SBOM Translation Project

Adolfo García Veytia <puerco@chianguard.dev>
Proposed 2023-05-16 **-** ***(DRAFT)***

TO: *DHS SBOM Cohort*

Overview

This proposal delineates a project to create a conversion model and companion libraries and tools to convert SBOMs between SPDX, CyloneDX, potentially other formats too. The model attempts to improve on the current handling of SBOM documents, which is mostly JSON manipulation. Instead, this approach focuses on "semantics" field so that conversion can move and transform data, maintain the semantics, and, if possible, avoid data loss.

The project encompasses four main components, dividing the work requirements into design, programming, and documentation.

1. A universal, format-neutral protocol buffers data structure that allows capturing the data from any SBOM format losslessly.
2. A set of read and write Go libraries:
    a. Reader libraries that can read any SBOM and serialize them into the protobuf structure
    b. Writer libraries that can render a standard format bill of materials from the protobuf structure
3. A golang cli tool that converts documents from one format to another leveraging those libraries.
4. Finally, a well-documented degradation strategy to understand how data loss happens when going from the neutral representation to each of the supported formats.

The advantages of this architecture are detailed in the sections below.

Background

Translating between software bill of materials formats results in data loss. There is no way around it. And there is a lot more at stake than just shuffling around data bits from one field to another; SBOM format translation is really about trying to conserve the semantic meaning of elements described in an SBOM as much as possible.

This project describes a conversion scheme that attempts to create a canonical way of converting documents. For the past months, some engineers from SPDX and CycloneDX have worked together privately, trying to achieve the best possible compromises to convert between both formats. This resulted in some of the changes in SPDX 2.3. While this effort is laudable, the reality in the field is that producers and consumers will face a more complex scenario, necessitating a more comprehensive approach than improvements to formats. Old formats are there. Tools are already using them. No one is going back to improve already existing SBOMs.

SBOM handling up until now has been based on shallow JSON parsing to ingest opinionated and often wrongly formatted documents. Most first-generation SBOM tools treat SBOMs as the resulting data structure of unmarshalling a JSON file. It is not uncommon to see “consumption tools” reducing SBOM data to a flat list of dependencies. In a world lacking more advanced parsers and SBOMs of poor quality, it is not hard to blame them. When discussing next-generation tools in this document we mean applications dealing with SBOM problems and tasks that require this smarter ingestion of documents.

FIXME SBOM processing limited to shallow JSON parsing is insufficient.

Goals

- A library that abstracts any standard SBOM into a format-neutral data representation containing packages and files related to each other.
- The library must have the ability to ingest data from SPDX and CycloneDX in any reasonably recent and future versions.
- Zero data loss from SBOM to the internal representation.
- Ability to export SBOM data to current SPDX and CycloneDX versions
- Tolerance for SBOM validity errors. The library should be able to ingest SBOMs that are not 100% conformant to their specifications while being able to understand (and remediate those errors).
- Planned degradation when rendering to each format/version pairt when lacking enough resolution to capture data.
- As a foundational piece, it will be strongly conformance tested to ensure a consistent behavior facing an SBOM landscape that is highly inconsistent.

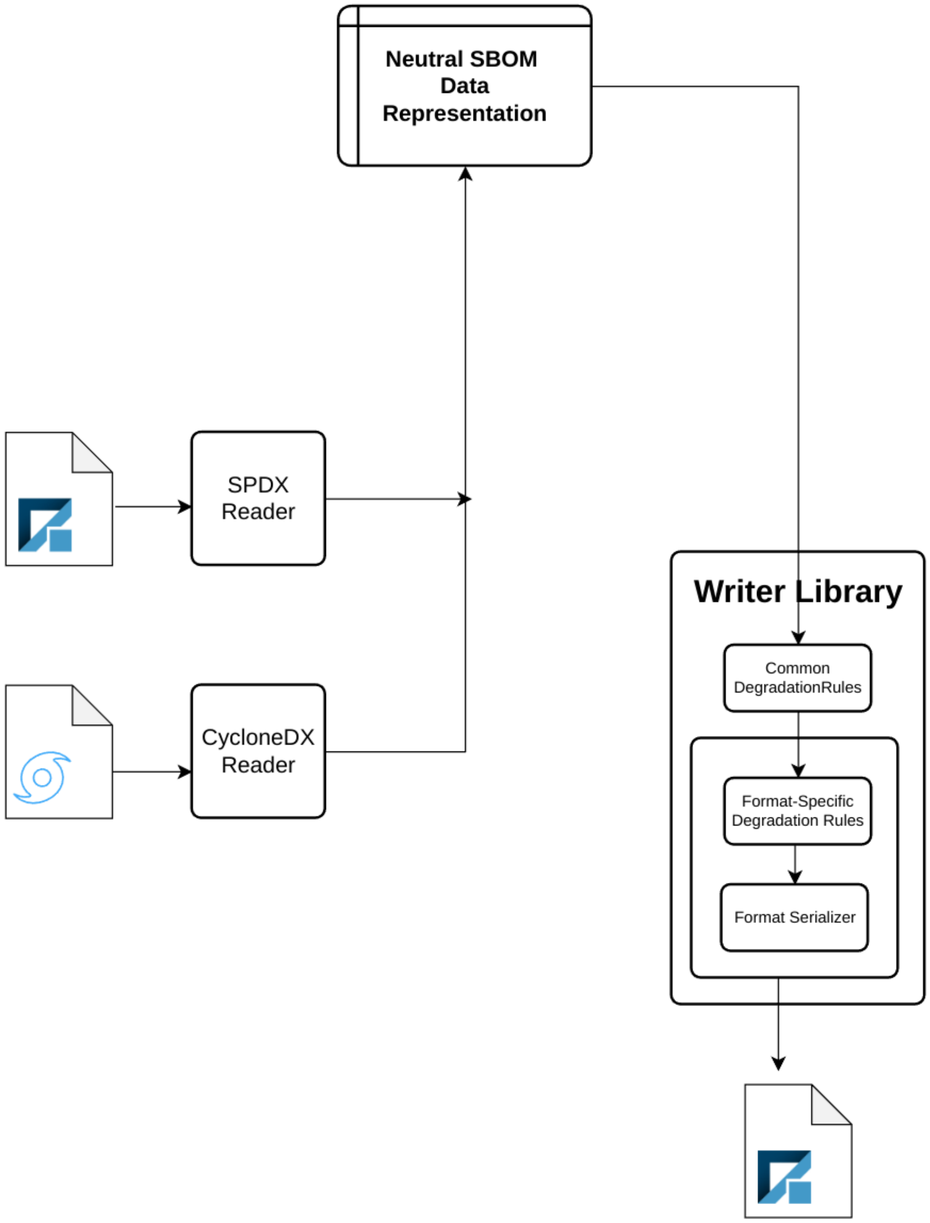
- Extensible enough to accommodate future SBOM formats
- Minimal implementation with the least number of dependencies possible to limit the impact on projects when importing it.

Non-Goals

- **Most Important Non-Goal: A new SBOM format!**
- Support for each format's non-SBOM features (ie vulnerability data, provenance, VEX, etc)
- SBOM generation
- SBOM composition
- Any feature beyond ingestion, internal representation. and export. While this library is intended to be a foundational piece of a wider ecosystem, the project itself needs to be scoped to be just a library to make SBOM handling easy.
- Creating clever hacks to avoid data loss, examples include cramming data into comments, annotations, etc.

Detailed Design

Conversion Schema



Effectively, SBOM conversion will be a three-step process:

1. Ingesting the documents through format-specific reader libraries into the neutral representation.
2. Applying a set of degradation rules, both common to all formats and specific to the target serialization format.
3. Passing the data through a format-specific serializer library.

Serializing To Protocol Buffers

Protocol buffers (or *protobuf* for short) provide a mechanism to serialize structured data into a language-neutral format. It is designed to play well with most languages and enable efficient transmission. Protobuf lets software developers define a data structure once and reuse it in other implementations. The project provides library generators for some of the most popular languages including C++, C#, Go, Java, and Python while 3rd party implementations are available for others.

An example protobuf structure:

JavaScript

```
message Package {
 string id = 1;
 string name = 2;
 string license = 3;
 string purl = 4;
}
```

The protocol buffers structure can then be used to generate native code, for example in Go:

C/C++

```
type Package struct {
  ID      string
  Name    string
  License string
  Purl    string
}
```

The centralized nature of the protobuf neutral representation gives the project a better chance to be more widely adopted. Combined with the written degradation strategy and strong conformance tests, implementing either writers or readers in other languages should prove to be straightforward.

The neutral representation should not be a new SBOM format but rather a data structure that captures all data from existing formats. The project is not aiming for expressivity or optimizing for lean documents but rather designing a structure detailed enough to capture all fields in the current standards that is also capable of maintaining the SBOM structure.

A Software Bill of Materials Format-Agnostic Data Structure

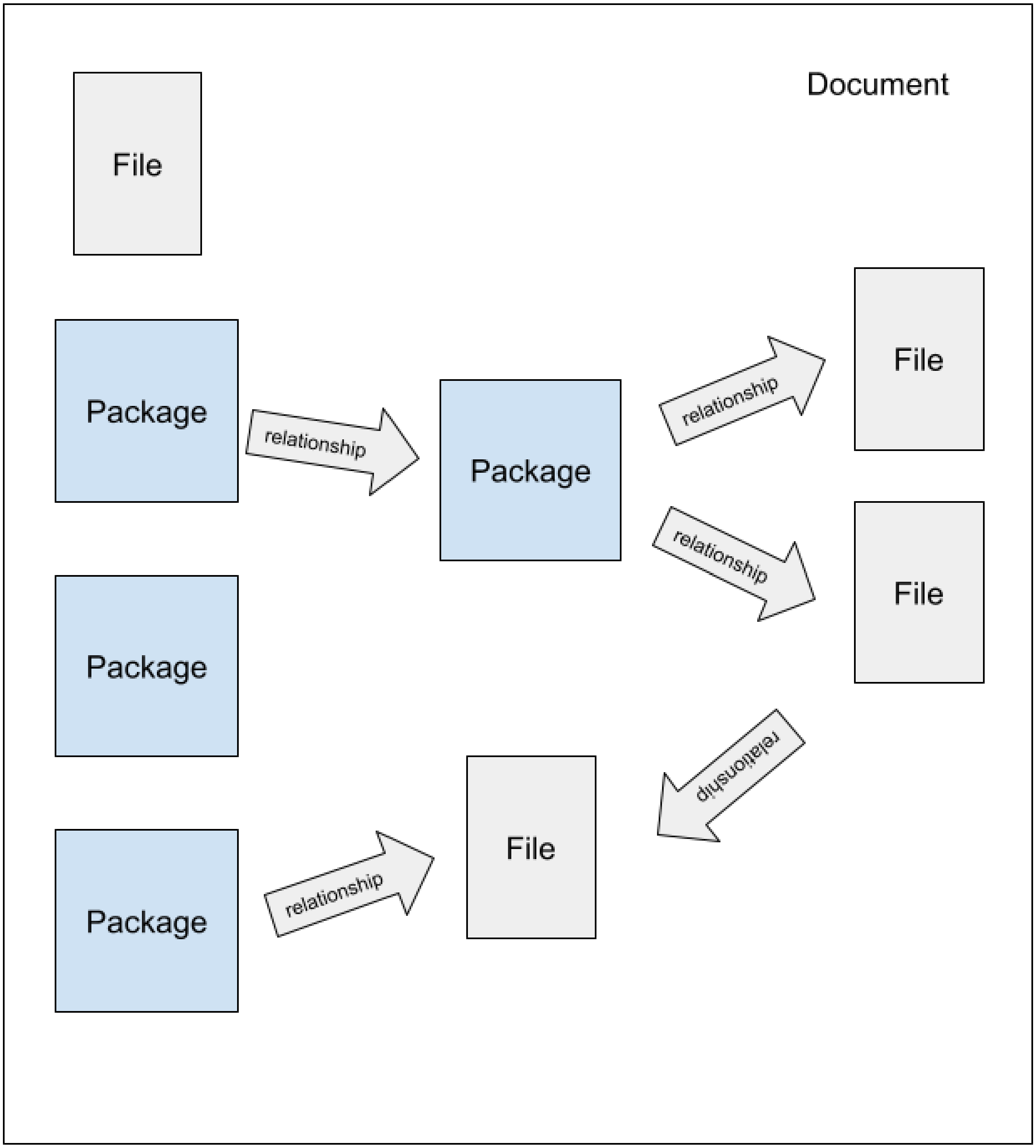
The SBOM Graph

Both major SBOM formats, CycloneDX and SPDX, model their data in a directed graph. SPDX was modeled as a graph from the start (as it was based on RDF) while CycloneDX had a components tree and added relationships to its nodes to be able to describe a dependency tree.

In essence, the SBOM graph groups together *entry* or *top-level* nodes which are ideally related to other elements to model the structure of a piece of software. Those nodes include the structural pieces of the software piece (binaries, library files, layers of a container image, etc) and its components. The notion of “component” in this section of the design document can extend from internal pieces of the software piece itself, all the way to build environment tools, tests, and anything the SBOM author and receiver deem relevant to express as part of the SBOM description.

Nodes in the SBOM graph can be finalized as either packages or files which are the most finely-grained elements common to both SBOM formats[1]. The following graph pictures a simple example of a graph and the relationships between its nodes.

[1] SPDX has also snippets, which are smaller than packages or files. These, however, are not in scope for the project and are rarely used.



A simplified SBOM graph

The Nodes

The SBOM graph is composed of nodes related to each other. Nodes can be either packages or files but any successful handling of SBOM data necessarily means traversing the graph regardless of kind. The model should handle all SBOM elements as abstract nodes while keeping awareness of their kind.

The data model used to capture each kind of node is extensible and can load and record any number of properties. The project intends to keep the internal representation model extensible, independent of the limitation of each format.

Relationships Between Nodes

While SPDX has a rich relationship system, CycloneDX does not. Nevertheless, CycloneDX's dependency tree is also formed by related nodes. The data model models the CDX tree using two relationship types (one for the dependency graph, and one for the components tree). No attempt is made to endow meaning to relationships between nodes in the CDX documents beyond those inferred from their position in the components tree or the dependency graph. This is true even if the SBOM contains data about the role one or more nodes have in the described software. For example, even if we infer a set of files or packages to be a test, the ingestion process will not attempt to relate them using a `TEST_OF` SPDX relationship[2] when adding them to the neutral structure. SPDX3 expands on the relationship model[3] and relationships can be subclassed and carry additional data, another fact the data representation needs to account for.

Data Export and Data Loss

While the neutral data model is designed to capture all data in the graph nodes, data loss can and will happen when rendering SBOMs to each of the formats. While it is inevitable to lose data, the project will have a predictable, documented degradation strategy that users can rely on and expect. This document does not capture the strategy yet as it will be documented as support to output to each format and version progresses.

Some degradation rules will apply globally (see the Relationships example above), while others will apply only when addressing the limitations of a particular format+version.

In no case will the ingestion process attempt to cram data into SBOMs when there is no appropriate field for it. This means the library will never use hacks such as using annotations or comments to perpetuate data. Also, no custom extensions will be used even when formats may support them.

[2] See the relationships chapter on the SPDX specification for more on the kinds of relationships available.
[3] See the current SPDX3 model relationship proposal:
https://github.com/spdx/spdx-3-model/blob/main/model/Core/Classes/Relationship.md

Drawbacks

Loss of Expanded Format Capabilities

Working with the converter library will make it easier for developers to consume and work with SBOMs. However, the library will not account for each format's features beyond those related to the Software Bill of Materials realm. If the project becomes successful, it could hinder the adoption of those features in the formats. We feel that the improvements the project offers to the overall SBOM landscape are worth it, especially since there are alternatives for the other features of the documents (like OpenVEX, SLSA, and even CSAF for advisories).

Core Open Questions

As the design progresses some bigger open questions start to emerge which need to be addressed before the final design is in place.

- How to handle CycloneDX's limitation of one top-level component[4] per SBOM
- Do we handle multiple (previous) formats of CDX/SPDX, or default to the latest
- How to handle relationship types that may not have a clear equivalency. The two obvious examples that come to mind are:
  - CycloneDX losing all relationship data when converting from SPDX
  - SPDX3 has directional relationships but the SPDX2 inverted relationships are no longer supported. This means that the graph needs to be modified (I've opened an issue here to try to keep them for compatibility).
- Licenses. Both of the major formats (CDX and SPDX) express licensing data using SPDX identifiers. Should we try to pursue further validation of the license tags? The alternative would be to treat them as strings and shuffle them around as the come in.
- Known unknowns: NOASSERTION in SPDX is not the same as null. How do we handle these known unknowns between formats?

Appendix A: Data Structure Proposals

Proposal 1: Wide-breadth structure to capture all SBOM fields.

[4] See https://cyclonedx.org/docs/1.4/json/#metadata_component

Repository: https://github.com/puerco/protobom/tree/full
(Note that this lives in the `full` branch)

The first proposal includes a graph structure with a single node type that can capture both packages and files in the SBOM. The node data structure has enough fields to capture all data losslessly. Nodes representing files and packages are differentiated with a Type field.

I've committed to the repo both the proto and the generated go library.

Regarding completion, the node data should be able to capture all information in SPDX 3, 2.x and CycloneDX 1.4. The document metadata is mostly complete but needs a check to ensure that it is capturing all required fields. There are specialized structs to record tools and persons. The graph edge which captures the relationships between nodes needs to be expanded to capture the SPDX3 semantics, but for now, it can work to complete the graph model