Transparent Persistence with Java Data Objects

- What is JDO:
  - Requirements on Transparent Persistence
  - Architecture of Java Data Objects
  - Available Implementations
- Applications using JDO:
  - Trivial
  - Indicium: AttributeList/Metadata for LCG
  - AIDA Persistence
  - Minerva: Lightweight Application Framework
- Prototypes using JDO:
  - Object Evolution
  - References

Objects can be made persistent without heavy complex systems polluting user applications.

J.Hrivnac (LAL/Orsay) for CHEP'03 in La Jolla, Mar'03

What is
Transparent (Orthogonal) Persistence (1)

- **Object model independent on persistence**
  - Automatic mapping of Java types to native storage types
  - Persistence for 3rd party objects
  - Persistent class source = Transient class source
  - All classes can be persistent
- **Illusion of in-memory access to data**
  - Implicit update of dirty instances
  - Automatic caching, synchronisation, retrieval, lazy loading
  - Persistence by reachability (all referenced objects are automatically persistent)

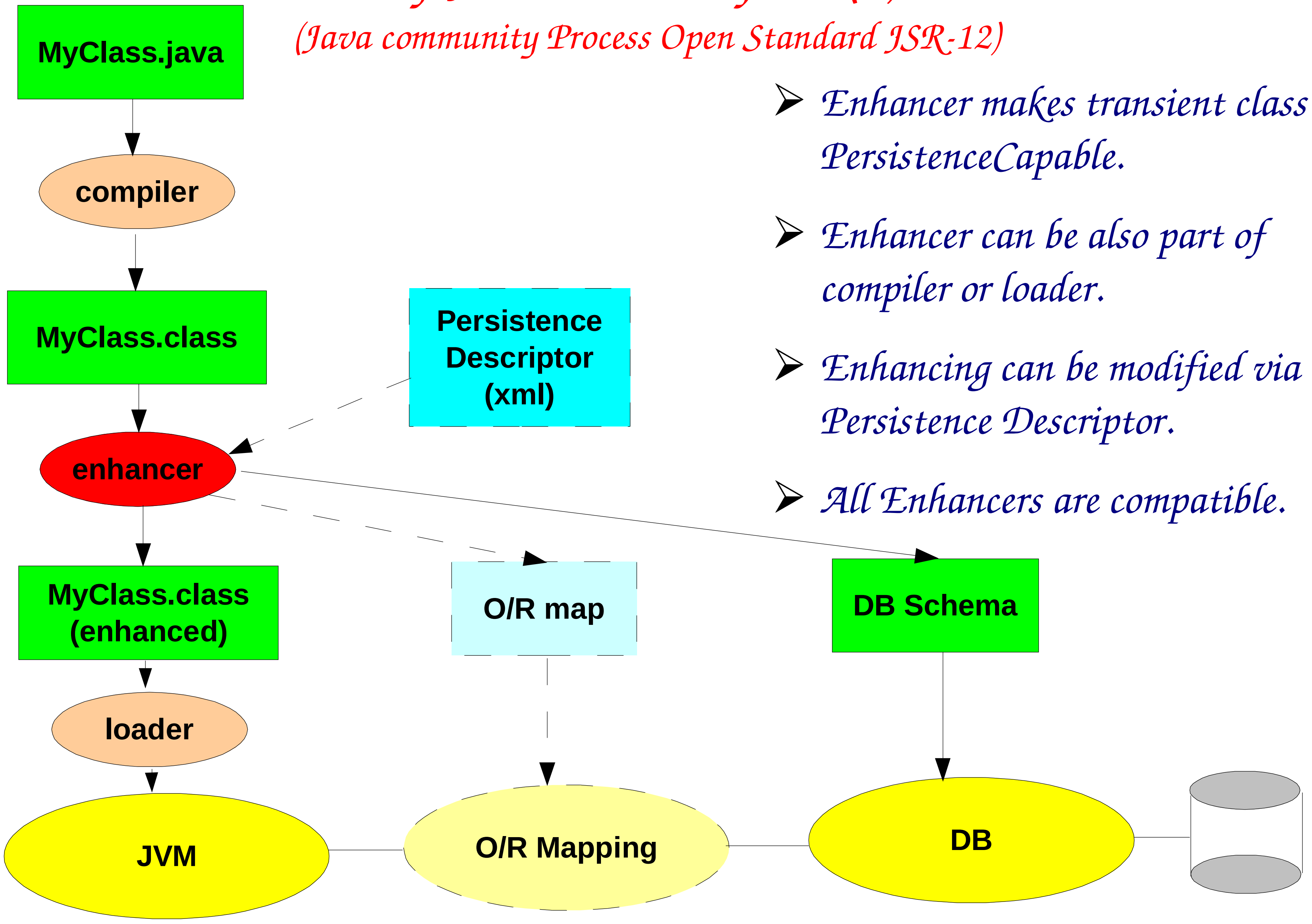
What is
Transparent (Orthogonal) Persistence (2)

- Portability across technologies
  - Data Storage: RDBS, ODBS, Files,...
  - API implementations
- Portability across platforms
- No need for different language (SQL,...) to handle persistence (incl. queries)
- Interoperability with Application Servers (EJB)

Architecture

of Java Data Objects (1)

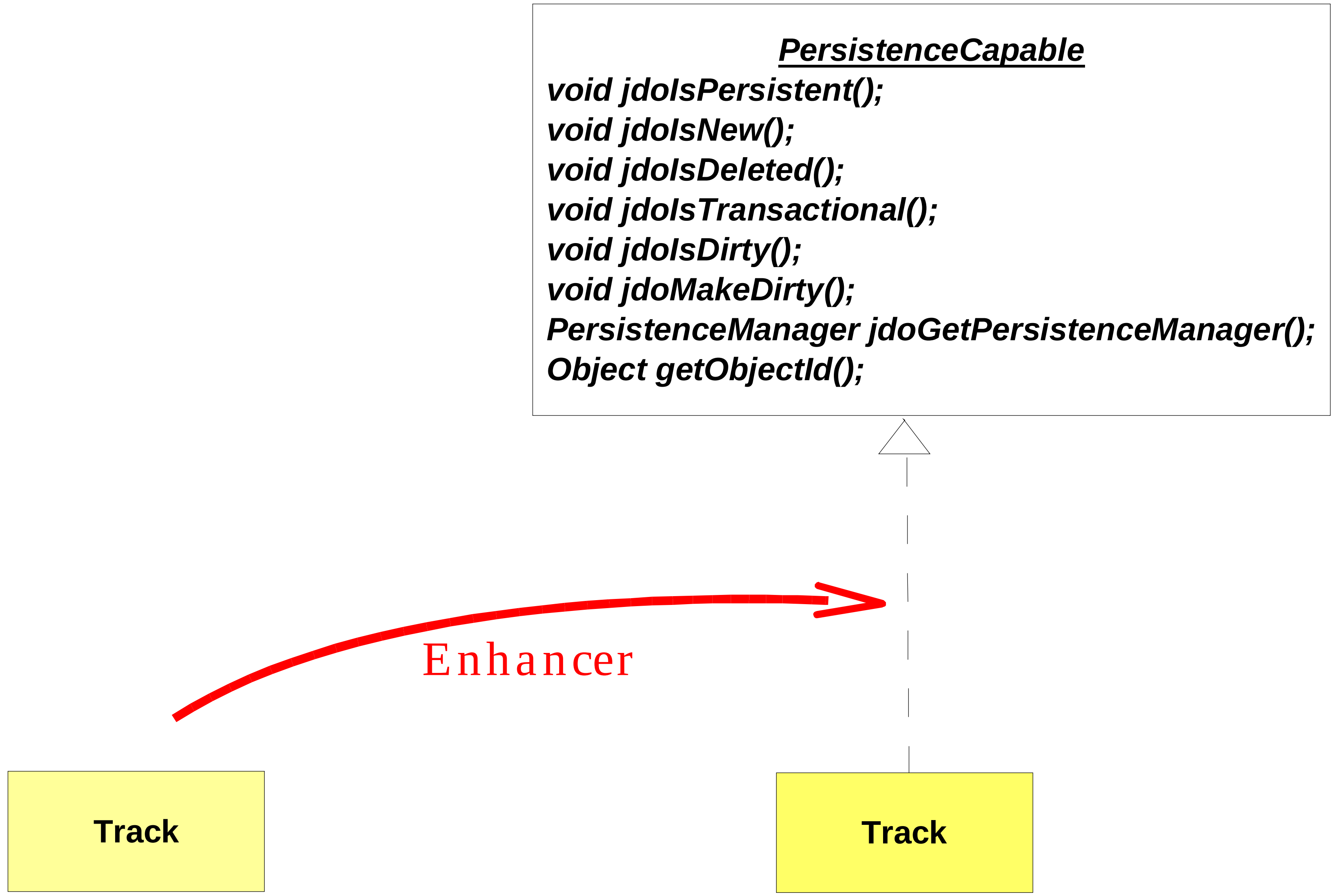
(Java community Process Open Standard JSR-12)



- *Enhancer makes transient class PersistenceCapable.*
- *Enhancer can be also part of compiler or loader.*
- *Enhancing can be modified via Persistence Descriptor.*
- *All Enhancers are compatible.*

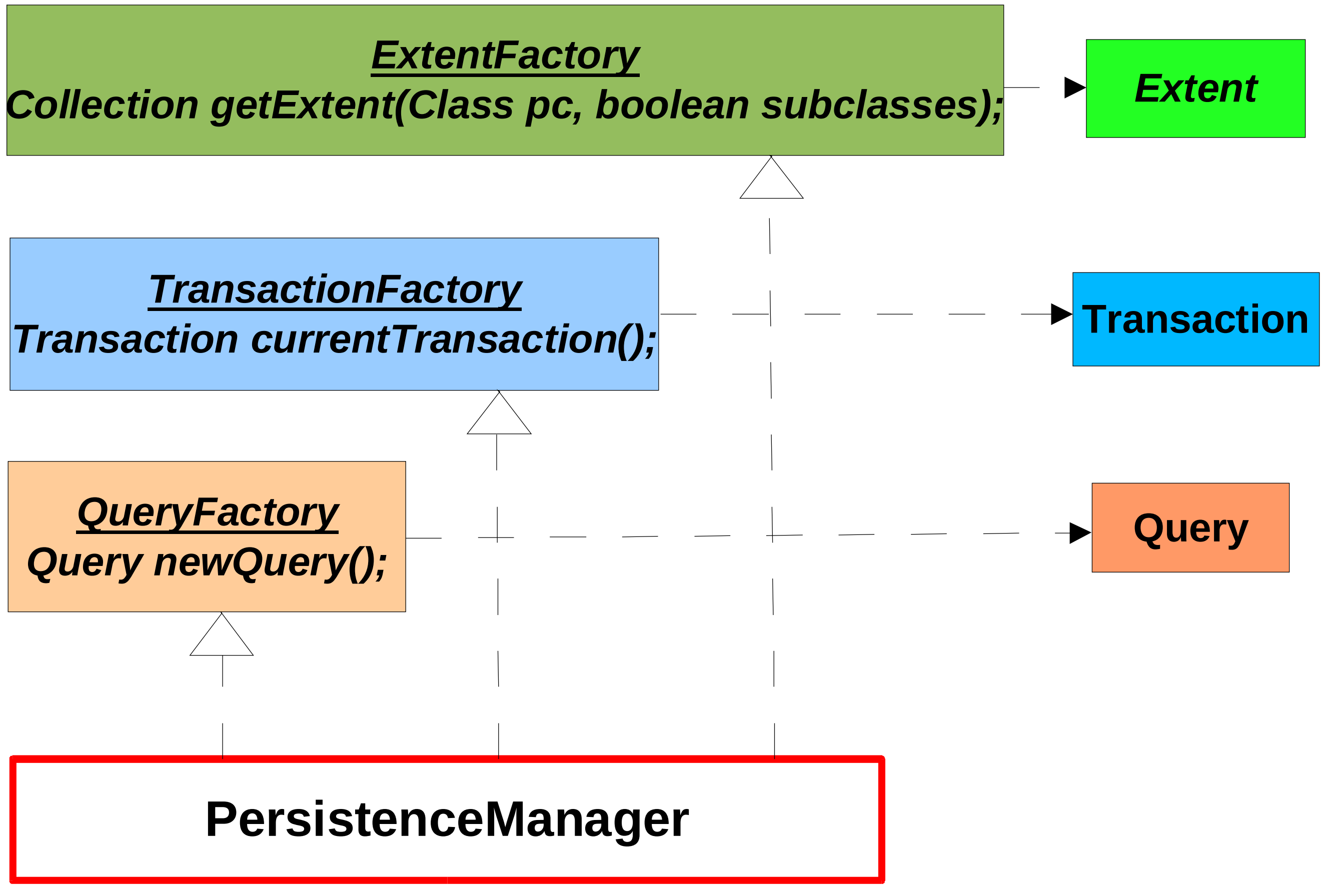
Architecture

of Java Data Objects (2)



Architecture

of Java Data Objects (3)



All interactions with Persistence is mediated by PersistenceManager:

- *Manages instances lifecycle*
- *Factory for Transactions*
- *Factory for Queries*
- *Factory for Extents*

Available Implementations

- Commercial (often with free community license):
  - enJin(Versant), FastObjects(Poet), FrontierSuit(ObjectFrontier), IntelliBO (Signsoft), JDOGenie(Hemisphere), JRelay(Object Industries), KODO(SolarMetric), LiDO(LIBeLIS), OpenFusion(Prism), Orient(Orient), PE:J(HYWY),...
- Open:
  - JDORI(Sun): + reference/standard; - only with files
  - TJDO(SourceForge): + high quality, all RDBS, automatically generated schema, full JDO; - inflexible mapping
  - XORM(SourceForge): + reuse of existing schema; - no schema generation, not full JDO
  - JORM(JOnAS/ObjectWeb)
  - OJB(Apache) : + mature mapping engine; - not full JDO

Supported Databases

- RDBS and ODBS:
  - Oracle, MS SQL Server, DB2, PointBase, Cloudscape, MSAccess, JDBC/OBDC Bridge, Sybase, Interbase, InstantDB, Informix, SAPDB, Postgress, MySQL, Hypersonic SQL, Versant,...
- Files:
  - XML, FOSTORE, flat, C-ISAM, ...
- JDO performance = DB performance, JDO itself introduces very small overhead.

Trivial Example

```
// Initialisation
PersistenceManagerFactory pmf = JDOHelper.getPersistenceManagerFactory(properties);
PersistenceManager pm = pmf.getPersistenceManager();
Transaction tx = pm.currentTransaction();

// Writing
tx.begin();
...
Event event = ...;
pm.makePersistent(event);
...
tx.commit();

// Searching using Java-like query language translated internally to DB native query language
// (SQL available too for RDBS)
tx.begin();
Extent extent = pm.getExtent(Track.class, true);
String filter = “pt > 20.0”;
Query query = pm.newQuery(extent, filter);
Collection results = query.execute();
...
tx.commit();
```

Indicium (1)

- Mission (as defined by LCG): To define, accumulate, store, search, filter and manage Attributes (metadata) external/additional to existing (Event) data. In other words: Better ntuples.
- Related to Collections (of Events).
- Satisfied by Java + JDO:
  - AttributeSet = Object with Attributes
  - Explicit Collection = Standard Java Collection
  - Implicit Collection (all objects of type T within DB) = Extent
- Works with any JDO/DB, the only DB-specific part is DB-management (creation, opening,...).
- JDO/DB implementation can be switched via properties file, no re-building is needed. Configuration for JDORI + FOSTORE and TJDO + Cloudscape/MySQL bundled, others are simple to add.
- Data stored by Indicium are accessible also via native database protocols (JDBC, SQL) and tools using them.

Indicium (2)

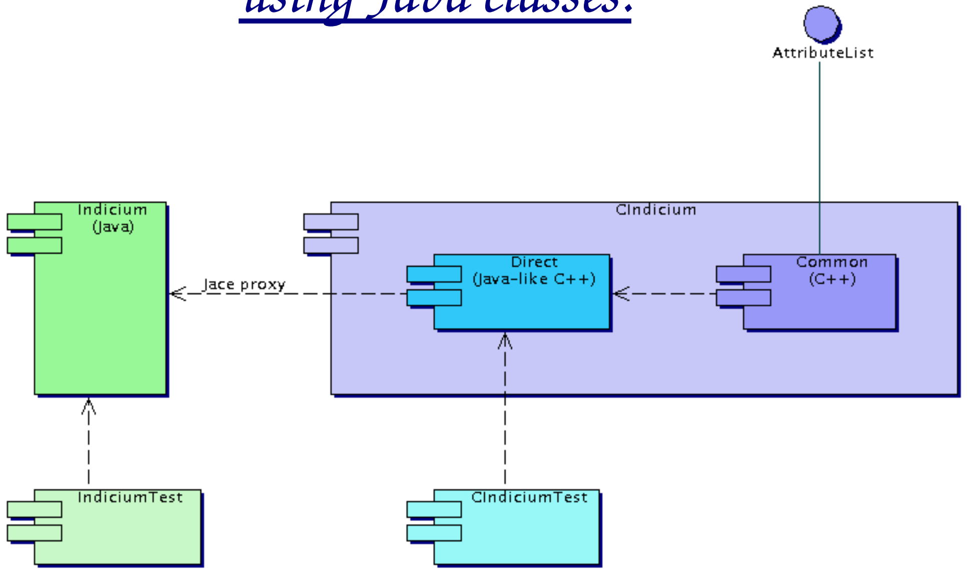
- AttributeSet interface introduced to define standard API.
- Four ways of creating AttributeSet:
  - Assembled: AttributeSet constructed at run-time; similar to classical n-tuples.
  - Generated: AttributeSet class generated from XML specification.
  - Implementing: AttributeSet interface implemented by hand.
  - FreeStyle: Any class can serve as AttributeSet.

Cindicium

- *Indicium C++ interface via automatically created JACE proxies.*
- *AttributeList interface, implementable even in C++, proposed.*

```
// Construct Signature
Signature signature("AssembledClass");
signature.add("j", "int", "Some Integer Number");
signature.add("y", "double", "Some Double Number");
signature.add("s", "String", "Some String");

// Obtain Accessor to database
Accessor accessor = AccessorFactory::createAccessor("MyDB.properties");

// Create Collection
accessor.createCollection("MyCollection", signature, true);

// Write AttributeSets into database
AssembledAttributeSet* as;
for (int i = 0; i < 100; i++) {
  as = new AssembledAttributeSet(signature);
  as->set("j", ...);
  as->set("y", ...);
  as->set("s", ...);
  accessor.write(*as);
  }

// Search database
std::string filter = "y > 0.5";
Query query = accessor.newQuery(filter);
Collection collection  = query.execute();
std::cout << "First: " << collection.toArray()[0].toString() << std::endl;
```

It is C++ application using Java classes.



(FreeHEP) AIDA Persistency

- AidaJDOStore implements Istore.
- The only necessary change to AIDA: Each managed class should have its XML description.

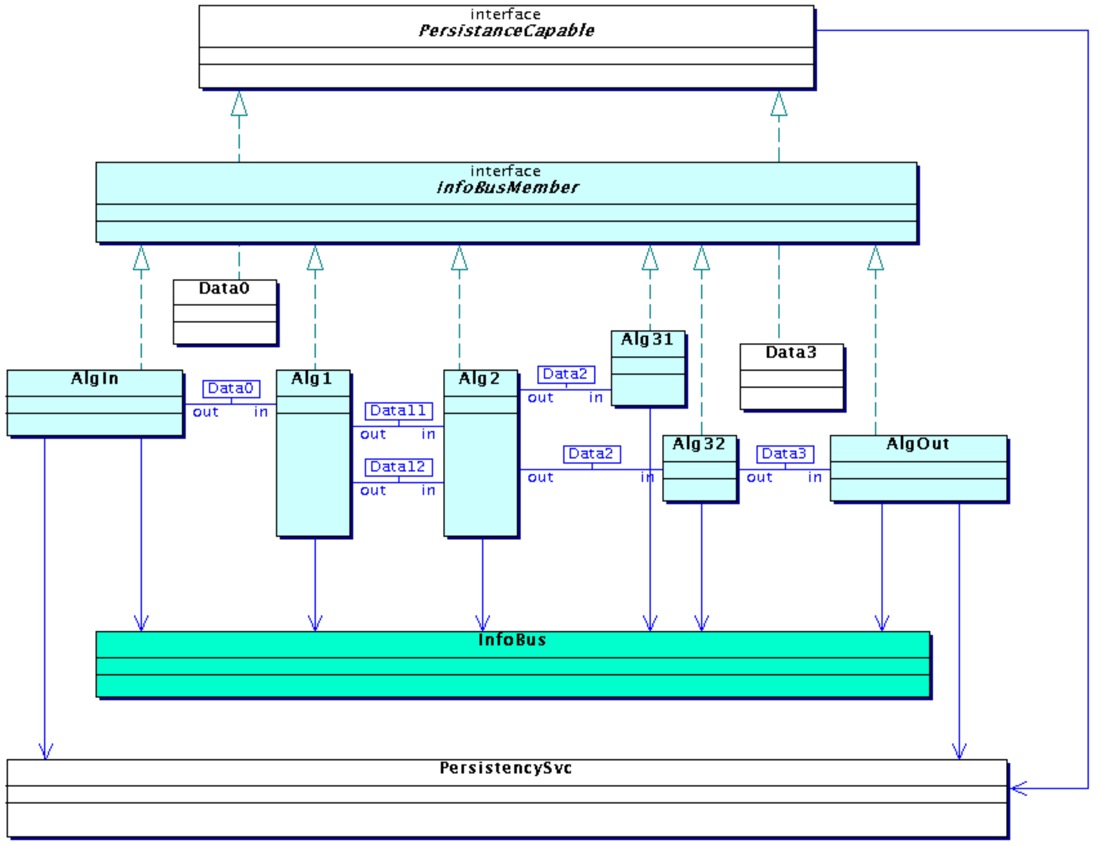
```
<jdo>
  <package name="hep.aida.ref.histogram">
    <class name="Histogram2D"
           persistence-capable-superclass="hep.aida.ref.histogram.Histogram">
     </class>
    </package>
  </jdo>
```

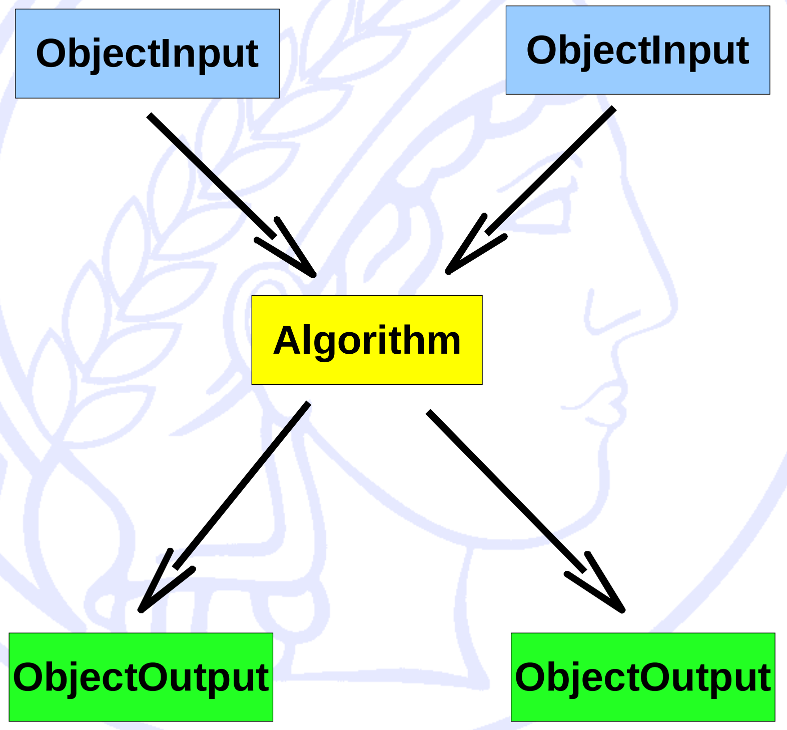
- Extentsions to existing API:
  - Istore should have more control over persistent objects.
  - Richer Query API should be introduced.
- JDO bug (4779785):
  - Persistent subclasses wrongly enhanced in Java 1.4.x .
  - Already fixed in JDO CVS, soon in release.
- Ituple is also a candidate for another LCG/Pool/AttributeSet API.

Minerva (1)

- Lightweight Java Framework implementing main Architecture principles of Athena/Gaudi:
  - Algorithm - Data Separation
  - Persistent - Transient Separation
  - Implementation independence
  - Modularity
- Based on InfoBus:
  - Data Producers + Data Consumers
  - Declared I/O types of Algorithms
  - Implicit scheduling
  - Algorithms and Services as Servers
- Multithreaded

Minerva (2)



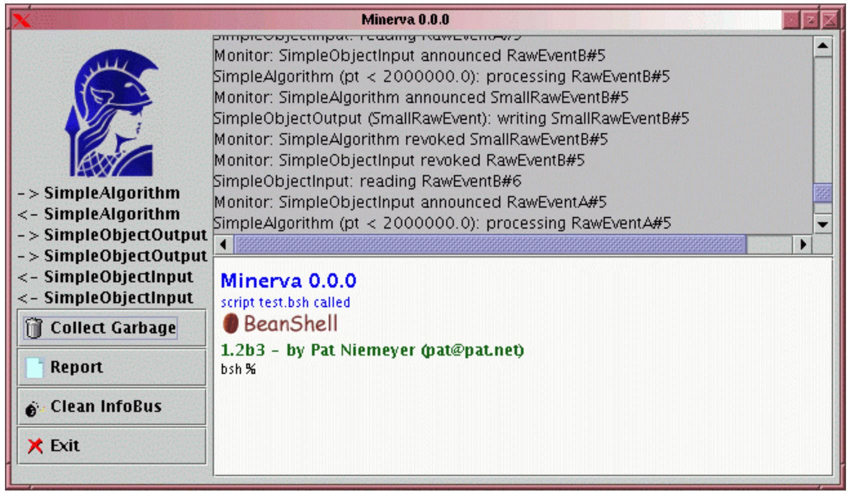


Script

new Algorithm(*<Algorithm properties>*);
new ObjectOutput(*<dbO1>*, *<Event characteristics1>*);
new ObjectOutput(*<dbO2>*, *<Event characteristics2>*);
new ObjectInput(*<db1>*);
new ObjectInput(*<db2>*);

5 Servers are running in parallel in this example. They read data from two databases, process them and write to other two databases.

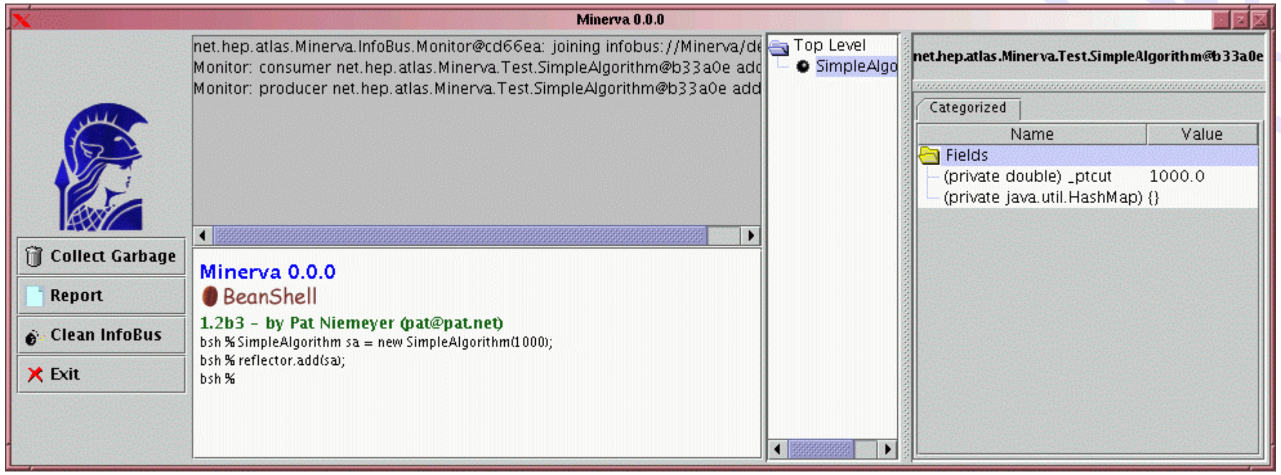
Minerva (3)



```
SimpleObjectInput: reading RawEventA#5
Monitor: SimpleObjectInput announced RawEventB#5
SimpleAlgorithm (pt < 2000000.0): processing RawEventB#5
Monitor: SimpleAlgorithm announced SmallRawEventB#5
SimpleObjectOutput (SmallRawEvent): writing SmallRawEventB#5
Monitor: SimpleAlgorithm revoked SmallRawEventB#5
Monitor: SimpleObjectInput revoked RawEventB#5
SimpleObjectInput: reading RawEventB#6
Monitor: SimpleObjectInput announced RawEventA#5
SimpleAlgorithm (pt < 2000000.0): processing RawEventA#5
```

```
Minerva 0.0.0
script test.bsh called
BeanShell
1.2b3 - by Pat Niemeyer (pat@pat.net)
bsh %
```

Running set of Producers/Consumers created from the script.



```
net.hep.atlas.Minerva.InfoBus.Monitor@cd66ea: joining infobus://Minerva/de
Monitor: consumer net.hep.atlas.Minerva.Test.SimpleAlgorithm@b33a0e add
Monitor: producer net.hep.atlas.Minerva.Test.SimpleAlgorithm@b33a0e add
```

```
Minerva 0.0.0
BeanShell
1.2b3 - by Pat Niemeyer (pat@pat.net)
bsh % SimpleAlgorithm sa = new SimpleAlgorithm(1000);
bsh % reflector.add(sa);
bsh %
```

net.hep.atlas.Minerva.Test.SimpleAlgorithm@b33a0e

Name	Value
Fields	
(private double) _ptcut	1000.0
(private java.util.HashMap) {}	

Using ObjectBrowser to inspect Algorithm.

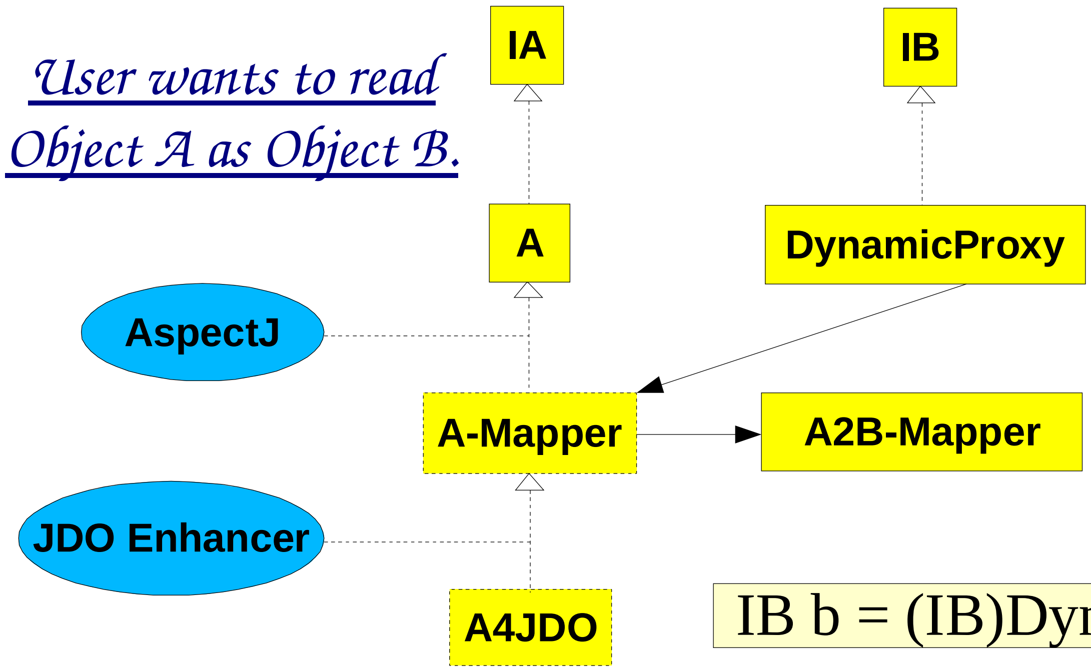
Object Evolution (1)

- Ability to change Object shape while keeping its content and identity.
- Not directly addressed by JDO.
- Two flavors:
  - Schema evolution (Versioning)
  - Object Mapping (DB Projection): Retrieving an Object of type A dressed as an Object of another type B.

Object Evolution (2)

- JDO Enhances class A so it is PersistenceCapable.
- AspectJ adds read callback with mapping IA->IB. It is called when JDO reads.
- DynamicProxy delivers content of A with interface of IB.
- DB of Mappers needed.

User wants to read Object A as Object B.



- Three concepts are used:
  - JDO enhancement
  - Aspect extensions
  - Dynamic Proxy

All this manipulation is of course hidden.

```
IB b = (IB)DynamicProxy.newInstance(A, IB);
```

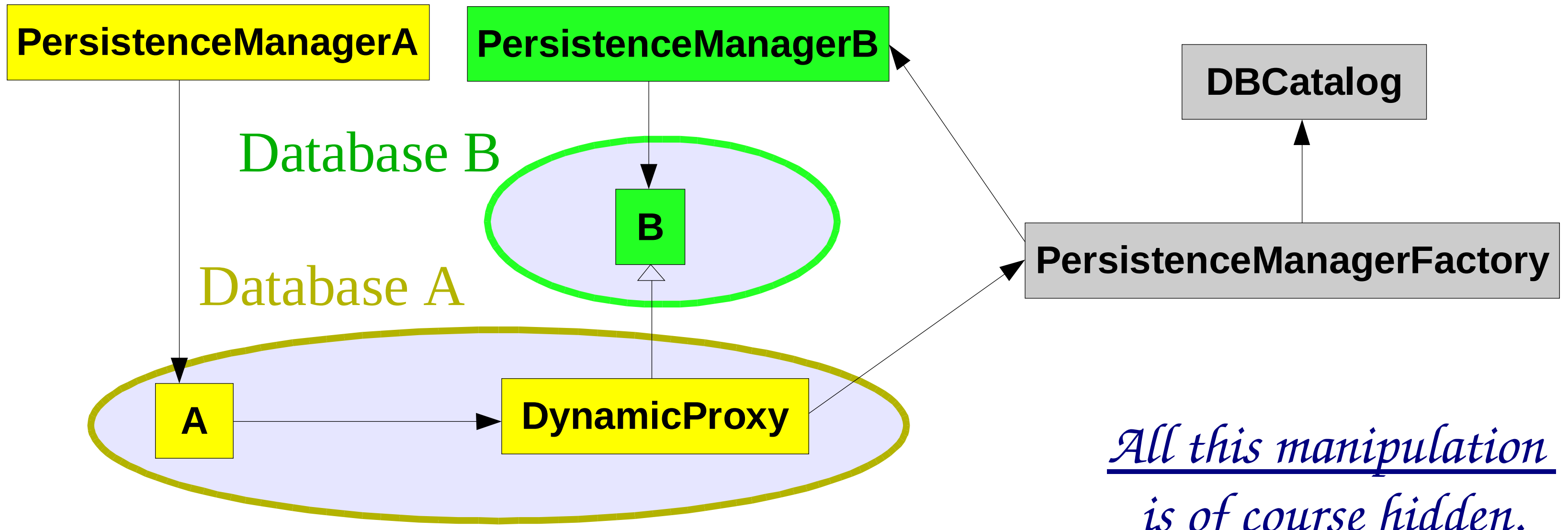
References (1)

- Home references (within the same DB) automatically resolved by JDO.
- Foreign references not resolved by JDO, but:
  - by underlying DB,
  - by Application Framework (EJB,...),
  - By PersistenceManagerFactory and Dynamic Proxy.

References (2)

- DynamicProxy is stored when foreign reference is needed.
- When read, DynamicProxy calls its callback to:
  - request PersistenceManager handling foreign Object,
  - receive that foreign Object,
  - cast itself into it.

Object A references Object B, which resides in different database.



All this manipulation is of course hidden.

Summary

- JDO standard provides suitable foundation of the persistence service for HEP applications.
- Two major characteristics of persistence solutions based on JDO are:
  - Not intrusiveness.
  - Wide range of available JDO implementation, both commercial and free, giving access to all major databases.
- JDO profits from the native databases functionality and performance (SQL queries,...), but presents it to users in a native Java API.

Links

- JDO:
  - Standard: http://java.sun.com/products/jdo
  - Portal: http://www.jdocentral.com
  - TJDO: http://tjdo.sourceforge.net
  - More details talks:
    - http://hrivnac.home.cern.ch/hrivnac/Activities/2002/June/JDO
    - http://hrivnac.home.cern.ch/hrivnac/Activities/2002/November/Indicium
- Indicium: http://hrivnac.home.cern.ch/hrivnac/Activities/Packages/Indicium
- AIDA: http://aida.freehep.org
- Minerva: http://hrivnac.home.cern.ch/hrivnac/Activities/Packages/Minerva
- JACE: http://sourceforge.net/projects/jace
- Author: http://hrivnac.home.cern.ch/hrivnac