

Before we begin

```
1 git clone git@github.com:qa/pv243-a4m36jee-2016-infinispan-  
   seminar-autumn.git  
2 cd pv243-a4m36jee-2016-infinispan-seminar-autumn  
3 git checkout task1  
4 mvn clean package  
5 mvn wildfly:run
```

Optionally:

```
1 wget http://downloads.jboss.org/infinispan/8.2.4.Final/  
   infinispan-server-8.2.4.Final-bin.zip
```

Infinispan

Vojtěch Juránek

JBoss - a division by Red Hat

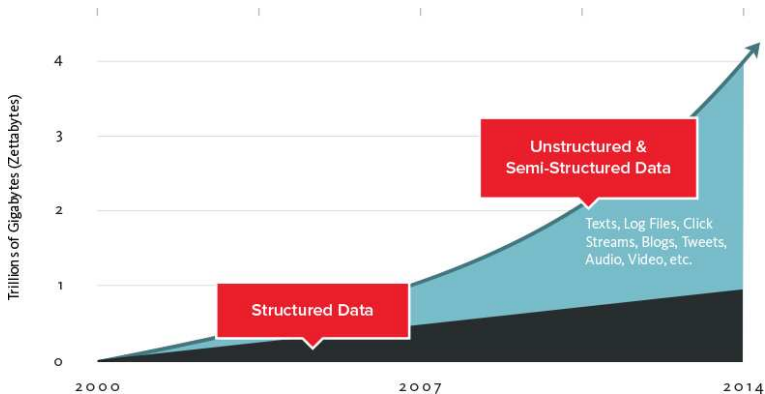
3. 11. 2017, CTU FEE, Prague

Course materials download

- Course materials, including this presentation:
<https://developer.jboss.org/wiki/AdvancedJavaEELabFELCVUTPodzim2017>
- This presentation (and source code):
https://github.com/vjuranek/presentations/tree/master/CTU_Prague2017_fall

Data today

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Source: <http://www.couchbase.com/nosql-resources/what-is-no-sql>

How big is Big data?

How big is Big data?



Source: https://twitter.com/DEVOPS_BORAT/status/288698056470315008

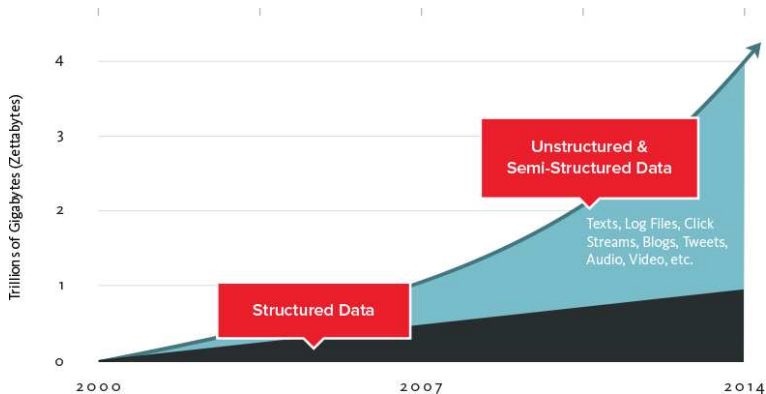
How big is Big data?



Source: https://twitter.com/DEVOPS_BORAT/status/288698056470315008

- Data collection so large and complex it's impossible to process it on one computer
- You can scale up, but sooner or later you'll have to scale out

Structure of the data



Source: <http://www.couchbase.com/nosql-resources/what-is-no-sql>

Big data - some of the challenges

- Analysis run on top of the huge amount of data
- Ability to store huge amount of unstructured data (often for performance reasons)
- But also ability to talk to RDBMS or query structured data is often needed as well
- Highly scalable solution (also because of cost effectiveness)
- Cloud architecture - everything is ephemeral
- Information privacy

- Nature of the data
 - More flexible data mode
 - Better scalability
 - Performance



Source: www.couchbase.com/sites/default/files/uploads/all/whitepapers/NoSQL-Whitepaper.pdf

NoSQL

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DevOps Borat
@DEVOPS_BORAT

 Follow

Attention devops: "learn NoSQL" is not same as "learn no SQL"!

RETWEETS
201

LIKES
19



8:09 PM - 28 Nov 2011

Source: https://twitter.com/devops_borat/status/141368065110708224

What is a in-memory data grid?

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In-memory = all data is kept in memory

Grid = too big to kept data on one node, data is distributed across more/many nodes

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- An in-memory distributed data store designed for fast access to large volumes of data and scalability.
- Commonly a complementary layer to the relational database and the application.

What is a data grid?

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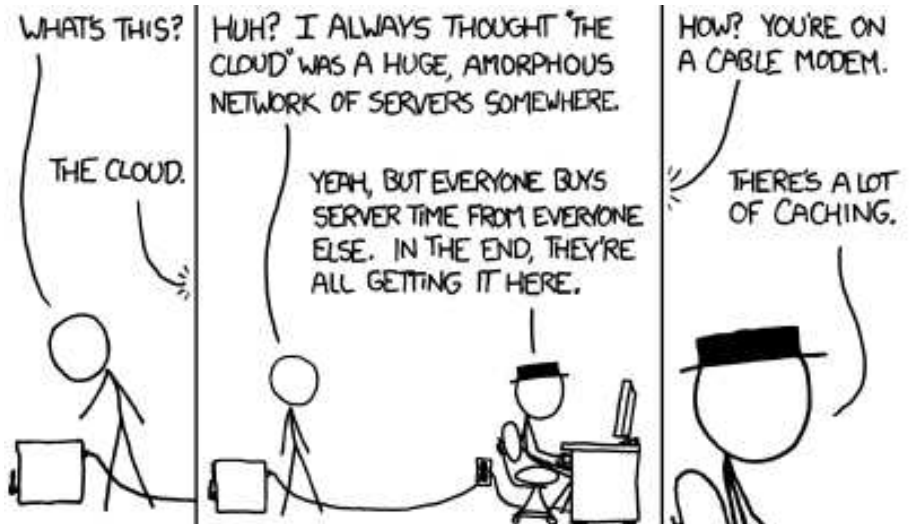
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- An in-memory distributed data store designed for fast access to large volumes of data and scalability.
- Commonly a complementary layer to the relational database and the application.

Key data grid characteristics:

- In-memory, distributed caching
- Elastic and scalable
- Advanced querying
- Data replication
- Processing for streaming data
- Transaction capabilities

Why in-memory



Source: Part of xkcd #908

Why in-memory

- Lots of data is needed in real-time (BigData → FastData)
- Some tasks can be completed much faster when data are kept in memory
- Keeping data in memory during processing of whole application stack, not only during processing in one application in the stack
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Infinispan



<https://infinispan.org>

<https://github.com/infinispan>

(Apache License, v2.0)

- In-memory data grid platform, written in Java
- Schema-less (optionally), No-SQL key-value data store
- Distributed cache - offers massive memory
- Elastic and scalable - can run on hundreds of nodes
- Highly available - no SPOF, resilient to node failures
- Multi-version concurrency control (MVCC)
- Transactional
- Queryable
- Processing for streaming data

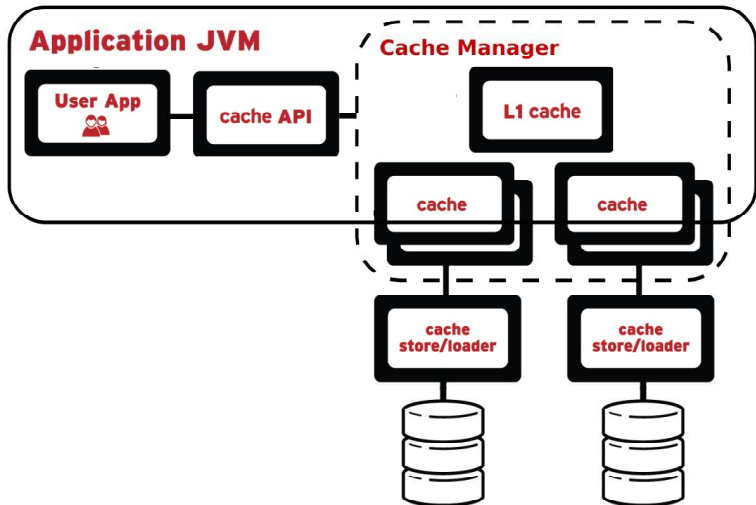
Infinispan cache

- Infinispan takes care about all that hard stuff.
- From user perspective Infinispan cache is **just a map!**

```
1 DefaultCacheManager cacheManager = new DefaultCacheManager(  
    "my_ispn_config.xml");  
2 Cache<String, String> cache = cacheManager.getCache("myCache");  
3  
4 cache.put("key", "value");  
5 String value = cache.get("key");
```

- ISPN configuration can be either programmatic (preferred for demos) or via XML (preferred in production as you don't have to re-compile the code due to conf. changes).

Infinispan (embedded) high level architecture



Basic features: eviction

Removing entries from the cache: eviction

```
1 ConfigurationBuilder().eviction().size(5).strategy(  
    EvictionStrategy.LRU)
```

```
1 Configuration conf = new ConfigurationBuilder().eviction().size  
    (5).strategy(EvictionStrategy.LIRS).build();  
2 EmbeddedCacheManager ecm = new DefaultCacheManager(conf);  
3 Cache<String, String> cache = ecm.getCache();  
4  
5 for (int i = 0; i < 100; i++) {  
6     cache.put("key" + i, "value" + i);  
7 }  
8  
9 System.out.printf("Cache size: %d\n", cache.size());  
10 ecm.stop();
```

Basic features: cache listener

```
1 cache.addListener(new EntryCreatedListener());
```

- There are actually two events emitted, before given operation happens and once it's finished.
- You can distinguish them by calling `isPre()` on the event (`true` for events prior the operation)

```
1 @Listener
2 public class EntryCreatedListener {
3     @CacheEntryCreated
4     public void onCreated(CacheEntryCreatedEvent e) {
5         if (e.isPre()) {
6             System.out.printf("Created %s -> %s\n", e.getKey(),
7                 e.getValue());
8         }
9     }
}
```

```
1 EmbeddedCacheManager cm = new DefaultCacheManager();
2 Cache<String, String> cache = cm.getCache();
3 cache.addListener(new EntryCreatedListener());
4
5 for (int i = 0; i < 100; i++) {
6     cache.put("key" + i, "value" + i);
7 }
8 cm.stop();
```

Basic features: CDI

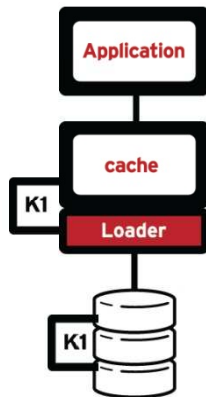
```
1 @Qualifier
2 @Target({ElementType.FIELD, ElementType.PARAMETER, ElementType.
    METHOD})
3 @Retention(RetentionPolicy.RUNTIME)
4 @Documented
5 public @interface EvictionCache {
6 }
```

```
1 @ConfigureCache("testcache")
2 @EvictionCache
3 @Produces
4 public Configuration greetingCacheConfiguration() {
5     return new ConfigurationBuilder().eviction().strategy(
6         EvictionStrategy.LRU).size(5).build();
7 }
```

```
1 @Inject
2 @EvictionCache
3 private Cache<String, String> cache;
```


Persistence: Cache stores

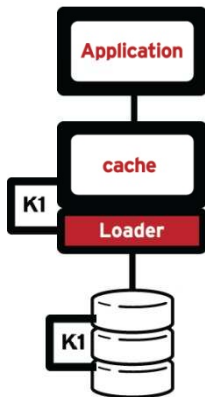
A way how to store cache content in some external (persistent) storage.



Persistence: Cache stores

A way how to store cache content in some external (persistent) storage.
Two modes:

- Synchronous (write-through)
- Asynchronous (write-behind)



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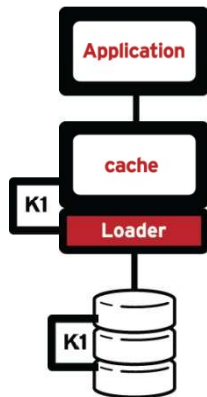
Two modes:

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- Asynchronous (write-behind)

Cache stores:

- Single file store and soft-index file store
- JDBC and JPA cache stores
- LevelDB cache store
- Cloud cache store
- Remote store
- Cassandra store
- ... and others

Also possible to define custom cache store.



Persistence: file cache store example

```
1 cfg.persistence().addSingleFileStore().location("/tmp/ispn-  
store");
```

```
1 ConfigurationBuilder cfg = new ConfigurationBuilder();  
2 cfg.persistence().addSingleFileStore();  
3 DefaultCacheManager cm = new DefaultCacheManager(cfg.build());  
4 Cache<String, String> cache = cm.getCache("test");  
5  
6 for (int i = 0; i < 100; i++) {  
7     cache.put("key" + i, "value" + i);  
8 }  
9 System.out.printf("Cache size: %d\n", cache.size());  
10  
11 cache.stop();  
12 cache.start();  
13  
14 System.out.printf("Cache size: %d\n", cache.size());  
15 cm.stop();
```

- **Support for indexing and searching of objects stored in the cache.**
- Search for data using data attributes instead of keys.
- Uses Hibernate Search and Apache Lucene to index and search objects.
- Queries can be constructed using ISPN fluent DSL API, Hibernate Search Query DSL or directly Lucene query API.
- Needs some data schema (protobuf file or annotations).
- Combine queries and aggregation functions (but doesn't support joins).
- Sort, filter, and paginate query results.
- Support for index or non-indexed queries.

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Examples: querying

```
1 public class Person {  
2     String name;  
3     String surname;  
4  
5     public Person(String name, String surname) {  
6         this.name = name;  
7         this.surname = surname;  
8     }  
9 }
```

Examples: querying

```
1 ConfigurationBuilder cb = new ConfigurationBuilder();
2 EmbeddedCacheManager cm = new DefaultCacheManager(cb.build());
3 Cache<String, Person> cache = cm.getCache();
4 cache.put("person1", new Person("Will", "Shakespeare"));
5
6 // Obtain a query factory for the cache
7 QueryFactory<?> queryFactory = Search.getQueryFactory(cache);
8
9 // Construct a query
10 Query query = queryFactory.from(Person.class).having("name").eq
    ("Will").toBuilder().build();
11
12 // Execute the query
13 List<Person> matches = query.list();
14
15 matches.forEach(person -> System.out.printf("Match: %s", person
    ));
16 cm.stop();
```

Transactions, consistency, locking and isolation

- JTA-compliant transactions
- Deadlock detection and recovery (e.g. when ISPN fails during commit phase of the transaction)
- Data versioning
- Ensures consistency of data, consistency guarantee: lock for key K is always acquired on the same node of the cluster (key **primary owner**), regardless of where the transaction originates

Commercial break: JGroups

JGroups is a toolkit for reliable messaging written in Java.

It can be used to create clusters whose nodes can send messages to each other.

Main features:

- Cluster creation and deletion. Cluster nodes can be spread across LANs or WANs.
- Membership detection and notification about joined/left/crashed cluster nodes.
- Sending and receiving of node-to-cluster messages (point-to-multipoint).
- Sending and receiving of node-to-node messages (point-to-point).
- Detection and removal of crashed nodes.

More about JGroups in upcoming **WildFly clustering course!**

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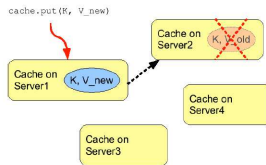
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Clustering modes

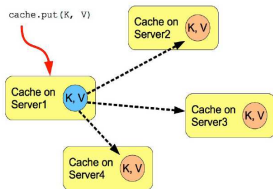
- Under the hood leverages JGroups project for clustering.
- Data is distributed and replicated in the background.
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Clustering modes

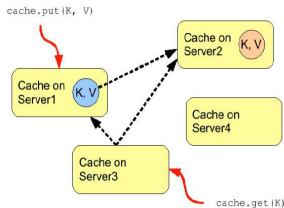
- Under the hood leverages JGroups project for clustering.
- Data is distributed and replicated in the background.
- Nodes can be added or removed smoothly.
- Local - no clustering
- Invalidation



- Replicated

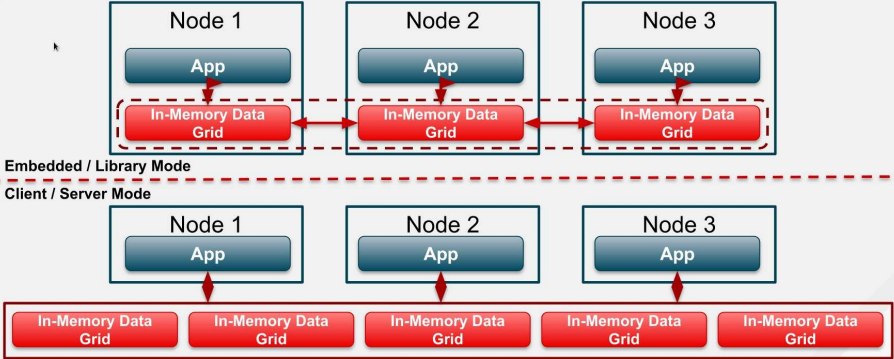


- Distributed



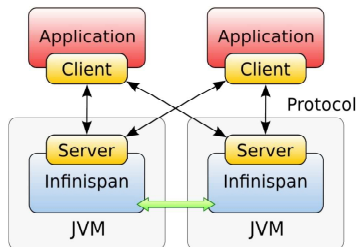
Infinispan modes

EMBEDDED OR CLIENT/SERVER



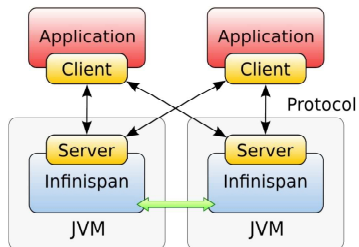
Remote protocols

- Hot Rod
 - hashing and topology aware
 - failover during topology changes
 - smart request routing
- Memcached
- REST



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Protocol	Format	Client libs	Clustered	Smart routing	Load balancing / Failover
Hot Rod	binary	Java, C++, C#, JS	yes	yes	dynamic
Memcached	text	many	yes	no	only predefined server list
REST	text	any HTTP client	yes	no	any HTTP load balancer

Hot Rod clients

Compatible with Java and non-Java platforms. Based on Protocol Buffers - Google's data interchange format.

Clients for

- Java
- C#
- C++
- JavaScript
- Python
- Ruby

Python and Ruby clients have only basic functionality.

Some other features - brief and selective list

- Full JSR-107 support (Java Temporary Caching API)
- Advanced security feature (role based access, encryption, integration with LDAP, Kerberos etc.)
- Remote events
- Continuous query
- Client near cache
- Rolling upgrades
- Cross data center replication (also Hot Rod clients support failover to another data center)
- Command line interface
- Distributed executors
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Examples of usecases

- Cache for backend
- Fast data backend
- HTTP session off-loading
- Hibernate 2-nd level cache
- In-memory Lucene index
- Fast data backend for Apache Spark or Hadoop
- ...

- Try Infinispan on OpenShift
- <https://www.openshift.com/>
- Platform as a Service (PaaS)



Source: <http://dilbert.com/strip/2011-01-07>

Search OpenShift demos on

<https://github.com/infinispan-demos/links>

Summary

- Amount and structure of the data has changed rapidly during past couple of years.
- Cloud applications and Big/Fast data require new approaches and tools, data grids are important building blocks of such solutions.
- Infinispan is mature and feature rich data grid solution, which integrates well with other frameworks and can be used as backbone for new generation of enterprise applications.

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Materials from this course

- This presentation: https://github.com/vjuranek/presentations/tree/master/CTU_Prague2016_fall
- ISPN embedded tutorial (The Weather App): <http://infinispan.org/tutorials/embedded>
- GitHub repo: <https://github.com/infinispan/infinispan-embedded-tutorial>
- ISPN simple tutorials: <https://github.com/infinispan/infinispan-simple-tutorials>
- ISPN quickstarts (simple applications) at the bottom of the page: <http://infinispan.org/tutorials>
- Some more ISPN snippets: <https://github.com/vjuranek/infinispan-snippets>

Infinispan downloads:

- Main ISPN download page: <http://infinispan.org/download/>
- If you want to play with ISPN in Docker: <https://hub.docker.com/r/jboss/infinispan-server/>

Further study materials

- [Infinispan documentation](#)
- [JSR 107: JCACHE - Java Temporary Caching API](#)
- M. Surtani, F. Marchioni, [Infinispan Data Grid Platform](#), Packt Publishing, 2012
- W. dos Santos, [Infinispan Data Grid Platform Definitive Guide](#), Packt Publishing, 2015
- M. Kleppmann, [Designing Data-Intensive Applications](#), O'Reilly Media, Inc., 2016
- M. Takada, [Distributed systems for fun and profit](#)

- B. Burke, A. Rubinger, [Enterprise JavaBeans 3.1](#), 6th Edition, O'Reilly Media, Inc., 2010

- [Coursera: Cloud Computing Concepts](#)
- [Coursera: Cloud Computing Concepts: Part 2](#)
- [Coursera: Cloud Computing Applications](#)

Student projects/theses with Infinispan

- <https://developer.jboss.org/wiki/StudentContributorProjectsWithInfinispan>
- <https://diplomky.redhat.com/>
- **Interested to work with Infinispan but non of the theses is interesting for you - drop me an email on `vjuranek[at]redhat.com`, we try to figure out something.**

Question?

THE
SIMPLE ANSWERS
TO THE QUESTIONS THAT GET ASKED
ABOUT EVERY NEW TECHNOLOGY:

WILL <input type="checkbox"/> MAKE US ALL GENIUSES?	NO
WILL <input type="checkbox"/> MAKE US ALL MORONS?	NO
WILL <input type="checkbox"/> DESTROY WHOLE INDUSTRIES?	YES
WILL <input type="checkbox"/> MAKE US MORE EMPATHETIC?	NO
WILL <input type="checkbox"/> MAKE US LESS CARING?	NO
WILL TEENS USE <input type="checkbox"/> FOR SEX?	YES
WERE THEY GOING TO HAVE SEX ANYWAY?	YES
WILL <input type="checkbox"/> DESTROY MUSIC?	NO
WILL <input type="checkbox"/> DESTROY ART?	NO
BUT CAN'T WE GO BACK TO A TIME WHEN—	NO
WILL <input type="checkbox"/> BRING ABOUT WORLD PEACE?	NO
WILL <input type="checkbox"/> CAUSE WIDESPREAD ALIENATION BY CREATING A WORLD OF EMPTY EXPERIENCES?	WE WERE ALREADY ALIENATED

Source: <https://xkcd.com/1289/>



<http://infinispan.org/>

Thank you for your attention!

Backup slides

Simple weather app using embedded Infinispan

- <http://infinispan.org/tutorials/embedded/>
- <https://github.com/infinispan/infinispan-embedded-tutorial>

```
1 git clone https://github.com/infinispan/infinispan-embedded
   -tutorial.git
2 cd infinispan-embedded-tutorial
3 git checkout -f step-2
4 sed -i 's/
```

Basic features: expiration

Removing entries from the cache: expiration

```
1 ConfigurationBuilder().expiration().maxIdle(5000L)
```

```
1 Configuration conf = new ConfigurationBuilder().expiration().
    maxIdle(expiration).build();
2 EmbeddedCacheManager ecm = new DefaultCacheManager(conf);
3 Cache<String, String> cache = ecm.getCache();
4
5 for (int i = 0; i < 100; i++) {
6     cache.put("key" + i, "value" + i);
7 }
8
9 System.out.printf("Cache size: %d\n", cache.size());
10 Thread.sleep(expiration);
11 System.out.printf("Cache size: %d\n", cache.size());
12
13 ecm.stop();
```

Examples: querying with index

```
1 @Indexed
2 public class Person {
3     @Field(analyze = Analyze.NO)
4     String name;
5
6     @Field(analyze = Analyze.NO, indexNullAs = Field.
7         DEFAULT_NULL_TOKEN)
8     String surname;
9
10    public Person(String name, String surname) {
11        this.name = name;
12        this.surname = surname;
13    }
14 }
```

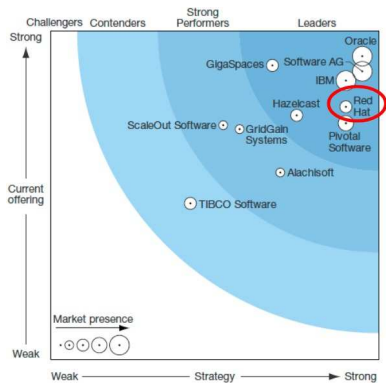

Examples: querying with index

```
1 ConfigurationBuilder cb = new ConfigurationBuilder();
2 cb.indexing().index(Index.ALL); //.addProperty("default.
   directory_provider", "ram");
3 EmbeddedCacheManager cm = new DefaultCacheManager(cb.build());
4 Cache<String, Person> cache = cm.getCache();
5 cache.put("person1", new Person("Will", "Shakespeare"));
6
7 // Obtain a query factory for the cache
8 QueryFactory<?> queryFactory = Search.getQueryFactory(cache);
9
10 // Construct a query
11 Query query = queryFactory.from(Person.class).having("name").eq
   ("Will").toBuilder().build();
12
13 // Execute the query
14 List<Person> matches = query.list();
15
16 matches.forEach(person -> System.out.printf("Match: %s", person
   ));
17 cm.stop();
```

Big data characteristics

- **Volume:** unprecedented amount of data being stored
- **Velocity:** speed at which the data is generated
- **Variety:** the type and nature of the data - from structured data in traditional databases to unstructured text documents, email, video, audio etc.
- **Variability:** the amount of incoming data can highly vary
- **Veracity:** the quality of captured data can vary greatly as well

Analyst recognition



Forrester Wave™: In-Memory Data Grids, Q3 2015



Forrester Wave™: In-Memory Databases, Q1 2017

- Hibernate
 - 2-nd level cache
- Lucene directory
 - In-memory Lucene index
- Apache Camel
 - Infinispan component for Camel
- Hadoop
 - In-memory data source for Hadoop cluster
- Apache Spark
 - Data source for Spark map-reduce jobs

Transactions, consistency, locking and isolation (cont.)

- **Pessimistic** and **optimistic** locking available

- Pessimistic locking: resource is locked all the time during the transaction (in ISPN when resource is changed, read is still possible).
- Optimistic locking: state of the resource is saved at the beginning of the transaction (prepare phase) and other transactions can access the resource. During commit phase of the resource is read again and if changed (write skew), transaction is rolled back.

- Isolation - how/when the changes made by one operation become visible to other. **Read committed** and **repeatable read** isolation levels.

- 1 Thread1: tx.begin()
- 2 Thread1: cache.get(k) returns v
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- 6 Thread2: tx.commit()
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- Role based access control
- User authentication
- Node authentication and authorization
- Encryption of communication
- Audit logging
- Integration with LDAP and/or Kerberos server (includes Active Directory)



- Functional API
- Distributed streams
- Continuous querying, grouping and aggregation
- New management console
- Integration with Apache Spark and Hadoop
- ... and more

Commercial break: Protocol Buffers

Protocol Buffers (protobuf) are language-neutral, platform-neutral, extensible mechanism for serializing structured data developed by Google.

- Supports C++, C#, Go, Java, Python.
- You need to define data structure in protobuf file.
- In ISPN you can use also annotations in the your model.

Example of protobuf file:

```
1  message Address {
2      required string street = 1;
3      required string postCode = 2;
4  }
5
6  message Person {
7      optional int32 id = 1;
8      required string name = 2;
9      required string surname = 3;
10     optional Address address = 4;
11     optional string license = 5;
12     enum Gender {
13         MALE = 0;
14         FEMALE = 1;
15     }
16 }
```