



Bridging the Gap to the Web of Things

On the Conversion between WoT Data Models and the Semantic Definition Format

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Semantic IoT device descriptions

Important for both machine-to-machine and human-to-machine interaction.

- Protocols
- Data formats
- Security mechanisms
- (human-readable) meta-data



Two kinds of interoperability problems

1. At the *instance* level
 - Incompatible data models and interface descriptions
2. At the *ecosystem* level
 - Lack of a common data and interaction model
 - → Difficult to universally describe *classes* of devices



Two Potential Solutions

- Web of Things Thing Description (WoT TD)
 - W3C Recommendation since 2020
 - Version 1.1 about to be published
 - Work on version 2.0 will begin in a few weeks

- Semantic Definition Format (SDF)
 - Specified by an IETF working group (ASDF)
 - Initiated by the OneDM group
 - Internet-Draft (currently version 13)





WoT TD and SDF

WoT TD

- Focus on device *instances*
- Simplifies interactions between Things and TD consumers

SDF

- Focus on device *classes*
- Aspires to be a universal modelling language

→ WoT TD as an interesting conversion target for SDF

However: Lack of a “canonical” mapping between the two specifications



Goals

- Comprehensive mapping between SDF and WoT
 - Support for round tripping
- Converter implementation
- Identify gaps/potential for alignment
- Discuss limitations/future improvements

**Many similarities, but also
important differences.**





Minimal Examples for WoT TD and SDF

WoT Thing Description

```
{
  "@context":
  "https://www.w3.org/2022/wot/td/v1.1",
  "title": "Smart Lamp",
  "security": [...],
  "securityDefinitions": {...},

  "properties": { ... },
  "actions": { ... },
  "events": { ... }
}
```

SDF Model

```
{
  "sdfObject": {
    "smartLamp": {
      "label": "Smart Lamp",

      "sdfProperty": { ... },
      "sdfAction": { ... },
      "sdfEvent": { ... },
    }
  }
}
```




Two important questions

1. How can we map abstract data models to WoT (TD)?
2. How can we map instance- or ecosystem-specific information to SDF?



Thing Descriptions vs. Thing Models

WoT Thing Description

```
{
  "@context":
  "https://www.w3.org/2022/wot/td/v1.1",
  "title": "Smart Lamp",
  "security": [ ... ],
  "securityDefinitions": { ... },
  "properties":
    "status": {
      "type": "string",
      "forms": [...]
    }
}
```

WoT Thing Model

```
{
  "@context":
  "https://www.w3.org/2022/wot/td/v1.1",
  "title": "Smart Lamp",
  "@type": "tm:ThingModel",
  "properties":
    "status": {
      "type": "string"
    }
}
```



SDF \Leftrightarrow Thing Model Conversion

SDF Model

```
{
  "sdfObject": {
    "Lamp": {
      "label": "Smart Lamp"
      "sdfProperty": {
        "status": {
          "type": "string"
        }
      }
    }
  }
}
```

WoT Thing Model

```
{
  "@context":
  ["https://www.w3.org/2022/wot/td/v1.1", {
    "sdf": "https://example.org/sdf",
  }],
  "@type": "tm:ThingModel",
  "title": "Smart Lamp",
  "sdf:objectKey": "Lamp",
  "properties":
    "status": {
      "type": "string"
    }
}
```



SDF Mapping Files (with WoT TD terms)

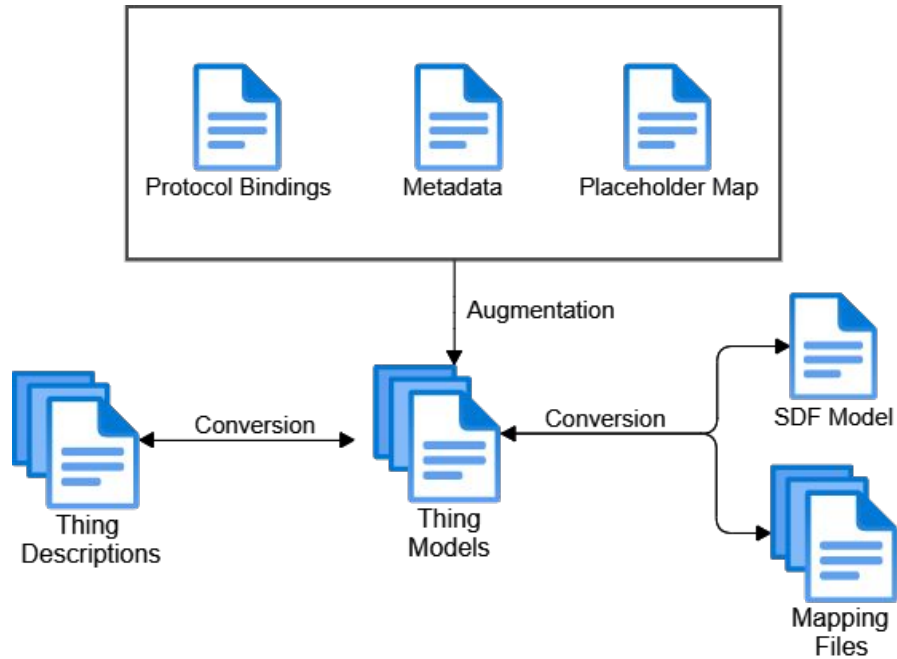
SDF Model

```
{
  "sdfObject": {
    "Lamp": {
      "label": "Smart Lamp"
      "sdfProperty": {
        "status": {
          "type": "string"
        }
      }
    }
  }
}
```

SDF Mapping File

```
{
  "map": {
    "#/sdfObject/Lamp": {
      "@context": "...",
      "security": [...],
      "securityDefinitions": {...},
    },
    "#/sdfObject/Lamp/sdfProperty/status": {
      "forms": [...]
    }
  }
}
```

Conversion Process





Conversion of Nested Models

SDF Model

```
{
  "sdfThing": {
    "TopLevel": {
      "sdfProperty": {
        ...
      },
      "sdfObject": {
        "SecondLevel": {
          ...
        }
      }
    }
  }
}
```

WoT "TM Collection"

```
{
  "TopLevel": {
    ...,
    "properties": { ... },
    "links": [
      {
        "href": "#/SecondLevel",
        "rel": "tm:submodel",
      }
    ]
  },
  "SecondLevel": {
    ...
  }
}
```

[Help](#)[Sponsors](#)[Log in](#)[Register](#)

sdf-wot-converter 1.10.0

```
pip install sdf-wot-converter
```



Released: Jan 13, 2023

Converter between WoT TD and SDF (including protocol bindings).

Navigation

[Project description](#)[Release history](#)[Download files](#)

Project links

[Homepage](#)[Bug Tracker](#)

Project description

Build Status **passing** pypi package **1.10.0** codecov **100%** code style **black**

SDF-WoT-Converter

This repository provides a Python-based converter from [SDF](#) to [WoT TD](#) including Thing Models.

The converter is both usable as a library and a command line tool. It provides conversion functions between WoT Thing Descriptions, WoT Thing Models and SDF Models (one for each combination). You can find a number of examples for the usage of the converter down below as well as overviews for the conversion between SDF and WoT TMs.

The CI pipeline is set up to automatically convert all (valid) models from the [oneDM playground](#) to WoT Thing Models

<https://github.com/JKRhb/sdf-wot-converter-py>



Library API

- Six top level functions
 - SDF to WoT TM and WoT TD
 - WoT TD to WoT TM and SDF
 - WoT TM to SDF and WoT TD



CLI tool

```
usage: sdf-wot-converter [-h] [--indent INDENT] [--suppress-roundtripping] {sdf-to-tm,sdf-to-td,tm-to-sdf,tm-to-td,td-to-sdf,td-to-tm} ...
```

Convert from SDF to WoT and vice versa.

positional arguments:

{sdf-to-tm,sdf-to-td,tm-to-sdf,tm-to-td,td-to-sdf,td-to-tm}

sdf-to-tm	Converts an SDF model and mapping files to one or more WoT Thing Models.
sdf-to-td	Converts an SDF model and mapping files to one or more WoT Thing Descriptions.
tm-to-sdf	Converts a WoT Thing Model to an SDF model and zero or more mapping files.
tm-to-td	Converts a WoT Thing Model to a WoT Thing Description.
td-to-sdf	Converts one or more WoT Thing Models to an SDF model and zero or more mapping files.
td-to-tm	Converts one or more WoT Thing Descriptions to one or more WoT Thing Models.

optional arguments:

-h, --help	show this help message and exit
--indent INDENT	Indentation depth for the output JSON files.
--suppress-roundtripping	Suppresses the addition of additional fields for enabling roundtripping, like "sdf:objectKey".

SDF WoT converter

SDF ▾ » « WoT TM ▾

```
{
  "info": {
    "title": "Example file for OneDM Semantic Definition Format",
    "version": "2019-04-24",
    "copyright": "Copyright 2019 Example Corp. All rights reserved.",
    "license": "https://example.com/license"
  },
  "namespace": {
    "cap": "https://example.com/capability/cap"
  },
  "defaultNamespace": "cap",
  "sdfObject": {
    "Switch": {
      "sdfProperty": {
        "value": {
          "description": "The state of the switch; false for off and true for on.",
          "type": "boolean"
        }
      },
      "sdfAction": {
        "on": {
          "description": "Turn the switch on; equivalent to setting value to true."
        },
        "off": {
          "description": "Turn the switch off; equivalent to setting value to false."
        },
        "toggle": {
          "description": "Toggle the switch; equivalent to setting value to its complement."
        }
      }
    }
  }
}
```

```
{
  "@context": [
    "https://www.w3.org/2022/wot/td/v1.1",
    {
      "cap": "https://example.com/capability/cap",
      "sdf": "https://example.com/sdf"
    }
  ],
  "@type": "tm:ThingModel",
  "sdf:objectKey": "Switch",
  "sdf:title": "Example file for OneDM Semantic Definition Format",
  "sdf:copyright": "Copyright 2019 Example Corp. All rights reserved.",
  "links": [
    {
      "href": "https://example.com/license",
      "rel": "license"
    }
  ],
  "version": {
    "model": "2019-04-24"
  },
  "sdf:defaultNamespace": "cap",
  "actions": {
    "on": {
      "description": "Turn the switch on; equivalent to setting value to true."
    },
    "off": {
      "description": "Turn the switch off; equivalent to setting value to false."
    }
  },
}
```

Clear Insert Example Format Clear Insert Example Format

Settings

- Output SDF Mapping files
- Include additional fields for roundtripping

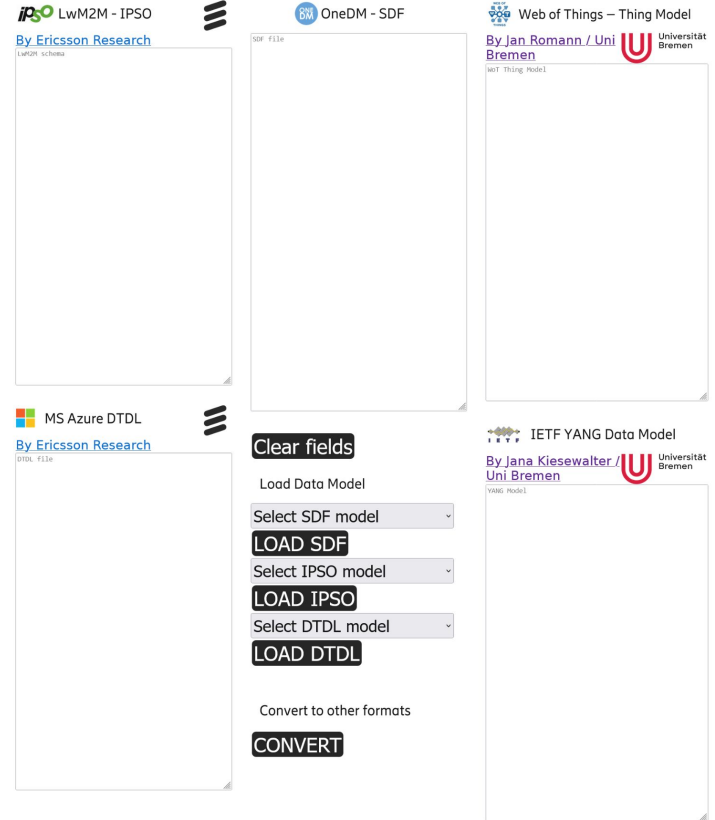


SDF Conversion Tool Collection

<http://wishi.nomadiclab.com/sdf-converter/>

Conversion tools for SDF

These are experimental tools for making conversions from data models in different IoT ecosystems to and from the Semantic Definition Format (SDF) models. Please check the [information page](#)



LwM2M - IPSO
By Ericsson Research
LwM2M scheme

OneDM - SDF
SDF file

Web of Things – Thing Model
By Jan Romann / Uni Bremen
Web of Things Model

MS Azure DTDL
By Ericsson Research
DTDL file

IETF YANG Data Model
By Jana Kiesewalter / Uni Bremen
YANG Model

Clear fields

Load Data Model

Select SDF model ▾

LOAD SDF

Select IPSO model ▾

LOAD IPSO

Select DTDL model ▾

LOAD DTDL

Convert to other formats

CONVERT



Conclusion and Future Work

- WoT and SDF can be mapped to each other
 - Additional concepts such as SDF mapping files are needed
 - WoT TMs as intermediaries
- Flexible converter implementation in Python
 - Library, CLI tool, and web interface



Conclusion and Future Work

- However: More standardization work needed
 - “Canonical” mapping specification?
 - Nested TMs/TDs in a single document?
 - Conversion of TMs to TDs
- Semantic alignment needed
 - Additional SDF concepts (sdfRelation, sdfChoice)
 - Namespace concept of SDF vs JSON-LD
- More thorough evaluation needed

Thank you for your attention!



References

- S. Käbisch, T. Kamiya, M. McCool, V. Charpenay, Web of Things (WoT) Thing Description 1.1, W3C Candidate Recommendation Snapshot, W3C, 2023. URL: <https://www.w3.org/TR/2023/CR-wot-thing-description11-20230119/>.
- M. Koster, C. Bormann, Semantic Definition Format (SDF) for Data and Interactions of Things, Internet-Draft draft-ietf-asdf-sdf-13, IETF, 2023. URL: <https://datatracker.ietf.org/doc/html/draft-ietf-asdf-sdf-13>, Work in Progress.
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- C. Bormann, J. Romann, Semantic Definition Format (SDF): Mapping files, Internet-Draft draft-bormann-asdf-sdf-mapping-02, IETF, 2023. URL: <https://datatracker.ietf.org/doc/html/draft-bormann-asdf-sdf-mapping-02>, Work in Progress.
- P. C. Bryan, K. Zyp, M. Nottingham, JavaScript Object Notation (JSON) Pointer, RFC 6901, IETF, 2013. doi:10.17487/RFC6901

Backup



JSON-LD @context vs namespaces

SDF Model

```
{
  "namespace": {
    "cap": "https://example.com/capability/cap"
  },
  "defaultNamespace": "cap",
  "sdfObject": { ... }
}
```

WoT Thing Model

```
{
  "@context": [
    "https://www.w3.org/2022/wot/td/v1.1",
    {
      "sdf": "https://example.org/sdf",
      "cap": "https://example.com/capability/cap",
    }
  ],
  "@type": "tm:ThingModel"
}
```



Reference Mechanisms

SDF (*sdfRef*)

```
{
  "sdfObject": {
    "foo": {
      "sdfProperty": {
        "bar": {
          "type": "string"
        },
        "baz": {
          "sdfRef": "#/sdfObject/foo/sdfProperty/bar"
        }
      }
    }
  }
}
```

WoT (*tm:ref*)

```
{
  ...,
  "properties": {
    "bar": {
      "type": "string",
      "observable": true
    },
    "baz": {
      "tm:ref": "#/properties/bar",
      "observable": true
    }
  }
}
```



sdfChoice

SDF (*sdfChoice*)

```
{
  "sdfChoice": {
    "foo": {
      "const": 2
    },
    "bar": {
      "const": 5
    }
  }
}
```

WoT (*enum*) – *mapping is not ideal yet*

```
{
  "enum": [
    {
      "sdf:choiceName": "foo",
      "const": 2
    },
    {
      "sdf:choiceName": "bar",
      "const": 5
    }
  ]
}
```



CLI Interface


Table 3

Overview of the available parameters for the sub-commands of our CLI.

Parameter	Arguments	Sub-Commands	Default
<code>--input, -i*</code>	File path(s) or URL(s) ^a	all	—
<code>--output, -o</code>	File path	all	—
<code>--suppress-roundtripping</code>	—	all	False
<code>--indent</code>	Natural number	all	4
<code>--origin-url</code>	URL	sdf-to-tm, sdf-to-td	—
<code>--mapping-files</code>	Zero or more file paths	sdf-to-tm, sdf-to-td	—
<code>--title</code>	String	sdf-to-tm, sdf-to-td	—
<code>--version</code>	String	sdf-to-tm, sdf-to-td	—
<code>--copyright</code>	String	sdf-to-tm, sdf-to-td	—
<code>--license</code>	String	sdf-to-tm, sdf-to-td	—
<code>--meta-data</code>	File path or URL	tm-to-sdf, tm-to-td	—
<code>--bindings</code>	File path or URL	tm-to-sdf, tm-to-td	—
<code>--placeholder-map</code>	File path or URL	tm-to-sdf, tm-to-td	—
<code>--mapping-file-output</code>	File path	tm-to-sdf, td-to-sdf	—
<code>--remove-not-required-affordances</code>	—	tm-to-td	False

* Mandatory Parameter.

^a Can be multiple paths/URLs when converting from WoT TM/TD – the imported TMs/TDs are then treated as Collections.




SDF → WoT

Table 1

Overview of mappings of the most important SDF keywords to WoT.

SDF Keyword	WoT Class/Keyword
sdfThing	TM with tm:submodel links
sdfObject	TM without tm:submodel links
sdfProperty	PropertyAffordance
writable	readOnly (negated)
readable	writeOnly (negated)
sdfAction	ActionAffordance
sdfOutputData	output
sdfInputData	input
sdfEvent	EventAffordance
sdfOutputData	output
sdfData	schemaDefinitions (at the TM level)
sdfRef	tm:ref
sdfChoice	Enum of JSON objects with sdf:choiceName
sdfRequired	tm:optional (by including all non-required interaction affordance keys)
namespaces	@context
defaultNamespace	sdf:defaultNamespace
info	Multiple targets:
version	model field in Version class
title	sdf:title
copyright	sdf:copyright
license	If URL: link with relation-type license Else: sdf:license



WoT → SDF

Table 2

Overview of mappings of the most important WoT classes and keywords [1, section 5] to SDF.

WoT Class/Keyword	SDF Keyword
Thing	sdfThing (TM has tm:submodel links), sdfObject
title	label
description	description
schemaDefinitions	sdfData
@context	namespaces of the SDF model (with exceptions)
DataSchema	dataqualities
readOnly	Mapping file
writeOnly	Mapping file
InteractionAffordance ^a	—
title	label
description	description
PropertyAffordance	sdfProperty
readOnly	writable (negated)
writeOnly	readable (negated)
observable	observable
ActionAffordance	sdfAction
input	sdfInputData
output	sdfOutputData
EventAffordance	sdfEvent
tm:ref	sdfRef
tm:optional	sdfRequired (by including all non-optional interaction affordance keys)
Link	Mapping file, except for special link types (e.g., license, tm:extends, tm:submodel)

^a This is the base class of the three affordance types.