Community Contribution Series

OSCAL-Pydantic: A python library for OSCAL

Credentive Security

Background

Oscal-Pydantic

https://github.com/RS-Credentive/oscal-pydantic/

- An API for creating and manipulating OSCAL data models in Python
- Provides high-fidelity schemas of all OSCAL data elements
- Strives to be the reference implementation of OSCAL in Python

pip install oscal-pydantic

Building blocks

- Python (https://python.org)
  - Popular scripting/programming language
    - #2 behind Javascript on Github
  - Applications include
    - Web programming (server side)
    - Scientific Computing (Big Data/AI)
  - Strict, Dynamically typed language
- Pydantic (https://docs.pydantic.dev/latest/)
  - Most widely used data validation library for Python
  - Leverages type hints to provide strict, static typing
  - Supports serialization to/from JSON

OSCAL Schema

https://pages.nist.gov/OSCAL-Reference/models/

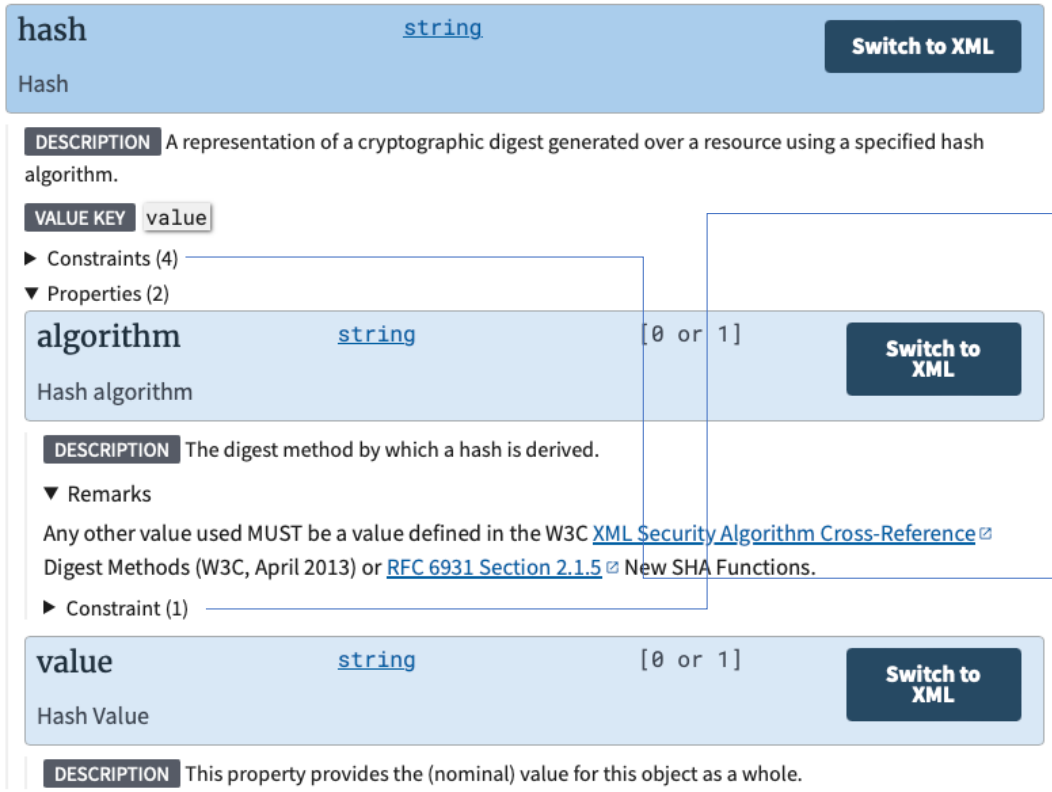
- Built on top of NIST Metaschema
  - https://pages.nist.gov/metaschema/
  - a common, format-agnostic modeling framework supporting schema, code, and documentation generation

Oscal-Pydantic v1

OSCAL-Pydantic v1

- Inspired by Compliance Trestle
  - https://github.com/IBM/compliance-trestle
- Dynamically generated from JSON Schema
  - OSCAL JSON Schema → Datamodel-code-generator → Pydantic Models
  - Hand tweaked to eliminate some issues with JSON Schema translation
    - JSON “format” vs Regex
    - Unicode Regex – e.g. “(\p{L}|_)(\p{L}|\p{N}|[.\-_])*”
- Outcome
  - Lightweight library to support generation and validation of OSCAL Data and import JSON objects

Example OSCAL data element



The value **may be locally defined**, or one of the following:

- **SHA-224**: The SHA-224 algorithm as defined by NIST FIPS 180-4.
- **SHA-256**: The SHA-256 algorithm as defined by NIST FIPS 180-4.
- **SHA-384**: The SHA-384 algorithm as defined by NIST FIPS 180-4.
- **SHA-512**: The SHA-512 algorithm as defined by NIST FIPS 180-4.
- **SHA3-224**: The SHA3-224 algorithm as defined by NIST FIPS 202.
- **SHA3-256**: The SHA3-256 algorithm as defined by NIST FIPS 202.
- **SHA3-384**: The SHA3-384 algorithm as defined by NIST FIPS 202.
- **SHA3-512**: The SHA3-512 algorithm as defined by NIST FIPS 202.

▼ Constraints (4)

MATCHES for `.[@algorithm=('SHA-224','SHA3-224')]`: a target (value) must match the regular expression '^[0-9a-fA-F]{28}$'.

MATCHES for `.[@algorithm=('SHA-256','SHA3-256')]`: a target (value) must match the regular expression '^[0-9a-fA-F]{32}$'.

MATCHES for `.[@algorithm=('SHA-384','SHA3-384')]`: a target (value) must match the regular expression '^[0-9a-fA-F]{48}$'.

MATCHES for `.[@algorithm=('SHA-512','SHA3-512')]`: a target (value) must match the regular expression '^[0-9a-fA-F]{64}$'.

OSCAL-Pydantic v1 Example

```
class Hash(BaseModel):
    class Config:
        extra = Extra.forbid

    algorithm: Annotated[
        str,
        Field(
            description="Method by which a hash is derived",
            regex="^\\S(.*\\S)?$",
            title="Hash algorithm",
        ),
    ]
    value: str
```

Issue: Machine code is not for humans

- Autogenerated schemas are tough to read and use
  - Lots of Root Models
  - A lot of repetition
- Difficult to extend/customize

Issue: Inherited JSON Schema limitations

- Constraints are limited to attribute values (regex) or “formats”
- No way to define relationships between attributes
  - IF “algorithm” == “SHA-224”
    - THEN ”value” must be a 28 character string
    - AND only comprised of the characters 0-9, a-f, or A-F

Oscal-Pydantic v2

Back to the drawing board

Oscal-Pydantic v2 Approach

- Leverage Pydantic v2
  - 4x – 50x faster than Pydantic v1 (~17x in general)
- Hand produced
  - Less Repetition
  - Designed for humans to extend and customize
  - Closer alignment with underlying metaschema
  - (In Progress) Support for all validation rules

OSCAL-Pydantic v2 Example

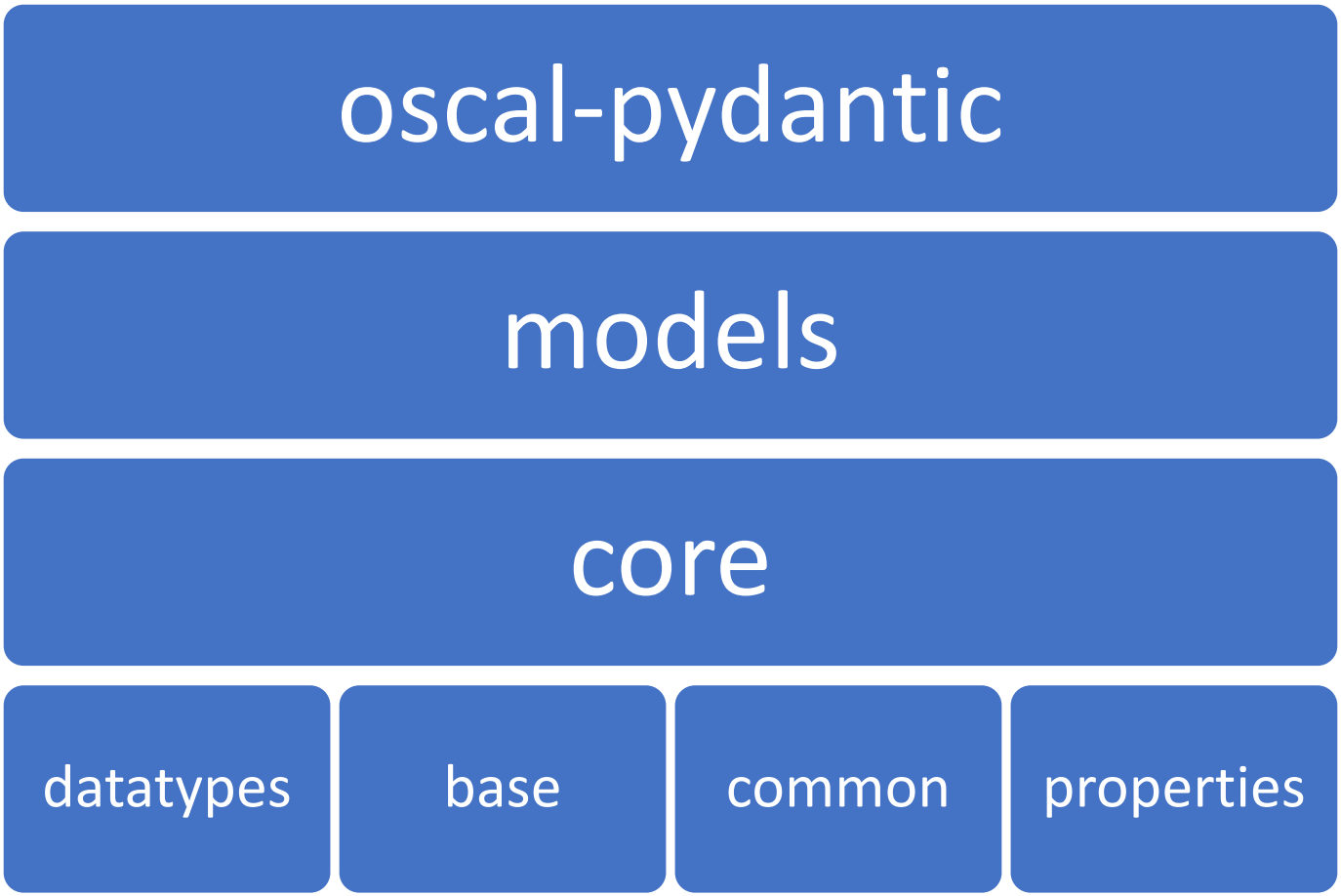
```python
OscalString = Annotated[str, constr(pattern=r"\s.\S+")]

class Hash(base.OscalModel):
    algorithm: datatypes.OscalString | None = Field(
        description="""
        Method by which a hash is derived <…>

        """,
        default=None,
        pattern="^SHA3?-(224|256|384|512)$",
    )
    value: datatypes.OscalString | None = Field(
        description="""
        The value of the hash
        """,
        default=None,
    )
```

OSCAL-Pydantic v2 Example

```python
@model_validator(mode="after")
def validate_hash_for_algorithm(self):
    if self.algorithm is not None and self.value is None:
        raise ValueError("Hash Algorithm specified without Value")
    elif self.algorithm == "SHA-224" or self.algorithm == "SHA3-224":
        if len(self.value) == 28 and self.value_is_hex():
            return self
        else:
            raise ValueError("Hash value length or contents do not match algorithm")
    elif self.algorithm == "SHA-256" or self.algorithm == "SHA3-256":
        <…>
    elif self.algorithm == "SHA-384" or self.algorithm == "SHA3-384":
        <…>
    elif self.algorithm == "SHA-512" or self.algorithm == "SHA3-512":
        <…>
    else:
        return self
```

```python
def value_is_hex(self) -> bool:
    # Quick trick to check if a string is only HEX
    # try to convert it to an int.
    # If it doesn't work, there's a bad character in there.
    try:
        int(self.value, 16)
        return True
    except ValueError:
        return False
```

A tour of OSCAL-Pydantic v2


oscal-pydantic
models
core
datatypes
base
common
properties

Oscal-Pydantic core modules

- oscal_pydantic.core.datatypes
  - core Metaschema datatypes
- oscal_pydantic.core.base.OscalModel
  - Subclass of pydantic.BaseModel
  - Common Field Alias Generator
    - Json attributes (“-”) to snake_case (“_”)
    - Can’t use “class” as a field (reserved word)
  - Override “model_dump_json” method
    - Exclude null, always use alias, pretty print
  - Maybe common content validator code?

Oscal-Pydantic core modules

- oscal-pydantic.core.common
  - Common OSCAL elements that appear in many parts of models
- oscal-pydantic.core.properties
  - Implements documented OSCAL properties
  - Implements full set of constraints
  - User Extensible
  - UNDER CONSTRUCTION

Oscal-Pydantic modules

- oscal_pydantic.catalog <- Now
- oscal_pydantic.system_security_plan
- oscal_pydantic.profile
- oscal_pydantic.component_definition
- oscal_pydantic.assessment_plan
- oscal_pydantic.assessment_results
- oscal_pydantic.plan_of_action_and_milestones

OSCAL Pydantic in Action

Help Wanted

Next Steps

- Fix Properties
- Finish Catalog
- Develop elements for Test Cases

Help Wanted: Properties

- Properties are very special parts of the OSCAL specification
  - Complex validation rules
  - Numerous different types of properties
  - Designed to be extensible
- OSCAL Pydantic must also provide full validation for all the various properties, and must support extension
- Currently working to identify the best way to enforce validation rules in an easily extensible way.

Help Wanted: Test Cases

- Integration testing is critical to maintaining a high-quality implementation
- Testing requires a library of valid and invalid artifacts
- Needed for every project implementing OSCAL regardless of language or domain.
- Suggestion: Should test cases be a separate project maintained on behalf of the community?