EnterpriseDB®

Scaling Hibernate Applications with Postgres

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JbossWord 2009
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Objectives of this Session

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- To show some the typical scaling techniques used by Postgres
- To demonstrate how Hibernate can leverage those techniques
- To highlight some issues using Hibernate with Postgres and how to overcome them

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Who Are We?

EnterpriseDB®

Bruce Momjian
Sr Database Architect
EnterpriseDB Corporation

Jim Mlodgenski
Chief Architect
EnterpriseDB Corporation

About EnterpriseDB

- Award-winning open source database company
- World's largest concentration of PostgreSQL expertise
- Headquartered in Westford, MA, USA
- 300+ customers including Sony, FTD, hi5 Networks, NetApp, FAA, LexisNexis, St. Jude Children's Hospital
- 35+ partners including Red Hat, IBM, Compiere

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About Hibernate

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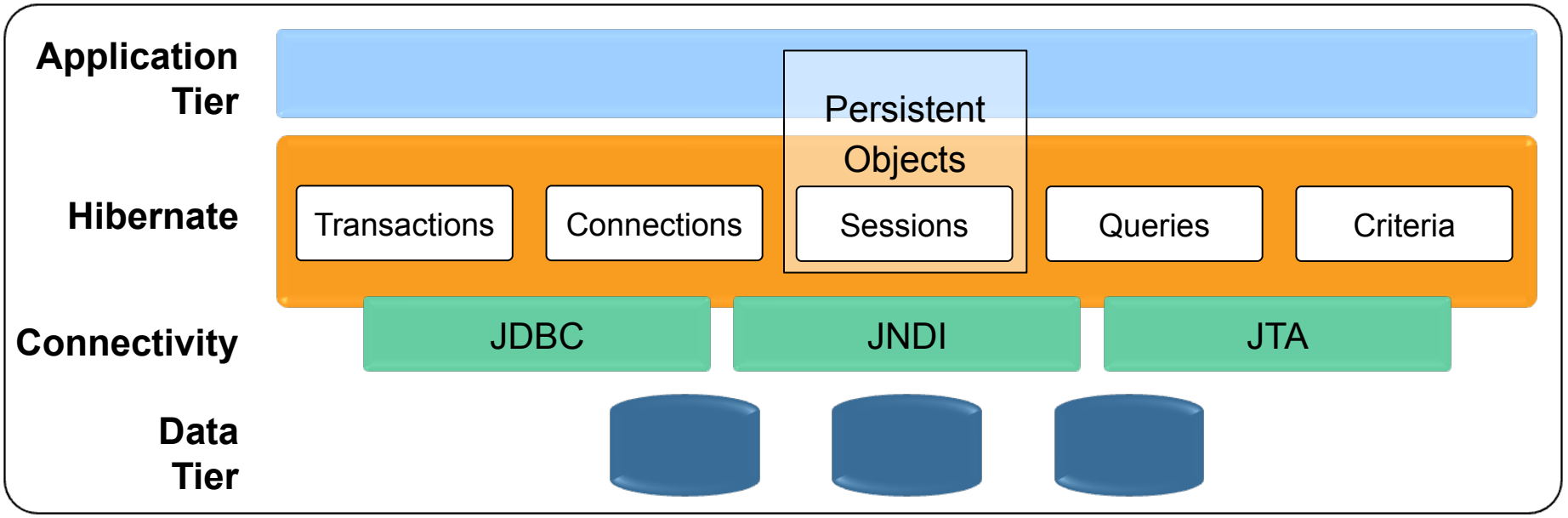
- Object-relational persistence framework
- Supports collections, object relations, composite types
- HQL query language, caching, JMX support



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About PostgreSQL and Postgres Plus

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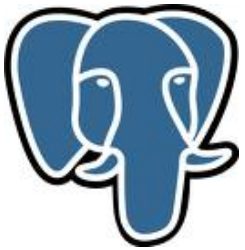

- Powerful open source object-relational database
- 20+ years of global community development
- Enterprise-class functionality

Fully ACID compliant	Views
Foreign Keys	Triggers
Joins	Stored Procedures (multiple languages)
Multi-version Concurrency Control	Point-in-Time Recovery
Tablespaces	Asynchronous Replication
Nested transactions	Heap Only Tuples
Online/hot backups	Write-ahead logging (fault tolerance)

- Mature Hibernate dialect

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Common Scaling Problems

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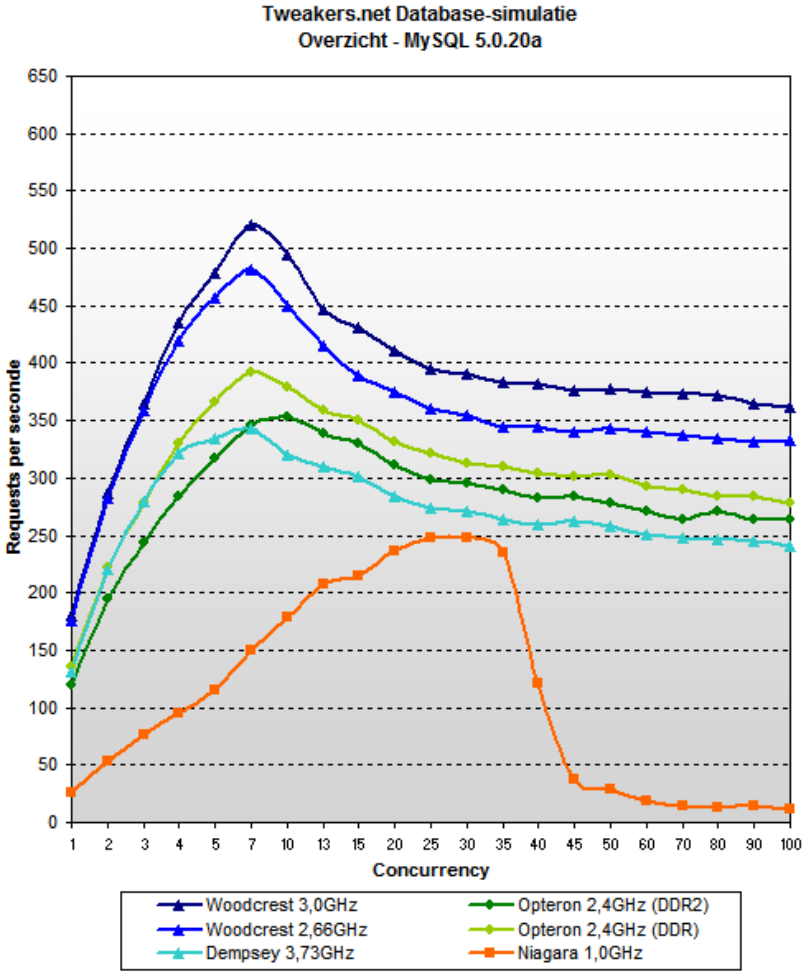
- Application Server overloaded
- Database overloaded
- Slow database queries

Developers:
"this database is a dog"

DBAs:
"quit sending all that inefficient SQL"



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Scaling Database Applications

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Three popular scaling strategies:

1. Add more hardware to scale horizontally or vertically
2. Improve the performance of individual operations
   - The faster an operation completes, the sooner the system is available for other work
3. Eliminate non-critical operations to reserve resources
   - Reduce the overhead of business logic execution to keep resources available for handling user loads

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What's Hibernate?!?!

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- Many database administrators have never heard of it
  - "Isn't that what bears do?"
- When they do hear of it, they rarely like it
- The business and development benefits are not always readily apparent to database administrators

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Fetching Strategies

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- When loading objects with a parent child relationship, there are a large number of selects performed on the database
  - The N+1 problem

```
LOG:  execute S_1: BEGIN
LOG:  execute <unnamed>: select fdgroup0_.fdgrp_cd as fd...
DETAIL:  parameters: $1 = '0100'
LOG:  execute <unnamed>: select fooddeses0_.fdgrp_cd as ...
DETAIL:  parameters: $1 = '0100'
LOG:  execute S_2: COMMIT
LOG:  execute S_1: BEGIN
LOG:  execute <unnamed>: select fdgroup0_.fdgrp_cd as fd...
DETAIL:  parameters: $1 = '0100'
LOG:  execute <unnamed>: select fooddeses0_.fdgrp_cd as ...
DETAIL:  parameters: $1 = '0100'
LOG:  execute S_2: COMMIT
DETAIL:  parameters: $1 = '0100'
LOG:  execute <unnamed>: select fooddeses0_.fdgrp_cd as ...
DETAIL:  parameters: $1 = '0100'
LOG:  execute S_2: COMMIT
```

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Fetching Strategies (cont.)

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- In many cases, the default fetching settings of “lazy” and “select” work well
  - When working with related tables that have many child records that are needed, this is inefficient

```
@Entity
@Table(name = "fd_group")
public class FdGroup implements Serializable {
    private static final long serialVersionUID = 1L;
    @Id
    @Basic(optional = false)
    @Column(name = "fdgrp_cd")
    private String fdgrpCd;
    …
    @OneToMany(cascade = CascadeType.ALL, mappedBy = "fdgrpCd")
    @org.hibernate.annotations.Fetch(org.hibernate.annotations.FetchMode.JOIN)
    private Collection<FoodDes> foodDesCollection;
```

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Caching

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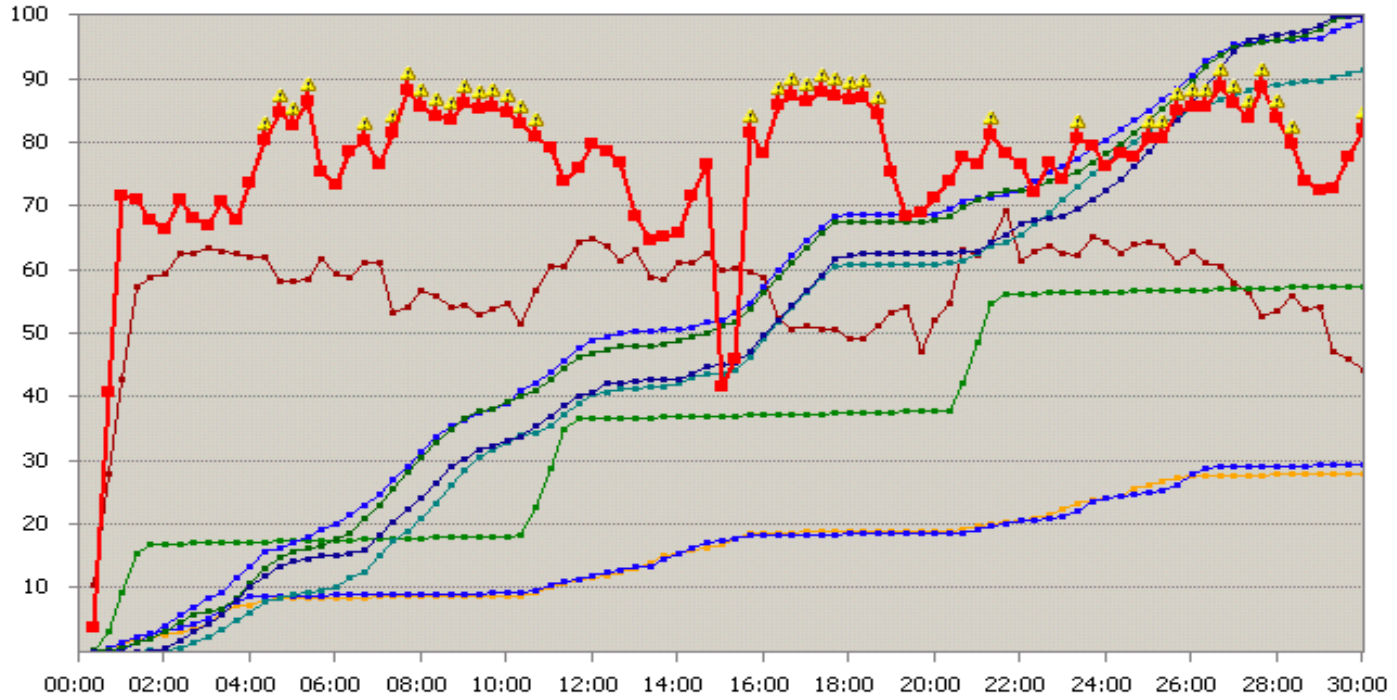
- The number of reads hitting the database are exceeding what a single server can handle.



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Caching (cont.)

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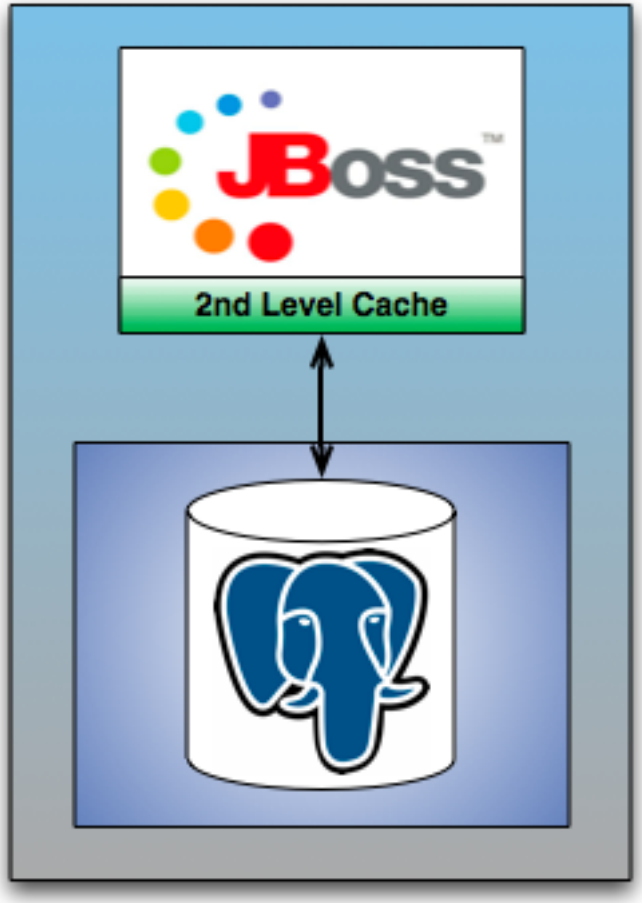
- A second level cache eliminates a lot of interaction with the database
- There are many options depending on the needs on the application
  - EhCache
  - OSCache
  - Terracotta
  - Infinispan
- Be aware of direct database changes causing cache invalidations



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Connection Pooling

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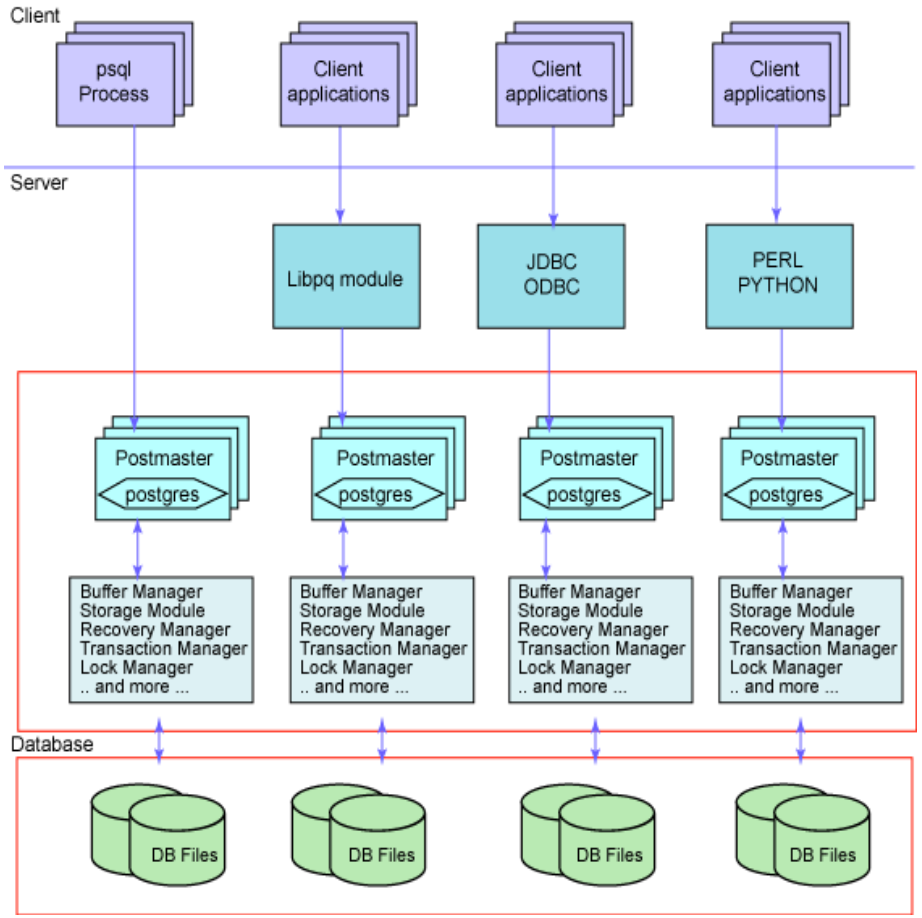
- As the number of concurrent users increase, the database has trouble dealing with all of the new connections
  - Postgres is process based so a new database connection is very expensive
  - This expense is magnified in a Windows environment



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Connection Pooling (cont.)

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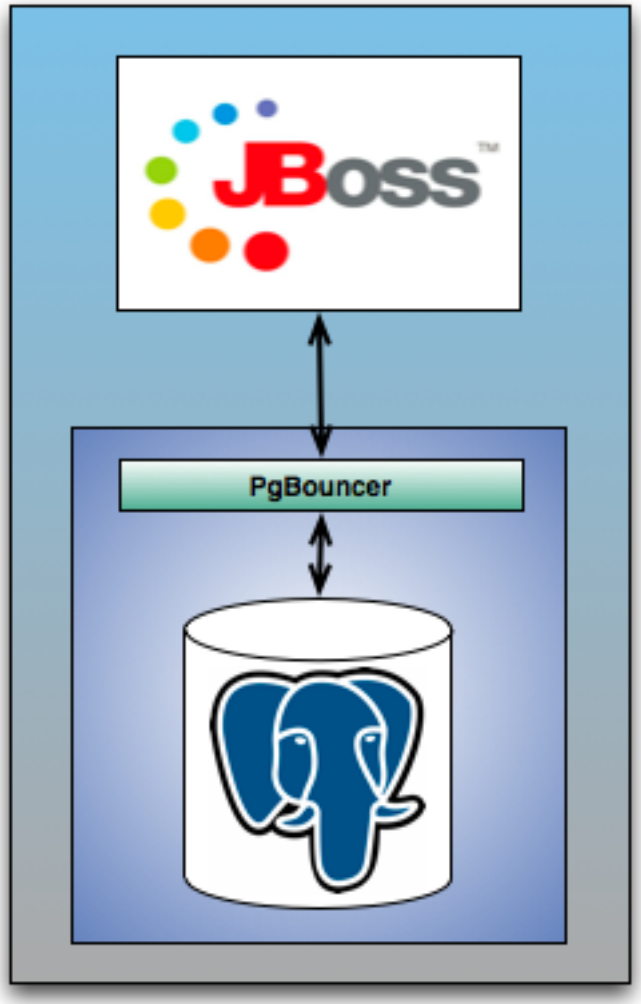
- PgBouncer provides an easy to administer connection pool for Postgres
  - This will be transparent to all Hibernate configurations
- Unfortunately, all data must pass through an additional layer adding overhead
- Ideal for use when clustering the application servers and a common pool across all servers is needed



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Connection Pooling (cont.)

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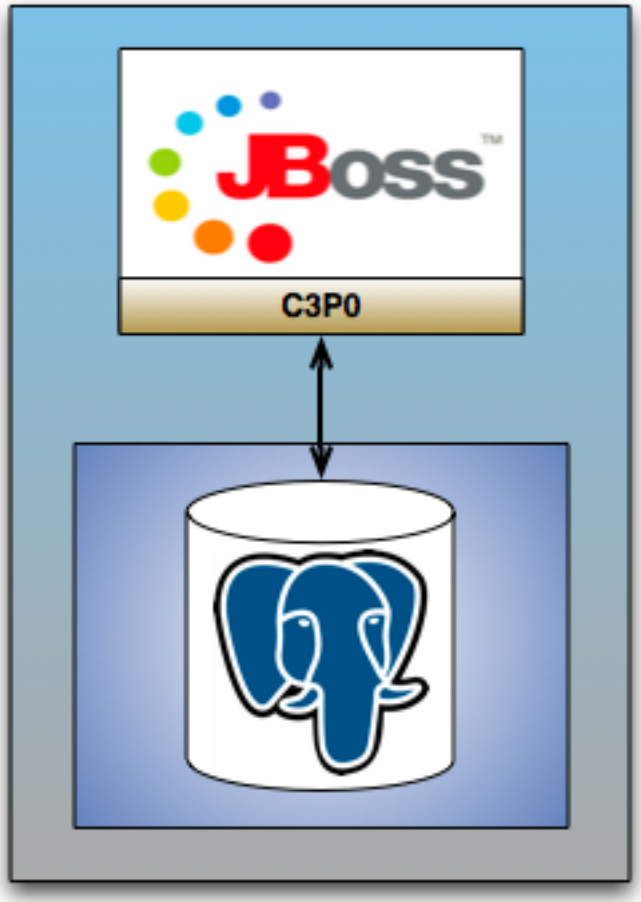
- A connection pool within the application server eliminates the overhead of a layer
  - C3P0, DBCP, and Proxool can all serve this purpose
  - Easily setup using the standard configuration files




```
hibernate.connection.driver_class = org.postgre...
hibernate.connection.url = jdbc:postgresql://lo...
hibernate.connection.username = postgres
hibernate.connection.password = password
hibernate.c3p0.min_size=5
hibernate.c3p0.max_size=20
hibernate.c3p0.timeout=1800
hibernate.c3p0.max_statements=50
hibernate.dialect = org.hibernate.dialect.Postg...
```

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Updates are Causing Havoc

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- The update statements send all of the columns even if they did not change
  - The Postgres logs show the following lines when just updating the column “filler” to “HelloWorld”

```
LOG:  execute <unnamed>: update tellers set bid=$1,
      filler=$2, tbalance=$3 where tid=$4
DETAIL:  parameters: $1 = '1', $2 = 'HelloWorld',
         $3 = '0', $4 = '1'
LOG:  execute S_2: COMMIT
```

- This causes several problems...

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Updates are Causing Havoc (cont.)

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- Why is this a problem?
  - The application server and the database are doing more work than necessary
    - A much longer SQL statement must be constructed by Hibernate
    - There is more network traffic as this is sent to the database
    - The database needs to parse a much bigger SQL statement
- Effect of curing this symptom (Minor)
  - Modern hardware has the CPU and network bandwidth to handle this additional overhead
  - Probably only noticeable with a large number of transactions

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Updates are Causing Havoc (cont.)

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- Why is this still a problem?
  - Foreign Key Integrity checks are fired unnecessarily
    - Adds significantly more load to the database for each update
    - This grows for each Foreign Key on the table
    - The amount of work increases as the size of the related table increases
- Effect of curing this symptom (Moderate)
  - If there are only a few Foreign Keys, this may not affect performance
  - If the related tables are small and updates are somewhat frequent, the buffers will be in the database cache

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Updates are Causing Havoc (cont.)

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- Really, why is this a problem?
  - None of the updates can leverage HOT if there are indexes on the table
    - This can cause table and index bloat for frequently updated tables
    - Adds additional maintenance overhead to the database to clean up the bloat
- Effect of curing this symptom (Major)
  - Performance steadily degrades on frequently updated tables

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Updates are Causing Havoc (cont.)

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- How is this solved?
  - Use the Dynamic Update annotation

```
@Entity
@Table(name = "tellers")
@org.hibernate.annotations.Entity(
        selectBeforeUpdate = true,
        dynamicInsert = true, dynamicUpdate = true)
@NamedQueries(
  {@NamedQuery(name = "Tellers.findAll",
     query = "SELECT t FROM Tellers t"),
   @NamedQuery(name = "Tellers.findByTid",
     query = "SELECT t FROM Tellers t WHERE t.tid = :tid"),
   @NamedQuery(name = "Tellers.findByBid",
     query = "SELECT t FROM Tellers t WHERE t.bid = :bid"),
   @NamedQuery(name = "Tellers.findByTbalance",
     query = "SELECT t FROM Tellers t
                WHERE t.tbalance = :tbalance")})
public class Tellers implements Serializable {
```

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Table Partitioning

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- A table is getting very large and the database administrator just partitioned the table, but now the application can no longer insert into the table.

```
Could not synchronize database state with session
org.hibernate.StaleStateException: Batch update returned unexpected
 row count from update [0]; actual row count: 0; expected: 1
        at org.hibernate.jdbc.Expectations$BasicExpectation.checkBatched(Expecta...
        at org.hibernate.jdbc.Expectations$BasicExpectation.verifyOutcome(Expect...
        at org.hibernate.jdbc.BatchingBatcher.checkRowCounts(BatchingBatcher.java:68)
        at org.hibernate.jdbc.BatchingBatcher.doExecuteBatch(BatchingBatcher.java:48)
        at org.hibernate.jdbc.AbstractBatcher.executeBatch(AbstractBatcher.java:246)
        at org.hibernate.engine.ActionQueue.executeActions(ActionQueue.java:237)
        at org.hibernate.engine.ActionQueue.executeActions(ActionQueue.java:141)
```

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Table Partitioning (cont.)

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- What is the problem?
  - From the database command line, psql, a row can be inserted
  - Hibernate is expecting the row count to be 1, but Postgres is returning 0
- How can the row be inserted into the database but return a message that 0 rows have be updated?
  - Postgres uses inherited tables and triggers to implement table partitioning
  - No rows are actually inserted into the base table, so the database is behaving correctly

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Table Partitioning (cont.)

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- How is this solved?
  - Change the Postgres trigger function to return a row

```
CREATE OR REPLACE FUNCTION accounts_insert_trigger()
  RETURNS trigger AS
$BODY$
DECLARE
  ret accounts%ROWTYPE;
BEGIN
    ret.aid = -1;
    .
    .
    .
    RETURN ret;
END;
$BODY$
  LANGUAGE 'plpgsql' VOLATILE
```

- But there are some side affects to this approach

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Table Partitioning (cont.)

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- Returning a row from the trigger function leaves a row in the base table which is not wanted
  - Create an After trigger to remove the row

```
CREATE OR REPLACE FUNCTION accounts_insert_clean_trigger()
  RETURNS trigger AS
$BODY$
BEGIN
    DELETE FROM accounts WHERE aid = -1;
    RETURN NULL;
END;
$BODY$
  LANGUAGE 'plpgsql' VOLATILE
```

- This is not very scalable. 2 inserts and 1 delete to create a single row is not practical

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Table Partitioning (cont.)

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- What is a better way to solve this?
  - Use the SQLInsert annotation to suppress the row count check when inserting the row

```
@Entity
@Table(name = "accounts")
@SQLInsert(
  sql="INSERT INTO accounts (abalance, bid, filler, aid)VALUES (?, ?, ?, ?)",
  check=ResultCheckStyle.NONE)
@NamedQueries({
  @NamedQuery(name = "Accounts.findAll",
    query = "SELECT a FROM Accounts a"),
  @NamedQuery(name = "Accounts.findByAid",
    query = "SELECT a FROM Accounts a WHERE a.aid = :aid"),
  @NamedQuery(name = "Accounts.findByBid",
    query = "SELECT a FROM Accounts a WHERE a.bid = :bid")})
public class Accounts implements Serializable {
```

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Data Model

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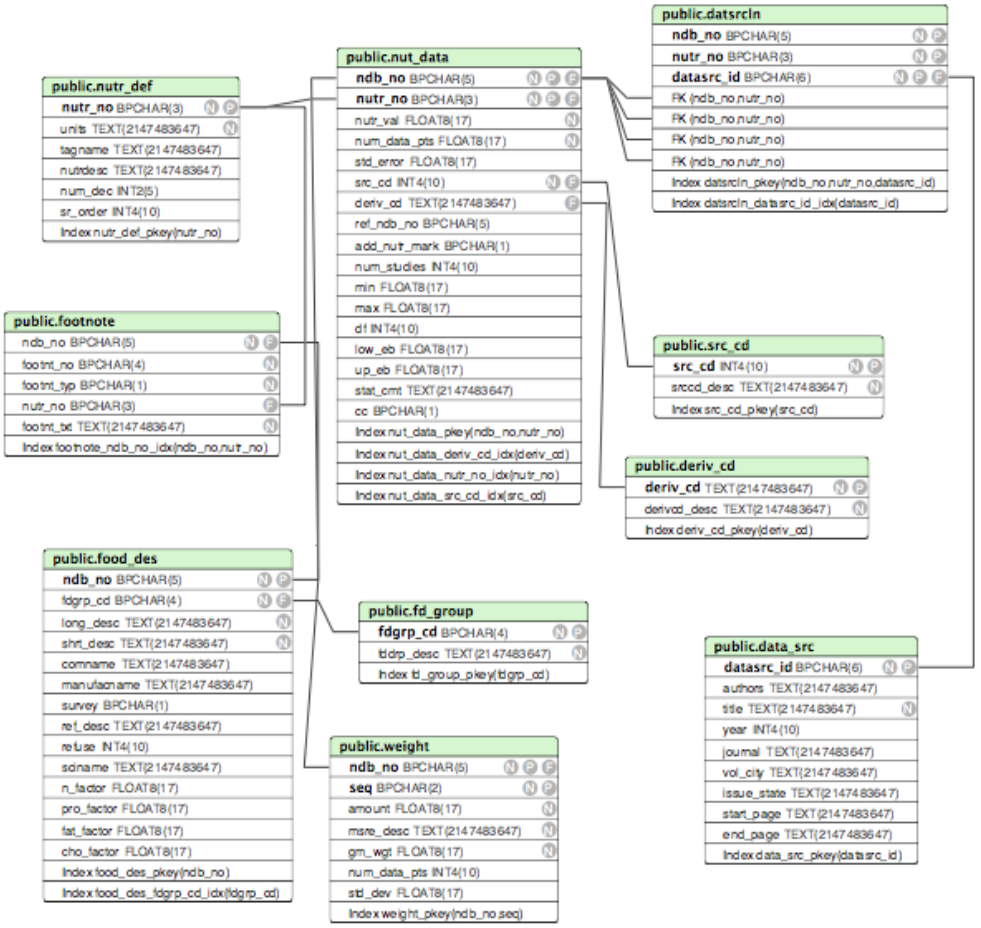
- There are a large number of joins necessary to get basic information for the application
- The data model is extremely flexible so any “widget” can be stored



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Data Model (cont.)

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- Denormalization is not always bad
  - But be careful not to have multiple versions of the truth
- Reduces the number of database calls or joins to get the data for the user
- A common technique is using Materialized Views or OLAP cubes
  - These are not native constructs in Postgres
  - But...they can be created with native Postgres constructs like Rule and Triggers

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Database Advanced Features

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- Some of the advanced features in Postgres will speed up the queries
  - Windowing Functions, Hierarchical Queries, Spatial, etc
- HQL does not support it and throws an exception

```
unexpected token: OVER near line 1, column 121 [SELECT insurance.insur...
```

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Database Advanced Features (cont.)

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- Send native SQL to the database

```
String SQL_QUERY = "SELECT insurance_name, id, invested_amount, avg(i...
                 + "invested_amount - avg(invested_amount) OVER(PARTI...
                 + "FROM insurance ";
Query query = session.createSQLQuery(SQL_QUERY)
                     .addScalar("insurance_name", Hibernate.STRING)
                     .addScalar("id", Hibernate.LONG)
                     .addScalar("invested_amount", Hibernate.LONG)
                     .addScalar("a", Hibernate.DOUBLE)
                     .addScalar("diff", Hibernate.DOUBLE);
```

- This adds database specific code inside the application

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Database Advanced Features (cont.)

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- Use a database view

```
CREATE VIEW insurance_diff AS
 SELECT insurance_name, id, invested_amount,
        avg(invested_amount) OVER(PARTITION BY insurance_name),
        invested_amount - avg(invested_amount)
        OVER(PARTITION BY insurance_name) AS diff
FROM insurance
```

- Allows the use of standard HQL
  - Prevents database specific code inside the application
- Puts the database specific code inside the database

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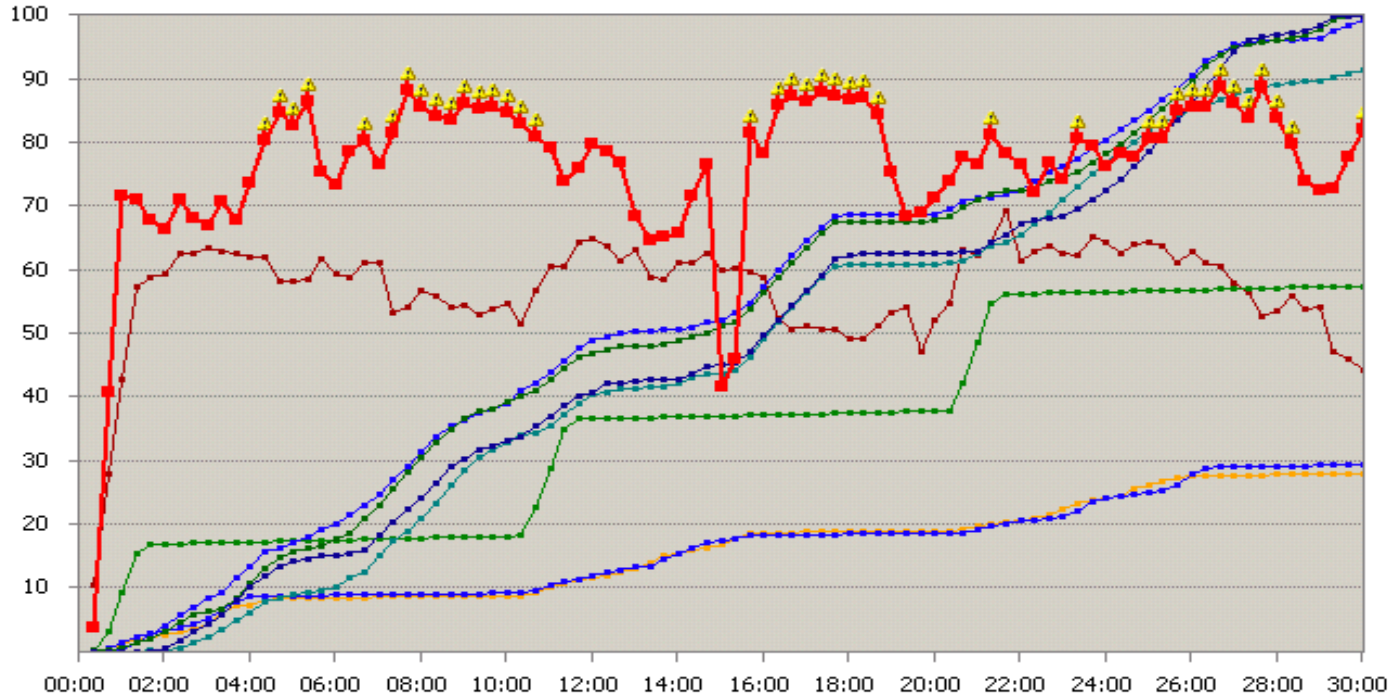
- The number of reads hitting the database are still exceeding what a single server can handle.
- Sometimes horizontal scaling is necessary



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Replication (cont.)

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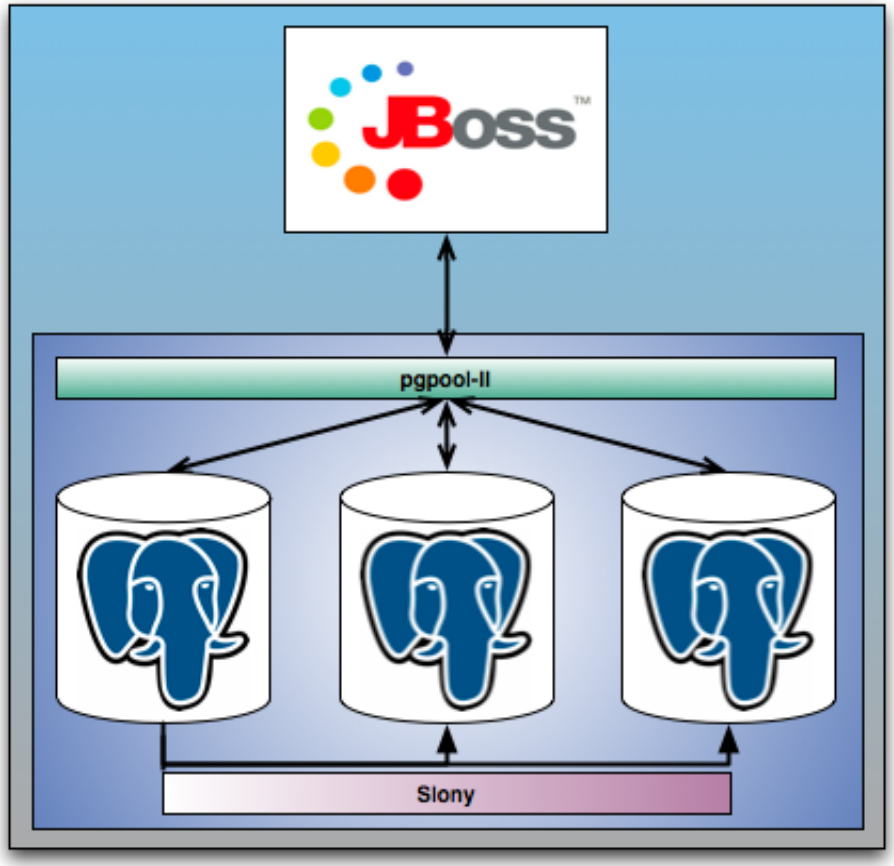
- Replicate using Slony to additional servers
  - Asynchronous single master multiple slave
- Load Balance reads using pgpool-II
- All writes go to the master node
- Connection pooling is also handled by pgpool-II



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Replication (cont.)

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- The possibility of row version problems exists
  - The application can read a row from the slave server before a new version is replicated
- Optimistic Concurrency Control can be used to solve these problems
  - Row versions are handled by the application by adding a version column to the tables

```
public class Accounts implemen...
    private static final long ...
    @Id
    @Basic(optional = false)
    @Column(name = "aid")
    private Integer aid;
    @Column(name = "bid")
    private Integer bid;
    @Column(name = "abalance")
    private Integer abalance;
    @Column(name = "filler")
    private String filler;
    @Version
    @Column(name = "version")
    private Integer version;
```

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Summary

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- Fetching strategies
- Caching
- Setup connection pooling
- Reduce the overhead of updates
- Partition large tables
- Optimize the data model
- Use advanced database features
- Replication

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Thank you.

Questions?

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