Caching Across Enterprise Application Tiers

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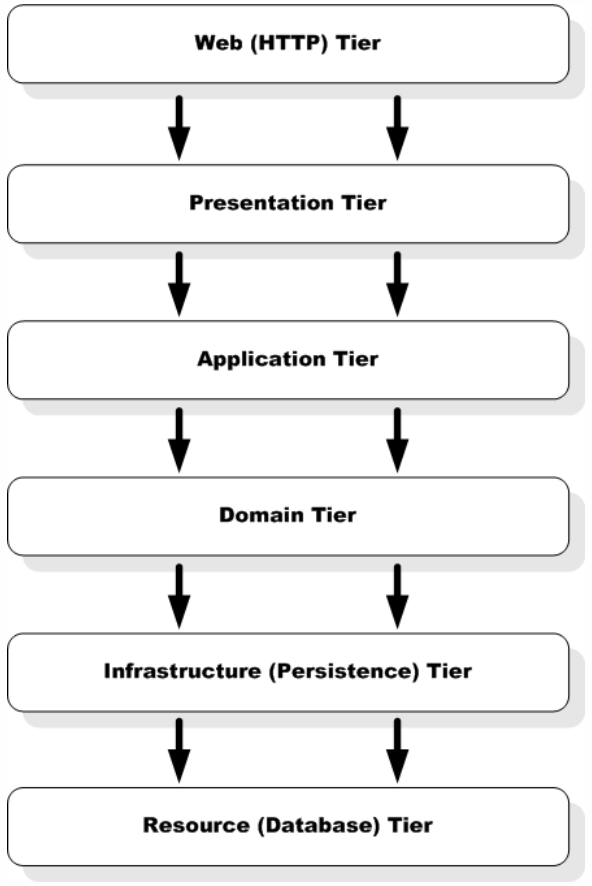
Caching

- **Caching is an essential tool for scaling web applications**
- **The basic concept is to avoid disk access, I/O, CPU power and network traffic – primarily to the backend relational database in modern web applications**
- **With memory becoming a commodity, it makes more and more sense to make intelligent use of caches – the real bottleneck is synchronization across the network**
- **Across enterprise application tiers, caching comes in many forms, some obvious and others not so obvious**

Enterprise Application Tiers

- **Layering is an essential way of managing complexity for non-trivial, team based (often distributed team based in a post-outsourcing world) enterprise applications**
- **Traditional layered architectures (a la J2EE 1.4 design patters) and domain driven design segment enterprise applications into roughly fours tiers**
- **Even a minimalist approach (a ala Seam) utilizes specialist APIs per logical tier**
- **Each of the tiers has caching of its own flavor**



Enterprise Application Tiers

Web (HTTP) Tier

- **Web (HTTP) tier caching is the easiest, most non-invasive and a very effective way of enhancing application performance**
- **You should consider caching static content such as straight HTML, images, PDF files, CSS and JavaScript**
- **You should also consider caching dynamic content that changes only infrequently**
- **The HTTP protocol provides robust support for caching**

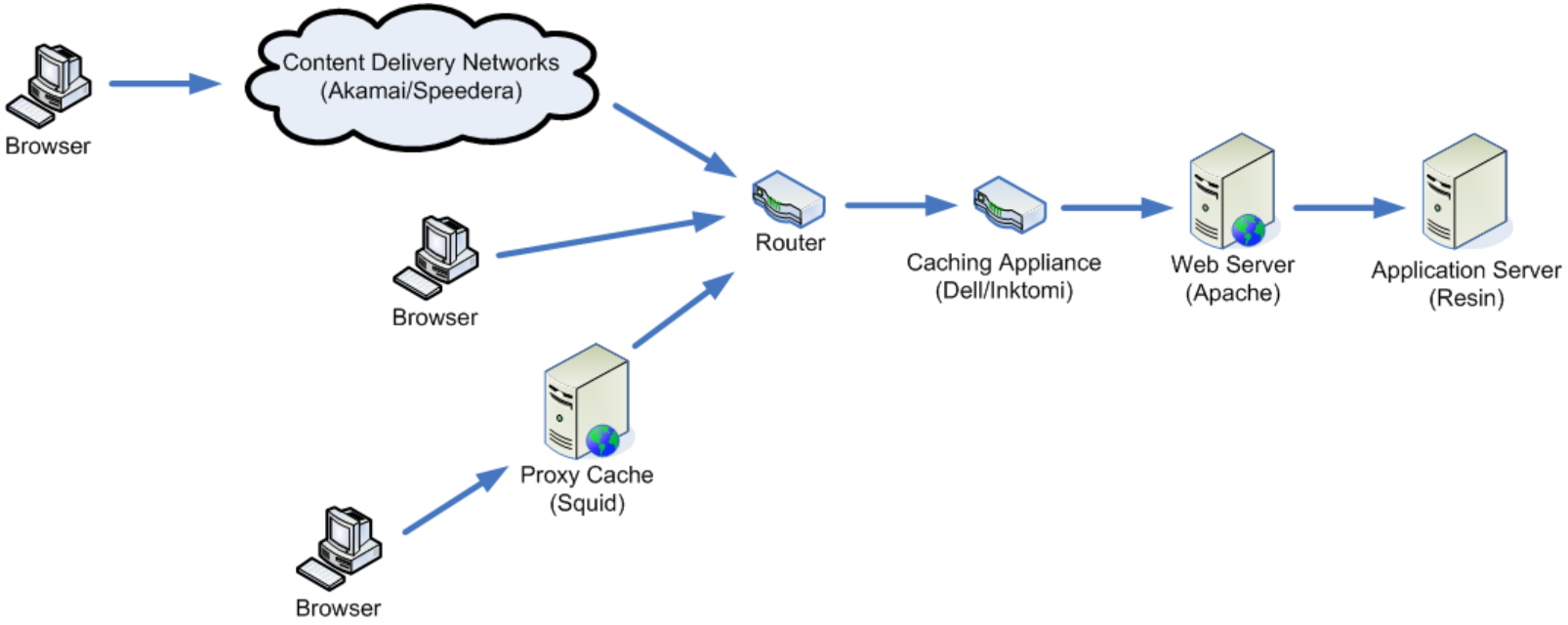
HTTP Caching Header Example

```
HTTP/1.1 200 OK
Date: Fri, 30 Oct 1998 13:19:41 GMT
Server: Apache/1.3.3 (Unix)
Cache-Control: max-age=3600, must-revalidate
Expires: Fri, 30 Oct 1998 14:19:41 GMT
Last-Modified: Mon, 29 Jun 1998 02:28:12 GMT
ETag: "3e86-410-3596fbbc"
Content-Length: 1040
Content-Type: text/html
```

HTTP Caching Headers

HTTP Header	Description
Last-modified	The time the content was last changed
ETag	Unique identifier for a given version of content
Expires	Time when content expires
Cache-Control	Explicit instructions for caching: *public* (definitely cache), *private* (browser cache only), *no-cache* (don't cache), *max-age=n* (set expiration), *s-maxage=n* (set expiration for proxy caches only), *must-revalidate* (no short-cuts for validation), proxy-revalidate (no short-cuts for validation for proxies only)

Web Caching in the Data Center



Apache Web Server Caching

```
### activate mod_expires
ExpiresActive On
### Expire .gif's 1 month from when they're accessed
ExpiresByType image/gif A2592000
### Expire everything else 1 day from when it's last
modified
### (this uses the Alternative syntax)
ExpiresDefault "modification plus 1 day"
### Apply a Cache-Control header to index.html
<Files index.html>
Header append Cache-Control "public, must-revalidate"
</Files>
```

Resin Proxy Caching

```
<resin xmlns="http://caucho.com/ns/resin">
  <cluster id="web-tier">
    <cache entries="16384”
           disk-size="2G"
           memory-size="256M"/>
    <server id="a" address="192.168.0.10"/>
    <host host-name="www.foo.com">
  </cluster>
</resin>
```

Programmatic Cache Control

```
<%@ page session="false" %>
<%! int counter; %>
<%
long now = System.currentTimeMillis();
response.setDateHeader("Expires", now + 15000);
%>
Count: <%= counter++ %>
```

Presentation Tier

- **Rich application state maintenance natural caching mechanism - avoids needless database interaction (a la old school CGI/PERL/PHP or some action-oriented web frameworks)**
- **Correct granularity (scope) is critical for efficient memory use**
- **Servlets/JSP, JSF, CDI (or Spring) provide roughly expanding granularity and abstraction**
- ***Activation/passivation critical for proper memory management***
- ***Most application servers automatically cluster state***

Web Tier Scopes

API	Scopes
Servlet/JSP	Application (Servlet Context), session, request, cookies
JSF	@ApplicationScoped, @SessionScoped, @ViewScoped, @RequestScoped, Flash object
CDI	@ApplicationScoped, @SessionScoped, @ConversationScoped, @RequestScoped (more scopes such as *named conversations* and *window scope* available through CDI plug-ins)
Spring	Singleton, global session, session, request, prototype (Spring Web Flow provides some expanded scopes such as conversations)

Saving State in Servets

```
request.setAttribute(“request-key", “request-value");

HttpSession session = request.getSession(false);

if (session != null) {
  session.setAttribute("session-key",
      "session-value");
}

getServletContext().setAttribute("application-key",
    "application-value");

response.addCookie(
    new Cookie("cookie-key", "cookie-value"));
```

JSF Page with CDI

```
<h:form>
  <h1>Login</h1>
  <h:panelGrid columns="2">
    <h:outputLabel for="username">
        Username:</h:outputLabel>
    <h:inputText id="username"
                 value="#{credentials.username}"/>
    <h:outputLabel for="password">
        Password:</h:outputLabel>
    <h:inputSecret id="password"
                   value="#{credentials.password}"/>
  </h:panelGrid>
  <h:commandButton value="Login“
      action="#{login.login}"/>
</h:form>
```

CDI JSF Model

```
@Named
@RequestScoped
public class Credentials implements Serializable {
    private String username;
    private String password;

    ... Getters and setters ...
}
```

CDI JSF Event Handler

```
@Named @SessionScoped
public class Login implements Serializable {
  @Inject
  private Credentials credentials;
  @Inject
  private UserService userService;
  private User user;

  public String login() {
    user =
        userService.getUser(credentials.getUsername());
    ... Do a password check here...
    return "account.xhtml";
  }

  @Named @Produces @LoggedIn
  public User getCurrentUser() {
    return user;
  }
}
```

CDI Web Tier Producer

```
public class AccountManager implements Serializable {
  @Inject @LoggedIn
  private User user;

  @Inject
  private AccountService accountService;

  @Named
  @Produces
  @SessionScoped
  @SelectedAccount
  public Account getCurrentAccount()
  {
    return accountService.getAccount(
        user.getUsername());
  }
}
```

JSF Workflow (Step 1)

```
<h1>From Bank Account</h1>
<h:panelGrid columns="2">
  <h:outputLabel for="fromBank">
      Bank Name:</h:outputLabel>
  <h:inputText id="fromBank"
      value="#{transfer.fromBank}"/>
  <h:outputLabel for="fromAccount">
    Account Number:
  </h:outputLabel>
  <h:inputText id="fromAccount“
               value="#{transfer.fromAccount}"/>
</h:panelGrid>
<h:commandButton value="Start“
                 action="#{transfer.enterToBank}"/>
```

JSF Workflow (Step 2)

```
<h1>To Bank Account</h1>
<h:panelGrid columns="2">
  <h:outputLabel for="fromBank">From Bank:</h:outputLabel>
  <h:outputText id="fromBank"
      value="#{transfer.fromBank}"/>
  <h:outputLabel for="fromAccount">
    From Account:
  </h:outputLabel>
  <h:outputText id="fromAccount“
                value="#{transfer.fromAccount}"/>
  <h:outputLabel for="toBank">Bank Name:</h:outputLabel>
  <h:inputText id="toBank" value="#{transfer.toBank}"/>
  <h:outputLabel for="toAccount">
    Account Number:
  </h:outputLabel>
  <h:inputText id="toAccount"
      value="#{transfer.toAccount}"/>
</h:panelGrid>
<h:commandButton value="Next" action="enter_amount.xhtml"/>
```

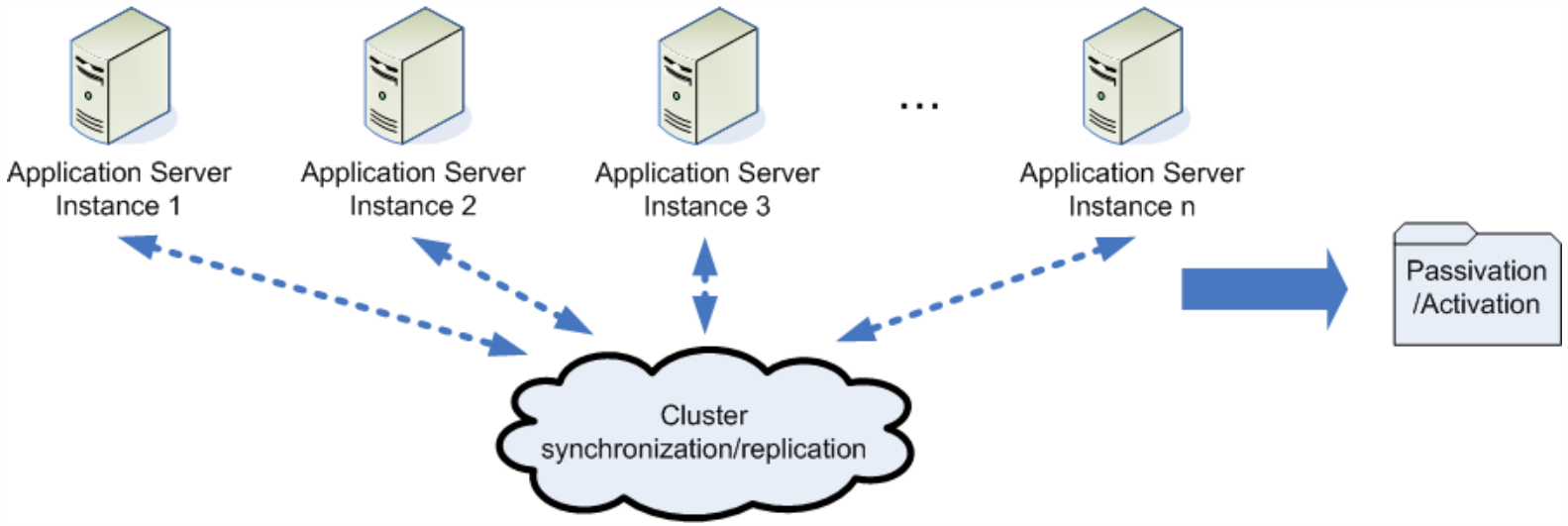
JSF Workflow (Step 3)

```
<h1>Transfer Amount</h1>
<h:panelGrid columns="2">
  <h:outputLabel for="fromBank">From Bank:</h:outputLabel>
  <h:outputText id="fromBank“ value="#{transfer.fromBank}"/>
  <h:outputLabel for="fromAccount">
      From Account:</h:outputLabel>
  <h:outputText id="fromAccount“
      value="#{transfer.fromAccount}"/>
  <h:outputLabel for="toBank">From Bank:</h:outputLabel>
  <h:outputText id="toBank" value="#{transfer.toBank}"/>
  <h:outputLabel for="toAccount">To Account:</h:outputLabel>
  <h:outputText id="toAccount“ value="#{transfer.toAccount}"/>
  <h:outputLabel for="amount">Amount:</h:outputLabel>
  <h:inputText id="amount" value="#{transfer.amount}"/>
</h:panelGrid>
<h:commandButton value="Finish“ action="#{transfer.transfer}"/>
```

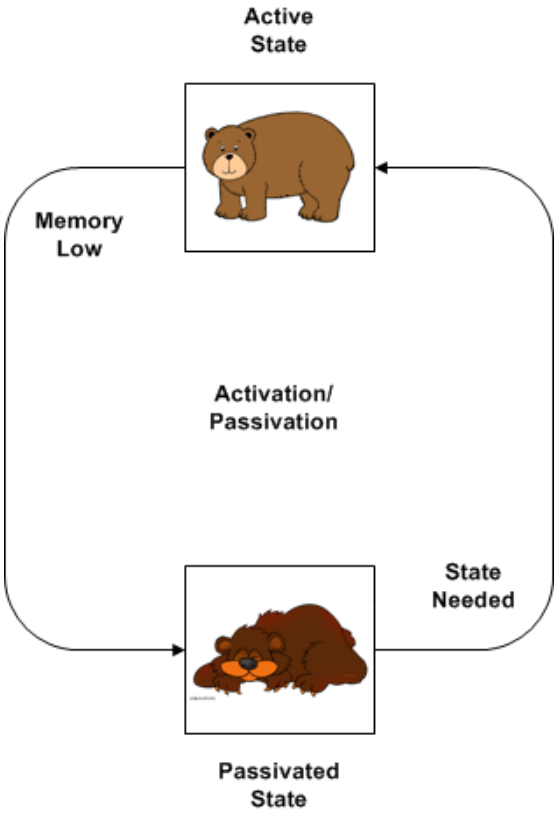
CDI Conversations

```
@Named @ConversationScoped
public class Transfer implements Serializable {
  @Inject
  private transient AccountService accountService;
  @Inject
  private Conversation conversation;
  private String fromBank;
  private String fromAccount;
  private String toBank;
  private String toAccount;
  private double amount;

  ... Getters and setters ...

  public String enterToBank() {
    conversation.begin();
    return "enter_to_bank.xhtml";
  }

  public String transfer() {
    accountService.transfer(toBank, toAccount, fromBank,
        fromAccount, amount);
    conversation.end();
    return "account.xhtml";
  }
}
```

Server State Behind the Scenes



Activation/Passivation



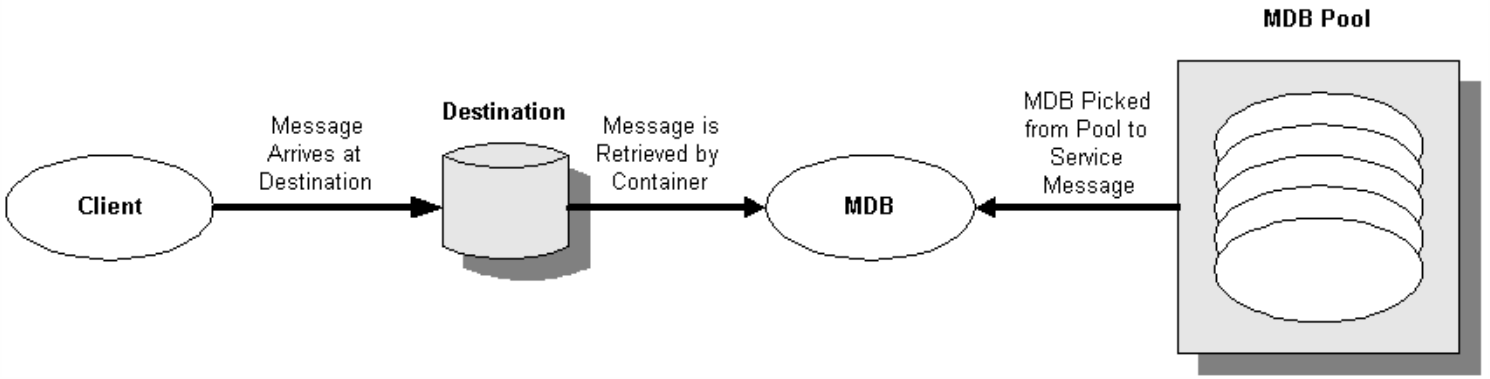
Application Tier

- **CDI's (or Spring's) scoping, context and state management capabilities can be used in the application tier as well**
- **EJB stateless beans/MDB offer pooling**
- **EJB stateful beans offer better support for activation/ passivation as well as persistence caches**
- **EJB singleton beans offer better support for concurrency**
- **Terracotta for Spring provides EJB-like clustering**
- ***We'll talk about direct distributed caching tools later***

Message-Driven Bean

```
@MessageDriven(activationConfig = {
    @ActivationConfigProperty(
        propertyName="destinationName",
        propertyValue="jms/OrderBillingQueue")})
public class OrderBillingMDB implements MessageListener {
  ...
  public void onMessage(Message message) {
    try {
      ObjectMessage objectMessage = (ObjectMessage) message;
      Order order = (Order) objectMessage.getObject();

      try {
        bill(order);
        notifyBillingSuccess(order);
        order.setStatus(OrderStatus.COMPLETE);
      } catch (BillingException be) {
        notifyBillingFailure(be, order);
        order.setStatus(OrderStatus.BILLING_FAILED);
      } finally {
        update(order);
      }
    } catch (Exception e) {
      e.printStackTrace();
    }
  }
  ...
}
```

Message-Driven Bean Pooling



EJB Stateful Bean

```
@Stateful
public class BidderAccountCreatorBean
    implements BidderAccountCreator {
  @Resource(name="jdbc/ActionBazaarDS")
  private DataSource dataSource;
  private Connection connection;
  ...
  @PostConstruct @PostActivate public void openConnection() {
    ...
    connection = dataSource.getConnection();
    ...
  }
  ...
  @PrePassivate @PreDestroy public void cleanup() {
    ...
    connection.close();
    ...
  }
}
```

EJB Singleton Bean

```
@Singleton @Startup
public class SharedDataBean {
  @PersistenceContext
  private EntityManager entityManager;
  private Data data;

  @PostConstruct private void init() {
    data = entityManager.find(Data.class, 1);
  }

  @PreDestroy private void destroy() {
    entityManager.merge(data);
  }

  @Lock(WRITE) public void setData(Data data) {
    this.data = data;
  }

  @Lock(READ) public Data getData() {
        return data;
  }
}
```

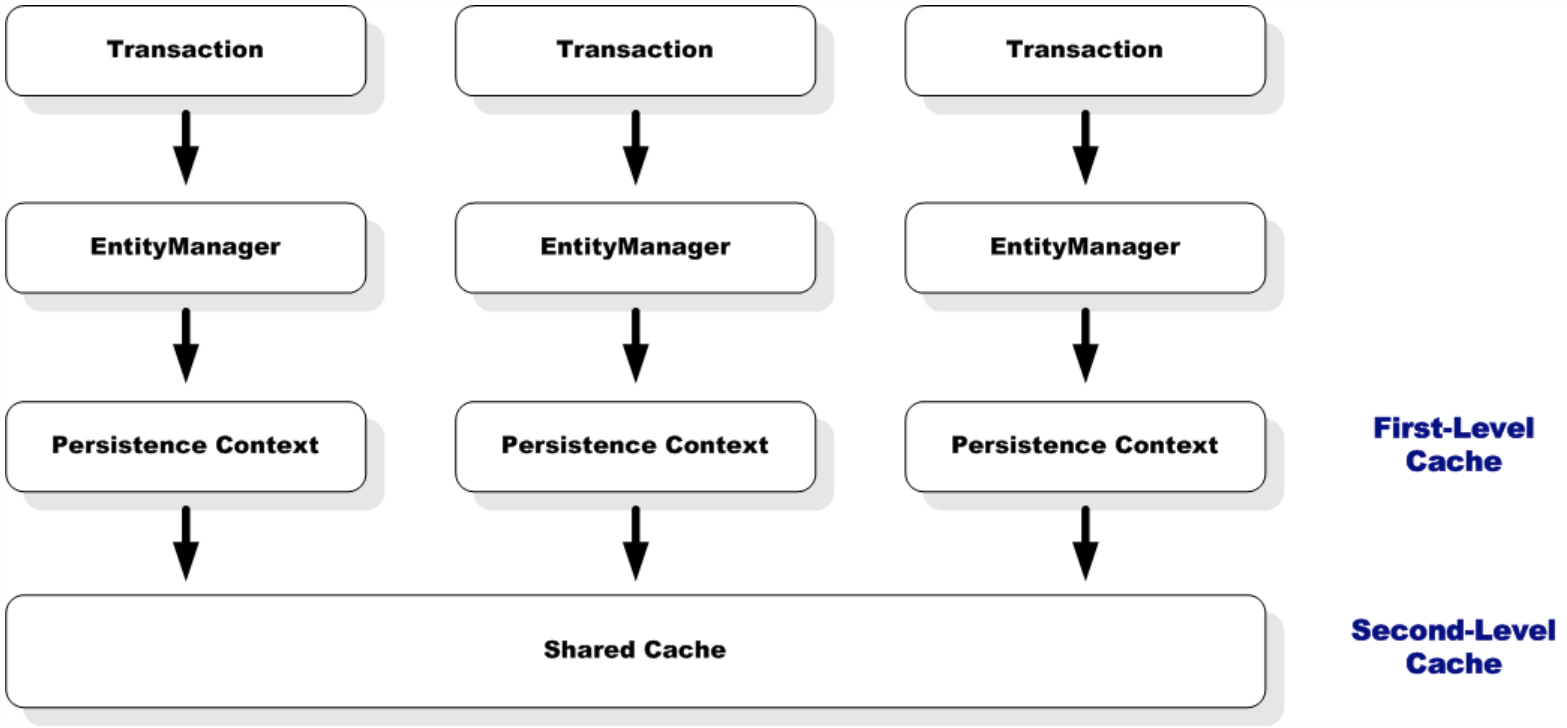
Extended Persistence Context

```
@Stateful
public class ShoppingCartBean implements ShoppingCart {
  @PersistenceContext(type=EXTENDED)
  private EntityManager entityManager;
  private Order order;
  ...
  public void createOrder() {
    order = new Order();
    ...
    entityManager.persist(order);
  }

  public void addToCart(Item item) {
    order.addItem(item);
  }
  ...
}
```

Domain/Infrastructure Tier

- **The persistence tier is an ideal point for caching since caching can be seen as a parallel concern to relational database centric persistence – particularly with ORM**
- **JPA 2 supports both transactional (1st level) and shared (2nd level) caching**
- **Persistence tier caching is well suited for domain objects with high read/write ratio**
- **Second level caching is largely an ORM adapter over existing distributed caches**

JPA 2 Caching



JPA Cache Configuration

```
<persistence xmlns="http://java.sun.com/xml/ns/persistence"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="http://java.sun.com/xml/ns/persistence
    http://java.sun.com/xml/ns/persistence/persistence_2_0.xsd"
    version="2.0">
  <persistence-unit name="AcmeBankDb">
    ...
    <shared-cache-mode>ENABLE_SELECTIVE</shared-cache-mode>
    <properties>
      ...
      <property name="hibernate.cache.provider_class"
          value="org.hibernate.cache.SingletonEhCacheProvider"/>
      <property name="hibernate.cache.use_second_level_cache"
          value="true"/>
      <property name="hibernate.cache.use_query_cache"
          value="true"/>
    </properties>
  </persistence-unit>
</persistence>
```

JPA Cache Configuration

```
@Entity
@Cacheable
@Cache(usage =
    CacheConcurrencyStrategy.NONSTRICT_READ_WRITE)
@Table(name = "CATEGORIES")
public class Category implements Serializable {
  @Id @GeneratedValue
  private Long id;
  private String name;
  @ManyToOne
  @JoinColumn(name = "PARENT_ID")
  private Category parent;
  @OneToMany(mappedBy = "parent")
  private Set<Category> subcategories;
  ...
}
```

JPA Cache Control API

```
public interface Cache {
  public boolean contains(Class clazz, Object key);
  public void evict(Class clazz, Object key);
  public void evict(Class clazz);
  public void evictAll();
}
```

Resource (Database) Tier

- **Database/resource connection pooling essential caching technique for any serious production application**
- **Most application servers will also provide prepared statement caching as part of the connection pool**
- **Tune both connection pool size and prepared statement cache size**
- **You can also do statement caching on the database end – talk to your DBA** 

Distributed Caches

- **Distributed caches are a key infrastructure piece for any caching or clustering solution**
- **They can be used directly in the application or persistence tier where they are needed (a relative rarity)**
- **It is a crowded field with many open source and commercial options**
- **Tools come in a variety of clustering, replication, transactionality, robustness and administrative features (cost and support are all over the map too)**

JCache (JSR-107) API Example

```
@Inject Cache cache;
...
cache.put(key, value);
...
String data = (String) cache.get("my-data");
```

Caching as an Aspect

```
public class DefaultBidDao implements BidDao {
  @Resource(name="jdbc/AcmeBankDB")
  private DataSource datasource;
  ...
  @Cache
  public Bid getBid(Long id) {
    ...
  }

  @FlushCache
  public void updateBid(Bid bid) {
    ...
  }
  ...
}
```

Java Distributed Caches

- **Coherence**
- **Terracotta**
- **GigaSpaces**
- **Infinispan/JBossCache**
- **EHCache**
- **JCS**
- **SwarmCache**
- **OSCache**

Summary

- **Caching an important optimization technique for vast majority of applications**
- **Each enterprise application tier is rife with opportunities for caching**
- **Some caching techniques are obvious and natural, others require more careful analysis**
- **Some are transparent while others are somewhat invasive**
- **Variety of options to match application needs**

References

- **Caching in HTTP,** http://www.w3.org/Protocols/rfc2616/rfc2616-sec13.html
- **Apache Caching Module,** http://httpd.apache.org/docs/2.0/mod/mod_expires.html
- **Resin Proxy Cache,** http://www.caucho.com/resin/admin/http-proxy-cache.xtp
- **Oracle Coherence,** http://www.oracle.com/technetwork/middleware/coherence/overview/index.html

References

- **Terracotta, http://www.terracotta.org**
- **GigaSpaces, http://www.gigaspaces.com**
- **Infinispan/JBossCache, http://www.jboss.org/infinispan**
- **EHCache, http://ehcache.org**
- **JCS, http://jakarta.apache.org/jcs/index.html**
- **SwarmCache, http://swarmcache.sourceforge.net**
- **OSCache, http://www.opensymphony.com/oscache/**

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