Redfish for Thermal Equipment

WORK IN PROGESS

DMTF Redfish Forum

February 2023

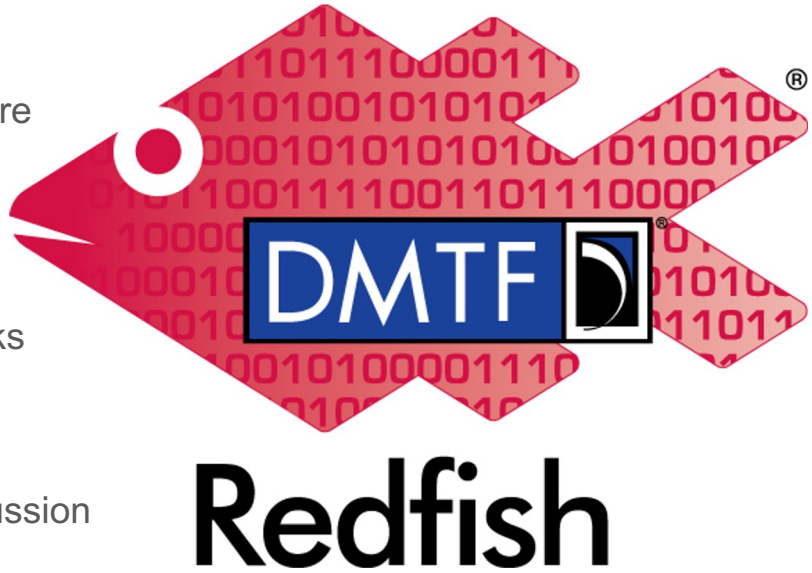
V0.95

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

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



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
    - Rear-door 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
  - Intend to model all equipment types covered by OCP requirements
- 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.
  - Leak Detection – new subsystem and set of detectors

Expected Release Timeline

- Work-in-Progress release v0.95
  - Further refinements from v0.90, final public review before v1.0
- Release v1.0 of this work expected to include:
  - **ThermalEquipment, CoolingUnit, CoolingLoop, CoolantConnection**
  - Subsystems / standalone equipment: **Pump, Reservoir, Filter**
  - **LeakDetection** and **LeakDetector** components
  - **Power** and **Environment** message registries
- Support in v1.0 expected for:
  - Rack-based or free-standing CDU's
  - Immersion cooling systems
  - Liquid-cooled (self-contained) servers
  - Rear-door heat exchangers
- Expect further additions in future Redfish releases

Changes between v0.90 and v0.95 work-in-progress

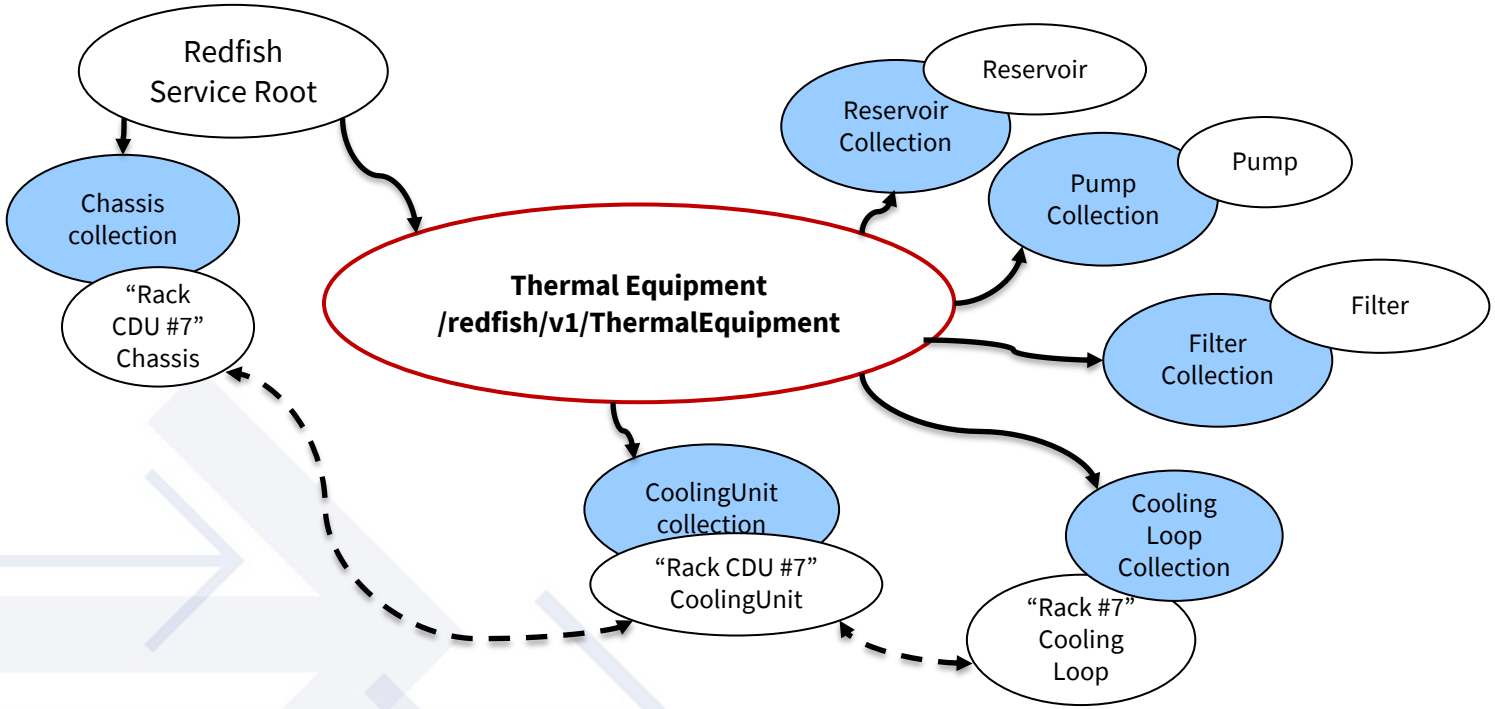
- Terminology improvements
  - **CoolingConnection** now **CoolantConnector**
  - *Fluid / Liquid* terms now *Coolant* (some exceptions)
- Sensor and unit adjustments
  - Flow in Liters/Minute, Pressure in kPa
- Common `Coolant` object definition
  - Properties related to the coolant itself now contained and common
- Removed separate **PowerMeter** resource
  - Power / energy measurements available via EnvironmentMetrics
- Removed discrete sensor concepts in favor of **LeakDetector**
  - Purpose-built schema to cover these devices
- Alignment of install / replace / service date and rating properties
- Moved all **Sensor** and **Control** collections to **Chassis**

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
  - Cooling Loops
    - Both facility-level (FWS) and rack/secondary (TCS) loops
  - Free standing Pumps, Filters, and Reservoirs
    - Equipment not included within a CDU

Thermal Equipment Model



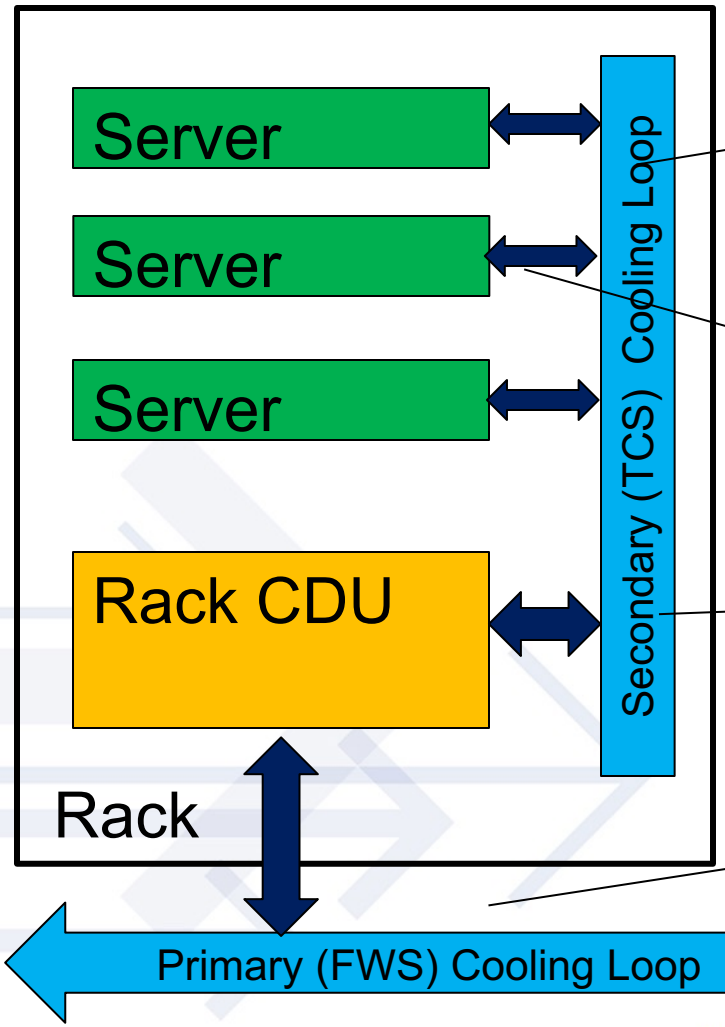
External | Collection | Resource

COOLING LOOP MODEL

Cooling Loop Model

- **CoolingLoop** model
  - Describes the physical characteristics and capacities of a cooling loop
  - Loop can be self-contained (within a rack or group of racks)
    - Or can be facility-wide (primary loops from external chillers, etc.)
  - Shows connectivity to equipment
    - Provides means for both “names” (strings) and links to resources
- **CoolantConnector** models connections to a **CoolingLoop**
  - Models the “supply” and “return” side of the managed equipment
    - An instance is either a connection pair, or an individual supply or return
  - Metrics are gathered at these connection points
    - Allows independent metrics 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



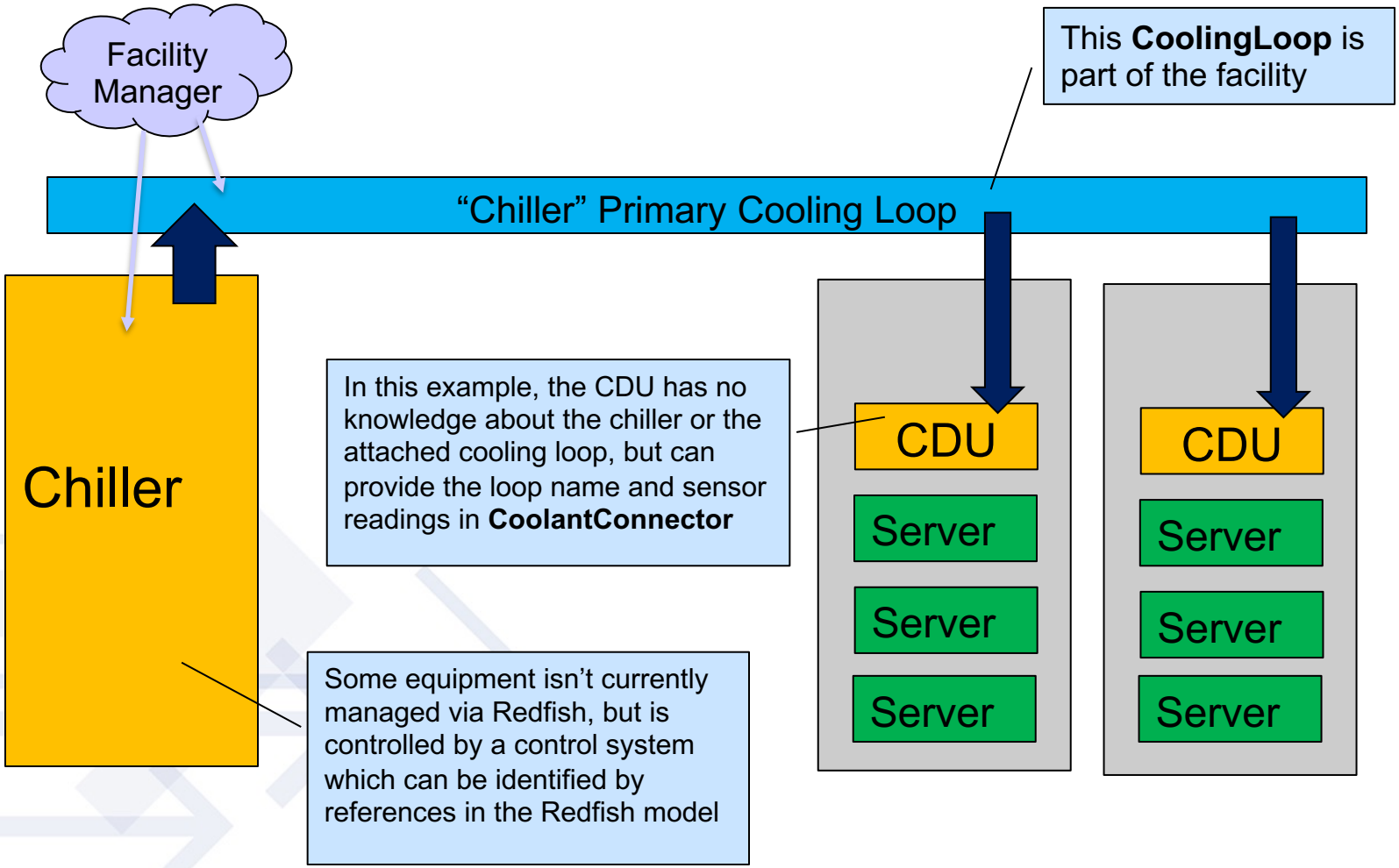
This **CoolingLoop** is within the rack, and can be modeled and populated by the RackCDU's Redfish service

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

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

Rack CDU *primary* **CoolantConnector** 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, location, and capacity for the loop
  - *CoolingLoopType* – Condenser, Facility, Technology, Immersion, Internal
- Describes the coolant properties
  - *CoolantType* – Water, Dielectric
  - *CoolantQuality* – Normal or Abnormal
  - *CoolantLevelStatus* – 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": "BuildingChiller",
    "Name": "Feed from building chiller",
    "Status": {
        "Health": "OK"
    },
    "CoolingLoopType": "Facility",
    "UserLabel": "Building Chiller",
    "Coolant": {
        "AdditiveName": "Generic cooling water biocide",
        "AdditivePercent": 0,
        "CoolantType": "Water"
    },
    "CoolantLevelStatus": "OK",
    "CoolantQuality": "Normal",
    "CoolantLevelPercent": {
        "Reading": 95
    },
    "HeatRemovedkW": {
        "Reading": 47.4
    },
    "SupplyEquipmentNames": ["Chiller"],
    "ConsumingEquipmentNames": ["Rack #1 CDU", "Rack #2 CDU", "Rack #3 CDU", "Rack #4 CDU"]
    "Links": {
        "ConsumingEquipment": [{
            "@odata.id": "/redfish/v1/ThermalEquipment/CDUs/1"
        }]
    },  << TRUNCATED >>
```


Details about coolant used in the loop

Sensor excerpts for coolant level and total heat removed

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

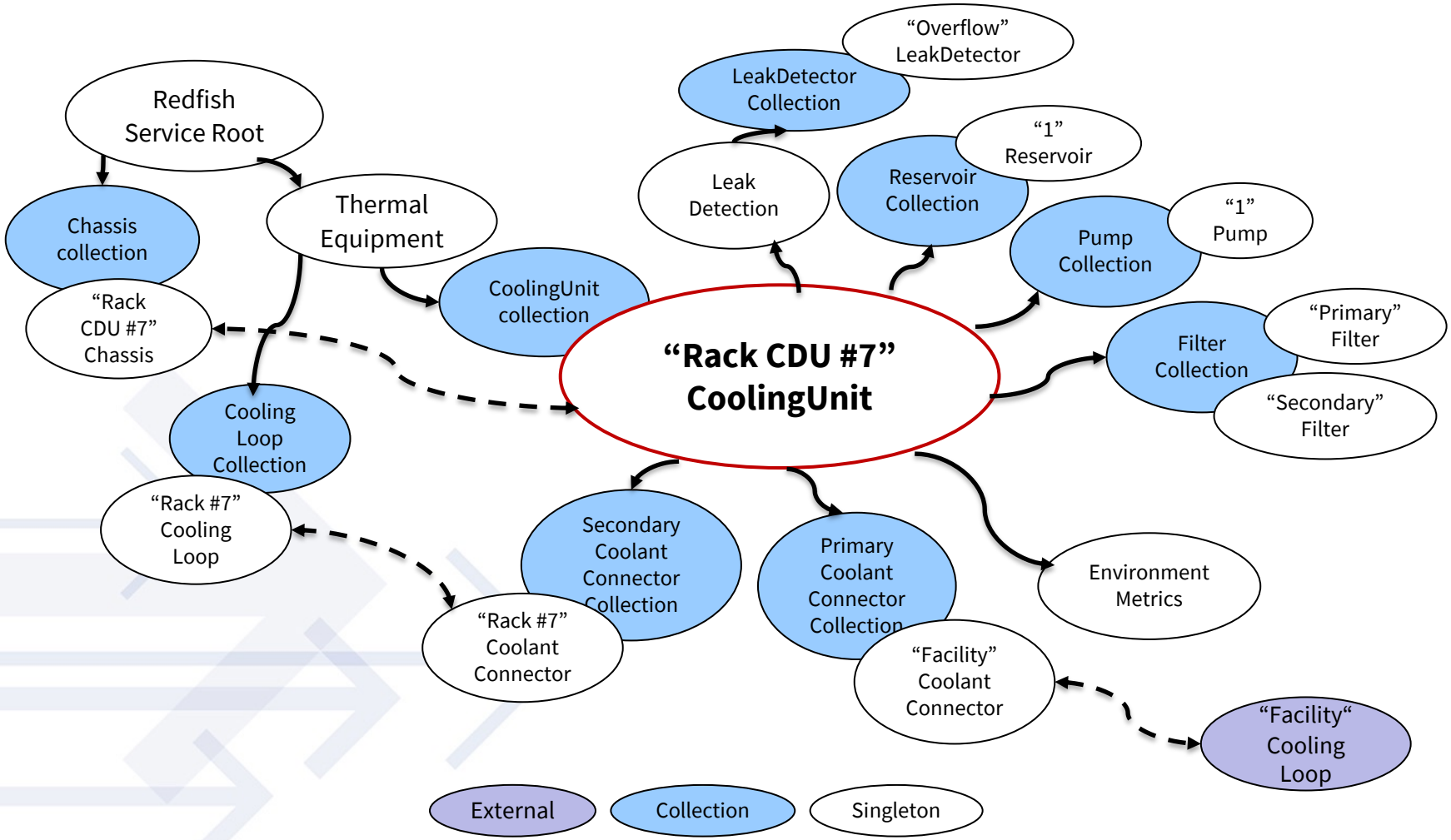
Links to Redfish-managed *Consuming* and *Source* resources

COOLING UNIT MODEL

NEW CoolingUnit schema and resources

- Unified schema covers many types of cooling gear
  - Equipment that cannot be modeled by a **Chassis** and **ThermalSubsystem**
    - Heat exchangers and manifolds expected to be covered as a Chassis
    - CoolingUnit equipment will have a containing Chassis resource
  - Share common modeling and property definitions
  - *EquipmentType* property provides specific identification
- Resource contents
  - General product identification – model, manufacturer, serial number, etc.
  - Versioning – Hardware revision, firmware version, date of manufacture
- *Links* to subordinate and related resources
  - Sensors, LeakDetection, Metrics (entire unit)
  - Primary (input) and Secondary (output) CoolantConnectors
  - Subsystems: Pumps, Filters, Reservoirs
  - Chassis that contains the equipment

Cooling Unit Model



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"
    },
    "PrimaryCoolantConnectors": { “@odata.id”: < Link to CoolantConnectorCollection > },
    "SecondaryCoolantConnectors": { “@odata.id”: < Link to CoolantConnectorCollection > },
    "Pumps": { “@odata.id”: < Link to PumpCollection > },
    "Filters": { “@odata.id”: < Link to FilterCollection > },
    "EnvironmentMetrics": { “@odata.id”: < Link to EnvironmentMetrics > },
     < TRUNCATED >
```

NEW CoolantConnector schema

- Describes a coolant-carrying connector and its equipment connections
  - Modeled either as a connector pair, or an individual “supply” or “return”
  - Provides numerous sensor readings and controls
    - Flow, Temperature, Pressure on both supply and return
    - Valve controls
  - 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 coolant connectors – input from facility chillers or other sources
  - Secondary coolant connectors– output from the cooling unit to feed “consuming” equipment

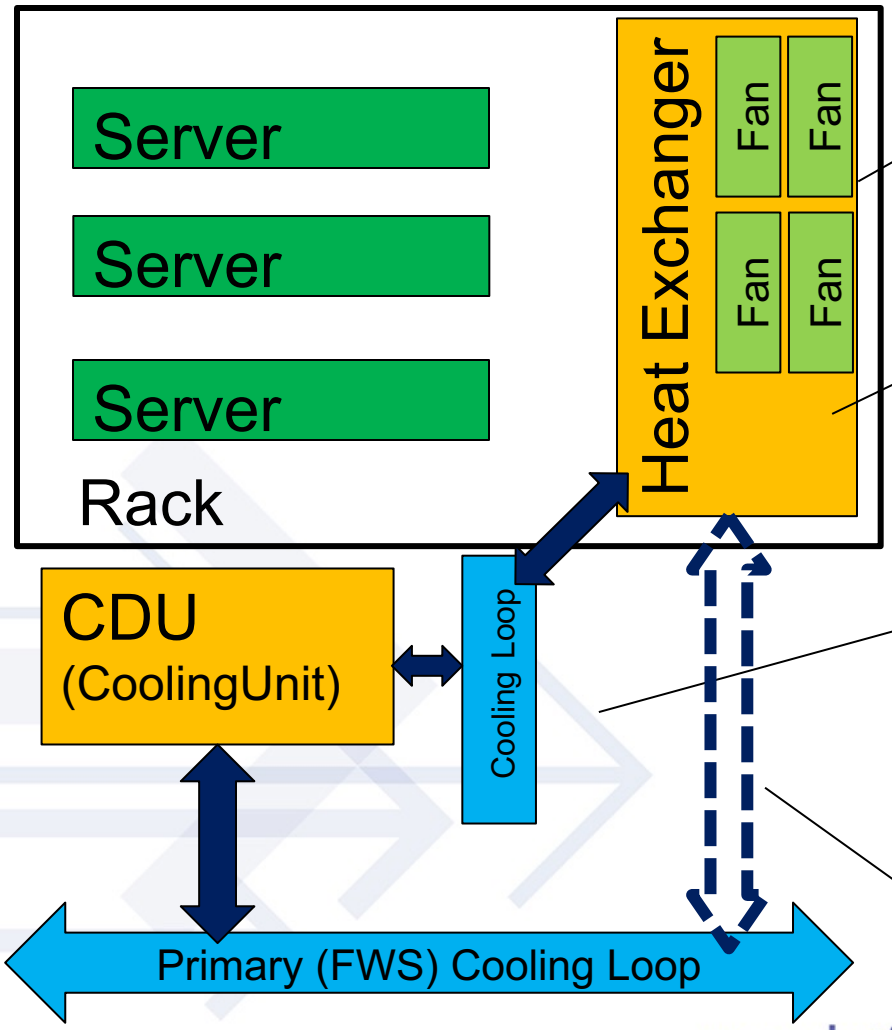
NEW CoolantConnector schema

```
{
    "@odata.type": "#CoolantConnector.v1_0_0.CoolantConnector",
    "Id": "Chiller",
    "Name": “Primary Input from Chiller",
    "Status": {
        "Health": "OK"
    },
    "CoolantConnectorType": “Primary",
    “CoolingLoopType”: “Facility”
    “Coolant”: {
        “CoolantType”: “Water”,
        “AdditiveName”: “Generic cooling water biocide”,
        “AdditivePercent”: 0
    }
    "RatedFlowLitersPerMinute": 120,
    "SupplyFlowValvePercent": {
        "DataSourceUri": "/redfish/v1/CoolingEquipment/RackCDUs/1/Controls/ChillerSupplyValve",
        "SetPoint": 70,
        "Reading": 65,
        "ReadingUnits": “L/min"
    },
    "SupplyTemperatureCelsius": {
        "DataSourceUri": "/redfish/v1/CoolingEquipment/RackCDUs/1/Sensors/LoopASupplyTemp",
        "Reading": 14.8
    },
   “SupplyPressurekPa": {
        "Reading": 319.6
    },
    < TRUNCATED >
```

As *CoolantConnectorType* is really a description of the loop – this may become a more general descriptor to indicate if this resource models a “pair” of supply/return connections or a single (typically facility-scale) supply OR return connection.

Sensor excerpts and *Control* excerpt for valves

Example: Rear Door Heat Exchanger – CDU and Chassis



The heat exchanger is modeled as a **Chassis** with a **ThermalSubsystem** that describes the **Fans**

ThermalMetrics has new sensor excerpts to describe airflow and delta pressure

CDU *primary* **CoolantConnector** attaches to the facility cooling loop and its *secondary* **CoolantConnector** connects to a technology loop, which in turn connects to the heat exchanger via **CoolantConnector**

OR the heat exchanger directly connects to the facility loop via a **CoolantConnector**

NEW Subsystems for CoolingUnit and ThermalEquipment

- Equipment that may appear as a subsystem or component of a **CoolingUnit**, or may be a free-standing device
  - Model allows for this equipment to reside under **ThermalEquipment**, or as subordinate resources to an individual **CoolingUnit**
- For initial release, these schema contain only basic inventory and identification data
  - Expect to add more specific properties as feedback is received
  - But even the basic part and product information is useful to customers
- **Pump** Resource Collection
  - Will have differential pressure / absolute pressure, flow, etc.
  - Variable Frequency Drive may need an object

NEW Subsystem schemas, continued

- **Reservoir** Resource Collection
  - Fill level, pressure sensors
  - Air bleed value (controls), fill valve, drain valve
  - May have connections between reservoirs (balancing)
- **Filter** Resource Collection
  - Pressure sensors
  - Service time / install time, life etc.
  - ASHRAE requirements / classifications
  - Flush / clean actions?

LEAK DETECTION

NEW LeakDetection schema

- Resource to describe leak detection equipment and report leaks
  - Allows discovery of detection equipment to validate customer requirements
- *DetectorGroups* supports multiple “zones” of detection
  - Each group represents a detection zone
  - Made up of one or more *LeakDetector instances*
  - Can also include a humidity sensor
  - “Policy” for what constitutes a reported leak is left to implementation
    - Assumes this is manufacturer or configuration based, not user-defined
- *Status* object provides means to report leaks
  - Will define messages for reporting leaks as *Conditions*

LeakDetection example

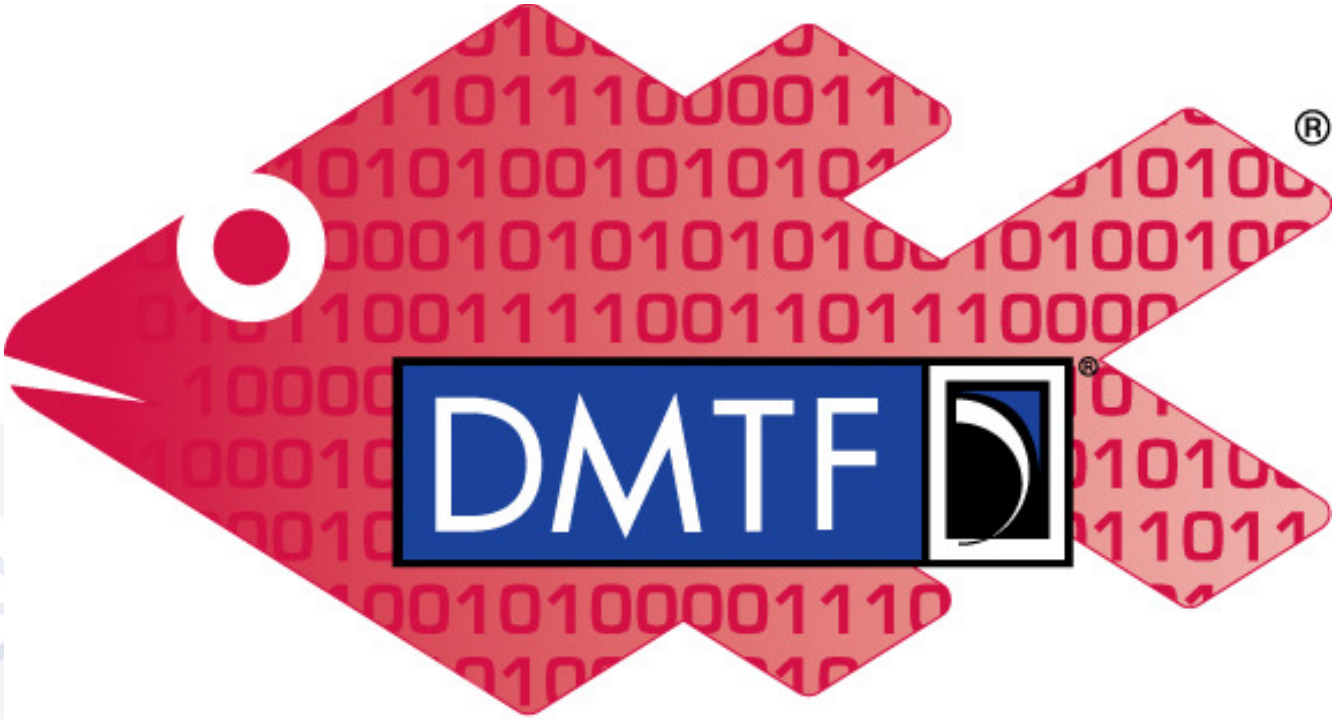

```
{
    "@odata.type": "#LeakDetection.v1_0_0.LeakDetection",
    "Name": "Leak Detection Systems",
    "Status": {
        "State": "Enabled",
        "Health": "OK",
        "Conditions": []
    },
    "LeakDetectorGroups": [{
        "GroupName": "Detectors under and around the CDU",
        "HumidityPercent": {
            "Reading": 45
        },
        "Detectors": [{
                "DataSourceURI": "/redfish/v1/ThermalEquipment/CDUs/1/DiscreteSensors/LeakDetection",
                "DeviceName": "Moisture-type Leak Detector",
                "DetectorState": "OK"
            },
            {
                "DataSourceURI": "/redfish/v1/ThermalEquipment/CDUs/1/DiscreteSensors/Overflow",
                "DeviceName": "Overflow Float Switch",
                "DetectorState": "OK"
            }
        ]
    }],
```


In this example with one LeakDetectorGroup, there are three sensors, with the implementation deciding the policy under which a leak is reported

Humidity reading, with an internal threshold to indicate a leak

Two types of Detectors, which will indicate a leak with a DetectorState of “Alert”

Q&A & Discussion



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