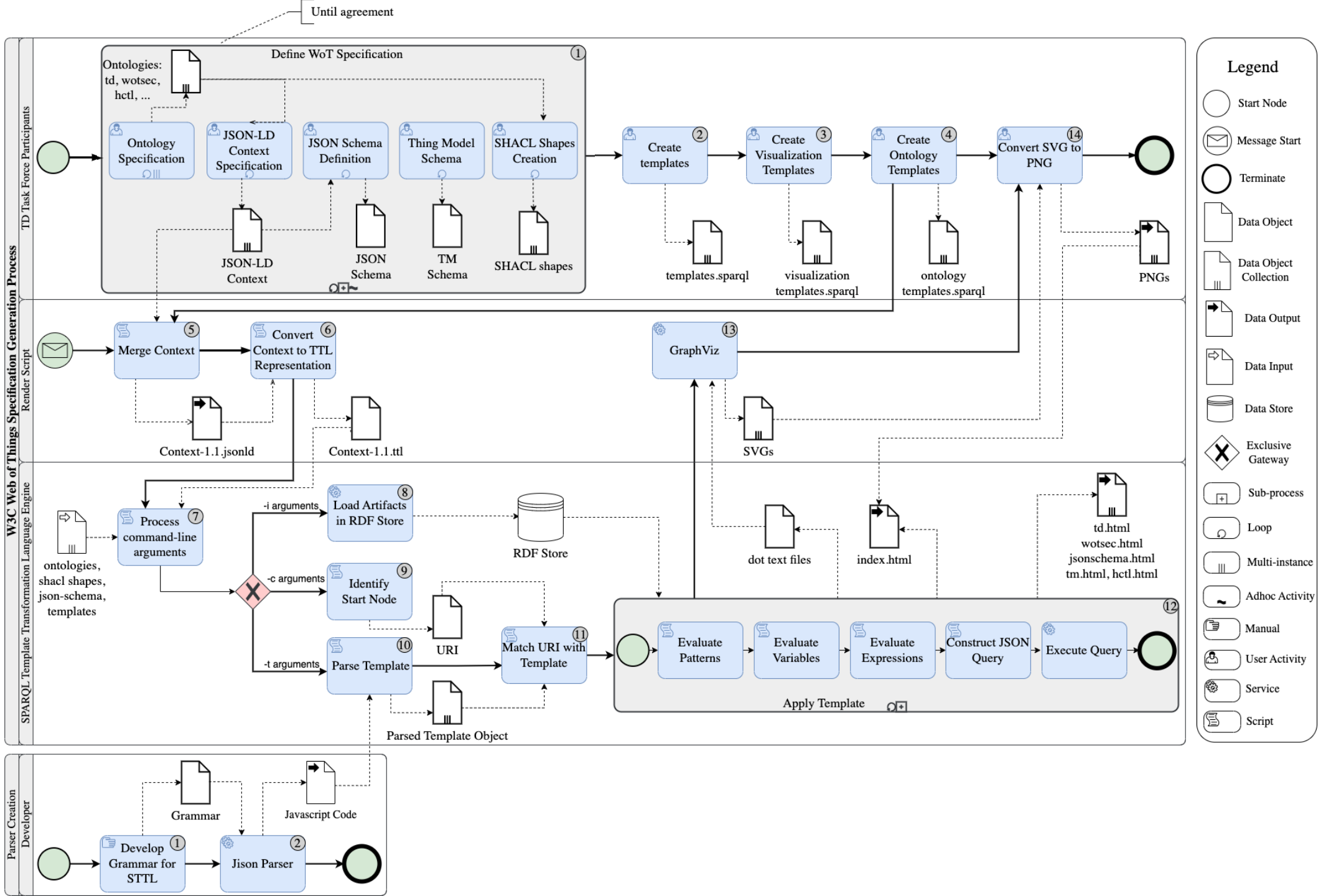
WoT Toolchain Update: LinkML Model as a Single-Source-of-Truth

Mahda Noura mahda.noura@siemens.com

TPAC 2025, November 13

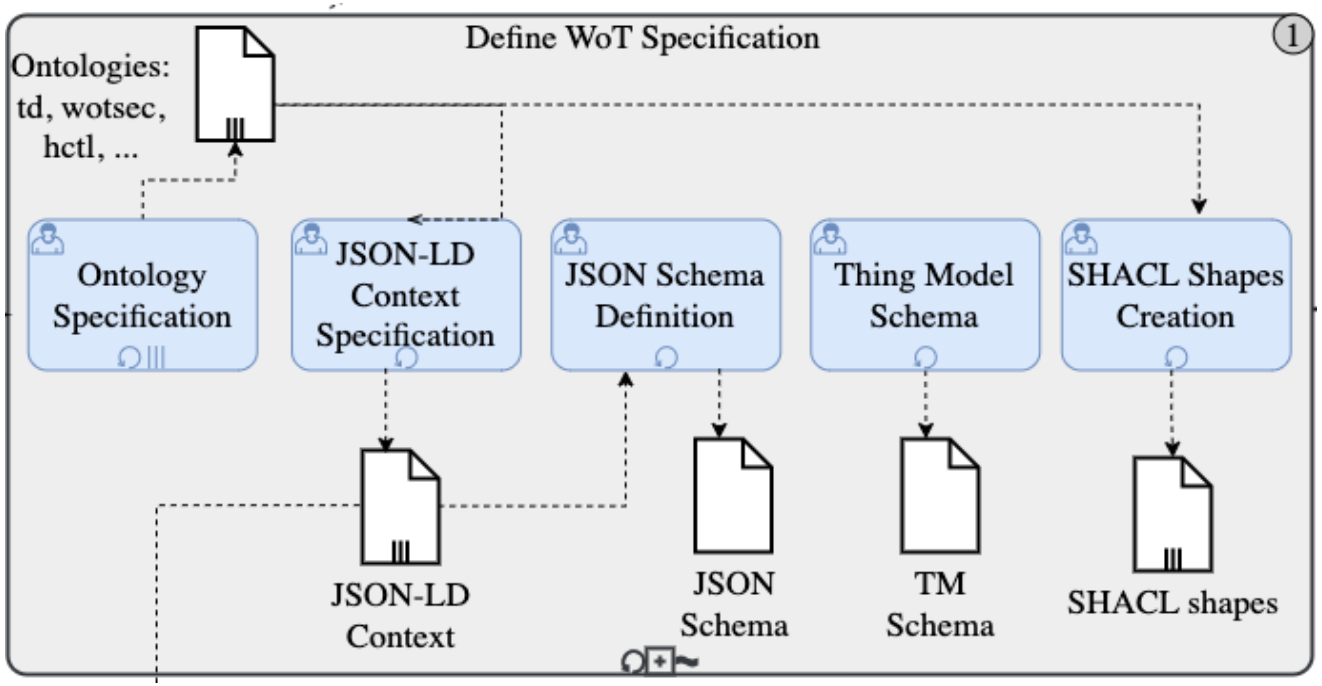
What we are currently doing!



Problem 1: Maintenance & Consistency

Every change to the WoT vocabulary requires simultaneous modification across all **four** artifacts

External Binding Developers are forced to acquire Semantic Web expertise to correctly author the artifacts



Example 1: Definition Inconsistency

SHACL

```
sh:property [
        sh:path td:hasForm ;
        skos:definition """Set of form hypermedia controls that
        describe how an operation can be performed. Forms are
        serializations of Protocol Bindings.
        <a>Thing level</a> forms are used to describe endpoints
        for a group of interaction affordances."""^^rdf:HTML ;
        sh:node :FormShape ;
        sh:order 14 ;
    ] ;
```

RDF (Turtle)

```
:hasForm rdf:type owl:ObjectProperty ;
    rdfs:label "hasForm" ;
    rdfs:comment "Set of form hypermedia controls that
    describe how an operation can be performed.
    Forms are serializations of Protocol Bindings.
    The array cannot be empty"@en ;
    schema:domainIncludes :InteractionAffordance, :Thing ;
    schema:rangeIncludes hctl:Form ;
    rdfs:isDefinedBy <https://www.w3.org/2019/wot/td> .
```

Example 2: Datatype Inconsistency

```
sh:property [
        sh:path td:title ;
        skos:definition """Provides a human-readable title (e.g., display
                a text for UI representation) based on a default
                language."""^^rdf:HTML ;
        sh:nodeKind sh:Literal ;
        sh:or ( [ sh:datatype xsd:string ] [ sh:datatype rdf:langString ] ) ;
        sh:minCount 1 ;
        sh:maxCount 1 ;
        sh:order 1 ;
    ] ;
```

`title`	Provides a human-readable title (e.g., display a text for UI representation) based on a default language.	mandatory	`string`

Problem 2: Tooling Complexity for Spec Developer

The final human-readable WoT specification document generator requires knowledge of STT query language

Not all WoT contributors are familiar with **STTL (Semantic Template Query Language)**, hard to maintain.

```
template :main {
    format {
        <file://./index.template.html>
        st:call-template(:classes, <https://www.w3.org/2019/wot/td#>)
        st:call-template(:classes, <https://www.w3.org/2019/wot/json-schema#>)
        st:call-template(:classes, <https://www.w3.org/2019/wot/security#>)
        st:call-template(:classes, <https://www.w3.org/2019/wot/hypermedia#>)
    }
} where {}

template :classes(?ns) {
    "<section>"

        format { "<h3><code>%s</code></h3>" st:call-template(:default-label, ?class) }

        if(?atRisk, "<p><span class=\"at-risk\">This section is at risk.</span></p>", "")

        format { "<p>%s</p>" ?def }

        format { "%s" st:call-template(:fields, ?class, ?ns) }

        format { "%s" st:call-template(:subclasses, ?class, ?ns) }

        format { "%s" st:call-template(:notes, ?class) }

    "</section>"
} where {
    ?shape a sh:NodeShape ;
           sh:targetClass ?class ;
           skos:definition ?def .
    filter(strstarts(str(?class), str(?ns)))
    optional { ?shape sh:order ?predefined }
    bind (if(bound(?predefined), ?predefined, "1000"^^xsd:integer) as ?rank)
    optional {
```

Example 3: XReferences

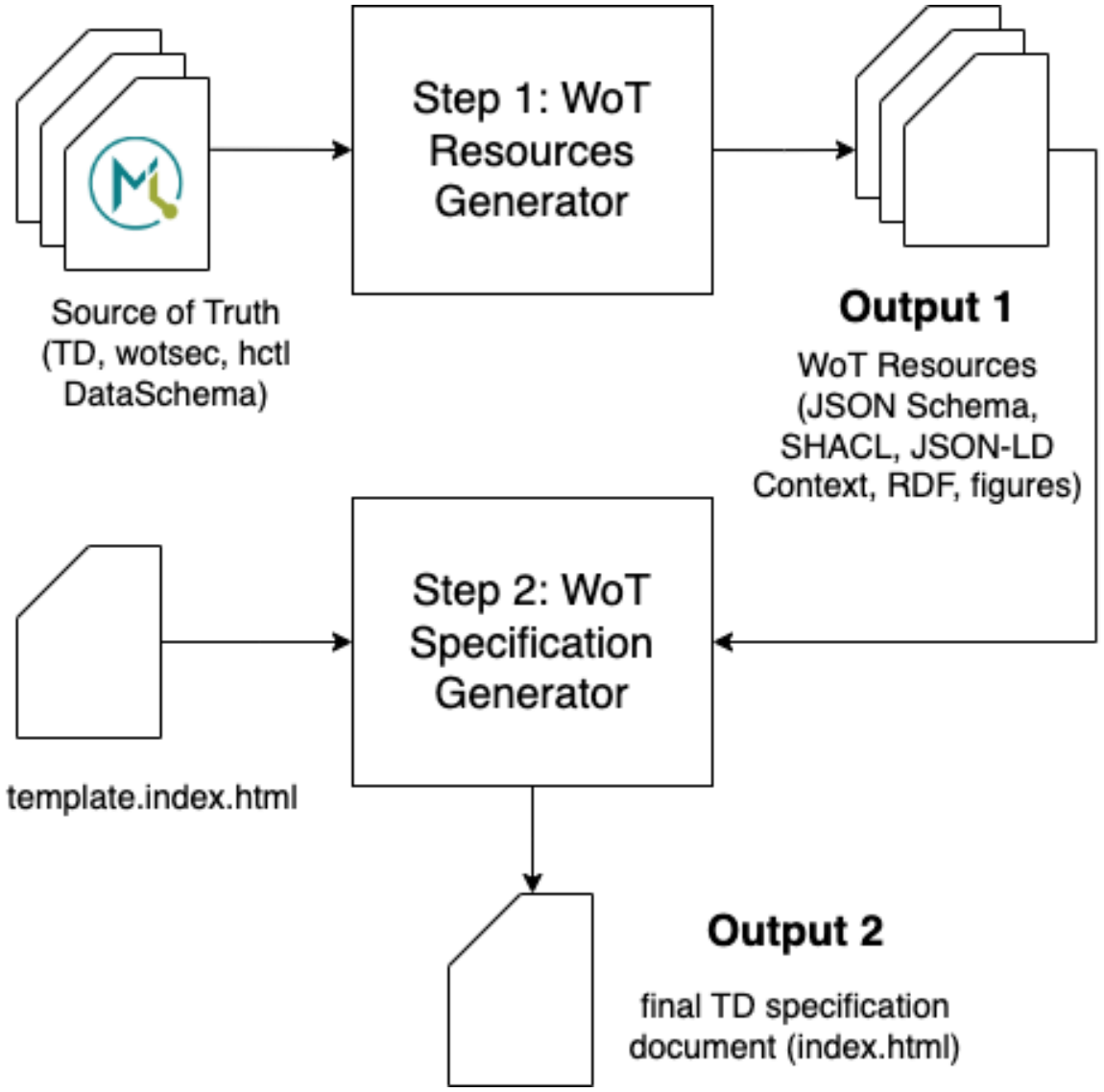
```
sh:property [
        sh:path td:baseURI ;
        skos:definition """Define the base URI that is used for all
                relative URI references throughout a TD document.
                In TD instances, all relative URIs are resolved
                relative to the base URI using the algorithm
                defined in [<cite><a class="bibref" data-link-type=
                "biblio" href='#bib-rfc3986' title=
                "Uniform Resource Identifier (URI):
                Generic Syntax">RFC3986</a></cite>].<br>
                <br>
                <code>base</code> does not affect the URIs used in
                <code>@context</code> and the IRIs used within
                Linked Data [<cite><a class="bibref"
                data-link-type="biblio" href='#bib-linked-data'
                title=
                "Linked Data Design Issues">LINKED-DATA</a></cite>]
                graphs that are relevant when semantic processing
                is applied to TD instances."""^^rdf:HTML ;
        sh:datatype xsd:anyURI ;
        sh:maxCount 1 ;
        sh:order 9 ;
    ] ;
```

Coupling RDF and HTML in SHACL shapes!

Solution

LinkML as a single-source-of-truth

For Spec generation requires only our template.index.html



Please Tryout the Tool - WoTIS

- https://github.com/w3c/wot-thing-description-toolchain-tmp

```
wotis generate-wot-resources [-i] [-d] [-s] [--help]

options:
  -i, --input_schema        Path to the input schema specified as LinkML yaml.
                            [default: resources/schemas/thing_description.yaml]

  -d, --generate_docs       Boolean for the final TD documentation generation.
                            [default: False]
  --help                    Show this help message and exit.
```

What do we still need from LinkML

- **Ongoing:** Natively support modeling RDF multi-language strings
- **Ongoing:** Require open mappings for Class attributes
- **Ongoing:** Support for JSON-LD arrays and containers
- Scoped JSON-LD contexts
- Improved representations of *URI*, *CURIE* and *URIORCURIE* types beyond the string type
- Schema name collision resolution - currently multiple schemas that have the same name are merged, even though they refer to different elements
- Implement RDF converters
- Contribution support on LinkML code architecture to lower the barrier