XML I/O in ROOT

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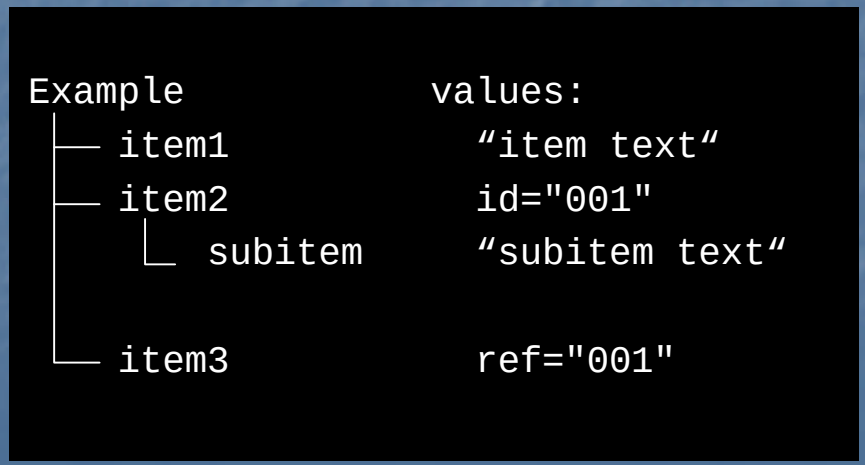
Motivation

- XML is well structured and formatted text format
- Widely used as metadata (configuration, parameters, geometry) storage format
- Good candidate to be used as exchange format between different applications
- ROOT has powerful I/O system, but had no (at the beginning of 2004) support of xml

eXtensible Markup Language (XML)

- Tree like structure (not ROOT tree) of text tags
- Each tag opened should be closed
- Tag can include other tags, contain text, has attributes
- In addition: DTD, XSLT, XML schema, namespaces, ...

```
<?xml version="1.0"?>
<Example>
  <item1>item text</item1>
  <item2 id="001">
    <subitem>subitem text</subitem>
  </item2>
  <item3 ref="001"/>
</Example>
```

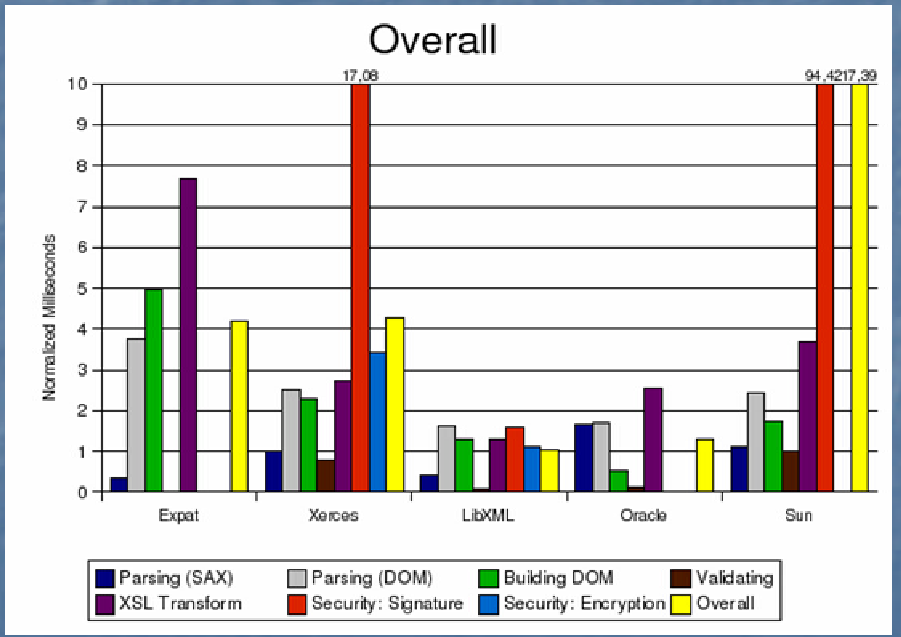


XML packages

C/C++ based XML packages:

- libxml (Gnome) http://xmlsoft.org
- Xerces-C++ (Apache) http://xml.apache.org/xerces-c/
- expat (Mozilla) http://expat.sourceforge.net

Benchmarks of XML packages:
http://xmlbench.sourceforge.net



Implementation details

- Slight changes (generalization) of TFile & TDirectory classes interfaces
- Virtualization of TBuffer interface
  => 3-5% speed penalty
- New TXMLBuffer class to convert basic data types to/from xml tags
- New TXMLEngine class to provide narrow interface to libxml2 library => possibility to use other xml packages
- New TXMLFile & TXMLKey classes for manipulation with xml files via common ROOT TFile interface
- Since May 2004 in ROOT distribution

Example of xml file

```
<?xml version="1.0"?>
<root setup="2xoo" ref="null">
 <XmlKey name="named" cycle="1">
  <Object class="TNamed">
   <TNamed version="1">
    <TObject fUniqueID="0" fBits="3000000"/>
    <fName str="ObjectName"/>
    <fTitle str="ObjectTitle"/>
   </TNamed>
  </Object>
 </XmlKey>
 <XmlKey name="box" cycle="1">
  <Object class="TBox">
   <TBox version="2">
    <TObject fUniqueID="0" fBits="3000000"/>
    <TAttLine version="1">
     <fLineColor v="1"/>
     <fLineStyle v="1"/>
     <fLineWidth v="1"/>
    </TAttLine>
    <TAttFill version="1">
     <fFillColor v="19"/>
     <fFillStyle v="1001"/>
    </TAttFill>
    <fX1 v="0.000000"/>
    <fY1 v="0.000000"/>
    <fX2 v="1.000000"/>
    <fY2 v="1.000000"/>
   </TBox>
  </Object>
 </XmlKey>
</root>
```

Standard ROOT xml file header with configuration data

XmlKey with name and cycle number

```
void example() {
   TNamed named("ObjectNa
   TBox box(0.0, 0.0, 1.0, 1.0
```

```
   TFile* fxml = TFile::Open("
   named.Write("named");
   box.Write("box");
   delete fxml;
}
```

Supported features

- “Transparent” usage of XML files via ROOT plug-in manager
- Except TTree, most of ROOT classes, including TClonesArray, can be stored
- Support of custom streamers in user classes
- Different layouts of xml files: class-specific and generic
- Optional usage of xml namespaces

Generic and class-specific layouts

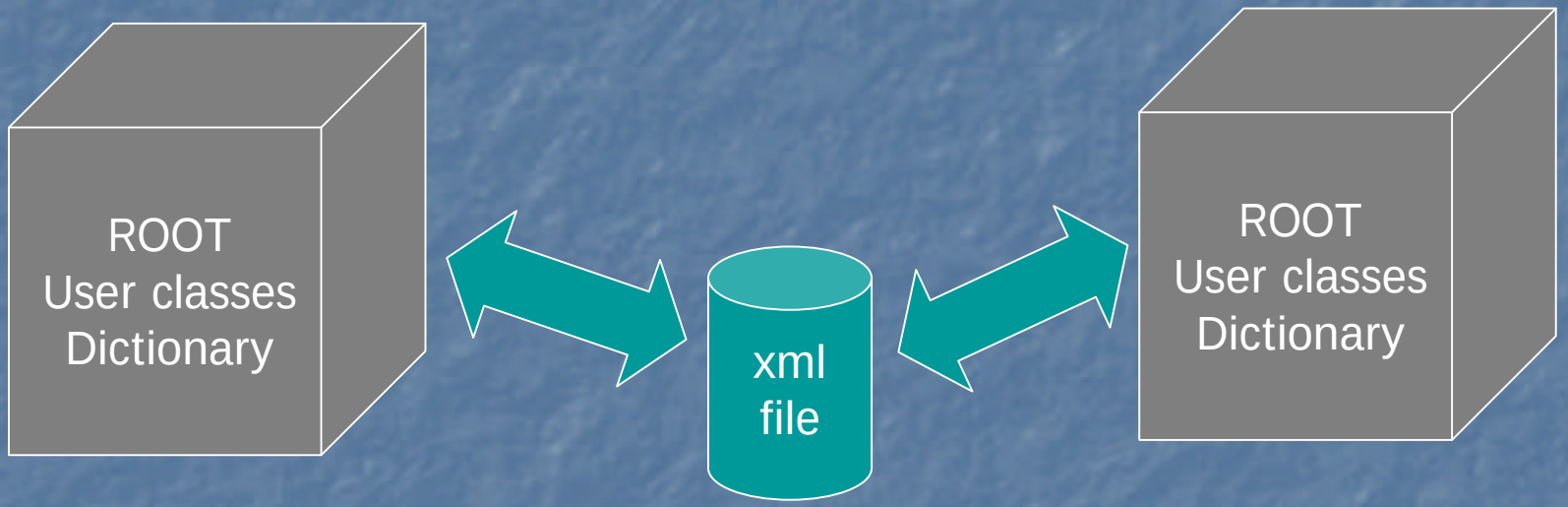
```
<Object class="TBox">
 <Class name="TBox" version="2">
  <Member name="TObject">
   <Item name="Version" v="1"/>
   <Item name="UInt_t" v="0"/>
   <Item name="UInt_t" v="50331648"/>
  </Member>
  <Member name="TAttLine" version="1">
   <Member name="fLineColor" v="1"/>
   <Member name="fLineStyle" v="1"/>
   <Member name="fLineWidth" v="1"/>
  </Member>
  <Member name="TAttFill" version="1">
   <Member name="fFillColor" v="19"/>
   <Member name="fFillStyle" v="1001"/>
  </Member>
  <Member name="fX1" v="0.000000"/>
  <Member name="fY1" v="0.000000"/>
  <Member name="fX2" v="1.000000"/>
  <Member name="fY2" v="1.000000"/>
 </Class>
</Object>
```

```
<Object class="TBox">
 <TBox xmlns:TBox="http://root.cern.ch/..." version="2">
  <TObject fUniqueID="0" fBits="3000000"/>
  <TAttLine xmlns:TAttLine="http://root.cern.ch/..." version="1">
   <TAttLine:fLineColor v="1"/>
   <TAttLine:fLineStyle v="1"/>
   <TAttLine:fLineWidth v="1"/>
  </TAttLine>
  <TAttFill xmlns:TAttFill="http://root.cern.ch/.." version="1">
   <TAttFill:fFillColor v="19"/>
   <TAttFill:fFillStyle v="1001"/>
  </TAttFill>
  <TBox:fX1 v="0.000000"/>
  <TBox:fY1 v="0.000000"/>
  <TBox:fX2 v="1.000000"/>
  <TBox:fY2 v="1.000000"/>
 </TBox>
</Object>
```

Data exchange scenarios

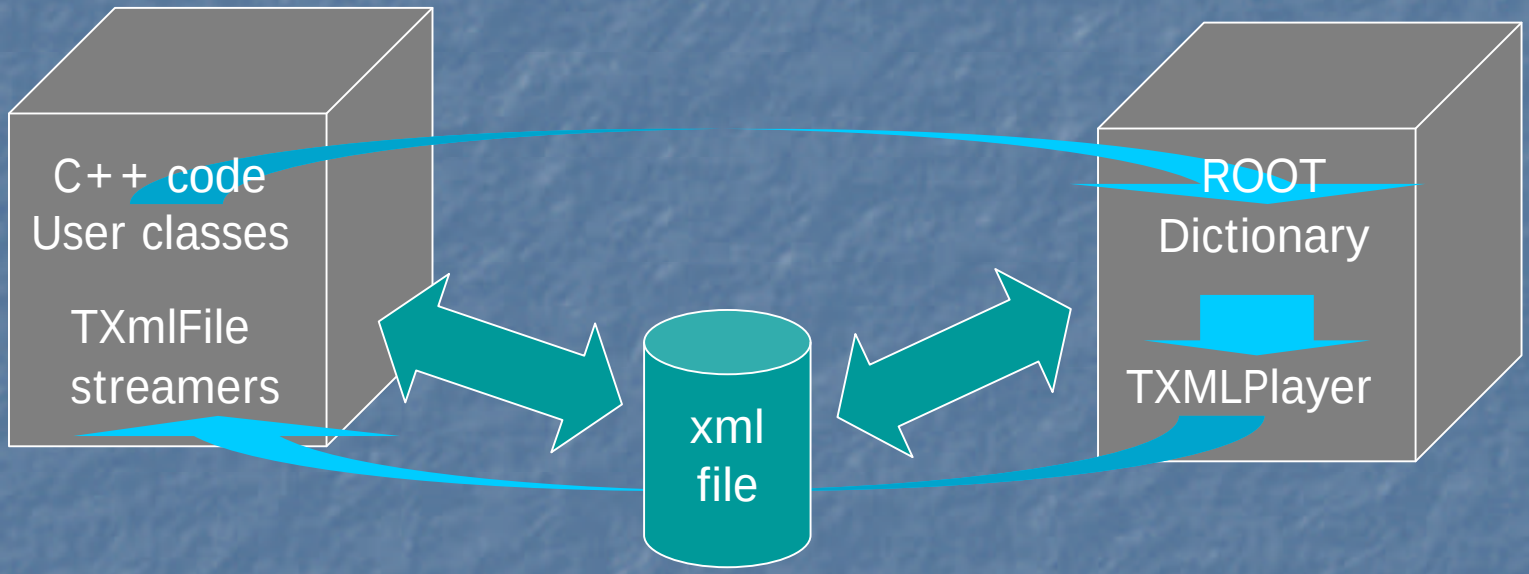
1. Communication between two ROOT applications
2. Import data from existing user C++ program with non-ROOT classes
3. Export data from existing ROOT application to other C++ application
4. Export data from existing non-ROOT xml files

Data exchange between ROOT applications



- Allows viewing/editing exchanged data with standard xml tools
- Has no big advantage compared to standard ROOT file format

Import data from C++ program



Supported in user classes:

- basic data types, arrays, const char*
- access to private and protected members
- objects, object pointers, array of objects, array of objects pointers
- classes inheritance tree
- STL string, vector, list, deque, set, map, multimap

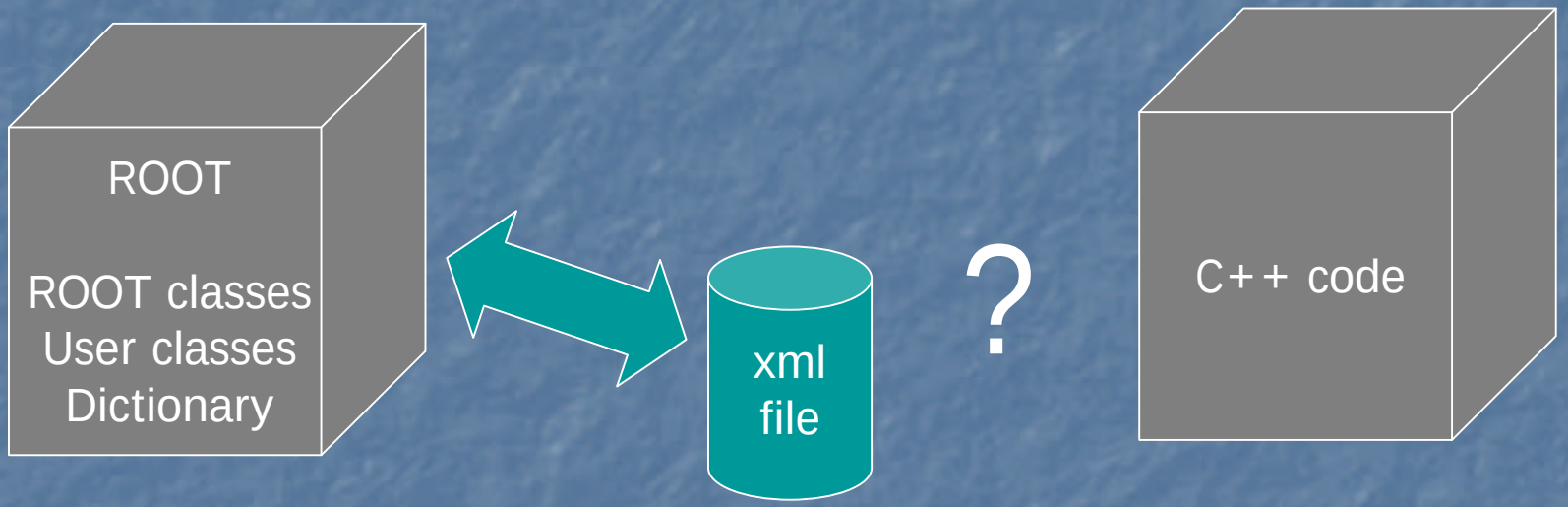
Import data from C++ program

- Create ROOT dictionary for user classes
- Using TXMLPlayer, create xml-streamers for user classes
- Add xml-streamers and TXmlFile class to user project
- Both reading & writing of xml files becomes possible
- “ROOT-like” interface in user code to access xml files:

```
TXmlFile file("test.xml");
TXmlEx1* ex1 = (TXmlEx1*) file.Get("ex1", TXmlEx1_streamer);
TXmlEx2* ex2 = (TXmlEx2*) file.Get("ex2", TXmlEx2_streamer);

TXmlFile outfile("test2.xml", "recreate");
outfile.Write(ex1, "ex1", TXmlEx1_streamer);
outfile.Write(ex2, "ex2", TXmlEx2_streamer);
```

Export data to C++ program



What is possible:

- do not use any ROOT classes, but then it is previous scenario
- generate class definitions and streamers for C++ code, converting ROOT containers to STL containers

Implementation is not yet clear and highly depend from real user requirements. Any suggestions are welcome.

Conclusion

- Generic XML I/O introduced in ROOT
- Several xml-layout options are supported
- Possibility for data exchange with other non-ROOT application

- Investigation required:
  - support of TTree?
  - support for SAX interface to read fairly big files?
  - use of alternative xml-engines?
  - DTD-generation
  - improvements in data exchange