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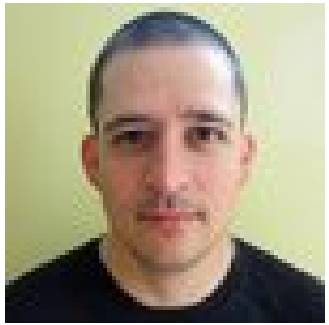
2014

Effective Application Development with GemFire using Spring Data GemFire

John Blum – Luke Shannon

Who Are We?



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Agenda

- GemFire Overview
- Spring Data GemFire
  - Overview
  - Feature Enhancements
  - Productivity Features
  - New in 1.5.0.RELEASE
  - EA Concerns
  - Customer Case Studies
  - Looking Ahead
- Resources
- QA

GemFire Overview

What is GemFire?

GemFire is an *in-memory data grid* (IMDG)

GemFire can function as a OLTP/OLAP data management solution offering *high-throughput*, *low-latency* data access with *horizontal scale-out*

In the simplest case though, GemFire is just a *cache*...

– Key/Value Store (Objects/JSON)

In-Memory

GemFire stores application data (state) in the **JVM Heap**

GemFire and application **performance** is impacted by GC...

– Object graphs can be stored in serialized form to reduce strain on the *Garbage Collector*.

No **off-heap** storage...

– GemFireXD, Pivotal's in-memory SQL-based store, supports off-heap

In-Memory Continued...

Support for managing resources used by the local *cache* is handled by GemFire's *`ResourceManager`*

Important **configuration settings**:

– `critical-heap-percentage` - % of heap at which the *cache* might become inoperable due to GC pauses or `OutOfMemoryErrors`

– `eviction-heap-percentage` - % of heap when eviction begins on a Region configured with Heap LRU eviction

Data Grid

GemFire pools system resources across multiple nodes joined in a cluster to manage the entire application's state and behavior...

– CPU, memory, network and (optionally) local disks

Members join the cluster as peers using either *UDP multicasting* or GemFire's *Locator* process...

Shared-Nothing Architecture

Each member of the cluster is independent and self-sufficient...

– Members do not share memory or disk.

GemFire's "*Shared-Nothing Disk Persistence Architecture"* manages data in local disk files on each member independently from other members that host the same *cache (Region)*...

High Scalability

Additional GemFire Server data nodes (peer members) can be added to the cluster, and data **rebalanced**, to uniformly distribute the load

– GemFire is "*elastic*"; easily scales up or down

GemFire really scales when data is **partitioned** across many members of the cluster uniformly...

– Application behavior can be routed, distributed and run in parallel with close proximity to the data required by application logic to improve **throughput**

High-Throughput / Low-Latency

GemFire uses concurrent, in-memory data structures and a highly optimized distribution infrastructure to minimize context switching and contention

– **high read throughput** is achieved through *synchronous* or *asynchronous replication* of data, and...

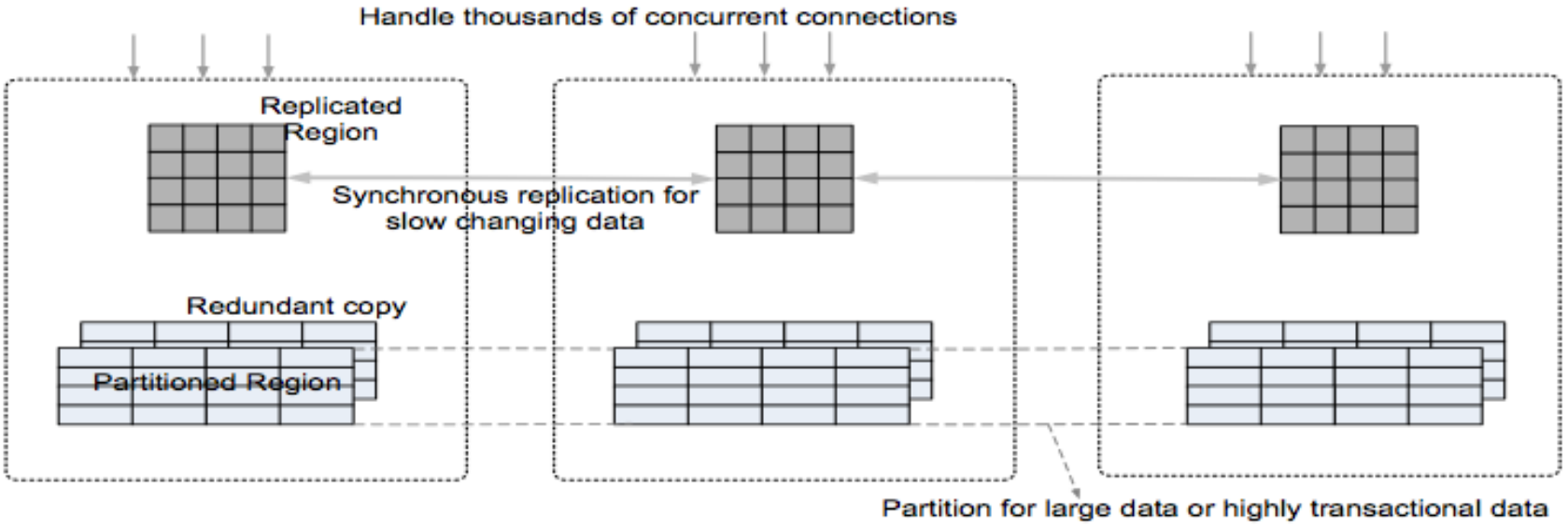
– **high read** and **write throughput** is achieved when data is *partitioned* across many nodes in the cluster

"*Linear increase in throughput is limited only by the backbone network capacity.*"

GemFire Data Storage Models

REPLICATE vs. PARTITION

In GemFire, a `Region` is the *cache...*



Region Configuration

Cache-like configuration settings...

- **Initial Capacity** and **Load Factor**
- **Key/Value-Constraints** (Class type)
- *Entry* **Eviction**
- *Region* and *Entry* **Expiration**

Additional Region Configuration

Type – *DataPolicy*, *Shortcuts*

Persistence – *DataPolicy*

Distribution – *DataPolicy*, *Scope*, *Subscription*

Disk Store – *Overflow* & *Persistence*

Statistics (used for *Expiration*)

Async and Subscription Message Conflation

Async Event Queue (e.g. "*Write-Behind*")

Gateway Sender (Site-to-Site WAN Replication)

Partition Region Specific Settings

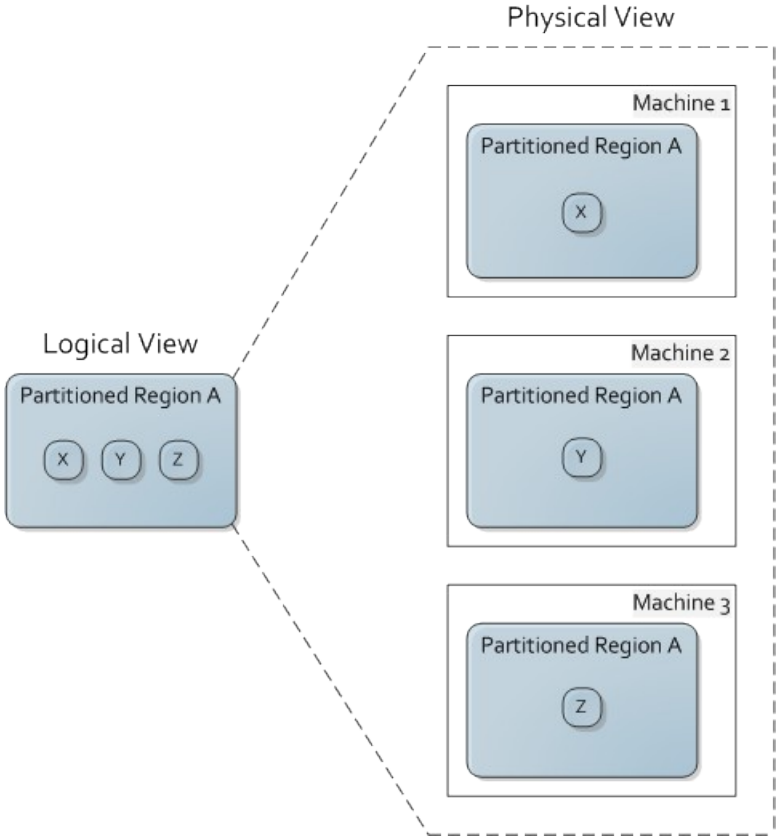
Local/Total Max Memory Size (MB)

Total Number of Buckets

Partition Resolver

Redundancy (# of Data Copies)

Collocation



Other Region Types

Distributed, Non-Replicated Regions

– Data is distributed; Each member only holds the data it has expressed "interests" in using *Subscription* or by defining cache entries (keys)

Local Region

– Data is not distributed; local-only (`Scope.LOCAL`) only to the member defining the *Region*

Empty Region

– Data accessor *Region* (PROXY); stores no data; receives events

Client Region

– `PROXY` or `CACHING_PROXY`

Consistency

Partition Regions

– *consistency* is maintained by routing all updates on a given key to the GemFire member holding the **primary** copy

– holds **lock** on key while distributing updates to other members having key

Replicated Regions

– concurrent updates → possibility of **conflicts** and **out-of-order updates**

– *conflict checking* ensures all members eventually apply the same value (*eventual consistency*)

– *conflict checking* ensures out-of-order updates are discarded.

Conflict checking is enabled with... `--concurrency-checks-enabled`

Cache Region Callbacks

Cache Listener

- `afterCreate`, `afterUpdate`, `afterDestroy`, `afterInvalidate`, ...

CacheLoader

- Synchronous “Read-Through” on *cache* misses from external data source

CacheWriter

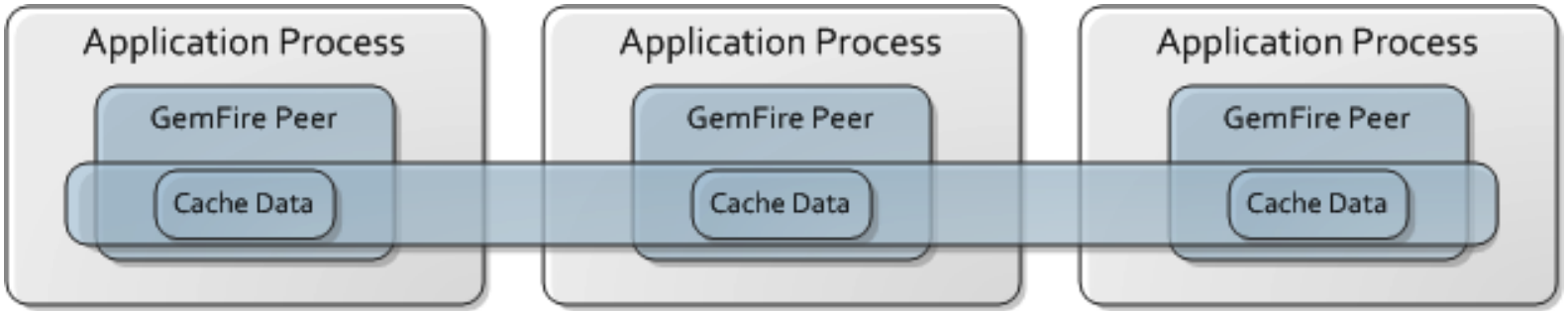
- Synchronous “Write-Through” to external data store

GemFire Topologies

Network Topologies
Peer-to-Peer (P2P)

Cache configuration designed for applications embedding the *cache* within the same process space and participate in the cluster...

– close proximity of application logic and data

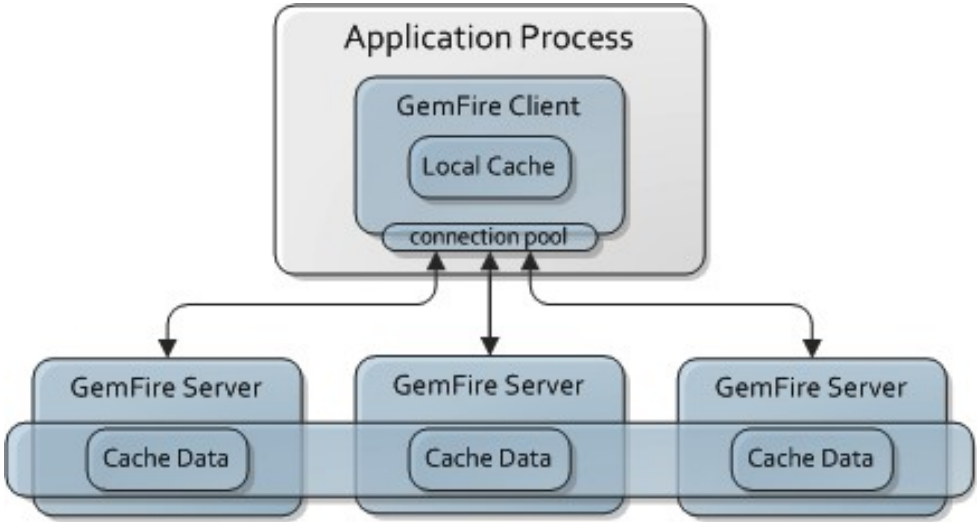


Network Topologies
Client / Server

Clients use single-hop data access...

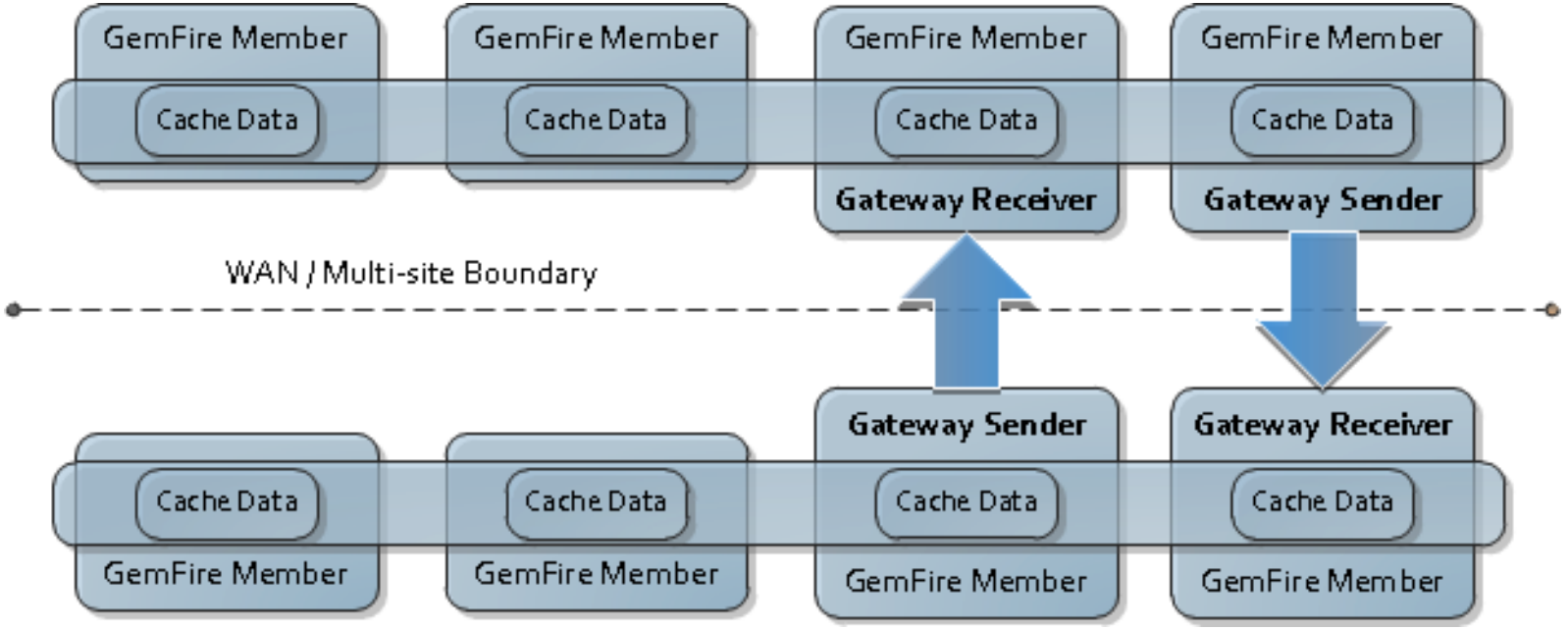
Continuously load balanced between servers based on load to get more predictable response-times...

Automatic fail-over when Servers fail or become unresponsive



Network Topologies
WAN

Site-to-Site Replication for DR



GemFire Features++

Still just scratching the surface...

- Cache and JTA-compliant Trans``action Management
- Functions
- OQL
- Client Register Interests or CQ
- Serialization (PDX, Java, DataSerialization)
- Security
- Native Support for Java and C++/C# Clients
- Memcache Integration
- REST Interface + JSON document storage
- Delta GII – when member **re-joins** the cluster
- Delta Propagation – distribute object changes only
- Rolling Upgrade - update GemFire version without having to bring the member/cluster down
- Split Brain Detection

GemFire Tips

1. Do not directly modify cached values...

   – Bypasses GemFire distribution as well as cache listeners/writers, expiration activities, transaction management leading to undesired results

   -- Instead, make a copy of the data by setting *–copy-on-read,* or use *CopyHelper*

2. *Key* class types must implement Object *equals(:Object)* and *hashCode()*;

3. GemFire serializes data entry keys and values during distribution, between client and server, and for persistence/overflow to Disk Stores, therefore keys/values must be serializable.

4. Application classes must be added to each peer member's CLASSPATH using the data in non-serialized form

5. Close the Region to release the resources held

6. Distributed System and Region configuration settings must match to be compatible systems

GemFire Cluster Demo

Spring Data GemFire

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Advantages of Using *Spring Data GemFire*

Uses Spring's powerful, non-invasive *programming model* and concepts with Pivotal GemFire to simplify configuration and development

Integration with other powerful *Spring IO Platform* Technologies...

 – Spring's *Caching Abstraction*

 – Spring's *Transaction Management*

 – *Spring Data Commons/REST*

 – *Spring Integration* (Inbound/Outbound Channel Adapters)

 – *Spring XD* (GemFire Input Source and Output Sink)

And...

Pivotal GemFire combined with **Spring Data GemFire** can already be used as a **JSR-107** *caching provider* when using **Spring Framework 4.1**

Dependencies Baseline

Spring Data GemFire (SDG) was sync'd with the **Spring Data** release train as of *Dijkstra (~March 2014, v1.4)*; just released with *Evans (v1.5)*

- *Spring Framework* 4.0.7
- *Spring Data Commons* 1.9
- GemFire 7.0.2
- Built/ran with JDK 7 & JKD 8

Feature Enhancements

Region bean definitions default to create (not lookup)...

```
<gfe:partitioned-region id="Example" .. ignore-if-exists="[true|false]">
    ...
</gfe:partitioned-region>
```

'Manual Start' for *GatewayReceivers*...

```
<gfe:gateway-receiver id="Example" .. manual-start="[true|false]">
    ...
</gfe:gateway-receiver>
```

Ability to execute *Spring Data GemFire* defined GemFire Functions using annotations in Gfsh

Productivity Features

Spring Boot Starter Data GemFire (**new**)...

```
<dependency>
    <groupId>org.springframework.boot</groupId>
    <artifactId>spring-boot-starter-data-gemfire</artifactId>
</dependency>
```

```
@Configuration
@ImportResource("/spring-data-gemfire-cache.xml")
@EnableAutoConfiguration
@EnableGemfireFunctions
@EnableGemfireRepositories
@EnableTransactionManagement
public class SampleDataGemFireApplication {

  public static void main(String[] args) {
    SpringApplication.run(SampleDataGemFireApplication.class, args);
  }
}
```

Productivity Features

GemfireTemplate

- simplified GemFire data access...
  - `contains[Key|Value], get, getAll, find, query,`
  - `put, putAll, putIfAbsent, replace`

Exception Translation

- maps GemFire Exceptions to `org.springframework.dao` Exceptions
- e.g. `EntryExistsException` → `DuplicateKeyException`

Productivity Features

Automatic creation of *DiskStore* “Disk Directory Location“ (**new**)...

```
<gfe:disk-store id=”Example” auto-compact=”true” ...>
    <gfe:disk-dir location=”/path/to/disk/files” max-size=”1024”/>
</gfe:disk-store>
```

Region Lookup 101

Spring Data GemFire supports GemFire `cache.xml`...

```
<gfe:cache cache-xml-location="/path/to/cache.xml" ...>
  ...
</gfe:cache>
```

GemFire 8 Cluster-based Configuration Management...

```
<util:map id="gemfireProperties">
  <prop key="name">SpringGemFireServer</prop>
  <prop key="use-cluster-configuration">[true|false]</prop>
</util:map>

<gfe:cache properties-ref="gemfireProperties" ...>
  ...
</gfe:cache>
```

Region Lookup

Given GemFire `cache.xml`...

```
<?xml version="1.0"?>
<!DOCTYPE cache PUBLIC  "-//GemStone Systems, Inc.
        //GemFire Declarative Caching 7.0//EN"
  "http://www.gemstone.com/dtd/cache7_0.dtd">
<cache>

  <region name="Parent" refid="REPLICATE">
    <region name="Child" refid="REPLICATE">
      <region name="Grandchild" refid="REPLICATE"/>
    </region>
  </region>

  <region name="Example" refid="PARTITION"/>

</cache>
```

Spring `context.xml` Was...

```
<gfe:cache cach-xml-location=”/path/to/cache.xml”/>

<gfe:lookup-region id="Parent">
  <gfe:lookup-region name="Child">
    <gfe:lookup-region name="Grandchild"/>
  </gfe:lookup-region>
</gfe:lookup-region>

<!-- or... -->
<gfe:lookup-region id="/Parent/Child"/>

<gfe:lookup-region id=”Example”/>
```

Region Lookup

```
@Repository("exampleRepo")
public class RegionBasedRepository extends DaoSupport {

  @Resource(name = "Parent")
  private Region<?, ?> parent;

  @Resource(name = "/Parent/Child")
  private Region<?, ?> child;

  @Resource(name = "/Parent/Child/Grandchild")
  private Region<?, ?> grandchild;

  @Resource(name = "/Example")
  private Region<?, ?> example;

  ...
}
```

Auto Region Lookup

Given same GemFire `cache.xml`...

```
<?xml version="1.0"?>
<!DOCTYPE cache PUBLIC  "-//GemStone Systems, Inc.
        //GemFire Declarative Caching 7.0//EN"
  "http://www.gemstone.com/dtd/cache7_0.dtd">
<cache>

  <region name="Parent" refid="REPLICATE">
    <region name="Child" refid="REPLICATE">
      <region name="Grandchild" refid="REPLICATE"/>
    </region>
  </region>

  <region name="Example" refid="PARTITION"/>

</cache>
```

Spring `context.xml` Now...

```
<gfe:cache cach-xml-location="/path/to/cache.xml"/>

<!--
<gfe:lookup-region id="Parent">
  <gfe:lookup-region name="Child">
    <gfe:lookup-region name="Grandchild"/>
  </gfe:lookup-region>
</gfe:lookup-region>
-->

<gfe:auto-region-lookup/>

<!-- optional -->
<gfe:lookup-region id="Example"/>
```

Auto Region Lookup

```
@DependsOn("gemfireCache")
@Repository("exampleRepo")
public class RegionBasedRepository extends DaoSupport {

  @Resource(name = "Parent")
  private Region<?, ?> parent;

  @Resource(name = "/Parent/Child")
  private Region<?, ?> child;

  @Resource(name = "/Parent/Child/Grandchild")
  private Region<?, ?> grandchild;

  @Resource(name = "/Example")
  private Region<?, ?> example;

  …
}
```

Region Templates

Region Templates are a way to share common configuration across multiple Region bean definitions in the Spring context...

```
<gfe:region-template id="base"/>

<gfe:replicate-region-template id="replica-tmpl" template="base"/>

<gfe:partition-region-template id="partition-tmpl" template="base"/>

<gfe:local-region-template id="local-tmpl" template="base"/>

<gfe:client-region-template id="client-tmpl" template="base"/>
```

Example...

```
…
<gfe:region-template id="Base" concurrency-checks-enabled="true"
    initial-capacity="51" load-factor="0.85" persistent="false" statistics="true">
  <gfe:cache-listener>
    <bean class="exmple.CacheListener" p:name="X"/>
  </gfe:cache-listener>
  <gfe:entry-tti timeout="600" action="DESTROY"/>
</gfe:region-template>

<gfe:region-template id="Ext" persistent=”true” template="Base">
  <gfe:gateway-sender-ref bean="ExampleGatewaySender"/>
</gfe:region-template>

<gfe:partitioned-region-template id="PartTmpl" copies="2" local-max-memory="8192"
    template="Ext">
  <gfe:cache-loader>
    <bean class="example.CacheLoader"/>
  </gfe:cache-loader>
  <gfe:subscription type="ALL"/>
</gfe:partitioned-region>

<gfe:partitioned-region id=”Example” colocated-with=”Neighbor” copies=”1”
     template=”PartTmpl”/>

<gfe:partitioned-region id=”Neighbor” persistent=”false” template=”Ext”/>
…
```

Region Template Oops

Cannot mix *Region* types; must be compatible...

```
<gfe:partition-region-template id="partition-tmpl" template="base"/>

<gfe:replicate-region id="Example" template="partition-tmpl"/>
```

Spring Data *Repositories* for GemFire

Spring Data GemFire's *Repository* is a provider implementation building on Spring Data Common's *Repository Abstraction*...

What is the *Repository Abstraction*...

- CRUD
- Querying
- ~~Pagination/Slices~~ & Sorting

Persisting Multiple Regions

Using Spring Data GemFire *Repositories*

Domain Class...

```
@Region("Gemstones")
public class Gemstone {

  @Id
  private Long id

  private String name;

  ...
}
```

Repository...

```
public interface GemstoneRepository extends GemfireRepository<Gemstone, Long> {
  ...
}
```

Repository Queries

```
public interface GemstoneRepository extends GemfireRepository<Gemstone, Long> {

     Gemstone findByName(String name);

     // @Query("FROM /Gemstones g WHERE g.price > $1")
     Gemstone findByPriceGreaterThan(BigDecimal price)

     List<Gemstone> findByNameOrderByNameDesc(Sort order);
}
```

Using *@Query* is useful for *joins* or *object graph traversal*...

```
public interface CustomerRepository extends GemfireRepository<Customer, Long> {

  @Query("<trace> SELECT DISTINCT c FROM /Customers c, c.addresses a
          WHERE a.city = $1")
  List<Customers> findCustomersInCity(String city)
}
```

@Region Repository

```
@Region("Gemstones")
public interface GemstoneRepository extends GemfireRepository<Gemstone, Long> {
}
```

```
@Region("ValuableRocks")
public interface GemstoneRepository extends GemfireRepository<Gemstone, Long> {
}
```

Transaction Management

Spring Data GemFire integrates nicely with the *Spring Framework's* **Transaction Management** infrastructure...

– supports both ***Cache*** and ***Global*** Transactions

For ***Cache*** Transactions...

```
<gfe:cache id="cache" …/>

...

<gfe:transaction-manager id="txManager" cache-ref="cache"/>
```

Transaction Management

@Service component...

```
@Service("gemstoneService")
public class GemsService {

protected static final List<String> APPROVED_GEMS = new ArrayList<String>(
    Arrays.asList( "ALEXANDRITE", "AQUAMARINE", "DIAMOND", "OPAL",
      "PEARL", "RUBY", "SAPPHIRE", "SPINEL", "TOPAZ"));

@Transactional(readOnly = false)
public Gemstone save(Gemstone gemstone) {
  gemstone = getGemFireGemsDao().save(getDatabaseGemsDao().save(gemstone));

  // NOTE deliberate, but stupid and naive business validation
  // after the mutating data access!
  if (!APPROVED_GEMS.contains(gemstone.getName().toUpperCase())) {
    // NOTE if the gemstone is not valid, blow chunks
    // (should cause transaction to rollback for GemFire and Database)!
    throw new IllegalGemstoneException(
      String.format("'%1$s' is not a valid gemstone!",
        gemstone.getName()));
  }

  return gemstone;
}
```

GemFire Function Support

Spring Data GemFire provides POJO-based, Function annotation support for creating, registering and executing GemFire Functions

- *@GemfireFunction*
- *@FunctionExecution*

Creating Function(s)

```
@Component
public class RegionFunctions {

  @GemfireFunction
  public String echo(String message) {
    return String.format("You said '%1$s'!", message);
  }

  @GemfireFunction
  public Integer regionSize(FunctionContext context, String regionNamePath) {
    Region region = getRegion(context, regionNamePath);

    if (region != null) {
      return region.size();
    }

    throw new RegionNotFoundException("The Region on which the size will be determined”
          was not found!");
  }

  protected Region getRegion(FunctionContext context, String regionNamePath) {
    …
  }
}
```

Registering Function(s) with GemFire

XML...

```
<gfe:annotation-driven/>

<bean class="example.RegionFunctions"/>
```

Component-scanning...

```
<gfe:annotation-driven/>

<context:component-scan base-package="example">
  ...
</context:component-scan>
```

Java Config...

```
@Configuration
@ImportResource("/spring-data-gemfire-context.xml")
@EnableGemfireFunctions
public class SpringGemFireConfiguration { … }
```

Function Execution

Peer Cache...

```
@OnMember(groups = "exampleGroup")
public interface OnMemberEchoFunctionExecution {

  String echo(String message);
}
```

Client Cache...

```
@OnServer(cache = "gemfireCache")
public interface OnServerEchoFunctionExecution {

  String echo(String message);
}
```

Function Execution

Peer Cache and Client Cache...

```
@OnRegion(region = "Example")
public interface OnRegionFunctionExecution {

  String echo(String message);

  Integer regionSize(String regionNamePath);
}
```

Function Execution Configuration

XML...

```
<gfe-data:function-executions base-package="example">
  <gfe-data:exclude-filter type="regex" expression=".*OnServer.*"/>
</gfe-data:function-executions>
```

Java Config...

```
@Configuration
@ImportResource("/spring-data-gemfire-context.xml")
@EnableGemfireFunctionExecutions
public class SpringGemFireConfiguration {
  ...
}
```

Function Execution Invocation

```
@Component
public class ApplicationComponent {

  @Autowired
  private OnRegionFunctionExecution functions;

  public ... someMethod(String regionNamePath) {
    Integer size = functions.regionSize(regionNamePath);
    …
  }

  …
}
```

Order Application Demo

Spring Data GemFire Case Studies

Case Study: GemFire Configuration with SDG

Set the stage... **3** Primary Use Cases of *Spring Data GemFire*...

1. **GemFire Configuration**
   - replacement for GemFire `cache.xml`
2. *Peer Cache* Application

```
<gfe:cache properties-ref=".." cache-xml-location=".." .../>
```

3. *Client Cache* Application

```
<gfe:client-cache properties-ref=".." cache-xml-location=".." .../>
```

But, how do you “launch” the GemFire Sever?

Java Main

```
public class SpringGemFireLauncher {

  // e.g. args[0] = "classpath:spring-gemfire-context.xml
  private static void validate(String[] args) {
    ...
  }

  private static void main(String[] args) {
    validate(args);
    new ClassPathXmlApplicationContext(args);
    ...
  }
}
```

1.4 Initializer

```
<?xml version="1.0"?>
<!DOCTYPE cache PUBLIC  "-//GemStone Systems, Inc.
     //GemFire Declarative Caching 7.0//EN"
     "http://www.gemstone.com/dtd/cache7_0.dtd">
<cache>
  <initializer>
    <class-name>
org.springframework.data.gemfire.support.SpringContextBootstrappingInitializer
    </class-name>
    <parameter name="contextConfigLocations">
      <string>
        classpath:com.example.package,org.example.another.package...
      </string>
    </parameter>
  </initializer>
</cache>
```

1.4 Initializer

```
<?xml version="1.0"?>
<!DOCTYPE cache PUBLIC  "-//GemStone Systems, Inc.
     //GemFire Declarative Caching 7.0//EN"
     "http://www.gemstone.com/dtd/cache7_0.dtd">
<cache>
  <region name="Example" refid="REPLICATE">
    <region-attributes initial-capacity="51" load-factor="0.85">
      <cache-loader>
        <class-name>example.CacheLoader</class-name>
      </cache-loader>
    </region-attributes>
  </region>
  <initializer>
    <class-name>
org.springframework.data.gemfire.support.SpringContextBootstrappingInitializer
    </class-name>
    <parameter name="contextConfigLocations">
      <string>
        classpath:path/to/spring-gemfire-context.xml,
        classpath:path/to/app-context.xml
      </string>
    </parameter>
  </initializer>
</cache>
```

1.4 LazyWiringDeclarableSupport

Used to be, use *Spring Data GemFire's* `WiringDeclarableSupport`

```
<!-- Spring context.xml -->
<gfe:cache cache-xml-location="/path/to/cache.xml" ... />

<!-- GemFire cache.xml →
<cache>
  <region name="Example" refid="REPLICATE">
    <region-attributes initial-capacity="51" load-factor="0.85">
      <cache-loader>
        <class-name>example.CacheLoader</class-name>
```

Now, must use...

```
package example;
public class CacheLoader
     extends LazyWiringDeclarableSupport
     implements CacheLoader<String, User> {

  @Autowired
  private DataSource dataSource;

  ...
}
```

GemFire 8 Gfsh Support


```
gfsh>start server -spring-xml-location="classpath:path/to/context.xml"
```

Resource Location Prefixes...

```
    -spring-xml-location="file:/path/to/context.xml"
```

DEMO

Case Study: Global Transaction Management

Using GemFire with an external data store (e.g. MySQL RDBMS) in a Global Transactional context...

– Use Spring's `JtaTransactionManager`; Not...

```
<!-- WRONG -->
<gfe:transaction-manager id="txManager" cache-ref="cache"/>
```

– Uses **GemFire's JTA Transaction Manager** provider implementation along with GemFire's **JNDI context** to *register DataSource* as well as *locate* GemFire's *TX Manager* and *JTA UserTransaction*

– Why not **Atomikos, Bitronix, or JOTM**?

Code...

DEMO

Case Study: Spring Caching Abstraction

Use Spring's *Caching Abstraction*...

Use GemFire as ***caching provider*** to replace ***Oracle Coherence***, but absolutely no presence of GemFire in the application...

Support for varying (some old, some new) application client ***versions***...

– New Domain Object class field “additions”

– Old Domain Objects should trigger a “cache miss”

– New Domain Object state must be preserved when used by an old application (PDX)

The **10% case** *Juergen* was talking about in *Caching and Messaging Improvements*

DEMO

Looking Ahead...

P0: Finish **GemFire 8** Support in **Spring Data GemFire 2.0**!

P0: Edit ***Spring Data GemFire Reference Guide***

P0: Rewrite ***Spring GemFire Examples***

P0: Provide *Spring GemFire Case Studies*

P0: Provide *Spring Data GemFire Reference Implementation*

P1: Integration Test Framework for Distributed Test Cases, WAN

P1: Integration with *Spring Security* as a facade over GemFire's Security Model

P2: Support for *Java-based Configuration* (Groovy)

P3: *Pagination* and *Slices*

Resources

GemFire Overview
http://gemfire.docs.pivotal.io/latest/userguide/index.html#getting_started/product_intro.html

GemFire User Guide
http://gemfire.docs.pivotal.io/latest/userguide/index.html

Spring Data GemFire Reference Guide
http://docs.spring.io/spring-data-gemfire/docs/current/reference/html/

Guide: https://spring.io/guides/gs/accessing-data-gemfire/
Guide: https://spring.io/guides/gs/caching-gemfire/

GitHub (source): https://github.com/spring-projects/spring-data-gemfire
GitHub (examples): https://github.com/spring-projects/spring-gemfire-examples

JIRA: https://jira.spring.io/browse/SGF

StackOverflow: https://stackoverflow.com/questions/tagged/spring-data-gemfire

Thank You!