

W3C WoT Thing Model

29 November 2021, Sebastian.Kaebisch@siemens.com

Motivation: Large-scale Production



- Typically, IoT devices are sold for the mass market
- During design phase of a new IoT device, data model and functionality can be specified once and are valid for all device instance from the same class (e.g., sensing temperature value, switch power on/off, etc.)
- However, communication and security information mostly known during the deployment phase (e.g., IP address, MQTT broker address, authorization server, etc.)
 - settings mostly depends on customer and its infrastructure
- Valid Thing Descriptions can be only provided at runtime
- Is there a way to have a kind of Thing Description without instance specific details?
E.g., for simulation purposes or pre-onboarding into a target system.

Motivation: Devices with same Basic Functionality

Example Smart Lamp



- Each smart lamp provides basic functions like
 - on/off
 - status
- Beside of the basic functions, some lamps provides one or more features like
 - dimming
 - set RGB color
 - operation time
 - ...
- How can new IoT devices adopt existing basic functions such as on/off and status for Thing Description without redefining them?

Source: https://upload.wikimedia.org/wikipedia/commons/thumb/d/d3/Wide_array_of_lamps.jpg/269px-Wide_array_of_lamps.jpg

The Answer: Thing Model

- **Definition:**

A **Thing Model** is a description for a class of Things that have the same capabilities. It describes the Properties, Actions, and Events and common metadata that are shared for an entire group of Things. Compared to a Thing Description, a Thing Model does not contain enough information to identify or interact with a Thing instance.

- ‘Thing Model’ name since Thing Description 1.1
 - under Thing Description 1.0 it is known as ‘Thing Description Template’
- Based on the same information model as the Thing Description, however, has less restrictions (e.g., **forms** and **securityDefinitions** are not mandatory)
- Uses JSON-LD 1.1 serialization
- Detail reading: <https://w3c.github.io/wot-thing-description/#thing-model>



Web of Things (WoT) Thing Description 1.1



W3C Working Draft 7 June 2021

This version:
<https://www.w3.org/TR/2021/WD-wot-thing-description11-20210607/>

Latest published version:
<https://www.w3.org/TR/wot-thing-description11/>

Previous version:
<https://www.w3.org/TR/2020/WD-wot-thing-description11-20201124/>

Latest editor's draft:
<https://w3c.github.io/wot-thing-description/>

Implementation report:
<https://w3c.github.io/wot-thing-description/testing/report.html>

Editors:
Sebastian Kaebisch (Siemens AG)
Takuki Kamiya (Fujitsu Laboratories of America)
Michael McCool (Intel)
Victor Charpenay (Siemens AG)

Participate:
[GitHub w3c/wot-thing-description](#)
[File an issue](#)
[Commit history](#)
[Pull requests](#)

Contributors
[In the GitHub repository](#)

Repository
[We are on GitHub](#)
[File a bug](#)

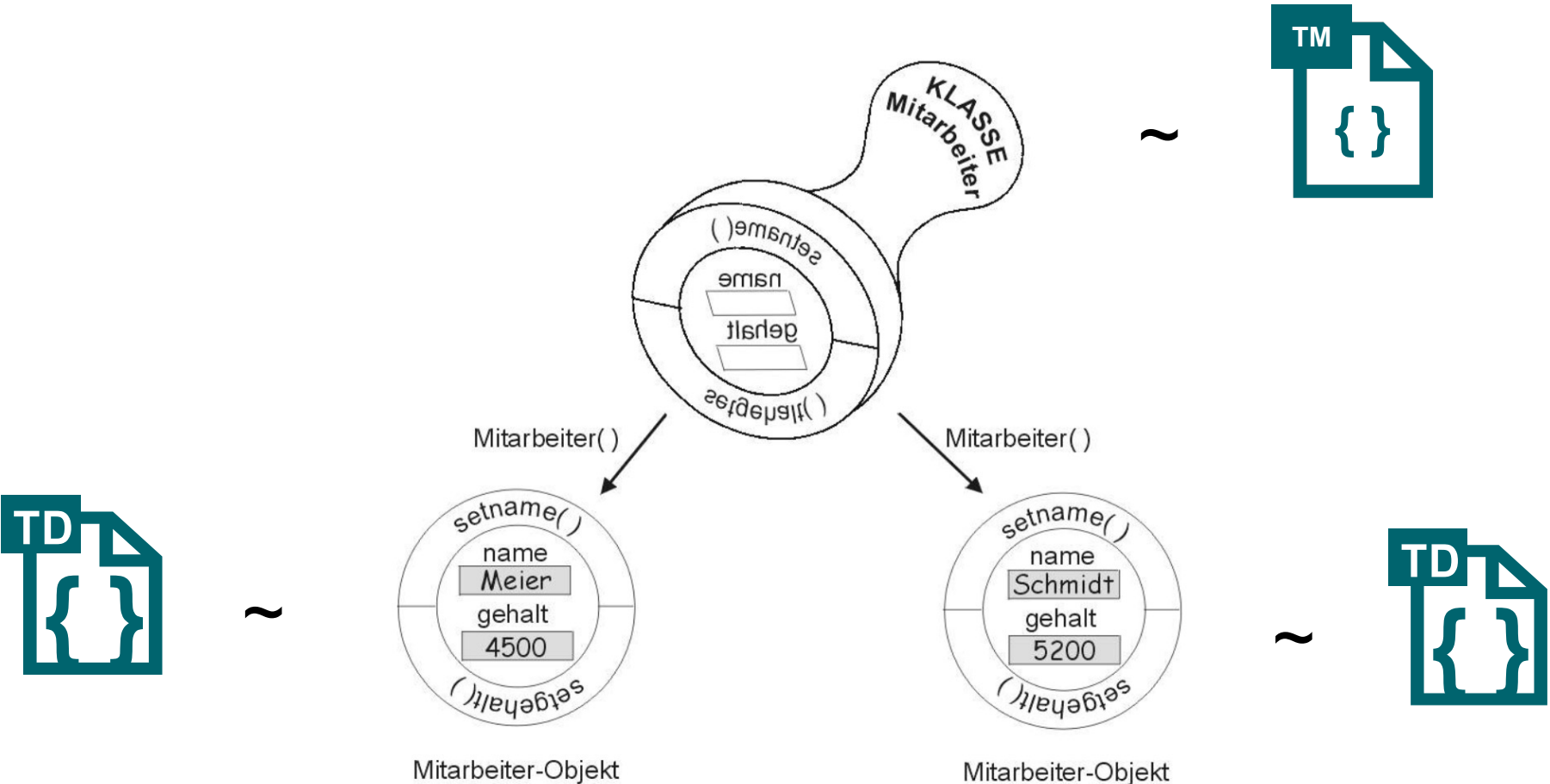
Copyright © 2017-2021 W3C® (MIT, ERCIM, Keio, Beihang). W3C liability, trademark and permissive document license rules apply.

Thing Model Example

```
{
  "@context": ["http://www.w3.org/ns/td"],
  "@type" : "tm:ThingModel",
  "title": "Lamp Thing Model",
  "properties": {
    "status": {
      "description": "current status of the lamp (on|off)",
      "type": "string",
      "readOnly": true
    }
  },
  "actions": {
    "toggle": {
      "description": "Turn the lamp on or off"
    }
  },
  "events": {
    "overheating": {
      "description": "Lamp reaches a critical temperature (overheating)",
      "data": {"type": "string"}
    }
  }
}
```

- No protocol information
 - No IP addresses
 - No content type
 - No security information
- But this is a valid TM!

Can be compared with...



Sources: <https://de.m.wikipedia.org/wiki/Datei:KlasseObjektBeispiel.png>

How to identify Thing Models?

```
{
  "@context": ["http://www.w3.org/ns/td"],
  "@type": "tm:ThingModel",
  "title": "Lamp Thing Model",
  "properties": {
    "status": {
      "description": "current status of the lamp (on|off)",
      "type": "string",
      "readOnly": true
    }
  },
  "actions": {
    "toggle": {
      "description": "Turn the lamp on or off"
    }
  },
  "events": {
    "overheating": {
      "description": "Lamp reaches a critical temperature (overheating)",
      "data": {"type": "string"}
    }
  }
}
```

- Thing Model namespace is provided within the TD context
- TM definitions must have **“@type”:”tm:ThingModel”**
- **tm:** prefix is used to identify Thing Model terms that can be only used for Thing Model definitions

Thing Model Design Tools

Extend Thing Models with *tm:extend*

```
{
  "@context": ["http://www.w3.org/ns/td"],
  "@type": "tm:ThingModel",
  "title": "Basic On/Off Thing Model",
  "properties": {
    "onOff": {
      "type": "boolean"
    }
  }
}
```

Basic On/Off Thing Model

```
{
  "@context": ["http://www.w3.org/ns/td"],
  "@type": "tm:ThingModel",
  "title": "Smart Lamp Control with Dimming",
  "links": [{
    "rel": "tm:extends",
    "href": "http://example.com/BasicOnOffTM",
    "type": "application/td+json"
  }],
  "properties": {
    "dim": {
      "type": "integer",
      "minimum": 0,
      "maximum": 100
    }
  }
}
```

Smart Lamp Control Thing Model extends **Basic On/Off Thing Model** by the **links** container with the entries “**rel**”:“**tm:extends**”, the location of the extended TM (**href**) and its (media) **type**.

→ Smart Lamp Control Thing Model has two properties: **dim** and **onOff**

→ Smart Lamp Control Thing Model overwrites the **title** of the **Basic On/Off Thing Model**

Import/Copy Definitions from existing Thing Models with *tm:ref*

```
{
  "@context": ["http://www.w3.org/ns/td"],
  "@type": "tm:ThingModel",
  "title": "Smart Lamp Control with Dimming",
  "links": [{
    "rel": "tm:extends",
    "href": "http://example.com/BasicOnOffTM",
    "type": "application/td+json"
  }],
  "properties": {
    "dim": {
      "type": "integer",
      "minimum": 0,
      "maximum": 100
    }
  }
}
```

Smart Lamp Control Thing Model

```
{
  "@context": ["http://www.w3.org/ns/td"],
  "@type": "tm:ThingModel",
  "title": "Smart Lamp Control",
  "properties": {
    "dimming": {
      "tm:ref" : "http://example.com/SmartLampControlwithDimming.tm.jsonld#properties/dim",
      "maximum": 80,
      "unit": "%"
    }
  }
}
```

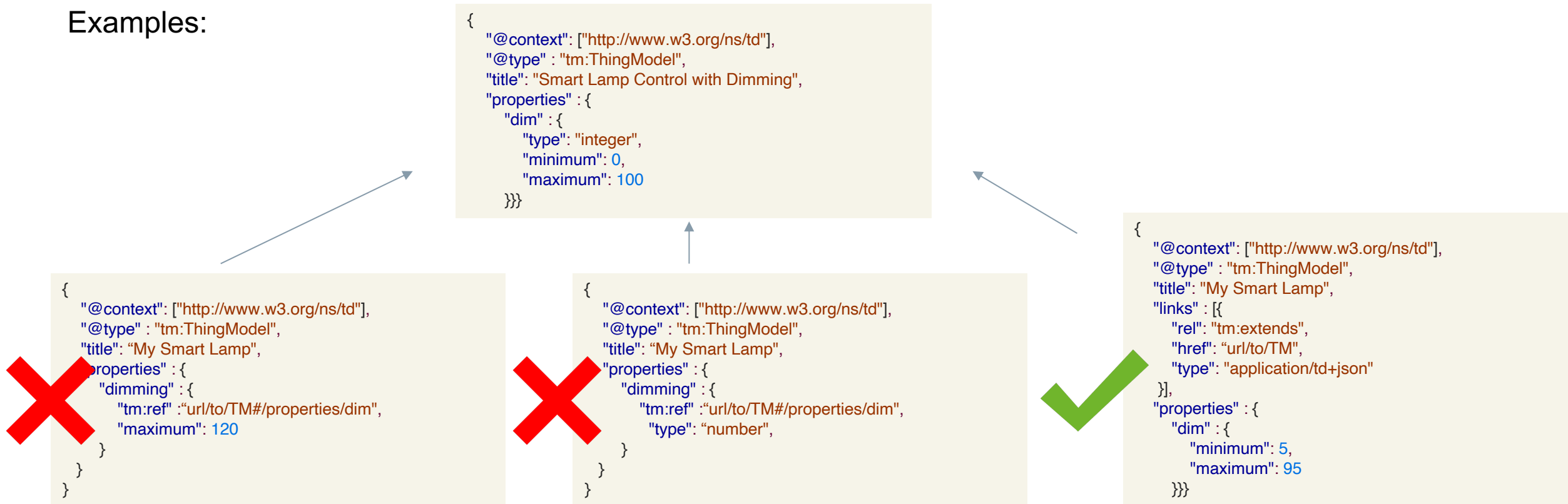
URL JSON Pointer

- **tm:ref** provides a reference based on a combination of an URL and a JSON Pointer to an existing definition that should be copied to the new definition
- Existing definitions can be overwritten (e.g., **maximum**) or extended (e.g., **unit**)

Overwriting

- The **extend** and **import** feature allows to overwrite existing definitions.
However, it is not allowed to overwrite the semantic meaning of the origin definition.
- Instances should be valid to the new definition AND to the origin definition

Examples:



Composition

→ compose existing Thing Model definitions to a new IoT system

```
{
  "@context": "http://www.w3.org/ns/td",
  "@type": "tm:ThingModel",
  "title": "Smart Ventilator Thing Model",
  "version": { "model": "1.0.0" },
  "links": [
    {
      "rel": "tm:submodel",
      "href": "./Ventilation.tm.jsonld",
      "type": "application/tm+json",
      "instanceName": "ventilation"
    },
    {
      "rel": "tm:submodel",
      "href": "./LED.tm.jsonld",
      "type": "application/tm+json",
      "instanceName": "led"
    }
  ],
  "properties": {
    "status": { "type": "string", "enum": ["On", "Off", "Error"] }
  }
}
```

tm:submodel points to an existing Ventilation TM which should be part of the new system.
instanceName associate an individual name to the composed (sub-) TM

Another included TM with 'type' LED

New IoT system can also have own interaction models

Modeling Tools for generating Thing Description Instances

- Thing Models can act as a template and can be used to generate Thing Description instances
- A Thing Description generator must
 - remove (e.g., tm:extends) or replace (eg., tm:ref) TM specific terms
 - provide specifics communications and security metadata
- To provide specific expectations to Thing Description instances, specific features tools can be used in TM:
 - **tm:required:** Based on JSON Pointers and tells, which definitions are mandatory and should be available in Thing Description instances
 - **Placeholder:** Provide **{{PLACEHOLDER_IDENTIFIER}}** pattern in TM which must be substituted with a concrete values when a TD instance is created
- Optional, the **rel=type** in **links** can be used in Thing Description to point to the Thing Model that is followed

tm:required



```
{
  "@context": ["http://www.w3.org/ns/td"],
  "@type": "tm:ThingModel",
  "title": "Lamp Thing",
  "description": "Control Lamp",
  "tm:required": [
    "#/properties/status",
    "#/actions/toggle"
  ],
  "properties": {
    "status": {
      "description": "current status of the lamp (on/off)",
      "type": "string",
      "readOnly": true
    }
  },
  "actions": {
    "toggle": {
      "description": "Turn the lamp on or off"
    }
  },
  "events": {
    "overheating": {
      "description": "Lamp reaches a critical temperature (overheating)",
      "data": {"type": "string"}
    }
  }
}
```



```
{
  "@context": "http://www.w3.org/ns/td",
  "id": "urn:dev:ops:32473-WoTLamp-1234",
  "title": "Lamp Thing",
  "securityDefinitions": {
    "basic_sc": {"scheme": "basic", "in": "header"}
  },
  "security": "basic_sc",
  "links": [{
    "rel": "type",
    "href": "url/to/TM",
    "type": "application/td+json"
  }],
  "properties": {
    "status": {
      "type": "string",
      "readOnly": true,
      "forms": [{"href": "https://mylamp.example.com/status"}]
    }
  }
}
```



tm:required



```
{
  "@context": ["http://www.w3.org/ns/td"],
  "@type": "tm:ThingModel",
  "title": "Lamp Thing",
  "description": "Control Lamp",
  "tm:required": [
    "#/properties/status",
    "#/actions/toggle"
  ],
  "properties": {
    "status": {
      "description": "current status of the lamp (on/off)",
      "type": "string",
      "readOnly": true
    }
  },
  "actions": {
    "toggle": {
      "description": "Turn the lamp on or off"
    }
  },
  "events": {
    "overheating": {
      "description": "Lamp reaches a critical temperature (overheating)",
      "data": {"type": "string"}
    }
  }
}
```



```
{
  "@context": "http://www.w3.org/ns/td",
  "id": "urn:dev:ops:32473-WoTLamp-1234",
  "title": "Lamp Thing",
  "securityDefinitions": {
    "basic_sc": {"scheme": "basic", "in": "header"}
  },
  "security": "basic_sc",
  "links": [{
    "rel": "type",
    "href": "url/to/TM",
    "type": "application/td+json"
  }],
  "properties": {
    "status": {
      "type": "string",
      "readOnly": true,
      "forms": [{"href": "https://mylamp.example.com/status"}]
    }
  },
  "actions": {
    "toggle": {
      "forms": [{"href": "https://mylamp.example.com/toggle"}]
    }
  }
}
```



tm:required



```
{
  "@context": ["http://www.w3.org/ns/td"],
  "@type": "tm:ThingModel",
  "title": "Lamp Thing",
  "description": "Control Lamp",
  "tm:required": [
    "#/properties/status",
    "#/actions/toggle"
  ],
  "properties": {
    "status": {
      "description": "current status of the lamp (on/off)",
      "type": "string",
      "readOnly": true
    }
  },
  "actions": {
    "toggle": {
      "description": "Turn the lamp on or off"
    }
  },
  "events": {
    "overheating": {
      "description": "Lamp reaches a critical temperature (overheating)",
      "data": {"type": "string"}
    }
  }
}
```



```
{
  "@context": "http://www.w3.org/ns/td",
  "id": "urn:dev:ops:32473-WoTLamp-1234",
  "title": "Lamp Thing",
  "securityDefinitions": {
    "basic_sc": {"scheme": "basic", "in": "header"}
  },
  "security": "basic_sc",
  "links": [
    {
      "rel": "type",
      "href": "url/to/TM",
      "type": "application/td+json"
    }
  ],
  "properties": {
    "status": {
      "type": "string",
      "readOnly": true,
      "forms": [{"href": "https://mylamp.example.com/status"}]
    }
  },
  "actions": {
    "toggle": {
      "forms": [{"href": "https://mylamp.example.com/toggle"}]
    }
  },
  "events": {
    "overheating": {
      "data": {"type": "string"},
      "forms": [
        {
          "href": "https://mylamp.example.com/oh",
          "subprotocol": "longpoll"
        }
      ]
    }
  }
}
```



Placeholder

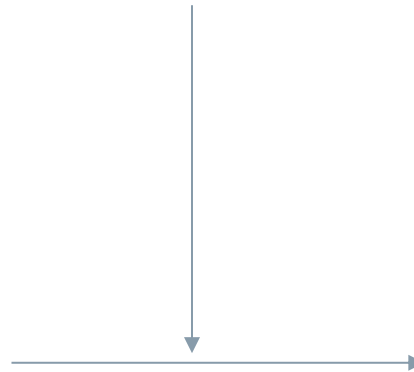
Placeholder Map



```
{
  "THERMOSTATE_NUMBER": 4,
  "MQTT_BROKER_ADDRESS": "192.168.178.72:1883",
  "THERMOSTATE_TEMPERATURE_MAXIMUM": 47.7,
  "THERMOSTATE_TEMPERATURE_OBSERVABLE": true
}
```



```
{
  "@context": ["http://www.w3.org/ns/td"],
  "@type": "tm:ThingModel",
  "title": "Thermostate No. {{THERMOSTATE_NUMBER}}",
  "base": "mqtt://{{MQTT_BROKER_ADDRESS}}",
  "properties": {
    "temperature": {
      "description": "Shows the current temperature value",
      "type": "number",
      "minimum": -20,
      "maximum": "{{THERMOSTATE_TEMPERATURE_MAXIMUM}}",
      "observable": "{{THERMOSTATE_TEMPERATURE_OBSERVABLE}}"
    }
  },
  "forms": [
    {
      "tm:ref": ""
    }
  ]
}
```



```
{
  "@context": ["http://www.w3.org/ns/td"],
  "@type": "Thing",
  "title": "Thermostate No. 4",
  "base": "mqtt://192.168.178.72:1883",
  "properties": {
    "temperature": {
      "description": "Shows the current temperature value",
      "type": "number",
      "minimum": -20.0,
      "maximum": 47.7,
      "observable": true
    }
  }
}
```

Live Demo

ediTDor

Share New Open Save Save As Convert To TD

```
1 {
2   "@context": [
3     "http://www.w3.org/ns/td"
4   ],
5   "@type": "tm:ThingModel",
6   "title": "Thermostate No. {{THERMOSTATE_NUMBER}}",
7   "base": "mqtt://{{MQTT_BROKER_ADDRESS}}",
8   "properties": {
9     "temperature": {
10      "description": "Shows the current temperature value",
11      "type": "number",
12      "minimum": -20,
13      "maximum": "{{THERMOSTATE_TEMPERATURE_MAXIMUM}}",
14      "observable": "{{THERMOSTATE_TEMPERATURE_OBSERVABLE}}"
15    }
16  }
17 }
```

Thermostate No. {{THERMOSTATE_NUMBER}}

@context >

@type tm:ThingModel

base mqtt://{{MQTT_BROKER_ADDRESS}}

> Forms

Add Top Level Form

Search Properties

Generate TD From TM

Please provide values to switch the placeholders with.

THERMOSTATE_NUMBER:

Enter a value...

MQTT_BROKER_ADDRESS:

Enter a value...

THERMOSTATE_TEMPERATURE_MAXIMUM:

Enter a value...

THERMOSTATE_TEMPERATURE_OBSERVABLE:

Enter a value...

Cancel Generate TD

Properties: 1 Actions: 0 Events: 0 Size: 368 bytes

ediTDor

Share New Open Save Save As Convert To TD

```
1 {
2   "@context": [
3     "https://www.w3.org/2019/wot/td/v1",
4     {
5       "saref": "https://w3id.org/saref#"
6     }
7   ],
8   "@type": "tm:ThingModel",
9   "title": "Bottle filling line TM",
10  "links": [
11    {
12      "rel": "tm:submodel",
13      "href": "BottleFill.tm.jsonld",
14      "type": "application/tm+json"
15    },
16    {
17      "rel": "tm:submodel",
18      "href": "BottleCapping.tm.jsonld",
19      "type": "application/tm+json"
20    },
21    {
22      "rel": "tm:submodel",
23      "href": "Sprayhead.tm.jsonld",
24      "type": "application/tm+json"
25    }
26  ],
27  "properties": {
28    "operatingState": {
29      "@type": "saref:MultiLevelState",
30      "description": "The current state of the bottle filling line",
31      "readOnly": true,
32      "observable": true,
33      "type": "string"
34    },
35    "productionCounter": {
36      "@type": "saref:Measurement",
37      "description": "The amount of bottles produced",
38      "readOnly": true,
39      "observable": true
40    }
41  }
42 }
```

Bottle filling line TM

@context >

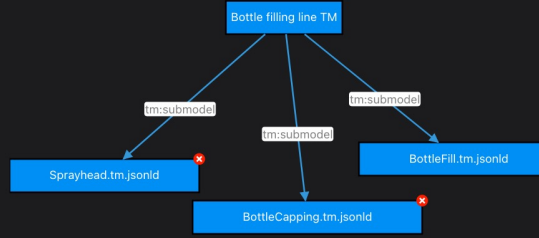
@type tm:ThingModel

> Forms

Add Top Level Form

< Links List Graph

Add Top Level Link



Properties: 2 Actions: 0 Events: 0 Size: 752 bytes

Version: 0.4.0 | We are on GitHub

<https://eclipse.github.io/editdor/>