Tutorial: Serialization

Antony Della Vecchia

Technische Universität Berlin

`polymake` Workshop
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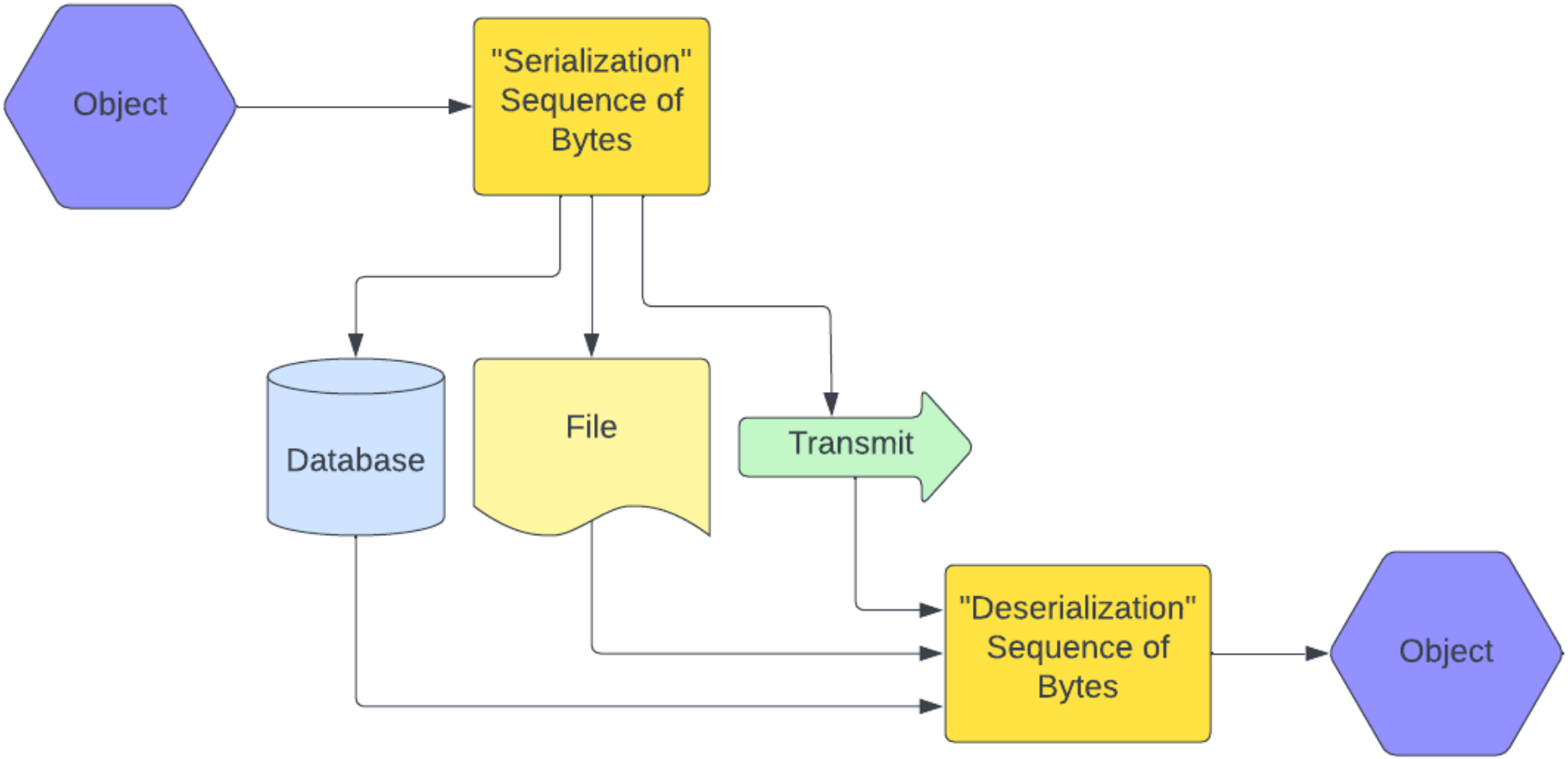
Overview

- What is Serialization?
- `polymake` Serialization
- `OSCAR` Serialization
- Differences and Similarities

Serialization

generated using ChatGPT

Serialization: High Level Overview



Serialization: Formats

```
<?xml version="1.0" encoding="utf-8"?>
<?pm chk="56e977e8"?>
<object name="square" type="polytope::Polytope&lt;Rational&gt;"
    version="3.0"
    xmlns="http://www.math.tu-berlin.de/polymake/#3">
  <description><![CDATA[cube of dimension 2]]></description>
  <property name="VERTICES">
    <m>
      <v>1 0 0</v>
      <v>1 1/3 0</v>
      <v>1 0 1/3</v>
      <v>1 1/3 1/3</v>
    </m>
  </property>
  <property name="FACETS"
      type="SparseMatrix&lt;Rational,NonSymmetric&gt;">
    <m cols="3">
      <v> <e i="1">1</e> </v>
      <v> <e i="0">1/3</e> <e i="1">-1</e> </v>
      <v> <e i="2">1</e> </v>
      <v> <e i="0">1/3</e> <e i="2">-1</e> </v>
    </m>
  </property>
  <property name="LINEALITY_SPACE"><m /></property>
  <property name="BOUNDED" value="true" />
  <property name="N_FACETS" value="4" />
  <property name="N_VERTICES" value="4" />
  <property name="VOLUME" value="1/9" />
  <property name="TRIANGULATION">
    <object name="unnamed#0">
      <property name="FACETS">
        <m>
          <v>0 1 2</v>
          <v>1 2 3</v>
        </m>
      </property>
      <property name="F_VECTOR">
        <v>4 5 2</v>
      </property>
    </object>
  </property>
</object>
```

- Text (MPS, LP)
- CSV
- XML (`polymake`)
- JSON (`polymake`, `OSCAR`)
- YAML
- ...

Polymake Demo

```
polytope > $c = cube(2);
polytope > $c->add("LP", LINEAR_OBJECTIVE=>[0, 1, -1]);
polytope > save($c, "c.json");
polytope > poly2lp($c, $c->LP, 0, "c.lp");
polytope > poly2mps($c, $c->LP, new Set<Int>(), "c.mps");
```

```
MINIMIZE
  obj: +1 x1 -1 x2
Subject To
  ie0: +1 x1 >= -1
  ie1: -1 x1 >= -1
  ie2: +1 x2 >= -1
  ie3: -1 x2 >= -1
BOUNDS
  x1 free
  x2 free
END
```

```
* Class:         LP
* Rows:          5
* Columns:       2
* Format:        MPS
*
NAME          unnamed#0
ROWS
 N  C0000000
 G  R0000000
 G  R0000001
 G  R0000002
 G  R0000003
COLUMNS
    x1        C0000000  1                   R0000000  1
    x1        R0000001  -1
    x2        C0000000  -1                  R0000002  1
    x2        R0000003  -1
RHS
    B         R0000000  -1                  R0000001  -1
    B         R0000002  -1                  R0000003  -1
BOUNDS
 FR BND       x1
 FR BND       x2
ENDATA
```

polymake JSON File


```
{
  "_id": "c.json",
  "_info": {
    "description": "cube of dimension 2\n"
  },
  "_ns": {
    "polymake": [
      "https://polymake.org",
      "4.11"
    ]
  },
  "_type": "polytope::Polytope<Rational>",
  "BOUNDED": true,
  "CONE_AMBIENT_DIM": 3,
  "CONE_DIM": 3,
  "FACETS": [ { "0": "1",  "1": "1"  },
              { "0": "1",  "1": "-1" },
              { "0": "1",  "2": "1"  },
              { "0": "1",  "2": "-1" },
              { "cols": 3 } ],
  "VERTICES_IN_FACETS": [[0, 2], [1, 3], [0, 1], [2, 3], {"cols": 4}],
  "_attrs": {
    "FACETS": {
      "_type": "SparseMatrix<Rational, NonSymmetric>"
    }
  }
}
```


Say we want to store:

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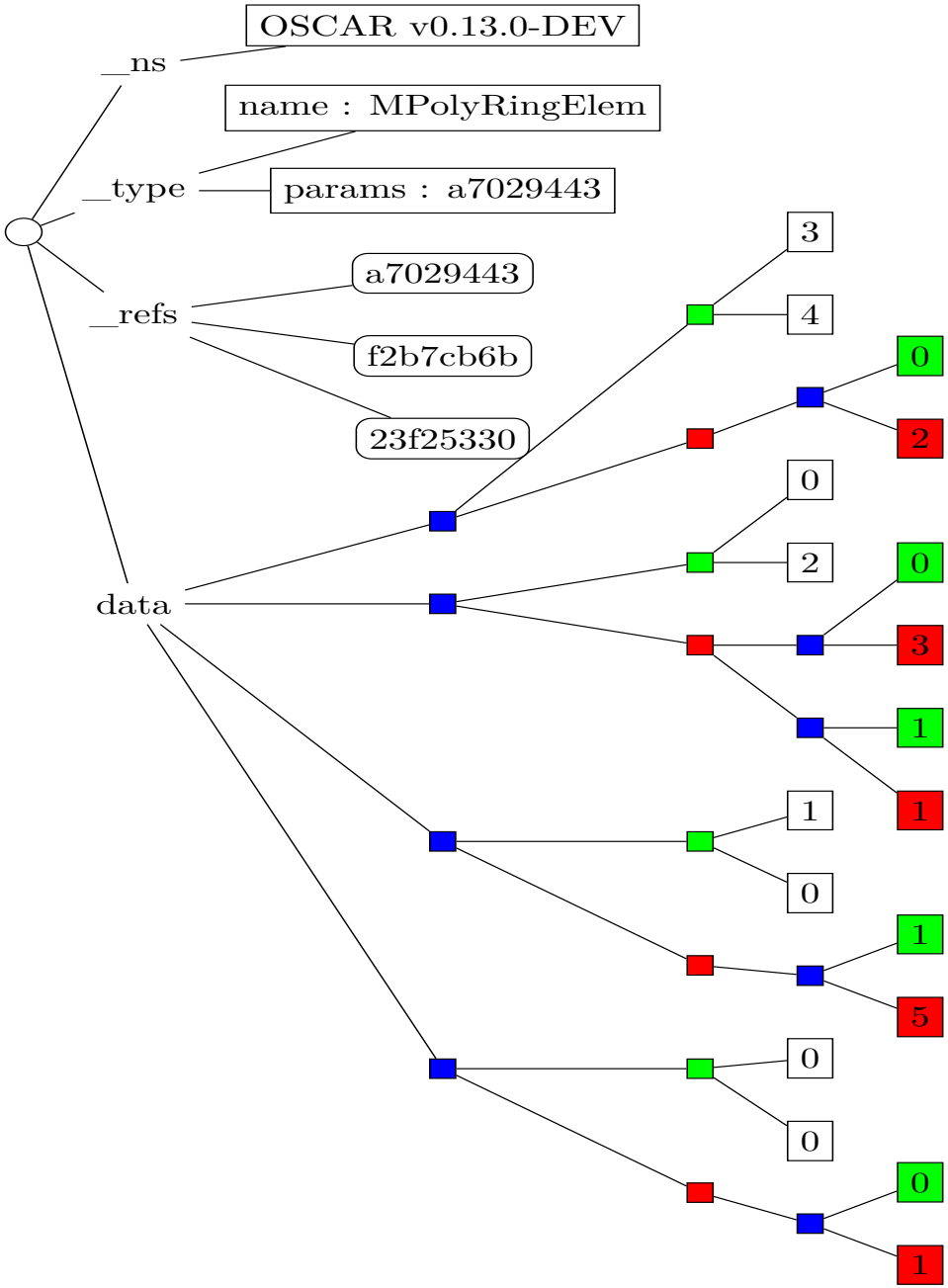
- Some technicalities with the coefficients.
- Is y considered a coefficient of z?
- What is **a**?
- How can we guarantee the objects behave as expected on load?

OSCAR Demo

```
julia> using Oscar

julia> F = GF(7)
Finite field of characteristic 7

julia> Fx, x = F["x"]
(Univariate polynomial ring in x over GF(7), x)

julia> L, a = FiniteField(x^2 + x + 1)
(Finite field of degree 2 over GF(7), o)

julia> Lyz, (y, z) = L["y", "z"]
(Multivariate polynomial ring in 2 variables over GF(7^2), fqPolyRepMPolyRingElem[y, z])

julia> p = 2 * z^4 * y^3 + (a + 3) * z^2 + 5*a*y + 1
2*y^3*z^4 + 5*o*y + (o + 3)*z^2 + 1

julia> q = z^2 + 3*y
3*y + z^2

julia> save("p.mrdi", p)

julia> save("q.mrdi", q)

julia> load("p.mrdi") * load("q.mrdi")
6*y^4*z^4 + 2*y^3*z^6 + o*y^2 + (o + 2)*y*z^2 + 3*y + (o + 3)*z^4 + z^2
```

Tree Structure



$$2y^3z^4 + (a+3)z^2 + 5ay + 1$$

Example File Serialized with OSCAR


```
{
  "_ns": { "Oscar": [ "https://github.com/oscar-system/Oscar.jl", "0.13.0-DEV" ]  },
  "_type": {
    "name": "MPolyRingElem",
    "params": "869a359a-43d3-43f4-9821-0af9346be019"
  },
  "_refs": {
    "152ac7bd-e85a-4b36-acc2-743ade2cad4f": {
      "_type": "PolyRing",
      "data": { "base_ring": { "data": "7",  "_type": "Nemo.fpField"},
                "symbols": ["x"] }
    },
    "869a359a-43d3-43f4-9821-0af9346be019": {
      "_type": "MPolyRing",
      "data": {
        "base_ring": "a8309b96-caec-443c-bedb-e23bb0634c14",
        "symbols": [ "y", "z" ]
      }
    },
    "a8309b96-caec-443c-bedb-e23bb0634c14": {
      "_type": "fqPolyRepField",
      "data": {
        "def_pol": {
          "_type": {
            "name": "PolyRingElem",
            "params": "152ac7bd-e85a-4b36-acc2-743ade2cad4f"
          },
          "data": [["0", "1"], ["1", "1"], ["2", "1"]]
        }
      }
    }
  }
  "data": [[["3", "4"], [["0", "2"]]],
           [["0", "2"], [["0", "3"], ["1", "1"]]],
           [["1", "0"], [["1", "5"]]],
           [["0", "0"], [["0", "1"]]]]
}
```


Current Status and Features of OSCAR Serialization

- Over 100* registered types.
- Can store sessions over multiple files.
- Parameter Overriding.
- Serialization extensible from outside OSCAR due to Julia multiple dispatch.
- Option to attach metadata (name and ORCID for author).
- Upgrade scripts.

Schema

Figure:
`https://www.pexels.com/photo/plastic-shape-shorter-toy-11030155/`

- A schema defines a structure for data.

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- Schemata allow data to be validated before loading.

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- Is possible to define recursive structure.
- Schemata allow data to be validated before loading.
- Adds structure to document based databases.
- `PolyDB`, Paffenholz [2017]

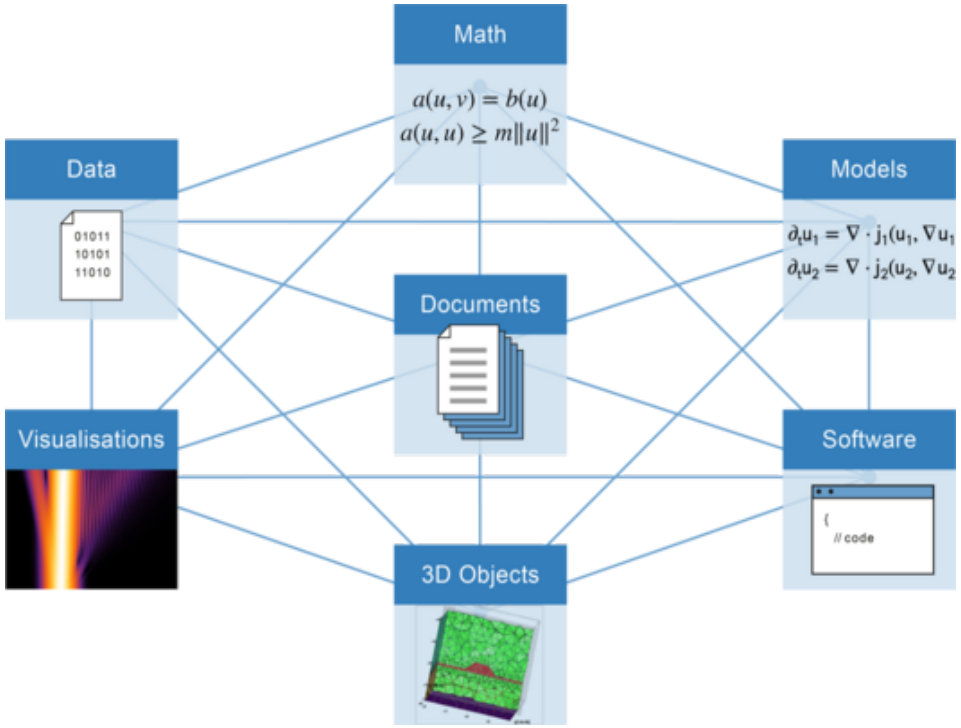
File Format Specification

```
julia> mrdi_schema = Schema(JSON.parsefile(schema_path))
A JSONSchema

julia> jsondict = JSON.parsefile(polynomial_path)
Dict{String, Any} with 4 entries:
  "data"  => Any[Any[Any["3", "4"], Any[Any["0", "2"]]], Any[Any["0", "2"], Ar
  "_ns"   => Dict{String, Any}("Oscar"=>Any["https://github.com/oscar-system/O
  "_type" => Dict{String, Any}("name"=>"MPolyRingElem", "params"=>"869a359a-43
  "_refs" => Dict{String, Any}("869a359a-43d3-43f4-9821-0af9346be019"=>Dict{St

julia> validate(mrdi_schema, jsondict)
```

```
{
  "$id": "https://oscar-system.github.io/schemas/data.json",
  "$schema": "https://json-schema.org/draft/2020-12/schema",
  "type": "object",
  "properties": {
    "_ns": { "type": "object" },
    "_type": {"oneOf": [
      {"type": "string"},
      {"type": "object",
       "properties": {
         "name": {"type": "string"},
         "params": {"$ref": "#/$defs/data"}
       }}
    ]},
    "data": {"$ref": "#/$defs/data"},
    "_refs": {
      "type": "object",
      "patternProperties":{
        "^[0-9a-fA-F]{8}-([0-9a-fA-F]{4}-){3}[0-9a-fA-F]{12}$":
        {"$ref": "#"}
      }
    }
  },
  "required": ["_type"],
  "$defs": {
    "data": {
      "oneOf": [
        {"type": "string"},
        {"type": "object",
         "patternProperties": {
           "[a-z]": { "$ref": "#/$defs/data" }
         }
        },
        {"type": "array", "items": {"$ref": "#/$defs/data"}}
      ]
    }
  }
}
```

MaRDI and the FAIR Principles

- **Ma**thematics **R**esearch **D**ata Initiative.
- Develop a mathematical research data infrastructure.
- Set standards for confirmable workflows and certified mathematical research data.
- Provide services to both the mathematical and wider scientific community.
- **F**indable **A**ccessible **I**nteroperable **R**eusable [M. D. Wilkinson et al. 2016]



End

Thank You!