Applying Components / Frameworks to the ObjectWeb Persistence Support

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Outline

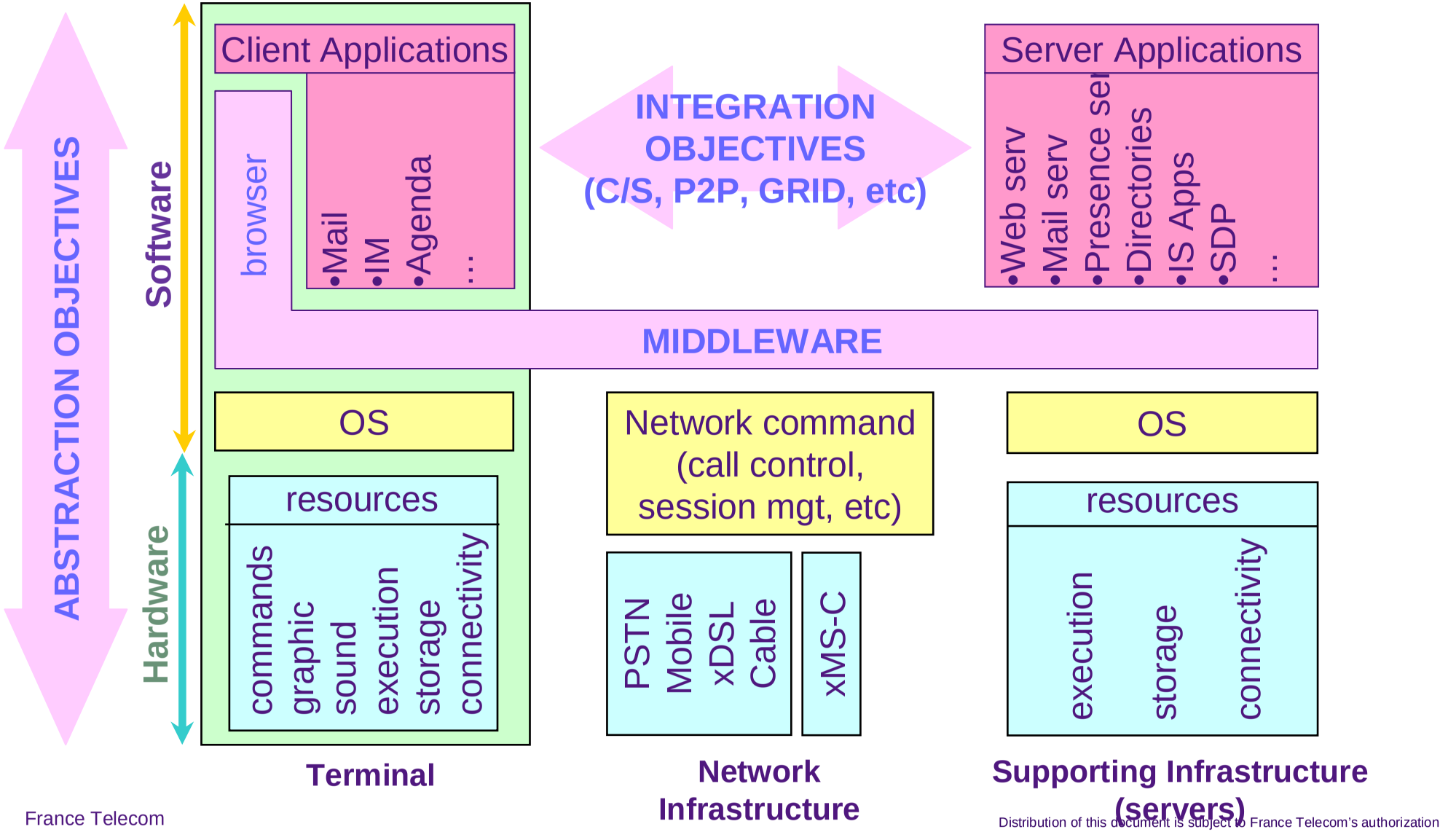
- Rationale for investigating components and frameworks
- Open Source for mutualizing efforts & for confronting real use
- Proposal for middleware organisation
- Application of the approach to persistent objects
  - Building persistent objects
  - Managing persistent objects
- Evaluation of the approach
- Lessons learned
- Conclusion

Rationale for investigating components and frameworks

Application requirements

- **Complexity increases**
  - A large variety of devices to interconnect (HW & SW heterogeneity)
  - Number of such devices gets bigger (billions of objects to interconnect)
  - A mix of many technical constraints to support (security, scalability, safety, adaptability, timing constraints, etc)
- **Constraints are stringent on economical issues (investment and operational expenses)**
- **Requirement for optimizing resources consumption**
  - They may be scarce, they are often expensive
- **Architecture issues become crutial**
  - No software actor has the capability to master the whole response on its own (integration issues are key)
  - Time to market gets more acute(need to reuse software/operational functions)

Roles of middleware (the "big picture")

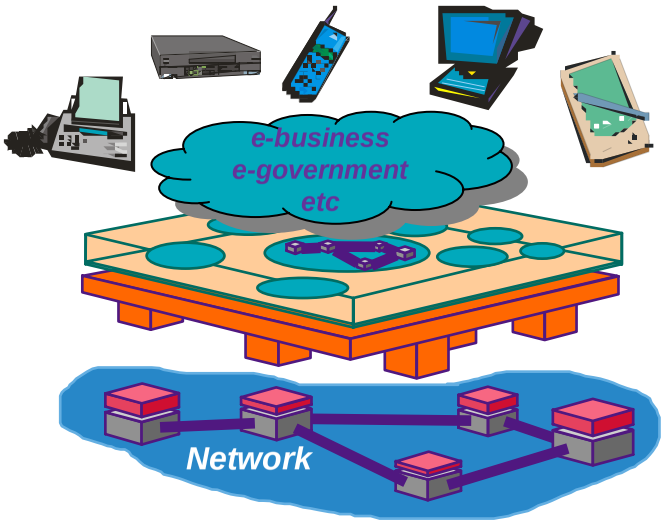


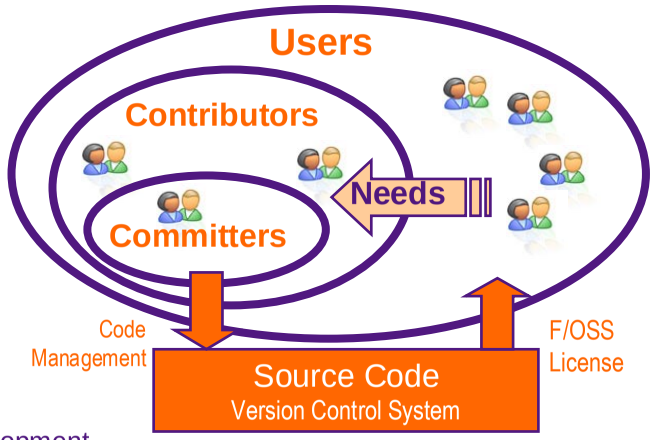
Open Source for mutualizing efforts and for confronting real users

France Telecom
Research & Development

ObjectWeb: gathering energies to tackle with the whole complexity

- **ObjectWeb is a community that aims at producing industrial-class open source middleware**
- **Members are …**
  - Individuals
  - Compagnies (from SMEs upto groups)
  - Universities & public labs





- **Open-Source as a Process**
  - Gathering energies to produce the largest basis for research purpose
  - Vehicule for dissemination
  - Confronting real users to OS products
  - Organising integration

Component-Based Offer

Reusable Technology

Fractal – component model
ASM – bytecode Engineering
Think – component for kernels
Kilim – configuration

Jonathan – ORB framework
Carol – Naming framework

Zeus – XML Data binding
Perseus – persistence framework
JORM – OR Mapping
Medor – OR Query
DODs – OR Mapping
FDB – file database

BSF – Rich-client framework
XMLC – XML/HTML compilation
Apollon – Swing UI generation
Lomboz – Eclipse plug-in for J2EE

Clif– benchmark / load injectors
Rubis – benchmark application
& demonstrators

Middleware COTS

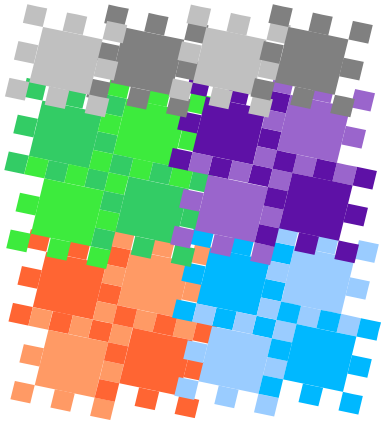
Data Centric
Speedo – JDO/EJB
C-JDBC – JDBC
Octopus – ETL
XQuark - XML

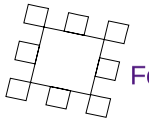
Integration Centric
JORAM – JMS
JOTM – JTA/JTS
Bonita – WfMc
Shark/JAWE – WfMc
OSCAR – OSGi
Sync4j - SyncML

Application Platforms

REUSE – REUSE - REUSE – REUSE - REUSE – REUSE

JOnAS - **J2EE**
OpenCCM – **CORBA**
ProActive **- Grid**
Enhydra **– WEB**





Foundations

Data Access

Application Integration

User Interface / IDE

Quality Control

Standard Specific

Proposal for middleware organisation

Middleware organisation challenge

- **Exo-kernel middleware: a view of middleware architecture**
- **Exo-kernel philosophy**
  - Open set of infrastructure services (adaptability / extensibility as the main focus)
  - Applications should be allowed to choose their supporting abstractions
- **4 strata towards a middleware exo-kernel**
  - Not software layers
  - Design principles (e.g., patterns, complex patterns)
- **Middleware as extensible, configurable component libraries**
- **Underlies ObjectWeb vision of middleware**

Exo-kernel middleware strata (1)

Stratum #1: Components

- Lightweight, reflective component model
- Middle/coarse-grain component: support for component and assembly description (extensible ADL)
- Fine-grain component (lots of instances): tools for code engineering (static and dynamic code generation and adaptation, e.g. AOP and the like)
- Basis for static and on-line system adaptation and evolution

Stratum #2 : Architectural Frameworks

- Pattern-based architectural frameworks for hard recurring issues
- Naming, types and meta-data
- Communications
- Monitoring and failure detection
- Resource management
- Distributed configuration management
- etc

Exo-kernel middleware strata (2)

Stratum #3: System services

- P2P indexing and routing
- Asynchronous communication services
- Transactions & Orchestration
- Configuration and Resource Management
- High-availability support
- Persistence support
- Set-oriented query support (a la SQL)
- etc

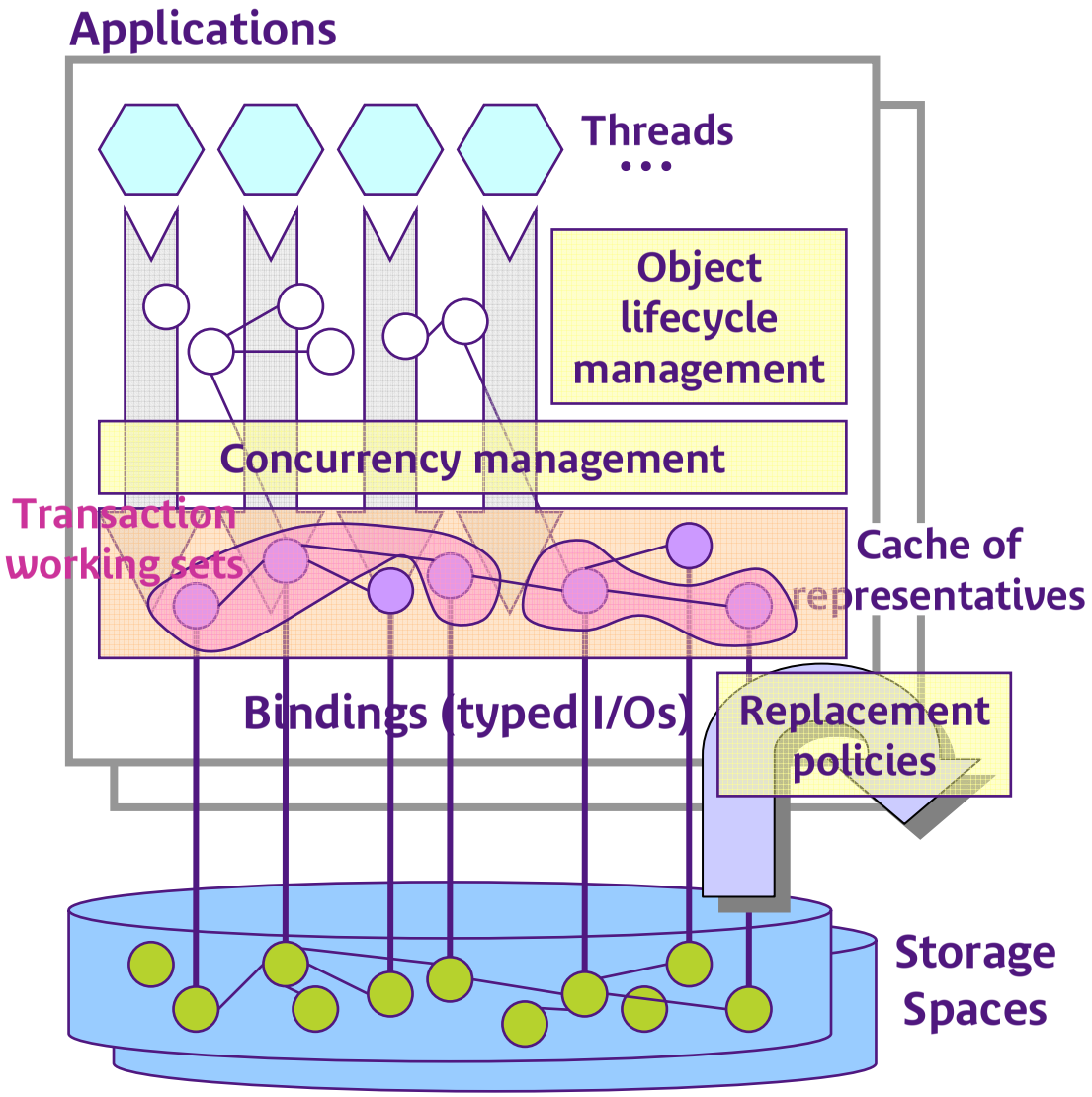
Stratum #4: Personalities

- J2EE
- Web Services
- OGSI
- CORBA
- etc

Application of the approach to persistent objects

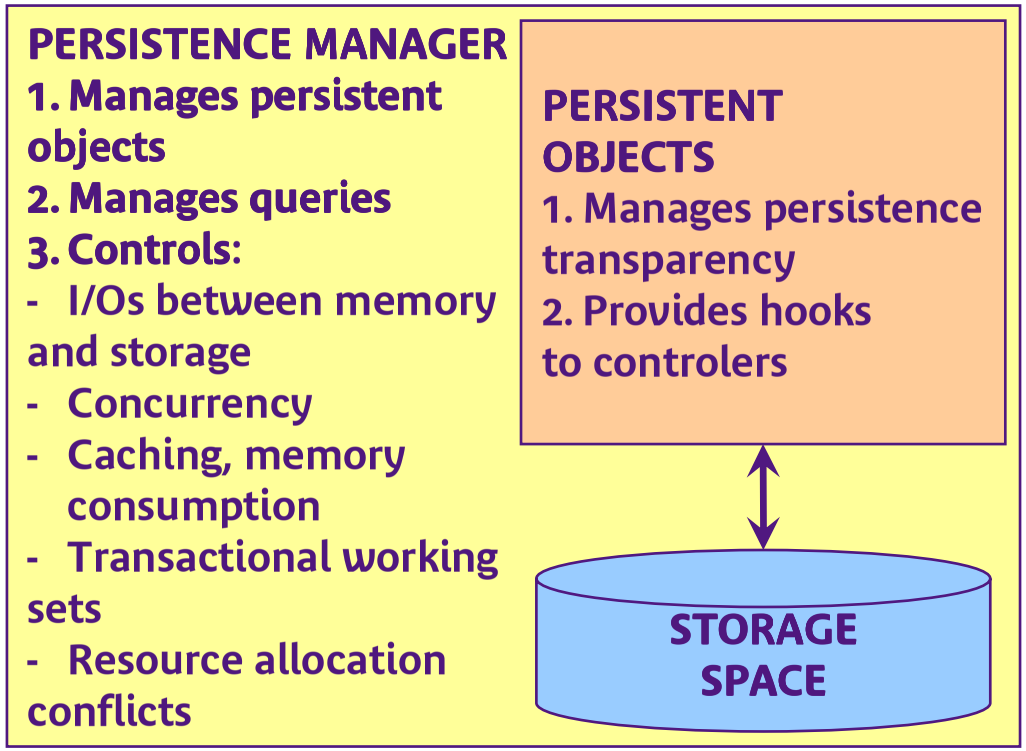
Positioning the problem

- **Provide transparent storage for business entities**
- **Support of mission critical constraints (e.g., tx behaviour)**
- **Manage resource consumption**
- **A complex support in itself**
  - Many functions: typed I/Os, queries, caching, concurrency, transactions, etc
  - Complex interactions
  - Policy related issues
  - An intensive standardisation activity (e.g., EJB, JDO, SDO, etc)



Applying the approach to Java persistence: the **Speedo** case

- **Apply component technologies**
  - Transparency support (code injection/modification through **ASM**)
  - Persistence manager organisation (**Fractal** architecture definition, assembly)
- **Define frameworks**
  - **JORM**: a Mapping framework (storage management supporting typed I/Os)
  - **MEDOR**: Query framework
  - **Perseus**: Persistence framework (relationships between managers of I/Os, concurrency, tx, cache, etc)
- **System service = persistence**
- **Personality support (EJB2, JDO2, EJB3)**



Building persistent objects

Which approach for building persistence capable objects?

- **Need fine-grain code engineering**
  - Sometimes recommended (e.g., JDO promote byte code enhancement)
  - Code manipulation done using **ASM** engine (visitor / decorator patterns)
- **Need to intercept**
  - Accesses to class variables
    - Differenciating read/write accesses
    - Dating latest accesses (time stamping)

    ⇒1. Use of programmed access to variables (JavaBean pattern, e.g., EJB2, Hibernate): alter transparency & may force encapsulation policies

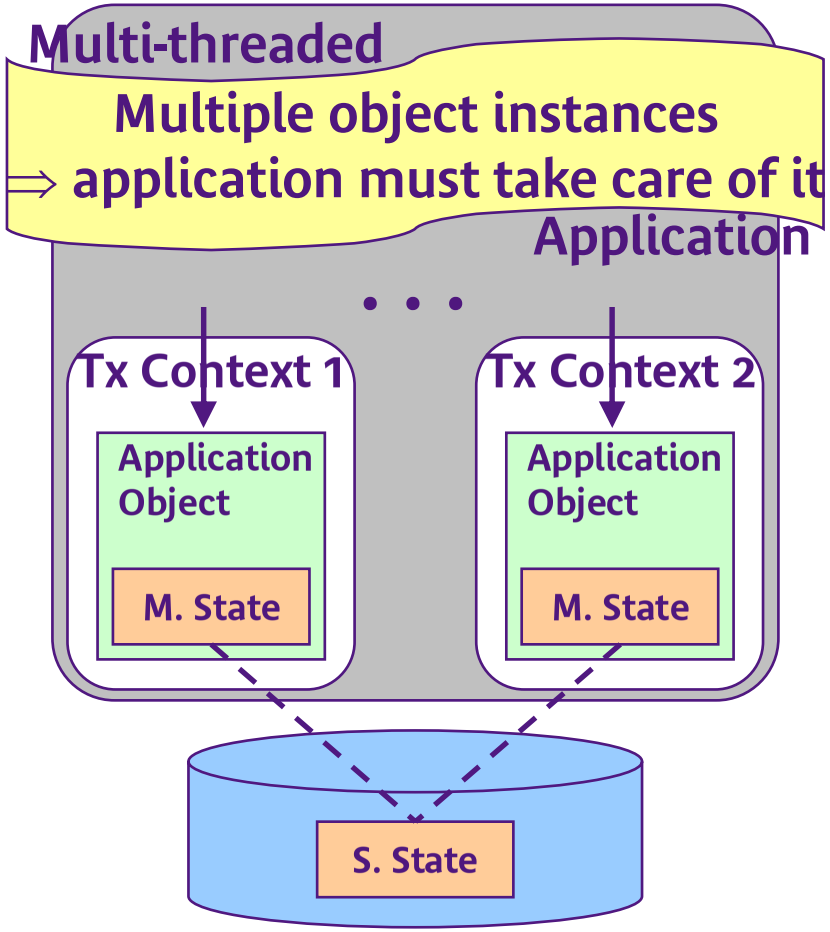
    ⇒2. Use of code manipulation engine (byte code engineering, e.g., ASM)
- **AOP was a candidate but…**
  - Usually too expensive to intercept at this granularity
  - Just support addition of code
  - Cannot reorganize code,cannot support "synthetized point cut"

Transparently manage persistent objects

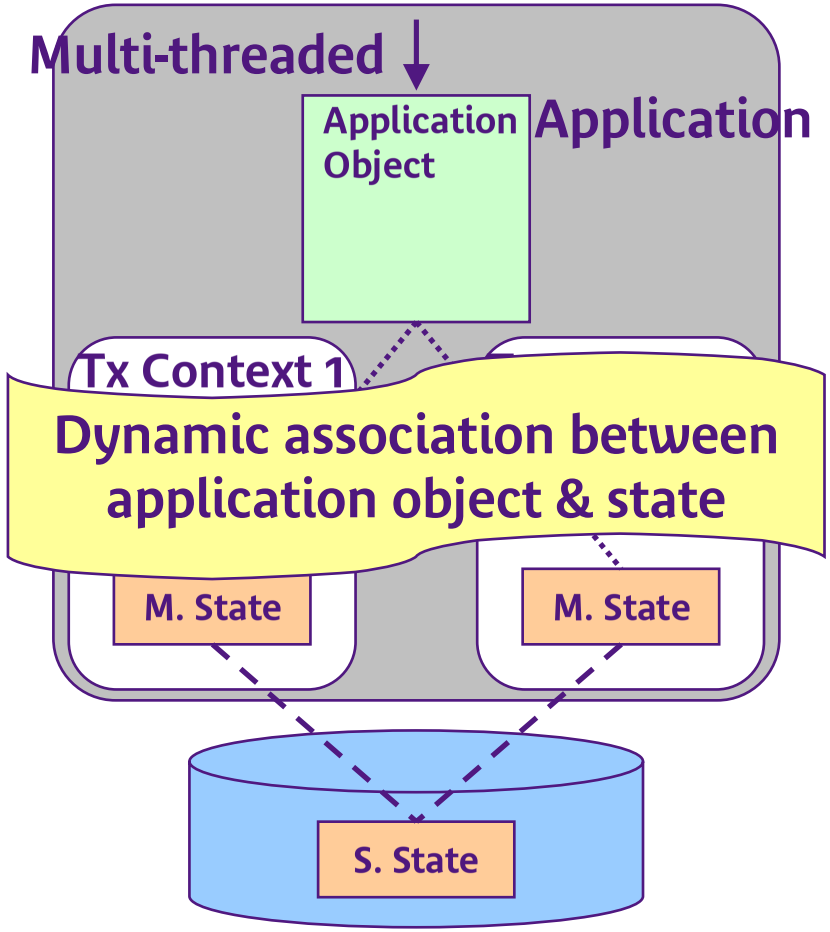
- **Orthogonal persistence: Using persistent objects like any other object at language level**
- **Adding persistence**
  - Some of the variables represent persistent information
  - Need to manage synchronisation/transformation between two different representations
    - Storage object state (further named S. State)
    - Memory object state (further named M. State)
- **Conflicting constraints on memory model**
  - Concurrent accesses require isolation between transactional contexts (different states for the same application object)
  - Full transparency requires a unique application object representing persistent information as long as it stay in memory

Two main solutions to the conflict

Mutiple Application Object Solution (MOA solution)



Single Application Object Solution (SOA solution)



Dealing with the tradeoff

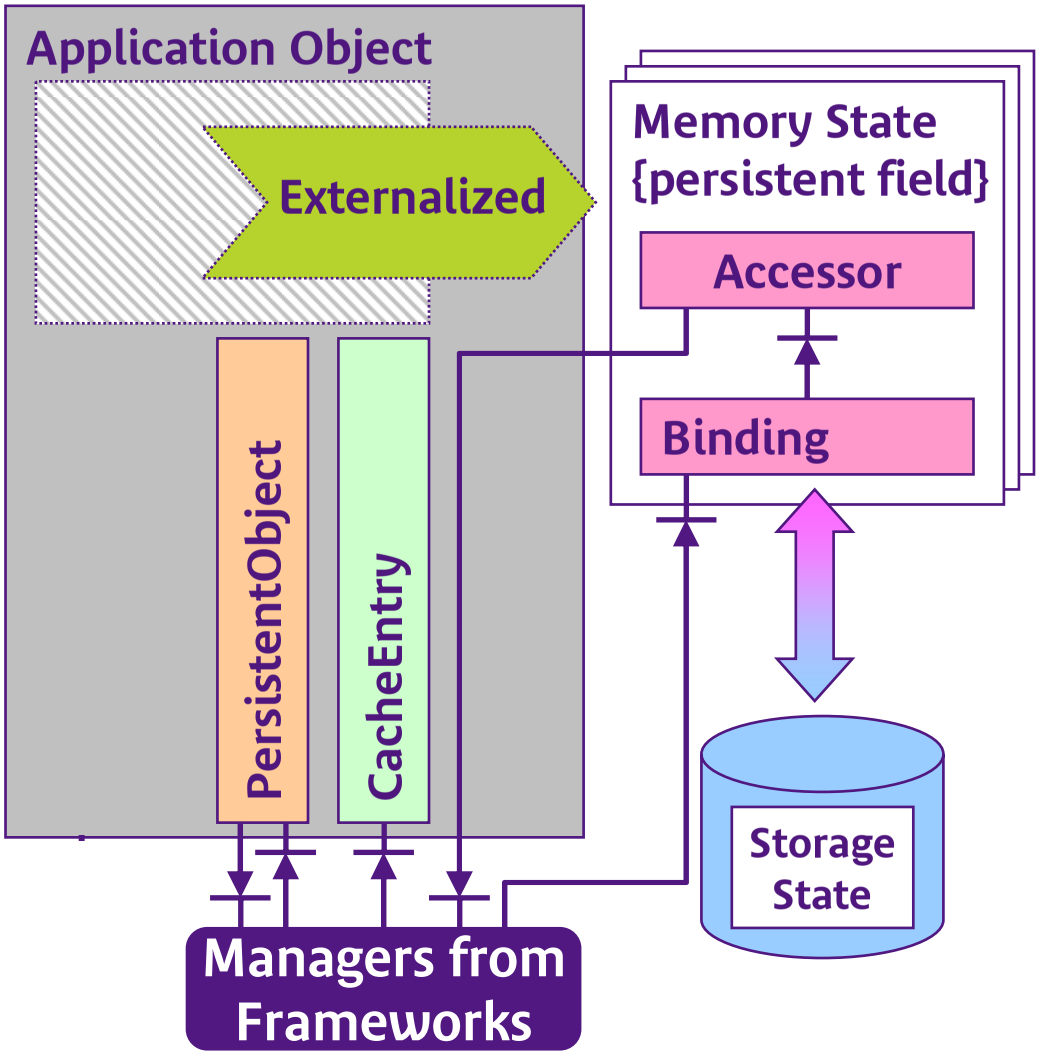
MAO Solution

- Reduce transparency: most of current standards and solutions only mandate this level (i.e., JDO2, EJB3, Hibernate, etc)
- Easy to implement
  - Application object can be mostly reused as is
  - No re-entrance to be managed on memory object instance

SAO Solution (Speedo choice)

- Total transparency wrt the Java programming model
- Requires heavy reorganisation of code
- Give access to advanced memory management (e.g., keep consistent object working set into memory while removing memory states)

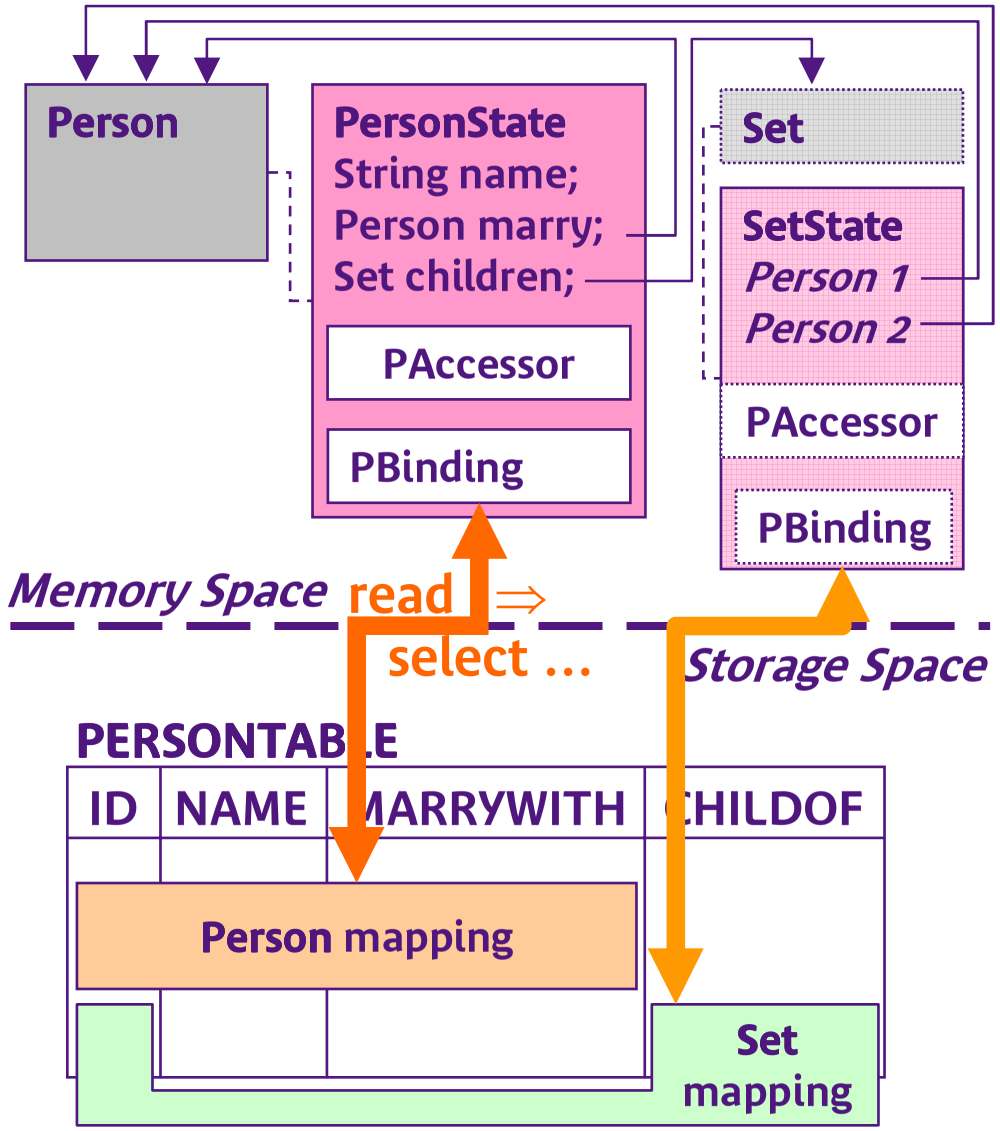
Architecturing persistent objects



- **Using the state pattern for managing M. States**
- **Injecting instance-related code pieces as hooks to other functions**
  - **Binding** for managing I/Os between **M. State** and **S. State**
  - **CacheEntry** for managing in memory object cache and information for replacement policies
  - **PersistentObject** for activating "synthetized point cuts" (intention to read or write attached to methods)
  - **Personality-specific code** as required by personalities (EJB, JDO, etc)

JORM mapping FW: setting up bindings

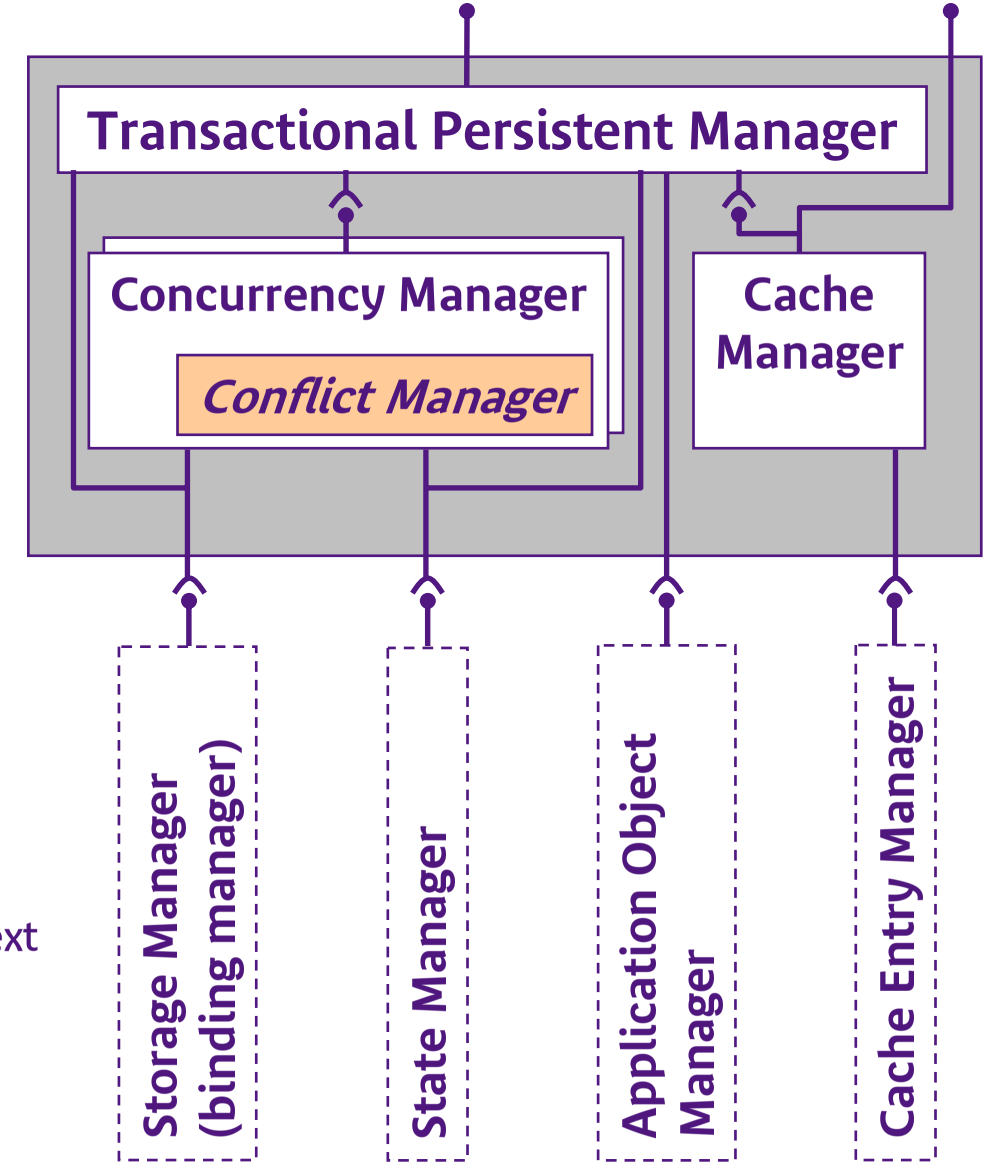
- "export/bind" pattern (same as for distributed object communication)
- Names used for identifiers and references
- Bindings as "stubs"
  - Bind m.state to its storage representative
  - A **name** identifies the storage object bound to the memory object
  - Support APIs to control binding & I/O
    - `bind,unbind,export,unexport`
    - `read,write,exist`
  - Manage translations between memory and storage representations



Managing persistent objects

The Perseus Framework

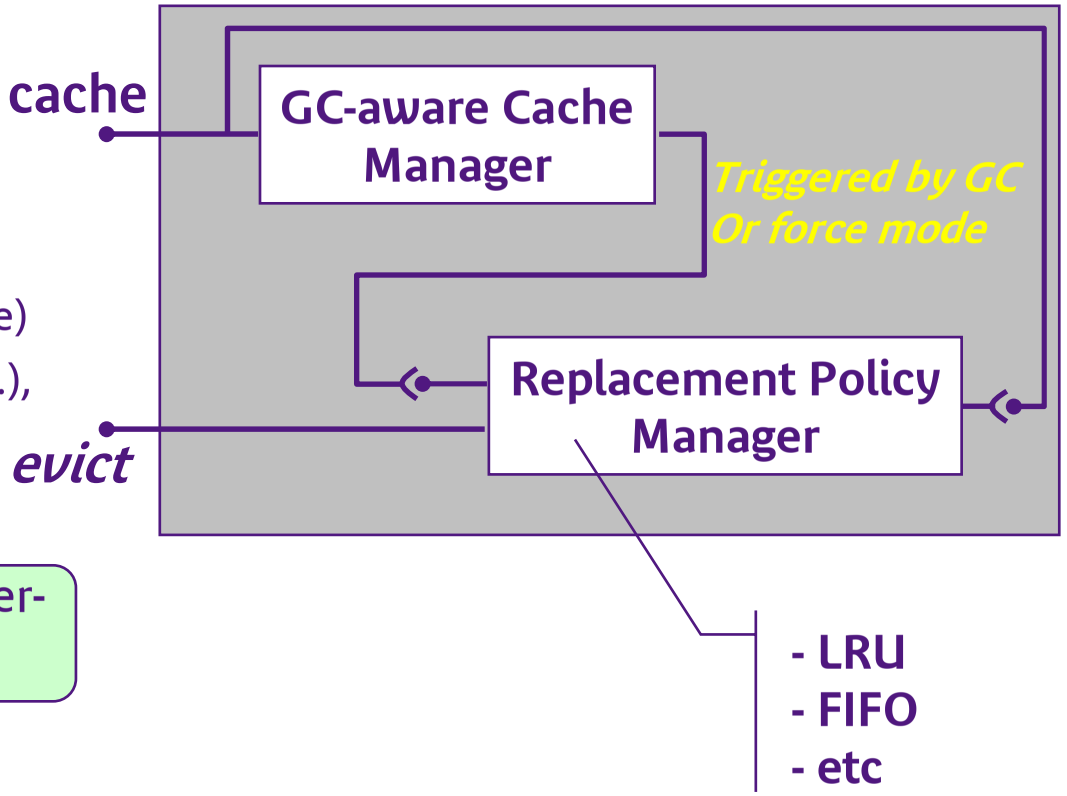
- **Provision of functions to engineer persistent systems**
  - Storage / memory I/Os control
  - Caching management
  - Concurrency management
  - State management
- **Framework applied to dedicated persistent systems**
  - Define a particular organization of functions and their interactions
  - Transactional Persistent System (TPM)
    - Components independent of usage context => pre-assembled into the TPM
    - Dependencies to component that should adapt to usage context



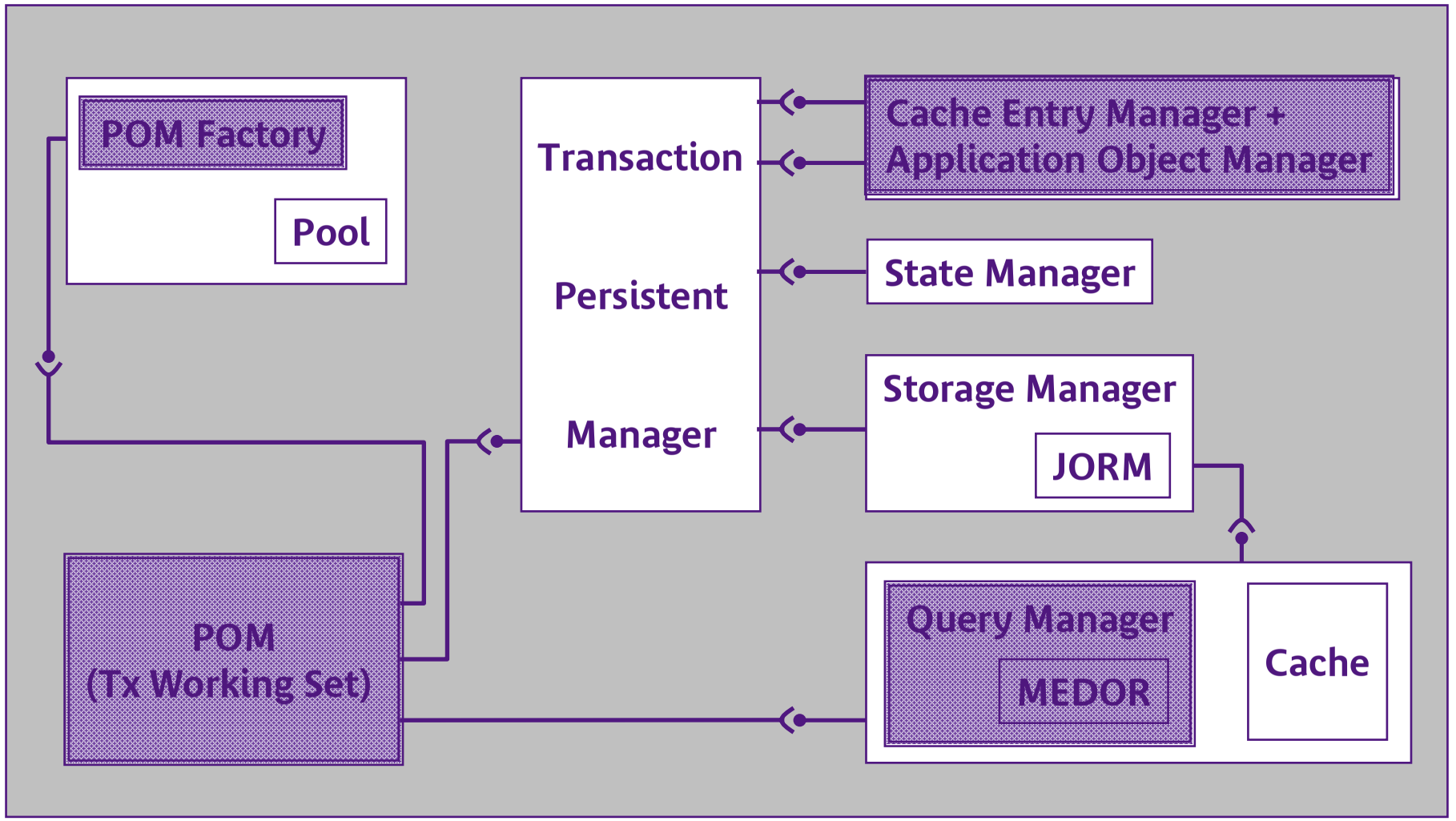
Cache Manager

- **Allow control over memory consumption**
- **Pattern involving two sub-components**
  - Cache (manage association table)
  - Replacement Policy
    - Decide which cache entry to remove)
    - Eviction based on GC (e.g., weak ref.), timer –based, explicit requests, etc
- **Two declinations into Speedo**
  - Application Objects Cache (for inter-transaction caching)
  - Compiled Queries Cache

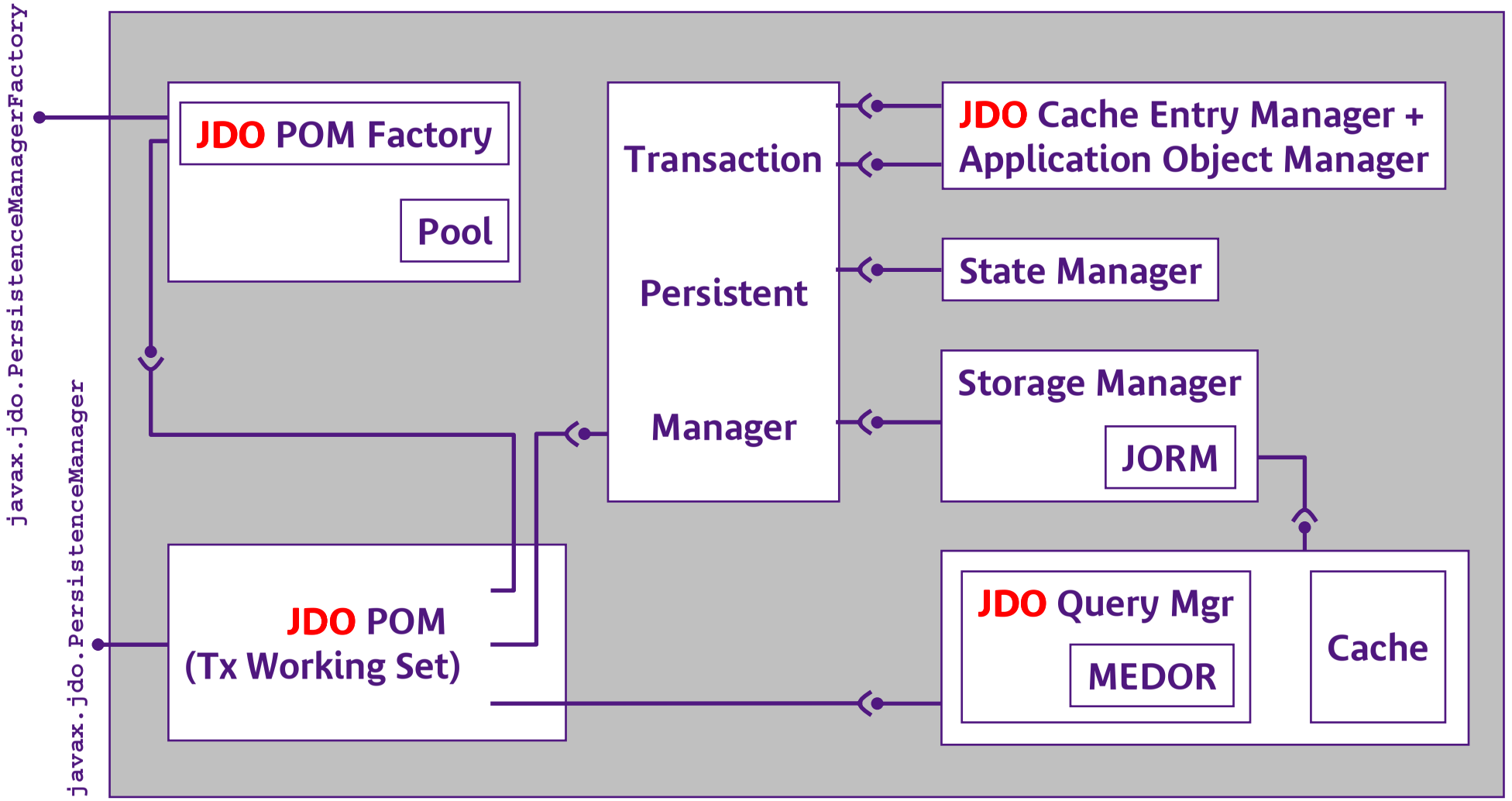
Example of the Application Object Cache



The Speedo Framework



The SpeedoJDO Personality



Evaluation of the approach & Conclusion

Evaluation results

Code Quantity (lines of code)

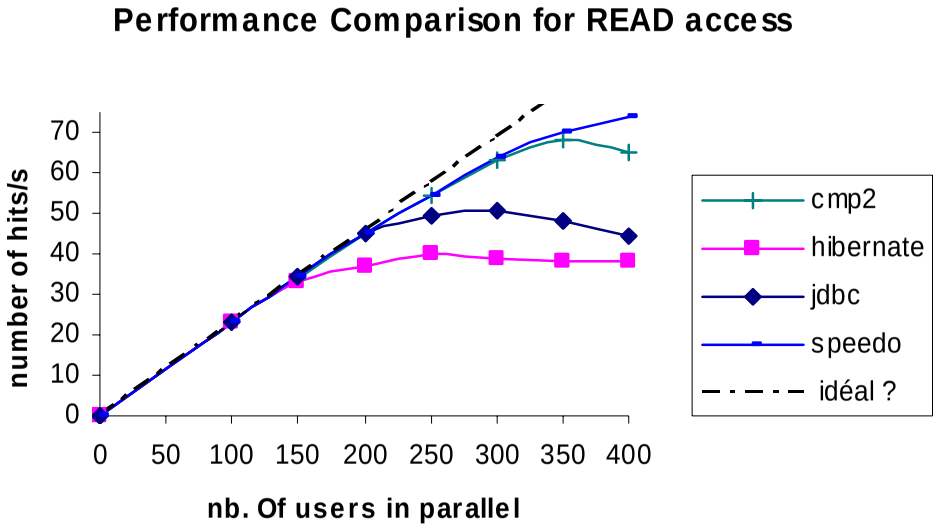
- JORM 62.000
- MEDOR 31.000
- Perseus 16.400
- Speedo 45.000
- Personalities
  - Speedo JDO 18.000
  - JOnAS EJB2 CMP 25.000

Level of Reusing

- JOnAS EJB2 CMP
  - JORM, MEDOR
  - New code 22 %
- Speedo Personalities
  - JORM, MEDOR, Perseus, Speedo
  - New code JDO 10 %
    EJB3 *under dev.*

A few Performance Insights

- EJBOO app: a typical IS application managing product catalogs and orders
- Test case: browsing products and look at details (mainly read access)



Lessons learned

- **Very helpful to have a support for dealing with architecture issues**
- **Designing is a complex task especially with complex software infrastructure**
- **Architecture issues are moving (trade-off is changing from case to case)**
  - Because of constraints that differ from one usage context to another
  - Because it is difficult for architects to find the good trade-off at first time

Conclusion

- **Propose an approach based on components & frameworks**
- **Confront the approach to real problems**
  - Persistence (no distribution yet, except for distributed concurrency)
  - Load injection framework / CLIF (involves distribution)
- **Use Fractal for mastering architecture**
  - Define assembly step by step
  - Identify adaptable sub-components or dependencies
  - Rely on reflexion to exhibit management capabilities (i.e., automated Mbean provisioning)
- **Improve reuse**
  - Clearly identify adherence
  - Remove adherence due to configuration code
- **Performance can be "as good as" non component-based code**

Thank you!!!

To "persistence" folks…

S. Chassande, A. Lefebvre, Y. Bersihand

To Fractal folks…

E. Bruneton, T. Coupaye, B. Dillenseger, N. Rivière, J.B. Stéfani

and many others from Bull, INRIA, IMAG/LSR, Redhat and France Télécom