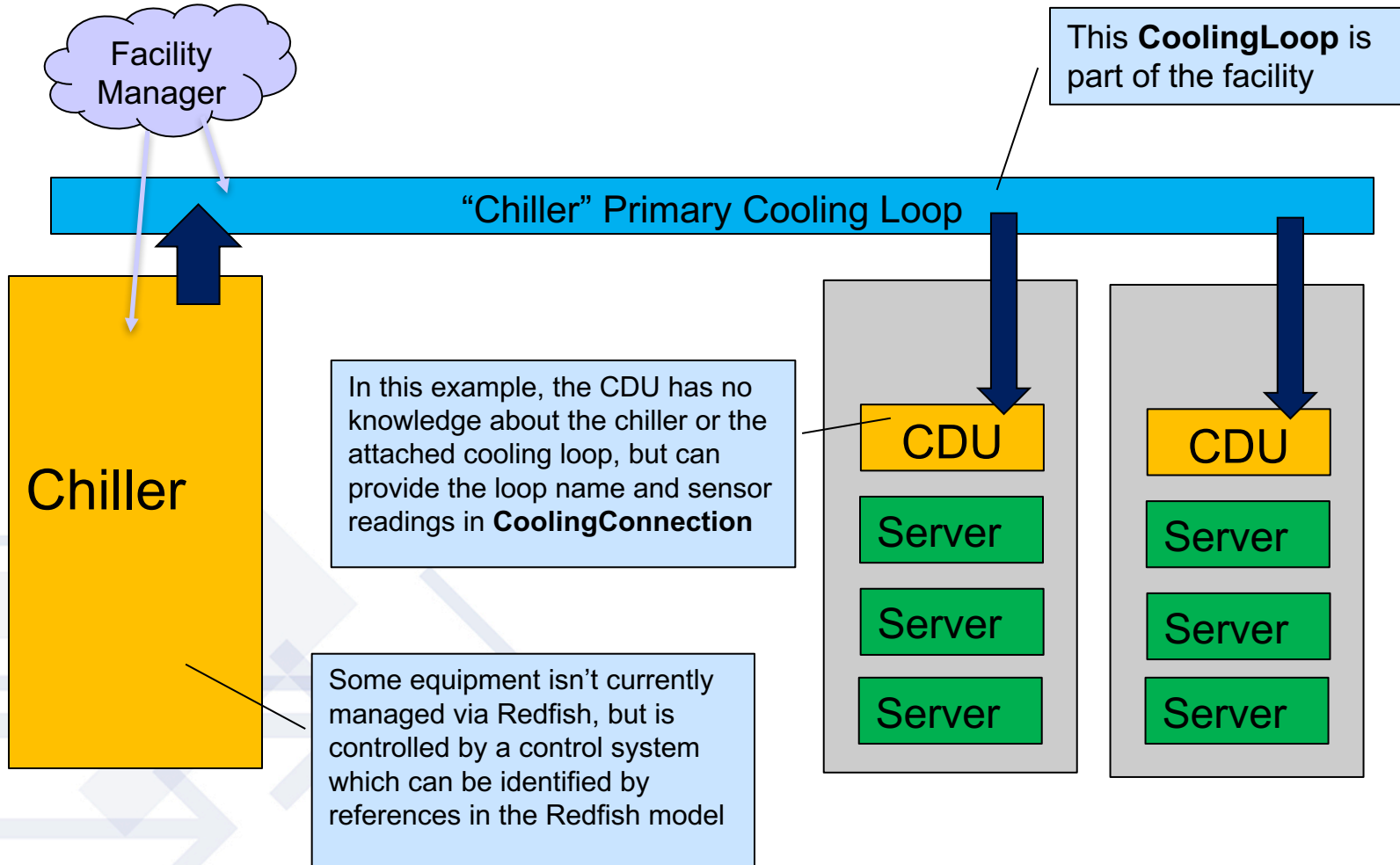
System's **CoolingConnection** links to the external **CoolingLoop** (in the Rack CDU)

Rack CDU *secondary* **CoolingConnection** connects to a **CoolingLoop** resource

Rack CDU *primary* **CoolingConnection** links to a **CoolingLoop** resource in the facility, or provides just the *LoopName*



Cooling Loop – facility level example





NEW CoolingLoop schema

- **CoolingLoopCollection** placed under **ThermalEquipment**
- Reports product and measurements for the loop itself
 - *CoolingLoopType* – Condenser, Facility, Technology, Immersion, Internal
- Describes the coolant properties
 - *FluidType* – Water, GlycolMixture, Dielectric
 - *FluidQuality* – Normal or Abnormal
 - *FluidLevelStatus* – OK, Warning, Critical
- Methods to represent connections to related equipment
 - *ConsumingEquipmentNames[]* – User-defined string for unmanaged gear
 - *ConsumingEquipment[]* – R/W array of links to **Chassis** resources
 - *CoolingManagerUri* – User-defined link to a management console



NEW CoolingLoop resource

```
{
  "@odata.type": "#CoolingLoop.v1_0_0.CoolingLoop",
  "Id": "Data Center Chiller",
  "LoopType": "Facility",
  "SupplyingEquipmentNames": [ "Chiller" ],
  "ConsumingEquipmentNames": [ "Rack #1 CDU", "Rack #2 CDU", "Rack #3 CDU", "Rack #4 CDU"],
  "FluidQuality": "Normal",
  "TemperatureCelsius": {
    "DataSourceUri": "/redfish/v1/Facilities/Room237/Sensors/ChillerTemp",
    "Reading": 13.7
  },
  "SupplyPressurePa": {
    "DataSourceUri": "/redfish/v1/Facilities/Room237/Sensors/ChillerPressure",
    "Reading": 3447.4
  },
  "SupplyFlowValve": {
    "DataSourceUri": "/redfish/v1/Facilities/Room237/Controls/ChillerFlow",
    "Reading": 1.58,
    "ReadingUnits": "L/s",
    "SetPoint": 80,
    "SetPointUnits": "%"
  },
  "Links": {
    "ConsumingEquipment": [
      {
        "@odata.id": "192.42.23.1/redfish/v1/CoolingEquipment/CDUs/1"
      }
    ]
  }
}
```

EquipmentNames allow users to manually add non-Redfish devices to help complete the model

Sensor excerpts and Control excerpt for valves

Need to explain "percent open" vs "percent closed" – Boolean property or normative language

Links to Redfish-managed *Consuming* and *Source* resources – likely references to external Redfish services



COOLING UNIT MODEL



NEW CoolingUnit schema and resources

- Unified schema defines several types of cooling gear
 - Share common modeling and property definitions
 - *EquipmentType* property provides specific identification
 - Separate collections of each type linked from **ThermalEquipment**
- Resource contents
 - General product identification – model, manufacturer, serial number, etc.
 - Versioning – Hardware revision, firmware version, date of manufacture
- Links to subordinate Resources and Resource Collections
 - Sensor Collection, Metrics (entire unit)
 - Primary (input) CoolingConnection(s)
 - Secondary (output) CoolingConnection(s)
 - Subsystems: Pumps, Filter, Reservoirs



NEW CoolingUnit schema

```
{
  "@odata.type": "#CoolingUnit.v1_0_0.CoolingUnit",
  "Id": "1",
  "EquipmentType": "CDU",
  "Name": "Rack #4 Cooling Distribution Unit",
  "FirmwareVersion": "3.2.0",
  "Version": "1.03b",
  "ProductionDate": "2020-12-24T08:00:00Z",
  "Manufacturer": "Contoso",
  "Model": "BRRR4000",
  "SerialNumber": "29347ZT536",
  "PartNumber": "ICE-9",
  "UUID": "32354641-4135-4332-4a35-313735303734",
  "AssetTag": "PDX5-92381",
  "Status": {
    "State": "Enabled",
    "Health": "OK"
  },
  "PrimaryCoolingConnections": { "@odata.id": < Link to CoolingConnectionCollection > },
  "SecondaryCoolingConnections": { "@odata.id": < Link to CoolingConnectionCollection > },
  "CoolingLoops": { "@odata.id": < Link to CoolingLoopCollection > }.
  "Pumps": { "@odata.id": < Link to PumpCollection > },
  "Filters": { "@odata.id": < Link to FilterCollection > },
  "EnvironmentMetrics": { "@odata.id": < Link to EnvironmentMetrics > },
  "PowerMeter": { "@odata.id": < Link to Circuit > },
  "Sensors": { "@odata.id": < Link to SensorCollection > },
  "Controls": { "@odata.id": < Link to ControlCollection > },
  < TRUNCATED >
}
```




NEW CoolingConnection schema

- The connection between the cooling unit and a CoolingLoop resource
 - Analogous to **Circuit** in relation to a **PowerDistribution** resource
 - Provides numerous sensor readings and controls
 - Flow, Temperature, Pressure on both supply and return
 - Valve controls, drain, etc.
 - If known, provide link to **CoolingLoop**
 - Or the loop name and Manager URI if known and populated by end user
- Main monitoring resource for the cooling unit's functionality
 - Primary cooling connections – input from facility chillers or other sources
 - Secondary cooling connections– output from the cooling unit to feed “consuming” equipment



NEW CoolingConnection schema

```
{
  "@odata.type": "#CoolingConnection.v1_0_0.CoolingConnection",
  "Id": "Chiller",
  "Name": "Primary Input from Chiller",
  "Status": {
    "Health": "OK"
  },
  "CoolingConnectionType": "Primary",
  "FluidType": "GlycolMixture",
  "GlycolPercent": 20,
  "RatedFlowLSeconds": 30,
  "SupplyFlowValve": {
    "DataSourceUri": "/redfish/v1/CoolingEquipment/RackCDUs/1/Controls/ChillerSupplyValve",
    "SetPoint": 70,
    "SetPointUnits": "%",
    "Reading": 9.5,
    "ReadingUnits": "L/s"
  },
  "SupplyTemperatureCelsius": {
    "DataSourceUri": "/redfish/v1/CoolingEquipment/RackCDUs/1/Sensors/LoopASupplyTemp",
    "Reading": 14.8
  },
  "SupplyPressurePa": {
    "DataSourceUri": "/redfish/v1/CoolingEquipment/RackCDUs/1/Sensors/LoopASupplyPressure",
    "Reading": 319.6
  },
  "ReturnTemperatureCelsius": < SENSOR EXCERPT >
  < TRUNCATED >
}
```

As *LiquidType* is really a description of the loop – this may become a more general *LoopType* that describes any loop, and could be populated if *CoolingLoop* is managed.

Sensor excerpts and *Control* excerpt for valves



Cooling Loops / Cooling Connections – open questions

- Leak detection – will need Sensor support
 - Determine presence / functional as well as actual “leak detected”
 - Expect to add *PhysicalContext* values (Floor, sub-floor, etc.)
- Support for Air / Phase Change / Liquid loops
 - Phase change (refrigerant) loops can be modeled with this pattern as well
 - Not recommended for initial release, wait for industry feedback
 - LoopType = Air, Liquid, Primary / Secondary?
 - An “air loop” could be the room, plenum, or ductwork
 - Air handling may not be ‘contained’, but the “loop interface” does still apply
- Chassis links and physical containment
 - Work left to ensure model supports consistent links for physical containment of cooling units and cooling loops
 - Support any mix of managed / unmanaged gear while minimizing the types of links and resources



NEW PowerMeter resource

- Immersion cooling units have additional power-related requirements
 - Ability to report the power consumption of all “immersed” equipment
 - Ability to control the power state of all immersed equipment
 - Both from a breaker (over current) and user-actuated control perspective
- Leverage existing **Circuit** schema for this purpose
 - Add new *CircuitType* of “PowerMeter”
 - Allows a **Circuit** resource to appear under **CoolingUnit**
 - Enables use of *PowerControl* and *BreakerControl* actions
- Power consumption and other monitoring of the cooling equipment itself is shown in **EnvironmentMetrics** or **PowerSubsystem** under the **Chassis** related to the **CoolingUnit**



Circuit schema as PowerMeter example

```
{
  "@odata.type": "#Circuit.v1_6_0.Circuit",
  "Id": "PowerMeter",
  "Name": "Pump #1 Power Meter",
  "Status": { < Status object > },
  "CircuitType": "PowerMeter",
  "PhaseWiringType": "TwoPhase3Wire",
  "NominalVoltage": "AC240V",
  "RatedCurrentAmps": 16,
  "BreakerState": "Normal",
  "PowerState": "On",
  "VoltageSensor": { < Single-phase voltage sensor > },
  "PolyPhaseVoltageSensors": { < Voltage per phase sensors > },
  "CurrentSensor": { < Total Current sensor > },
  "PolyPhaseCurrentSensors": { < Current per phase sensors > },
  "PowerSensor": { < Total Power sensor > },
  "PolyPhasePowerSensors": { < Power per phase sensors > },
  "FrequencySensor": { < Frequency sensor > },
  "EnergySensor": { < Energy sensor > },
  "Actions": { < ResetBreaker, ResetStatistics > }
  "@odata.id": "/redfish/v1/CoolingEquipment/RackCDUs/1/Pumps/1/PowerMonitor",
}
```



NEW Subsystem schemas for Cooling Unit

- **Pump Resource Collection**
 - Will have differential pressure / absolute pressure, flow, etc.
 - Can be a physical sensor or a synthesized value (model as sensor)
 - Variable Frequency Drive may need an object
 - *PowerMeter* (Circuit) subordinate resource
 - May be 3-phase, have a breaker, etc.
- **Filter Resource Collection**
 - Pressure sensors
 - Service time / install time, life etc.
 - ASHRAE requirements / classifications
 - Flush / clean actions?



NEW Subsystem schemas for Cooling Unit, continued

- **HeatExchanger Resource Collection**
 - For air-liquid systems
 - Likely a unit with a **Fan** collection with redundancy information
 - Fans may appear under the **ThermalSubsystem** in the associated **Chassis**
 - Temperature, power, other sensors
 - Controls and policies
- **Reservoir Resource Collection**
 - Fill level, pressure sensors
 - Air bleed value (controls), fill valve, drain valve
 - May have connections between reservoirs (balancing)



QUESTIONS FOR INDUSTRY

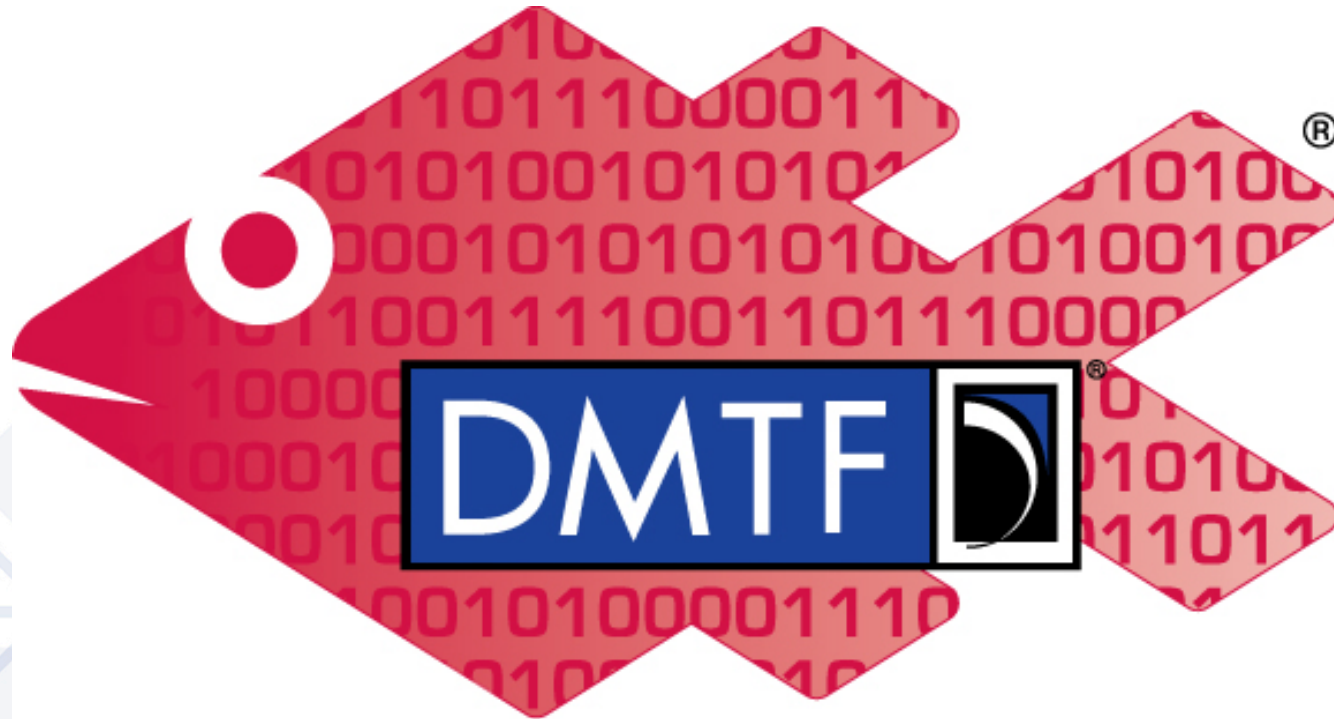


Status and open topics

- Model is solidifying with several name changes since last release
 - Expect more property additions prior to v1.0, dependent on feedback
- Expect support for air-liquid cooling units
 - Reviewing model to ensure this support can be added
 - Not expected for the v1.0 release of this material
- Significant number of common messages to define for Events / Alarms
 - Expect to define new message registries
 - Should be able to harvest existing SNMP trap definitions as a starting point
 - Will be prioritizing this portion of the effort to enable products to be fully managed using Redfish (and without requiring SNMP “in practice”)



Q&A & Discussion



Redfish