EDM Toolkit - **PODIO**

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Outline

- Introduction and Motivation
- Design and Implementation
- Recent Developments
- Next Steps
- Summary and Outlook

Introduction and Motivation for PODIO

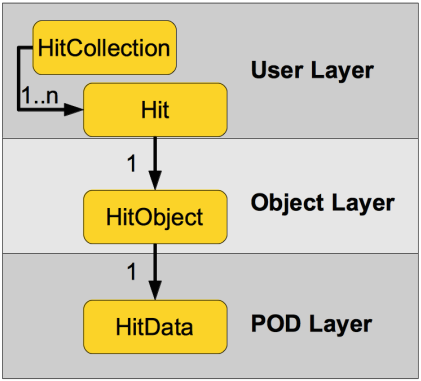
- Motivation: experience from previous event data models (EDMs) revealed some shortcomings:
  - overly complex, deep object hierarchies with strong use of inheritance (LHC)
  - virtual function calls and non-optimal I/O performance (LC)
- new projects, like the FCC are an opportunity to do better this time
  - use what worked well - throw away what didn't
- PODIO is developed in context of the **FCC** study
  - addressing the problem in a generic way
  - allowing potential re-use by other HEP groups
- planned application to **LC** (LCIO) will provide cross check for generality
- one of the first projects adopted by the **HEP Software Foundation**

Design Choices for PODIO

- use **PODs** for the event data objects (**P**lain-**O**ld-**D**ata object)
  - simple memory model
  - support for vectorization
  - allowing for(very) fast I/O
- simple user API and class hierarchies
  - use concrete types: favor composition over inheritance
- apply code generation
- support for C++ and Python
- build in thread-safety
- allow for different I/O implementations

Implementation: the three PODIO layers

- user layer (API):
  - handles to EDM objects (e.g. **Hit**)
  - collection of EDM object handles (e.g. **HitCollection**).
- object layer
  - transient objects (e.g. **HitObject**) handling vector members and *references* to other objects
- POD layer
  - the actual POD data structures holding the persistent information (e.g. **HitData**)



Object ownership in PODIO

clear design of ownership (hard to make mistakes) in two stages:

objects added to event store are *owned by event store*

```
auto& hits = store.create<HitCollection>("hits") ;
auto h1 = hits.create( 1.,2.,3.,42.) ; // init w/ values
auto h2 = hits.create() ; // default construct
h2.energy( 42.) ;
```

objects created standalone are *reference counted* and automatically garbage collected:

```
auto h3 = Hit() ;
auto h4 = Hit() ;
hits.push_back( h3 ) ;
//  h1,h2,h3 are automatically deleted with collection
//  h4 is garbage collected
```

Relations between Objects

allow to have 1-1, 1-N or N-M relationships, e.g.

```
auto& hits = store.create<HitCollection>("hits");
auto& clusters = store.create<ClusterCollection>("clusters");
auto hit1 = hits.create(); auto hit2 = hits.create();
auto cluster = clusters.create();
cluster.addHit(hit1);
cluster.addHit(hit2);
```

referenced objects can be accessed via iterator or directly

```
for( auto h = cluster.Hits_begin(),end = cluster.Hits_end(); h!=end ++h){
    std::cout << h->energy() << std::endl;
}
auto hit  = cluster.Hits(42);
```

also standalone relations between arbitrary EDM objects

Code generation

- code (C++/Python) for the EDM classes is generated from yaml files
- EDM objects (data structures) are built from
  - basic type data members
  - components (structs of basic types)
  - references to other objects
- additional user code (member functions) can be defined in the yaml files

```
# LCIO MCParticle
  MCParticle:
    Description: "LCIO MC Particle"
    Author : "F.Gaede, B. Hegner"
    Members:
      - int pDG               // PDG code of the particle
      - int generatorStatus   // status as defined by the generator
      - int simulatorStatus   // status from the simulation
        #...
    OneToManyRelations:
      - MCParticle parents // The parents of this particle.
      - MCParticle daughters // The daughters this particle.
    ExtraCode:
      const_declaration:
      "bool isCreatedInSimulation() const {
          return simulatorStatus() != 0 ;
       } \n"
```

Python Interface

- Python is treated as first class citizen in the provided library
- can use *pythonic* code for iterators etc.
- implemented with PyROOT and some special usability code in Python

Python code example:

```
store = EventStore(filenames)
for i, event in enumerate(store):
  hits = store.get("hits")
  for h in hits:
    print h.energy()
```

I/O implementation

- PODIO's I/O is rather trivial at the moment
- PODs are directly stored using ROOT I/O
  - auto generated streamer code via dictionary
  - not properly optimized for PODs yet
- object references are translated into *ObjectIDs* before being stored

To-Do-item:

- implement a direct binary I/O (storing array of structs) for performance comparison with ROOT and to demonstrate the potential performance advantage of storing PODs
  - planned for this summer (CERN summerstudent programme)

Recent Developments (since last annual meeting)

- moved to use C++14
- implemented support for I/O of *std::array*
  - needed iteration with ROOT developers
  - requires recent ROOT version
- simplified the example event store
- fixed a number of bugs and issues
- iterated on definition of FCC EDM
  - making use of new std::array features
- implemented streamer methods for EDM classes
- implemented prototype for usage with LCIO

Implementation of streamer methods

- automatically create two methods for each EDM object:
  - proven to be extremely useful in LCIO for debugging and analysis

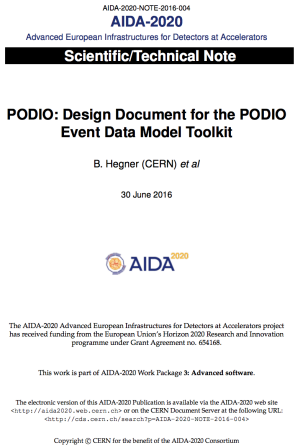
```
// ostream operator for detailed dump of EDM object
// prints every member of the POD struct in one line
std::ostream& operator<<(std::ostream& o,const ConstMCParticle& v);
```

```
// ostream operator for tabular dump of EDM collection
// prints one line per EDM object
std::ostream& operator<<(std::ostream& o,const MCParticleCollection& v);
```

Milestones and Deliverables

Name	What	When
MS19	Design document for EDM Toolkit	M14
MS90	Application of EDM Toolkit to LC	M44
D3.4	Event Data Model Toolkit	M40

- reached MS19 on time
- some time to go for MS90 and D3.4



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AIDA-2020

Advanced European Infrastructures for Detectors at Accelerators

Scientific/Technical Note

PODIO: Design Document for the PODIO Event Data Model Toolkit

B. Hegner (CERN) *et al*

30 June 2016

AIDA 2020

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Next Steps

implement binary I/O making use of array-of-POD

- need to benchmark the reading performance against current ROOT I/O
  - uses member wise streaming and XDR (big endian)

finalize implementation of LCIO with PODIO

- prototype implementation with ~90% of LCIO exists, missing:
  - vector/array member types -> use new *std::array* feature
  - meta data for run, event and collections
  - suitable *Event Store*, compatible w/ current LCIO/Marlin

modify the treatment of constness

- current implementation has extra types for *const* objects, e.g. *ConstMCParticle*
- prototype implementation exists that ensures constness transparently
  - need to be merged with *master* branch

Summary and Outlook

- EDM toolkit PODIO developed in context of FCC/LC
  - with general HEP in mind
  - storing EDM objects in arrays of PODs
  - currently using ROOT I/O
  - code automatically generated for C++ and Python
  - first implementation in full use by FCC
  - under evaluation for LC

Outlook

- address open points
  - alternative binary I/O
  - full implementation of LCIO
  - modified treatment of *constness*

Links and Pointers

- GitHub repository + docs:
  - `https://github.com/hegner/podio`
- doxygen page:
  - `https://fccsw.web.cern.ch/fccsw/podio/index.html`
- issue tracker:
  - `https://sft.its.cern.ch/jira/projects/PODIO`
- plcio (EDM for LCIO w/ podio) git repository:
  - `https://stash.desy.de/projects/IL/repos/plcio`
- PODIO Library Design Document:
  - `http://cds.cern.ch/record/2212785`