

# 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
```

# Introduction to Infinispan

Vojtěch Juránek

JBoss - a division by Red Hat

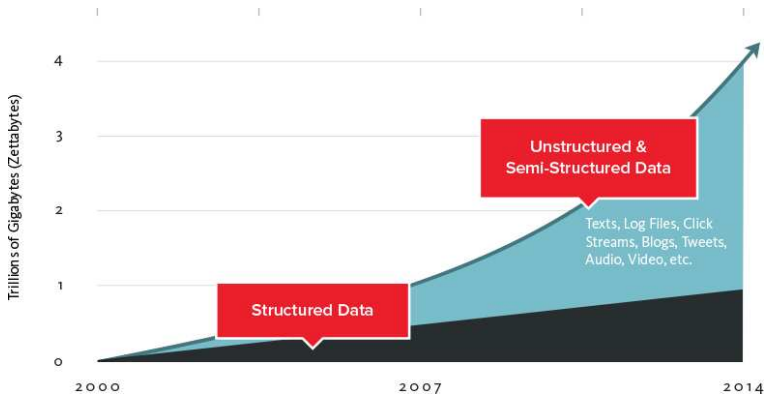
21. 10. 2016, CTU FEL, Prague

# Course materials download

- Course materials, including this presentation:  
<https://developer.jboss.org/wiki/AdvancedJavaEELabFELCVUTPodzim2016>
- This presentation (and source code):  
[https://github.com/vjuranek/presentations/tree/master/CTU\\_Prague2016\\_fall](https://github.com/vjuranek/presentations/tree/master/CTU_Prague2016_fall)

# Data today

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

# How big are Big data?

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Source: [https://twitter.com/DEVOPS\\_BORAT/status/288698056470315008](https://twitter.com/DEVOPS_BORAT/status/288698056470315008)

# How big are Big data?

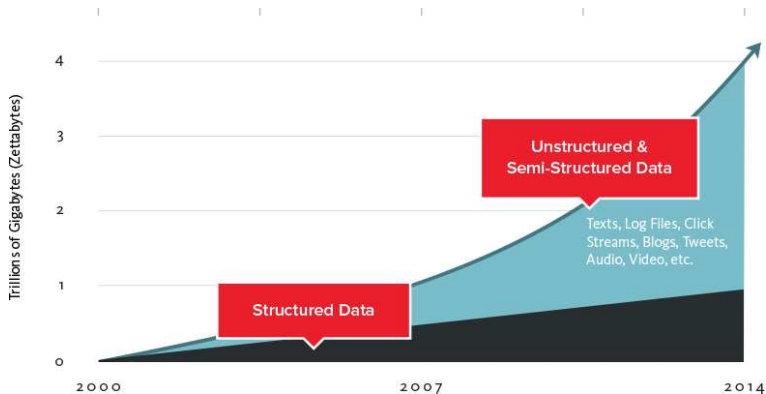


Source: [https://twitter.com/DEVOPS\\_BORAT/status/288698056470315008](https://twitter.com/DEVOPS_BORAT/status/288698056470315008)

- 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 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
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# 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







**DevOps Borat**  
@DEVOPS\_BORAT



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](https://twitter.com/devops_borat/status/141368065110708224)

# NoSQL

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



Source: [www.couchbase.com/sites/default/files/uploads/all/whitepapers/NoSQL-Whitepaper.pdf](http://www.couchbase.com/sites/default/files/uploads/all/whitepapers/NoSQL-Whitepaper.pdf)

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# What is a data grid?

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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.



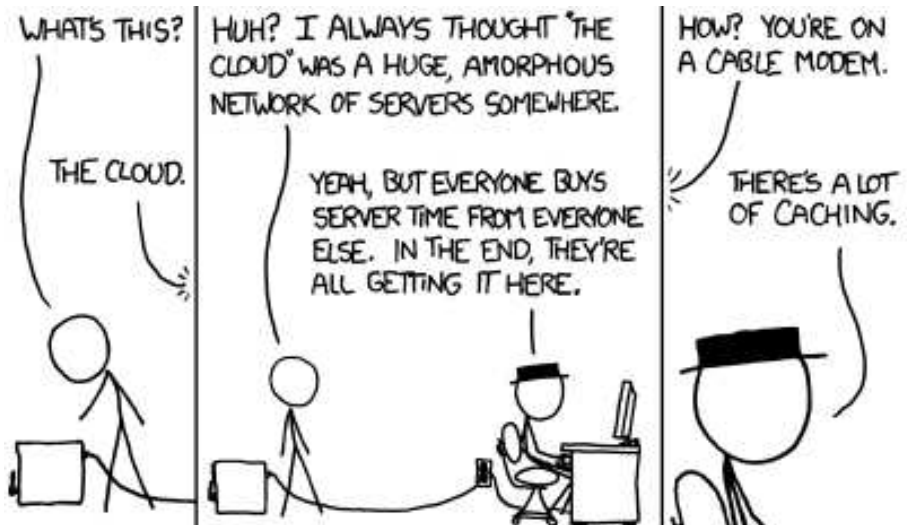
# What is a data grid?

- 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
- With data replication you can keep your data only in memory (no need to store them in persistent storage)

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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
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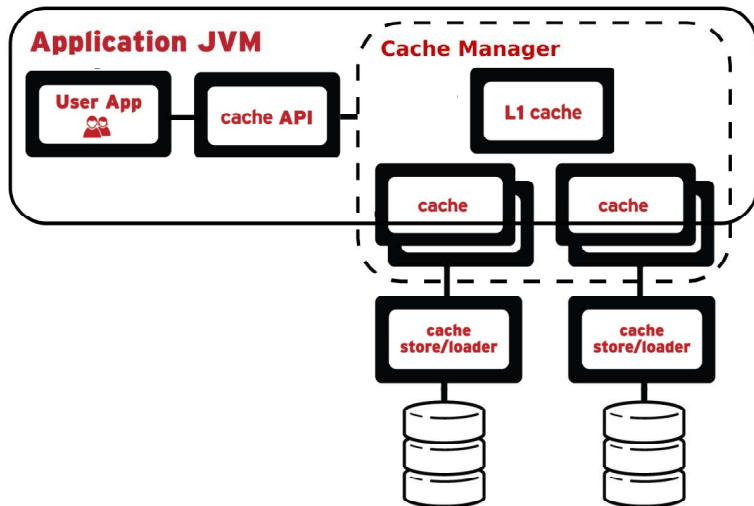
# Infinispan cache

- 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: 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();
```

# 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

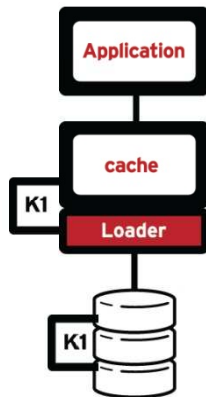
```
1 @Qualifier
2 @Target({ElementType.FIELD, ElementType.PARAMETER, ElementType.
    METHOD})
3 @Retention(RetentionPolicy.RUNTIME)
4 @Documented
5 public @interface EvictionCache {
6 }
```

```
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.

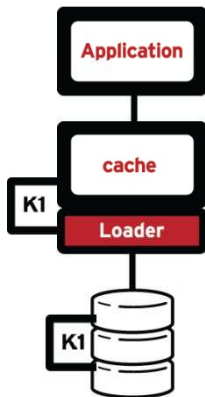




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Two modes:

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



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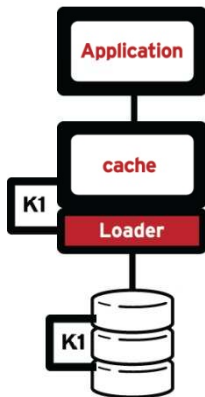
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Cache stores:

- 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();
```

# Examples: querying with index

```
1 @Indexed
2 public class Person {
3     @Field(store = Store.YES, analyze = Analyze.NO)
4     String name;
5
6     @Field(store = Store.YES, analyze = Analyze.NO, indexNullAs =
7         Field.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");
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4 Cache<String, Person> cache = cm.getCache();
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- 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



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# 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).
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# 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).
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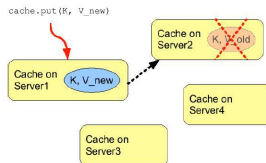
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# Clustering modes

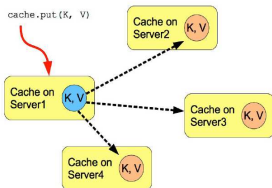
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# Clustering modes

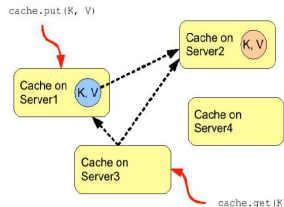
- Under the hood leverages JGroups project for clustering.
- Data is distributed and replicated in the background.
- Nodes can be added or removed smoothly.
- Local - no clustering
- Invalidation



- Replicated

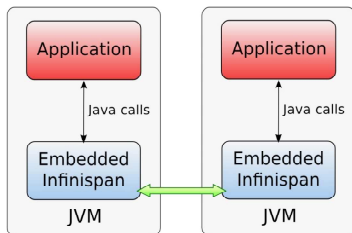


- Distributed

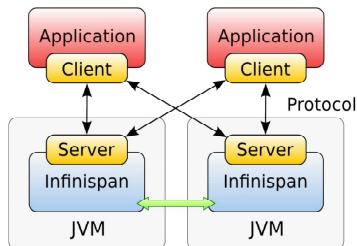


# Infinispan modes

- Embedded (library, in-VM)

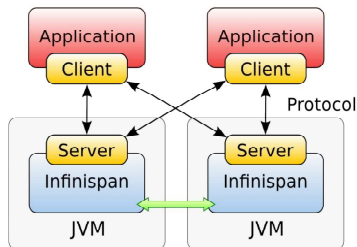


- Client-server (remote)



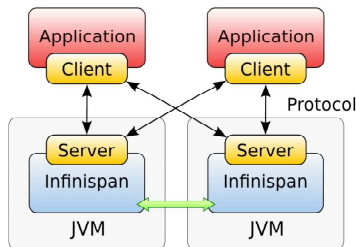
# Remote protocols

- 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 (**new!**)
- 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
- Distributed streams



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# Examples of usecases

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

# 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](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
- 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

# Infinispan embedded tutorial

## 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/<!-- a/<a;/s/t -->/t>/' pom.xml #switch to local
   random weather service
5  mvn clean package
6  mvn exec:exec
```

# Transactions, consistency, locking and isolation (cont.)

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

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  - Integration with Apache Spark and Hadoop
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# Recently implemented features: Infinispan 8



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# 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 }
```