cogs

Configuration Object Generation System

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Some requirements for a configuration system

Configuration information:

- must be **valid**
  - well defined structure
  - constraints on values
  - valid-by-construction patterns
  - centralized validation methods
- is needed in **multiple contexts**
  - contract between producers and consumers
  - authoring, displaying, storing, serializing, native code types
- must support **varied and changing forms**
  - many types of applications and services
  - some common “base” for implementing “roles”
  - application- and instance-specific variety
  - evolution of structure and values over time

Caveat ✿cogs✿-itate

- The initial development of ✿cogs✿ focuses on harder core problems and is not yet intended for “user/developers”.
- Much still remains to be designed, implemented, integrated, etc.

The ✿cogs✿ approach

schema

Define formal **schema** to describe structure and constraints.

codegen

Generate code to validate, produce, transport and consume configuration.

correctness

Enable the pattern "single source of truth" (SSOT).

automate

Minimize human effort and the chaos it brings.

✿cogs✿ definition of schema

a **schema** is a **data structure**
which may be **interpreted**
as **describing** the **structure of data**
(*including that of schema!*)

Categories of schema interpretation

- `translate(schema)` $\rightarrow$ `schema`
- `codegen(schema, template)` $\rightarrow$ `code`
- `validate(schema, data)` $\rightarrow$ *true* | *false*

These functions are largely provided to ✿cogs✿ by the moo tool.

Defining schema

✿cogs✿ supports authoring schema with functions of an **abstract base schema** in the Jsonnet data templating language[1].

```
function(schema) {
   types: [schema.string(pattern="^[a-zA-Z][a-zA-Z0-9_]*$")],
}
```

- When called, function defines an *application-level* schema consisting of a single **string type** taking a **valid value** that must match the given pattern.
- The `schema` object holds functions that return schema from a particular **schema domain** (eg, Avro, JSON Schema)
- App-level schema defined abstractly in terms these function calls.

[1] ✿cogs✿ (via moo) also supports defining schema in other languages (JSON, YAML, INI, XML or languages that generate these) but these lack support for the abstract base schema.

Larger Schema Example

Describe the configuration for a “node” with “ports” and “components” from the ✿cogs✿ demo.

```
function(schema) {
  // ... other locals ...

  local node = schema.record("Node", fields=[
      schema.field("ident", ident,
              doc="Identify the node instance"),
      schema.field("portdefs", schema.sequence("Port"),
              doc="Define ports used by components"),
      schema.field("compdefs", schema.sequence("Comp"),
              doc="Describe components needing ports"),
  ], doc="A node configures ports and components"),

  types: [ ltype, link, port, comp, node ],
}
```

Abstract base schema

```
function(schema) {
   types: [schema.string(pattern="^[a-zA-Z][a-zA-Z0-9_]*$")],
}
```

`schema` object is like OO "abstract base class" instance.
✿cogs✿ demo includes these concrete **domain schema**:

- `avro-schema.jsonnet` for codegen with Avro CPP or just `moo` and for using serialization provided by `nlohmann::json`.
- `json-schema.jsonnet` for object validation via JSON Schema and `moo`.

Expected future work:

- New domains: Protobuf / Cap'N Proto, depending on RPC choices.
- Jsonnet functions for valid-by-construction configuration authoring.
- A totally different, simpler abstraction pattern (see backup slides).

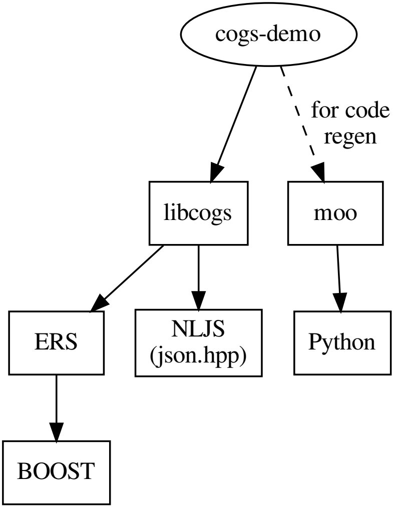
moo

…provides a Python3 CLI and module for processing of schema defined in Jsonnet, JSON, XML, YAML, INI, etc, validation of objects in the same languages and template-based file generation using Jinja.

```
$ moo --help
Usage: moo [OPTIONS] COMMAND [ARGS]...

  moo command line interface

Options:
  --help  Show this message and exit.

Commands:
  compile      Compile a model to JSON
  imports      Emit a list of imports required by the model
  many         Render many files
  render       Render a template against a model.
  render-many  Render many files for a project.
  validate     Validate a model against a schema
```

moo essentially replaces a large set of other tools (`jsonnet`, `jq`, `j2`, `grep`, `awk`, etc) and the shell glue to connect them.

✿cogs✿ package dependency graph



✿cogs✿ package features

configuration stream
: methods for **deserialization** of configuration objects from multiple sources and formats.

configurable base
: an abstract base mixin class for user code to receive **dynamically or statically typed** configuration objects.

tech opinions
: ERS for exceptions, `nlohmann::json` for dynamic typed intermediate data representation.

non-trival demo
: `moo` generated C++ config `struct` types and serialization, component-based mocked framework and main application (link to doc).

✿cogs✿ configuration stream

A configuration is delivered as an ordered sequence (stream) of objects.

```
std::string uri = "....";
stream_p s = cogs::make_stream(uri);
cogs::object o = s->pop();
```

- The `make_stream()` factory returns steam based on parsing URI.
  - Stream will draw configuration bytes from resource at URI.
- The returned `unique_ptr<cogs::Stream>` is abstract.
- `cogs::object` is a `typedef` for `nlohmann::json` and provides a dynamic typed intermediate data representation layer.
- Exceptions defined by ERS may be thrown if stream is corrupt or an attempt is made to `pop()` past its end.

✿cogs✿ stream types

URIs with built-in support:

`file://config.json` a JSON array of configuration objects

`file://config.jstream` a JSON Stream of configuration objects

Potential future stream types URIs:

- Files via `https://` addressing.
- RPC server address (eg, hardwired host/port)
- ZeroMQ/ZIO port spec (eg, direct or auto-discovered address)
- Factory improvements for streams from shared lib / plugins.

✿cogs✿ delivery of configuration to consumer

A consumer may receive its configuration object by inheriting from a **virtual mixin** class and implementing the method:

A **dynamic typed** interface

The user code must interpret a **dynamic object**.

```
struct ConfigurableBase {
    virtual void configure(cogs::object obj) = 0;
};
```

A **static typed** interface

The user code receives C++ `struct`.

```
template<class CfgObj>
struct Configurable : virtual public ConfigurableBase {
    virtual void configure(CfgObj&& cfgobj) = 0;
};
```

In the ✿cogs✿ demo, the `struct` is generated from **schema** via `moo`.

✿cogs✿ demo stream

The ✿cogs✿ demo stream assumes a pair-wise ordering:

component 1: `democfg::ConfigHeader`
component 1: corresponding config object
...
component N: `democfg::ConfigHeader`
component N: corresponding config object

Each pair:

- header identifies a component **implementation** and **instance** name
- payload provides config object for the identified component

This *stream-level* contract is governed by schema in the ✿cogs✿ demo. In general, it is up to the application to define.

Demo stream model and schema

Building model with helper functions (not shown)

```
model: [
    head("demoSource", "mycomp_source1"),
    source(42),

    head("demoNode", "mynode_inst1"),
    node("mynode1",
         ports=[portdef("src",[
             link("bind","tcp://127.0.0.1:5678")])],
      comps=[compdef("mycomp_source1", "demoSource", ["src"])]
],
schema: [
    schema.head,
    schema.comp,
    schema.head,
    schema.node,
],
```

Details on `schema` array next.

Demo stream schema (more)

JSON Schema requires types to be defined in a special location in the structure. The `compound()` function helps prepare that.

```
local jscm = import "json-schema.jsonnet";
local compound(types, top=null) = {
    ret : {
        definitions: {[t._name]:t for t in types}
    } + if std.type(top) == "null"
    then types[std.length(types)-1]
    else top,
}.ret;

local schema = {
    head: compound(head_schema(jscm).types),
    comp: compound(comp_schema(jscm).types),
    node: compound(node_schema(jscm).types),
};
```

tl;dr: understand *stream-level* schema then factor this complexity away from user view.

Perform validation

The moo tool can dig data structure it is given a schema and model and perform validation on a single object (default) or on an array.

```
$ moo validate --sequence \
  -S schema -s demo/demo-config.jsonnet \
  -D model demo/demo-config.jsonnet
```

Currently returns `null` for success or a traceback into the model and schema data structures showing where validation failed.

Some work still needed for DUNE FD DAQ

- Redesign the *abstract schema pattern* from using functions to using to meta-schema objects (details in backups)
- Move general parts from demo to moo.
- Integration with DUNE FD DAQ appfmk may include:
  - a "stream manager" hooking into appfmk factory
- A choice of RPC for larger CCM may influence replacement of moo generated config structs and serialization (eg with Protobuf, Cap'N Proto, etc).
- Understand if ✿cogs✿ and moo approach can help with connecting CCM RPC to appfmk.
- Understand larger configuration issues (authoring, version control, schema evolution, wholesale validation).

$\mathcal{FIN}$