



# Redfish for Thermal Equipment

**WORK IN PROGRESS**

DMTF Redfish Forum

February 2022

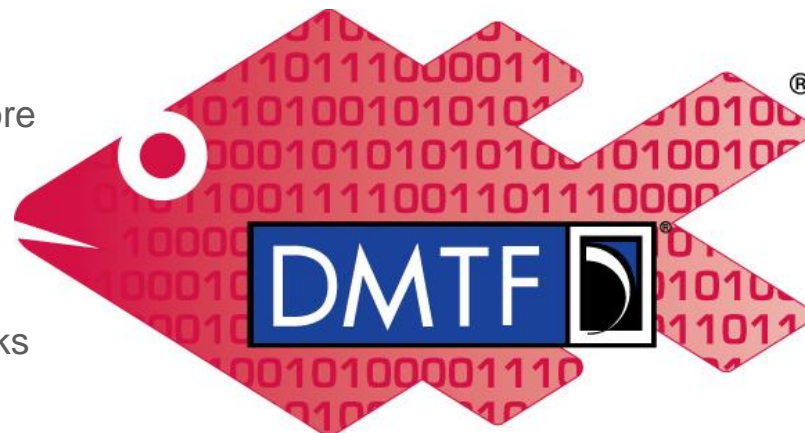
V0.8

## Disclaimer

- The information in this presentation represents a snapshot of work in progress within the DMTF.
- 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](http://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.

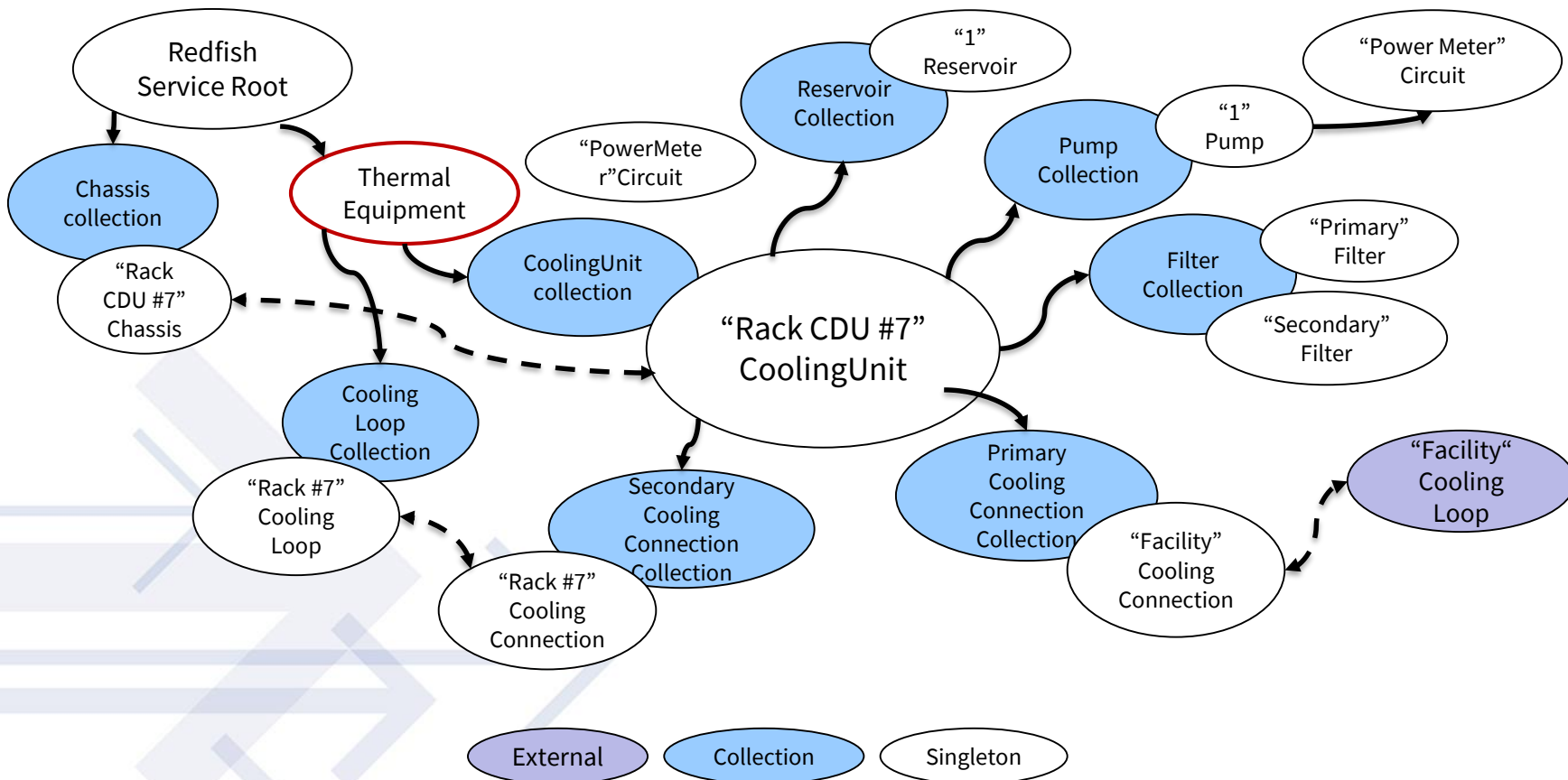


# THERMAL EQUIPMENT MODEL

## **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



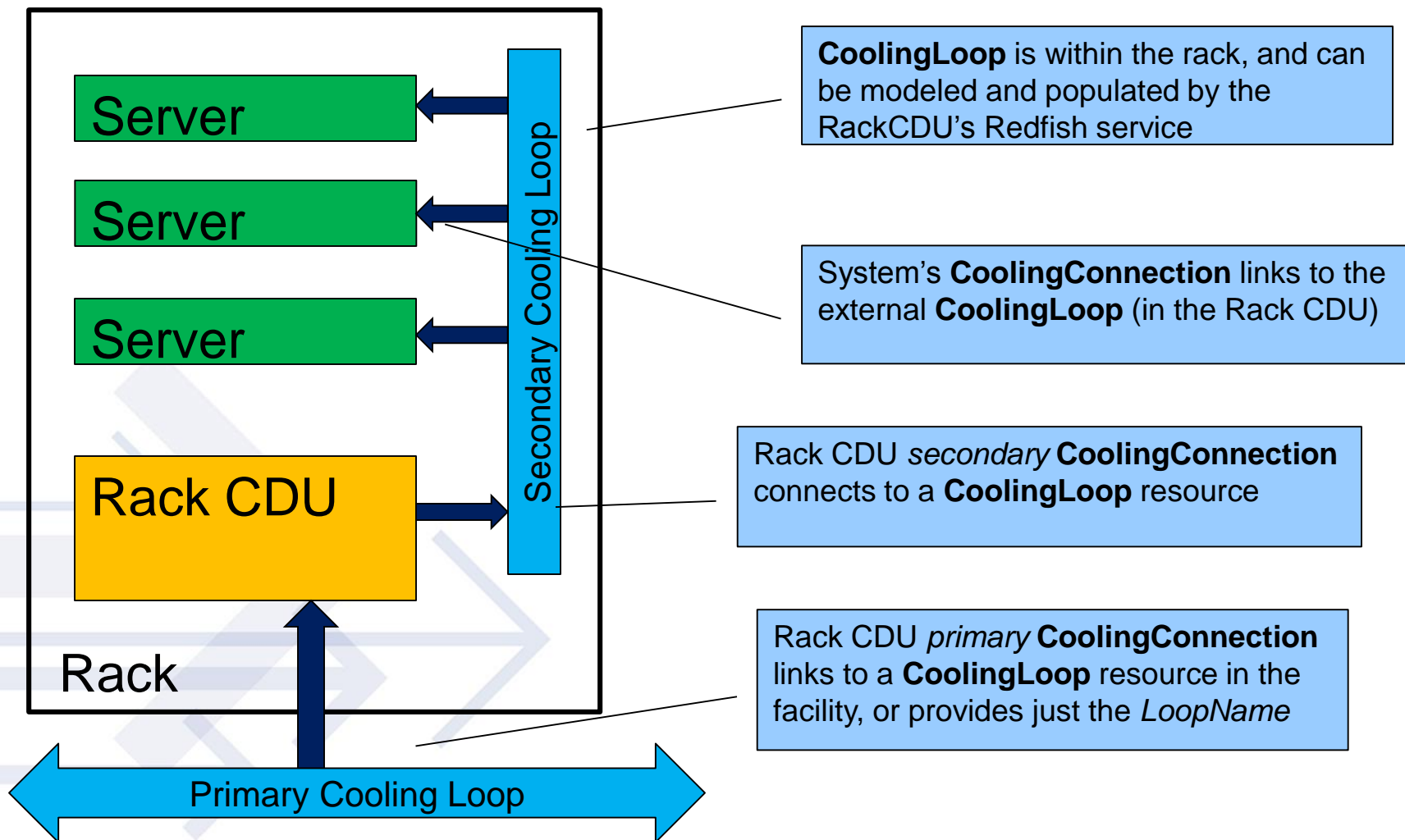
# COOLING LOOP MODEL



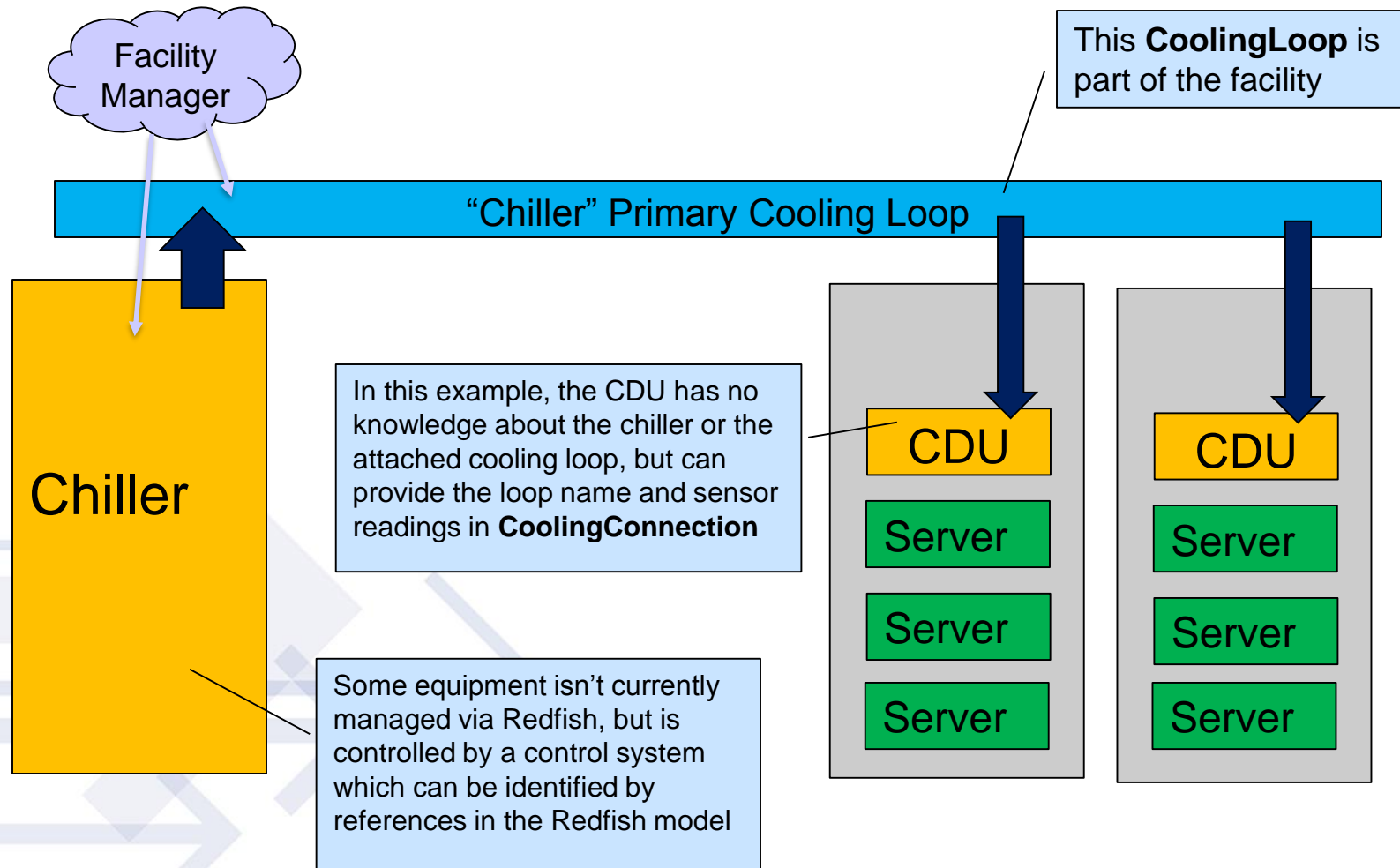
## Cooling Loop Model

- 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



## 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 valve (controls), fill valve, drain valve
  - May have connections between reservoirs (balancing)



# QUESTIONS FOR INDUSTRY

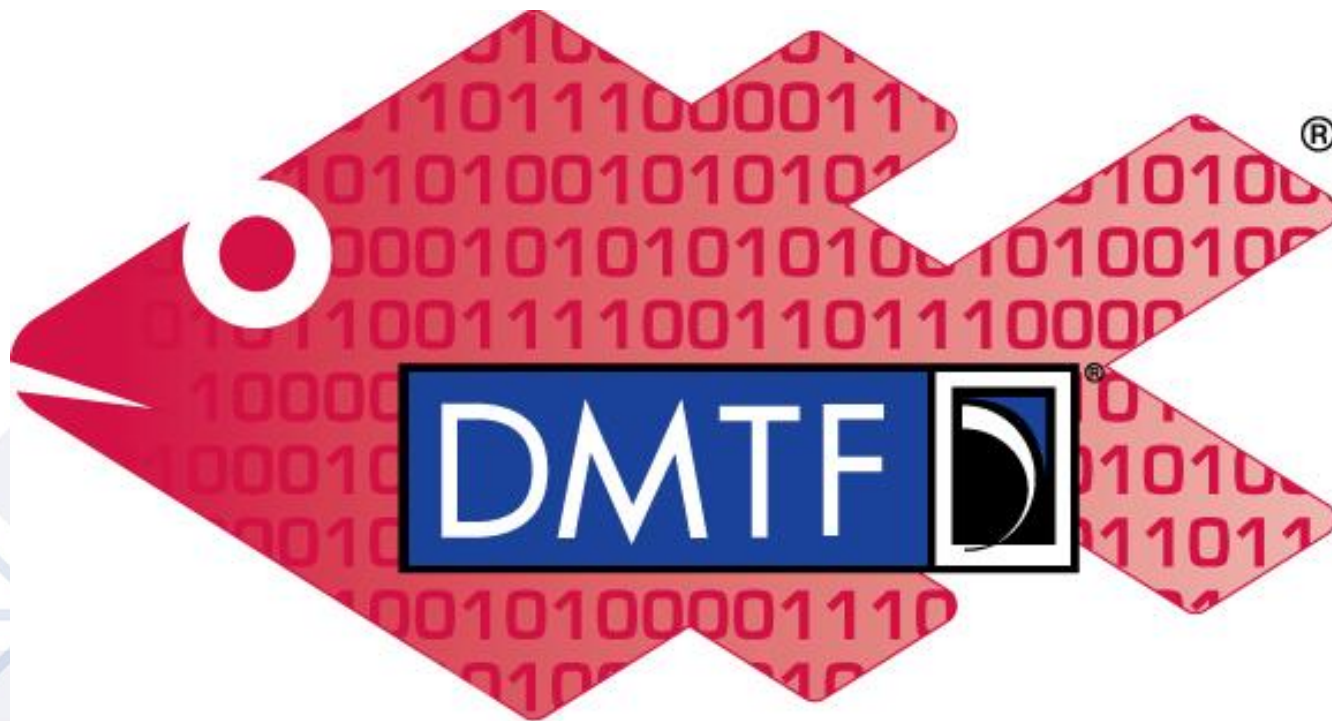


## Status and open topics

- 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