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Preface

Full text search engines like Apache Lucene are very powerful technologies to add efficient free text search capabilities to applications. However, Lucene suffers several mismatches when dealing with object domain models. Amongst other things indexes have to be kept up to date and mismatches between index structure and domain model as well as query mismatches have to be avoided.

Hibernate Search addresses these shortcomings - it indexes your domain model with the help of a few annotations, takes care of database/index synchronization and brings back regular managed objects from free text queries. To achieve this Hibernate Search is combining the power of Hibernate and Apache Lucene.

Since version 5.6 Hibernate Search sports an experimental integration with Elasticsearch. Elasticsearch is built on Apache Lucene so we can now expose very similar features, making most of this reference documentation a valid guide to both approaches. For details specific to Elasticsearch, jump to Integration with Elasticsearch. The other sections of this guide will assume you’re using Lucene without the Elasticsearch indirection.
Chapter 1. Getting started

Welcome to Hibernate Search. The following chapter will guide you through the initial steps required to integrate Hibernate Search into an existing Hibernate ORM enabled application. In case you are a Hibernate new timer we recommend you start here.

1.1. System Requirements

Table 1. System requirements

<table>
<thead>
<tr>
<th>Component</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Java Runtime</td>
<td>Requires Java version 8 or greater. You can download a Java Runtime for Windows/Linux/Solaris here.</td>
</tr>
<tr>
<td>Hibernate Search</td>
<td>hibernate-search-5.7.3.Final.jar and all runtime dependencies. You can get the jar artifacts either from the dist/lib directory of the Hibernate Search distribution or you can download them from the JBoss maven repository.</td>
</tr>
<tr>
<td>Hibernate ORM</td>
<td>You will need hibernate-core-5.2.8.Final.jar and its dependencies (either from the distribution bundle or the maven repository).</td>
</tr>
<tr>
<td>JPA 2.1</td>
<td>Hibernate Search can be used without JPA but the following instructions will use JPA annotations for basic entity configuration (@Entity, @Id, @OneToMany, ...).</td>
</tr>
</tbody>
</table>

1.2. Migration notes

If you are upgrading an existing application from an earlier version of Hibernate Search to the latest release, make sure to check out the migration guide.

1.3. Required libraries

The Hibernate Search library is split in several modules to allow you to pick the minimal set of dependencies you need. It requires Apache Lucene, Hibernate ORM and some standard APIs such as the Java Persistence API and the Java Transactions API. Other dependencies are optional, providing additional integration points. To get the correct jar files on your classpath we highly recommend to use a dependency manager such as Maven, or similar tools such as Gradle or Ivy. These alternatives are also able to consume the artifacts from the Using Maven section.
1.3.1. Using Maven

The Hibernate Search artifacts can be found in Maven’s Central Repository but are released first in the JBoss Maven Repository. See also the Maven Getting Started wiki page to use the JBoss repository.

All you have to add to your pom.xml is:

**Example 1. Maven artifact identifier for Hibernate Search**

```xml
<dependency>
  <groupId>org.hibernate</groupId>
  <artifactId>hibernate-search-orm</artifactId>
  <version>5.7.3.Final</version>
</dependency>
```

**Example 2. Optional Maven dependencies for Hibernate Search**

```xml
<dependency>
  <groupId>org.infinispan</groupId>
  <artifactId>infinispan-directory-provider</artifactId>
  <version>8.2.4.Final</version>
</dependency>
```

Only the `hibernate-search-orm` dependency is mandatory. `infinispan-directory-provider` is only required if you want to use Infinispan to store the Lucene indexes.

1.3.2. Manual library management

You can download zip bundles from Sourceforge containing all needed Hibernate Search dependencies. This includes - among others - the latest compatible version of Hibernate ORM. However, only the essential parts you need to start experimenting with are included. You will probably need to combine this with downloads from the other projects, for example the Hibernate ORM distribution on Sourceforge also provides the modules to enable caching or use a connection pool.

1.4. Deploying on WildFly

If you are creating an application to be deployed on WildFly you’re lucky: Hibernate Search is included in the application server. This means that you don’t need to package it along with your application, unless you want to use a different version than the one included. The Hibernate Search dependencies are automatically activated since WildFly 10; see Hibernate Search as a
WildFly module for details.

Since this version of Hibernate Search requires Hibernate ORM version 5.2.3+ - which is more recent than the Hibernate ORM version included in WildFly 10 - you will also need to follow the instructions in the Hibernate ORM WildFly upgrade guide.

1.5. Configuration

Once you have added all required dependencies to your application you have to add a couple of properties to your Hibernate configuration file. If you are using Hibernate directly this can be done in hibernate.properties or hibernate.cfg.xml. If you are using Hibernate via JPA you can also add the properties to persistence.xml. The good news is that for standard use most properties offer a sensible default. An example persistence.xml configuration could look like this:

Example 3. Basic configuration options to be added to hibernate.properties, hibernate.cfg.xml or persistence.xml

```xml
...<property name="hibernate.search.default.directory_provider" value="filesystem"/>
<property name="hibernate.search.default.indexBase" value="/var/lucene/indexes"/>
...```

First you have to tell Hibernate Search which DirectoryProvider to use. This can be achieved by setting the hibernate.search.default.directory_provider property. Apache Lucene has the notion of a Directory to store the index files. Hibernate Search handles the initialization and configuration of a Lucene Directory instance via a DirectoryProvider. In this tutorial we will use a a directory provider which stores the index on the file system. This will give us the ability to inspect the Lucene indexes created by Hibernate Search (eg via Luke). Once you have a working configuration you can start experimenting with other directory providers (see Directory configuration). You also have to specify the default base directory for all indexes via hibernate.search.default.indexBase. This defines the path where indexes are stored.

Let's assume that your application contains the Hibernate managed classes example.Book and example.Author and you want to add free text search capabilities to your application in order to search the books contained in your database.
Example 4. Example entities Book and Author before adding Hibernate Search specific annotations

```java
package example;
...
@Entity
public class Book {
    @Id
    @GeneratedValue
    private Integer id;
    private String title;
    private String subtitle;
    @ManyToMany
    private Set<Author> authors = new HashSet<Author>();
    private Date publicationDate;
    public Book() {
    } // standard getters/setters follow
    ...
}

package example;
...
@Entity
public class Author {
    @Id
    @GeneratedValue
    private Integer id;
    private String name;
    public Author() {
    } // standard getters/setters follow
    ...
}
```

To achieve this you have to add a few annotations to the Book and Author class. The first annotation @Indexed marks Book as indexable. By design Hibernate Search needs to store an untokenized id in the index to ensure index uniqueness for a given entity (for now don’t worry if you don’t know what untokenized means, it will soon be clear).

Next you have to mark the fields you want to make searchable. Let’s start with title and subtitle and annotate both with @Field. The parameter index=Index.YES will ensure that the text will be indexed, while analyze=Analyze.YES ensures that the text will be analyzed using the default Lucene analyzer. Usually, analyzing or tokenizing means chunking a sentence
into individual words and potentially excluding common words like "a" or "the". We will talk more about analyzers a little later on. The third parameter we specify is `store=Store.NO`, which ensures that the actual data will not be stored in the index. Whether data is stored in the index or not has nothing to do with the ability to search for it. It is not necessary to store fields in the index to allow Lucene to search for them: the benefit of storing them is the ability to retrieve them via projections (see `Projection`).

Without projections, Hibernate Search will per default execute a Lucene query in order to find the database identifiers of the entities matching the query criteria and use these identifiers to retrieve managed objects from the database. The decision for or against projection has to be made on a case by case basis.

Note that `index=Index.YES, analyze=Analyze.YES` and `store=Store.NO` are the default values for these parameters and could be omitted.

After this short look under the hood let’s go back to annotating the `Book` class. Another annotation we have not yet discussed is `@DateBridge`. This annotation is one of the built-in field bridges in Hibernate Search. The Lucene index is mostly string based, with special support for encoding numbers. Hibernate Search must convert the data types of the indexed fields to their respective Lucene encoding and vice versa. A range of predefined bridges is provided for this purpose, including the `DateBridge` which will convert a `java.util.Date` into a numeric value (a `long`) with the specified resolution. For more details see `Built-in bridges`.

This leaves us with `@IndexedEmbedded`. This annotation is used to index associated entities (`@ManyToMany`, `@*ToOne`, `@Embedded` and `@ElementCollection`) as part of the owning entity. This is needed since a Lucene index document is a flat data structure which does not know anything about object relations. To ensure that the author names will be searchable you have to make sure that the names are indexed as part of the book itself. On top of `@IndexedEmbedded` you will also have to mark the fields of the associated entity you want to have included in the index with `@Field`. For more details see `Embedded and associated objects`.

These settings should be sufficient for now. For more details on entity mapping refer to `Mapping an entity`.
Example 5. Example entities after adding Hibernate Search annotations

```java
package example;
...
@Entity
@Indexed
class Book {
    @Id
    @GeneratedValue
    private Integer id;

    @Field(index=Index.YES, analyze=Analyze.YES, store=Store.NO)
    private String title;

    @Field(index=Index.YES, analyze=Analyze.YES, store=Store.NO)
    private String subtitle;

    @Field(index=Index.YES, analyze=Analyze.NO, store=Store.YES)
    @DateBridge(resolution=Resolution.DAY)
    private Date publicationDate;

    @IndexedEmbedded
    @ManyToMany
    private Set<Author> authors = new HashSet<Author>();

    public Book() {
    }

    // standard getters/setters follow here
    ...
}

@Entity
public class Author {
    @Id
    @GeneratedValue
    private Integer id;

    @Field
    private String name;

    public Author() {
    }

    // standard getters/setters follow here
    ...
}
```

1.6. Indexing

Hibernate Search will transparently index every entity persisted, updated or removed through Hibernate ORM. However, you have to create an initial Lucene index for the data already present...
in your database. Once you have added the above properties and annotations it is time to trigger an initial batch index of your books. You can achieve this by using one of the following code snippets (see also Rebuilding the whole index):

**Example 6. Using Hibernate Session to index data**

```java
FullTextSession fullTextSession = Search.getFullTextSession(session);
fullTextSession.createIndexer().startAndWait();
```

**Example 7. Using JPA to index data**

```java
EntityManager em = entityManagerFactory.createEntityManager();
FullTextEntityManager fullTextEntityManager = Search.getFullTextEntityManager(em);
fullTextEntityManager.createIndexer().startAndWait();
```

After executing the above code, you should be able to see a Lucene index under `/var/lucene/indexes/example.Book` (or based on a different path depending how you configured the property `hibernate.search.default.directory_provider`).

Go ahead and inspect this index with Luke: it will help you to understand how Hibernate Search works.

### 1.7. Searching

Now it is time to execute a first search. The general approach is to create a Lucene query, either via the Lucene API ([Building a Lucene query using the Lucene API](#)) or via the Hibernate Search query DSL ([Building a Lucene query with the Hibernate Search query DSL](#)), and then wrap this query into a `org.hibernate.Query` in order to get all the functionality one is used to from the Hibernate API. The following code will prepare a query against the indexed fields, execute it and return a list of `Book` instances.
Example 8. Using Hibernate Session to create and execute a search

```java
FullTextSession fullTextSession = Search.getFullTextSession(session);
Transaction tx = fullTextSession.beginTransaction();

// create native Lucene query using the query DSL
// alternatively you can write the Lucene query using the Lucene query parser
// or the Lucene programmatic API. The Hibernate Search DSL is recommended though
QueryBuilder qb = fullTextSession.getSearchFactory()
    .buildQueryBuilder().forEntity(Book.class).get();
org.apache.lucene.search.Query query = qb
    .keyword()
    .onFields("title", "subtitle", "authors.name")
    .matching("Java rocks!")
    .createQuery();

// wrap Lucene query in a org.hibernate.Query
org.hibernate.Query hibQuery =
    fullTextSession.createFullTextQuery(query, Book.class);

// execute search
List result = hibQuery.list();

tx.commit();
session.close();```
Example 9. Using JPA to create and execute a search

```java
EntityManager em = entityManagerFactory.createEntityManager();
FullTextEntityManager fullTextEntityManager =
    org.hibernate.search.jpa.Search.getFullTextEntityManager(em);
em.getTransaction().begin();

// create native Lucene query using the query DSL
// alternatively you can write the Lucene query using the Lucene query parser
// or the Lucene programmatic API. The Hibernate Search DSL is recommended though
QueryBuilder qb = fullTextEntityManager.getSearchFactory().
    .buildQueryBuilder().forEntity(Book.class).get();
org.apache.lucene.search.Query query = qb
    .keyword()
    .onFields("title", "subtitle", "authors.name")
    .matching("Java rocks!")
    .createQuery();

// wrap Lucene query in a javax.persistence.Query
javax.persistence.Query persistenceQuery =
    fullTextEntityManager.createFullTextQuery(query, Book.class);

// execute search
List result = persistenceQuery.getResultList();
em.getTransaction().commit();
em.close();
```

1.8. Analyzer

Let’s make things a little more interesting now. Assume that one of your indexed book entities has the title "Refactoring: Improving the Design of Existing Code" and you want to get hits for all of the following queries: "refactor", "refactors", "refactored" and "refactoring". In Lucene this can be achieved by choosing an analyzer class which applies word stemming during the indexing as well as the search process. Hibernate Search offers several ways to configure the analyzer to be used (see Analyzer):

- Setting the `hibernate.search.analyzer` property in the configuration file. The specified class will then be the default analyzer.
- Setting the `@Analyzer` annotation at the entity level.
- Setting the `@Analyzer` annotation at the field level.

When using the `@Analyzer` annotation one can either specify the fully qualified classname of the analyzer to use or one can refer to an analyzer definition defined by the `@AnalyzerDef` annotation. In the latter case the analyzer framework with its factories approach is utilized.
To find out more about the factory classes available you can either browse the Lucene JavaDoc or read the corresponding section on the Solr Wiki.

You can use @AnalyzerDef on any:

- @Indexed entity regardless of where the analyzer is applied to;
- parent class of an @Indexed entity;
- package-info.java of a package containing an @Indexed entity.

This implies that analyzer definitions are global and their names must be unique. The @AnalyzerDef is a repeatable annotation, so you can declare multiple analyzer definitions on each of these types.

Why the reference to the Apache Solr wiki?

Apache Solr was historically an independent sister project of Apache Lucene and the analyzer factory framework was originally created in Solr. Since then the Apache Lucene and Solr projects have merged, but the documentation for these additional analyzers can still be found in the Solr Wiki. You might find other documentation referring to the "Solr Analyzer Framework" - just remember you don't need to depend on Apache Solr anymore to use it. The required classes are part of the core Lucene distribution.

In the example below a StandardTokenizerFactory is used followed by two filter factories, LowerCaseFilterFactory and SnowballPorterFilterFactory. The standard tokenizer splits words at punctuation characters and hyphens. It is a good general purpose tokenizer. For indexing email addresses or internet hostnames it is not the best fit as it would split them up. You may either make use of Lucene's ClassicTokenizerFactory in such cases or implement a custom tokenizer and factory. The lowercase filter converts to lowercase the letters in each token whereas the snowball filter finally applies language specific stemming.

Generally, when using the Analyzer Framework you have to start with a tokenizer followed by an arbitrary number of filters.
Using \texttt{@AnalyzerDef} only defines an Analyzer, you still have to apply it to entities and or properties using \texttt{@Analyzer}. Like in the above example the \texttt{customanalyzer} is defined but not applied on the entity: it’s applied on the \texttt{title} and \texttt{subtitle} properties only. An analyzer definition is global, so you can define it on any entity and reuse the definition on other entities.

1.9. What’s next

The above paragraphs helped you getting an overview of Hibernate Search. The next step after this tutorial is to get more familiar with the overall architecture of Hibernate Search (Architecture) and explore the basic features in more detail. Two topics which were only briefly
touched in this tutorial were analyzer configuration (Analyzer) and field bridges (Bridges). Both are important features required for more fine-grained indexing. More advanced topics cover clustering (JMS Master/Slave back end, Infinispan Directory configuration) and large index handling (Sharding indexes).
Chapter 2. Architecture

2.1. Overview

Hibernate Search consists of an indexing component as well as an index search component. Both are backed by Apache Lucene.

Each time an entity is inserted, updated or removed in/from the database, Hibernate Search keeps track of this event (through the Hibernate event system) and schedules an index update. All these updates are handled without you having to interact with the Apache Lucene APIs directly (see Enabling Hibernate Search and automatic indexing). Instead, the interaction with the underlying Lucene indexes is handled via so called IndexManagers.

Each Lucene index is managed by one index manager which is uniquely identified by name. In most cases there is also a one to one relationship between an indexed entity and a single IndexManager. The exceptions are the use cases of index sharding and index sharing. The former can be applied when the index for a single entity becomes too big and indexing operations are slowing down the application. In this case a single entity is indexed into multiple indexes each with its own index manager (see Sharding indexes). The latter, index sharing, is the ability to index multiple entities into the same Lucene index (see Sharing indexes).

The index manager abstracts from the specific index configuration. In the case of the default index manager this includes details about the selected backend, the configured reader strategy and the chosen DirectoryProvider. These components will be discussed in greater detail later on. It is recommended that you start with the default index manager which uses different Lucene Directory types to manage the indexes (see Directory configuration). You can, however, also provide your own IndexManager implementation (see Configuring the IndexManager).

Once the index is created, you can search for entities and return lists of managed entities saving you the tedious object to Lucene Document mapping. The same persistence context is shared between Hibernate and Hibernate Search. As a matter of fact, the FullTextSession is built on top of the Hibernate Session so that the application code can use the unified org.hibernate.Query or javax.persistence.Query APIs exactly the same way a HQL, JPA-QL or native query would do.

To be more efficient Hibernate Search batches the write interactions with the Lucene index. This batching is the responsibility of the Worker. There are currently two types of batching. Outside a transaction, the index update operation is executed right after the actual database operation. This is really a no batching setup. In the case of an ongoing transaction, the index update operation is scheduled for the transaction commit phase and discarded in case of transaction rollback. The batching scope is the transaction. There are two immediate benefits:

- Performance: Lucene indexing works better when operation are executed in batch.
• ACIDity: The work executed has the same scoping as the one executed by the database transaction and is executed if and only if the transaction is committed. This is not ACID in the strict sense of it, but ACID behavior is rarely useful for full text search indexes since they can be rebuilt from the source at any time.

You can think of those two batch modes (no scope vs transactional) as the equivalent of the (infamous) autocommit vs transactional behavior. From a performance perspective, the in transaction mode is recommended. The scoping choice is made transparently. Hibernate Search detects the presence of a transaction and adjust the scoping (see Worker configuration).

It is recommended - for both your database and Hibernate Search - to execute your operations in a transaction, be it JDBC or JTA.

Hibernate Search works perfectly fine in the Hibernate / EntityManager long conversation pattern aka. atomic conversation.

2.2. Back end

Hibernate Search offers the ability to let the batched work being processed by different back ends. Several back ends are provided out of the box and you have the option to plugin your own. It is important to understand that in this context back end encompasses more than just the configuration option hibernate.search.default.worker.backend. This property just specifies a implementation of the BackendQueueProcessor interface which is a part of a back end configuration. In most cases, however, additional configuration settings are needed to successfully configure a specific backend setup, like for example the JMS back end.

2.2.1. Lucene

In this mode, all index update operations applied on a given node (JVM) will be executed to the Lucene directories (through the directory providers) by the same node. This mode is typically used in non clustered environment or in clustered environments where the directory store is shared.
This mode targets non clustered applications, or clustered applications where the Directory is taking care of the locking strategy.

The main advantage is simplicity and immediate visibility of the changes in Lucene queries (a requirement in some applications).

An alternative back end viable for non-clustered and non-shared index configurations is the near-real-time backend.

### 2.2.2. JMS

All index update operations applied on a given node are sent to a JMS queue. A unique reader will then process the queue and update the master index. The master index is then replicated on a regular basis to the slave copies. This is known as the master/slaves pattern. The master is the sole responsible for updating the Lucene index. The slaves can accept read as well as write operations. However, while they process the read operations on their local index copy, they will delegate the update operations to the master.
This mode targets clustered environments where throughput is critical, and index update delays are affordable. Reliability is ensured by the JMS provider and by having the slaves working on a local copy of the index.

The JMS integration can be transactional. With this backend (and currently only this backend) you can have Hibernate Search send the indexing work into the queue within the same transaction applying changes to the relational database. This options requires you to use an XA transaction.

By default this backend’s transactional capabilities are disabled: messages will be enqueued as a post-transaction event, consistently with other backends. To change this configuration see also Worker configuration.

2.2.3. JGroups

The JGroups based back end works similar to the JMS one and is designed after the same
master/slave pattern. However, instead of JMS the JGroups toolkit is used as a replication mechanism. This back end can be used as an alternative to JMS when response time is critical, but i.e. JNDI service is not available.

Note that while JMS can usually be configured to use persistent queues, JGroups talks directly to other nodes over network. Message delivery to other reachable nodes is guaranteed, but if no master node is available, index operations are silently discarded. This backend can be configured to use asynchronous messages, or to wait for each indexing operation to be completed on the remote node before returning.

The JGroups backend can be configured with static master or slave roles, or can be setup to perform an auto-election of the master. This mode is particularly useful to have the system automatically pick a new master in case of failure, but during a re-election process some indexing operations might be lost. For this reason this mode is not suited for use cases requiring strong consistency guarantees. When configured to perform an automatic election, the master node is defined as an hash on the index name: the role is therefore possibly different for each index or shard.

2.3. Reader strategy

When executing a query, Hibernate Search interacts with the Apache Lucene indexes through a reader strategy. Choosing a reader strategy will depend on the profile of the application (frequent updates, read mostly, asynchronous index update etc). See also Reader strategy configuration

2.3.1. shared

With this strategy, Hibernate Search will share the same IndexReader, for a given Lucene index, across multiple queries and threads provided that the IndexReader is still up-to-date. If the IndexReader is not up-to-date, a new one is opened and provided. Each IndexReader is made of several SegmentReaders. This strategy only reopens segments that have been modified or created after last opening and shares the already loaded segments from the previous instance. This approach is quite efficient and guarantees that each query is run on the most recent index snapshot; the drawback is that for every query the strategy will have to verify if the IndexReader is still fresh, and if not perform a refresh; such a refresh is typically a cheap operation but if you have a significant amount of writes and queries happening concurrently then one of the other strategies might be preferred. This strategy is the default.

The name of this strategy is shared.

2.3.2. not-shared

Every time a query is executed, a Lucene IndexReader is opened. This strategy is not efficient since opening and warming up an IndexReader can be a relatively expensive operation, but is
very simple code. Use it as an example implementation if you’re interested to learn about Hibernate Search internals or want to extend it.

The name of this strategy is **not-shared**.

### 2.3.3. async

This implementation keeps an IndexReader open and ready to be used by all queries, while a background thread periodically verifies if there is need to open a fresh one, replaces the active one and disposes the outdated one. The frequency of checks - and refreshing - of this background thread is configurable, but defaults to 5000 milliseconds. The drawback of this design is that queries are effectively run on an index snapshot which might be approximately 5 seconds out of date (assuming the refresh period is not reconfigured); the benefit is that if your application writes frequently to the index, the query performance will be more consistent.

The name of this strategy is **async**.

### 2.3.4. Custom

You can write your own reader strategy that suits your application needs by implementing org.hibernate.search.reader.ReaderProvider. The implementation must be thread safe.
Chapter 3. Configuration

3.1. Enabling Hibernate Search and automatic indexing

Let's start with the most basic configuration question - how do I enable Hibernate Search?

3.1.1. Enabling Hibernate Search

The good news is that Hibernate Search is enabled out of the box when detected on the classpath by Hibernate ORM. If, for some reason you need to disable it, set `hibernate.search.autoregister_listeners` to false. Note that there is no performance penalty when the listeners are enabled but no entities are annotated as indexed.

3.1.2. Automatic indexing

By default, every time an object is inserted, updated or deleted through Hibernate, Hibernate Search updates the according Lucene index. It is sometimes desirable to disable that features if either your index is read-only or if index updates are done in a batch way (see Rebuilding the whole index).

To disable event based indexing, set

```properties
hibernate.search.indexing_strategy = manual
```

In most case, the JMS backend provides the best of both world, a lightweight event based system keeps track of all changes in the system, and the heavyweight indexing process is done by a separate process or machine.

3.2. Configuring the IndexManager

The role of the index manager component is described in Architecture. Hibernate Search provides two possible implementations for this interface to choose from.

- **directory-based**: the default implementation which uses the Lucene Directory abstraction to manage index files.
- **near-real-time**: avoid flushing writes to disk at each commit. This index manager is also Directory based, but also makes uses of Lucene's NRT functionality.

To select an alternative you specify the property:
3.2.1. directory-based

The default IndexManager implementation. This is the one mostly referred to in this documentation. It is highly configurable and allows you to select different settings for the reader strategy, back ends and directory providers. Refer to Directory configuration, Worker configuration and Reader strategy configuration for more details.

3.2.2. near-real-time

The NRTIndexManager is an extension of the default IndexManager, leveraging the Lucene NRT (Near Real Time) features for extreme low latency index writes. As a trade-off it requires a non-clustered and non-shared index. In other words, it will ignore configuration settings for alternative back ends other than lucene and will acquire exclusive write locks on the Directory.

To achieve this low latency writes, the IndexWriter will not flush every change to disk. Queries will be allowed to read updated state from the unflushed index writer buffers; the downside of this strategy is that if the application crashes or the IndexWriter is otherwise killed you’ll have to rebuild the indexes as some updates might be lost.

Because of these downsides, and because a master node in cluster can be configured for good performance as well, the NRT configuration is only recommended for non clustered websites with a limited amount of data.

3.2.3. Custom

It is also possible to configure a custom IndexManager implementation by specifying the fully qualified class name of your custom implementation. This implementation must have a no-argument constructor:

```
hibernate.search.[default|<indexname>].indexmanager = my.corp.myapp.CustomIndexManager
```

Your custom index manager implementation doesn’t need to use the same components as the default implementations. For example, you can delegate to a remote indexing service which doesn’t expose a Directory interface.
3.3. Directory configuration

As we have seen in Configuring the IndexManager the default index manager uses Lucene’s notion of a Directory to store the index files. The Directory implementation can be customized and Lucene comes bundled with a file system and an in-memory implementation. DirectoryProvider is the Hibernate Search abstraction around a Lucene Directory and handles the configuration and the initialization of the underlying Lucene resources. List of built-in DirectoryProvider shows the list of the directory providers available in Hibernate Search together with their corresponding options.

To configure your DirectoryProvider you have to understand that each indexed entity is associated to a Lucene index (except of the case where multiple entities share the same index - Sharing indexes). The name of the index is given by the index property of the @Indexed annotation. If the index property is not specified the fully qualified name of the indexed class will be used as name (recommended).

Knowing the index name, you can configure the directory provider and any additional options by using the prefix hibernate.search.<indexname>. The name default (hibernate.search.default) is reserved and can be used to define properties which apply to all indexes. Configuring directory providers shows how hibernate.search.default.directory_provider is used to set the default directory provider to be the filesystem one. hibernate.search.default.indexBase sets then the default base directory for the indexes. As a result the index for the entity Status is created in /usr/lucene/indexes/org.hibernate.example.Status.

The index for the Rule entity, however, is using an in-memory directory, because the default directory provider for this entity is overridden by the property hibernate.search.Rules.directory_provider.

Finally the Action entity uses a custom directory provider CustomDirectoryProvider specified via hibernate.search.Actions.directory_provider.

Example 11. Specifying the index name

```java
package org.hibernate.example;

@Indexed
public class Status { ... }

@Indexed(index="Rules")
public class Rule { ... }

@Indexed(index="Actions")
public class Action { ... }
```
Example 12. Configuring directory providers

```
hibernate.search.default.directory_provider = filesystem
hibernate.search.default.indexBase = /usr/lucene/indexes
hibernate.search.Rules.directory_provider = ram
hibernate.search.Actions.directory_provider =
com.acme.hibernate.CustomDirectoryProvider
```

Using the described configuration scheme you can easily define common rules like the directory provider and base directory, and override those defaults later on a per index basis.

Table 2. List of built-in DirectoryProvider

<table>
<thead>
<tr>
<th>Name and description</th>
<th>Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>ram: Memory based directory. The directory will be uniquely identified (in the same deployment unit) by the <code>@Indexed.index</code> element</td>
<td>none</td>
</tr>
<tr>
<td>filesystem: File system based directory. The directory used will be <code>&lt;indexBase&gt;/&lt;indexName&gt;</code></td>
<td><code>indexBase</code>: base directory <code>indexName</code>: override <code>@Indexed.index</code> (useful for sharded indexes) <code>locking_strategy</code>: optional, see LockFactory configuration <code>filesystem_access_type</code>: allows to determine the exact type of FSDirectory implementation used by this DirectoryProvider. Allowed values are <code>auto</code> (the default value, selects NIOFSDirectory on non Windows systems, SimpleFSDirectory on Windows), <code>simple</code> (SimpleFSDirectory), <code>nio</code> (NIOFSDirectory), <code>mmap</code> (MMapDirectory). Make sure to refer to Javadocs of these Directory implementations before changing this setting. Even though NIOFSDirectory or MMapDirectory can bring substantial performance boosts they also have their issues.</td>
</tr>
<tr>
<td>Name and description</td>
<td>Properties</td>
</tr>
<tr>
<td>----------------------</td>
<td>------------</td>
</tr>
<tr>
<td>filesystem-master: File system based directory. Like filesystem. It also copies the index to a source directory (aka copy directory) on a regular basis. The recommended value for the refresh period is (at least) 50% higher that the time to copy the information (default 3600 seconds - 60 minutes). Note that the copy is based on an incremental copy mechanism reducing the average copy time. DirectoryProvider typically used on the master node in a JMS back end cluster. The buffer_size_on_copy optimum depends on your operating system and available RAM; most people reported good results using values between 16 and 64MB.</td>
<td>indexBase: base directory indexName: override @Indexed.index (useful for sharded indexes) sourceBase: source (copy) base directory. source: source directory suffix (default to @Indexed.index). The actual source directory name being &lt;sourceBase&gt;/&lt;source&gt; refresh: refresh period in seconds (the copy will take place every refresh seconds). If a copy is still in progress when the following refresh period elapses, the second copy operation will be skipped. buffer_size_on_copy: The amount of MegaBytes to move in a single low level copy instruction; defaults to 16MB. locking_strategy: optional, see LockFactory configuration filesystem_access_type: allows to determine the exact type of FSDirectory implementation used by this DirectoryProvider. Allowed values are auto (the default value, selects NIOFSDirectory on non Windows systems, SimpleFSDirectory on Windows), simple (SimpleFSDirectory), nio (NIOFSDirectory), mmap (MMapDirectory). Make sure to refer to Javadocs of these Directory implementations before changing this setting. Even though NIOFSDirectory or MMapDirectory can bring substantial performance boosts they also have their issues.</td>
</tr>
</tbody>
</table>
**Name and description**

filesystem-slave: File system based directory. Like filesystem, but retrieves a master version (source) on a regular basis. To avoid locking and inconsistent search results, 2 local copies are kept. The recommended value for the refresh period is (at least) 50% higher that the time to copy the information (default 3600 seconds - 60 minutes). Note that the copy is based on an incremental copy mechanism reducing the average copy time. If a copy is still in progress when refresh period elapses, the second copy operation will be skipped. DirectoryProvider typically used on slave nodes using a JMS back end. The buffer_size_on_copy optimum depends on your operating system and available RAM; most people reported good results using values between 16 and 64MB.

**Properties**

indexBase: Base directory
indexName: override @Indexed.index (useful for sharded indexes)
sourceBase: Source (copy) base directory
source: Source directory suffix (default to @Indexed.index). The actual source directory name being <sourceBase>/<source>
refresh: refresh period in second (the copy will take place every refresh seconds).

buffer_size_on_copy: The amount of MegaBytes to move in a single low level copy instruction; defaults to 16MB.

locking_strategy: optional, see LockFactory configuration

retry_marker_lookup: optional, default to 0. Defines how many times we look for the marker files in the source directory before failing. Waiting 5 seconds between each try.

retry_initialize_period: optional, set an integer value in seconds to enable the retry initialize feature: if the slave can’t find the master index it will try again until it’s found in background, without preventing the application to start: full-text queries performed before the index is initialized are not blocked but will return empty results. When not enabling the option or explicitly setting it to zero it will fail with an exception instead of scheduling a retry timer. To prevent the application from starting without an invalid index but still control an initialization timeout, see retry_marker_lookup instead.

filesystem_access_type: allows to determine the exact type of FSDirectory implementation used by this DirectoryProvider. Allowed values are auto (the default value, selects NIOFSDirectory on non Windows systems, SimpleFSDirectory on Windows), simple (SimpleFSDirectory), nio (NIOFSDirectory), mmap (MMapDirectory). Make sure to refer to Javadocs of these Directory implementations before changing this setting. Even though NIOFSDirectory or MMapDirectory can bring substantial performance boosts they also have their issues.
### Name and description

<table>
<thead>
<tr>
<th>Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>infinispan</strong>: Infinispan based directory. Use it to store the index in a distributed grid, making index changes visible to all elements of the cluster very quickly. Also see <a href="#">Infinispan Directory configuration</a> for additional requirements and configuration settings. Infinispan needs a global configuration and additional dependencies; the settings defined here apply to each different index.</td>
</tr>
<tr>
<td><strong>locking_cachename</strong>: name of the Infinispan cache to use to store locks. <code>data_cachename</code>: name of the Infinispan cache to use to store the largest data chunks; this area will contain the largest objects, use replication if you have enough memory or switch to distribution. <strong>metadata_cachename</strong>: name of the Infinispan cache to use to store the metadata relating to the index; this data is rather small and read very often, it’s recommended to have this cache setup using replication. <strong>chunk_size</strong>: large files of the index are split in smaller chunks, you might want to set the highest value efficiently handled by your network. Networking tuning might be useful.</td>
</tr>
</tbody>
</table>

---

If the built-in directory providers do not fit your needs, you can write your own directory provider by implementing the `org.hibernate.store.DirectoryProvider` interface. In this case, pass the fully qualified class name of your provider into the `directory_provider` property. You can pass any additional properties using the prefix `hibernate.search.<indexname>`.

### 3.3.1. Infinispan Directory configuration

Infinispan is a distributed, scalable, cloud friendly data grid platform, which Hibernate Search can use to store the Lucene index. Your application can benefits in this case from Infinispan’s distribution capabilities making index updates available on all nodes with short latency.

This section describes how to configure Hibernate Search to use an Infinispan Lucene Directory.

When using an Infinispan Directory the index is stored in memory and shared across multiple nodes. It is considered a single directory distributed across all participating nodes: if a node updates the index, all other nodes are updated as well. Updates on one node can be immediately searched for in the whole cluster.

The default configuration replicates all data which defines the index across all nodes, thus consuming a significant amount of memory but providing the best query performance. For large indexes it’s suggested to enable data distribution, so that each piece of information is replicated to a subset of all cluster members. The distribution option will reduce the amount of memory required for each node but is less efficient as it will cause high network usage among the nodes.

It is also possible to offload part or most information to a CacheStore, such as plain filesystem, Amazon S3, Cassandra, MongoDB or standard relational databases. You can configure it to have a CacheStore on each node or have a single centralized one shared by each node.
A popular choice is to use a replicated index aiming to keep the whole index in memory, combined with a CacheStore as safety valve in case the index gets larger than expected.

See the Infinispan documentation for all Infinispan configuration options.

Requirements

To use the Infinispan directory via Maven, add the following dependencies:

Example 13. Maven dependencies for Hibernate Search using Infinispan

```xml
<dependency>
  <groupId>org.hibernate</groupId>
  <artifactId>hibernate-search-orm</artifactId>
  <version>5.7.3.Final</version>
</dependency>
<dependency>
  <groupId>org.infinispan</groupId>
  <artifactId>infinispan-directory-provider</artifactId>
  <version>8.2.4.Final</version>
</dependency>
```

This dependency changed in Hibernate Search version 5.2.

Previously the DirectoryProvider was provided by the Hibernate Search project and had Maven coordinates 'org.hibernate:hibernate-search-infinispan', but the Infinispan team is now maintaining this extension point so since this version please use the Maven definition as in the previous example.

The version printed above was the latest compatible at the time of publishing this Hibernate Search version: it's possible that more recently improved versions of Infinispan have been published which are compatible with this same Hibernate Search version.

Architecture

Even when using an Infinispan directory it’s still recommended to use the JMS Master/Slave or JGroups backend, because in Infinispan all nodes will share the same index and it is likely that IndexWriter instances being active on different nodes will try to acquire the lock on the same index. So instead of sending updates directly to the index, send it to a JMS queue or JGroups channel and have a single node apply all changes on behalf of all other nodes.

Configuring a non-default backend is not a requirement but a performance optimization as locks are enabled to have a single node writing.
To configure a JMS slave only the backend must be replaced, the directory provider must be set to `infinispan`; set the same directory provider on the master, they will connect without the need to setup the copy job across nodes. Using the JGroups backend is very similar - just combine the backend configuration with the `infinispan` directory provider.

Infinispan Configuration

The most simple configuration only requires to enable the backend:

```
hibernate.search.[default|<indexname>].directory_provider = infinispan
```

That's all what is needed to get a cluster-replicated index, but the default configuration does not enable any form of permanent persistence for the index; to enable such a feature an Infinispan configuration file should be provided.

To use Infinispan, Hibernate Search requires a CacheManager; it can lookup and reuse an existing CacheManager, via JNDI, or start and manage a new one. In the latter case Hibernate Search will start and stop it (closing occurs when the Hibernate SessionFactory is closed).

To use and existing CacheManager via JNDI (optional parameter):

```
hibernate.search.infinispan.cachemanager_jndiname = [jndiname]
```

To start a new CacheManager from a configuration file (optional parameter):

```
hibernate.search.infinispan.configuration_resourcename = [infinispan configuration filename]
```

If both parameters are defined, JNDI will have priority. If none of these is defined, Hibernate Search will use the default Infinispan configuration included in `infinispan-directory-provider.jar`. This configuration should work fine in most cases but does not store the index in a persistent cache store.

As mentioned in List of built-in DirectoryProvider, each index makes use of three caches, so three different caches should be configured as shown in the `default-hibernatesearch-infinispan.xml` provided in the `infinispan-directory-provider.jar`. Several indexes can share the same caches.
Infinispan relies on JGroups for its networking functionality, so unless you are using Infinispan on a single node, an Infinispan configuration file will refer to a JGroups configuration file. This coupling is not always practical and we provide a property to override the used JGroups configuration file:

```
hibernate.search.infinispan.configuration.transport_override_resourcename = jgroups-ec2.xml
```

This allows to just switch the JGroups configuration while keeping the rest of the Infinispan configuration.

The file `jgroups-ec2.xml` used in the example above is one of the several JGroups configurations included in Infinispan. It is a good starting point to run on Amazon EC2 networks. For more details and examples see usage of pre-configured JGroups stacks in the Infinispan configuration guide.

### 3.4. Worker configuration

It is possible to refine how Hibernate Search interacts with Lucene through the worker configuration. There exist several architectural components and possible extension points. Let’s have a closer look.

First there is a Worker. An implementation of the Worker interface is responsible for receiving all entity changes, queuing them by context and applying them once a context ends. The most intuitive context, especially in connection with ORM, is the transaction. For this reason Hibernate Search will per default use the TransactionalWorker to scope all changes per transaction. One can, however, imagine a scenario where the context depends for example on the number of entity changes or some other application (lifecycle) events. For this reason the Worker implementation is configurable as shown in Scope configuration.

<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>hibernate.search.worker.scope</code></td>
<td>The fully qualified class name of the Worker implementation to use. If this property is not set, empty or <code>transaction</code> the default TransactionalWorker is used.</td>
</tr>
<tr>
<td><code>hibernate.search.default.worker.*</code></td>
<td>All configuration properties prefixed with <code>hibernate.search.default.worker</code> are passed to the Worker during initialization. This allows adding custom, worker specific parameters.</td>
</tr>
</tbody>
</table>
Once a context ends it is time to prepare and apply the index changes. This can be done synchronously or asynchronously from within a new thread. Synchronous updates have the advantage that the index is at all times in sync with the databases. Asynchronous updates, on the other hand, can help to minimize the user response time. The drawback is potential discrepancies between database and index states. Let's look at the configuration options shown in Execution configuration.

The following options can be different on each index; in fact they need the `indexName` prefix or use `default` to set the default value for all indexes.

<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>synchronous</code> execution (default)</td>
<td><code>async</code>: asynchronous execution</td>
</tr>
</tbody>
</table>

So far all work is done within the same Virtual Machine (VM), no matter which execution mode. The total amount of work has not changed for the single VM. Luckily there is a better approach, namely delegation. It is possible to send the indexing work to a different server by configuring `hibernate.search.default.worker.backend` - see Backend configuration. Again this option can be configured differently for each index.

<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
</tr>
</thead>
</table>

hibernate.search.<indexName>.worker.backend
d

**local:** The default backend which runs index updates in the same JVM. Also used when the property is undefined or empty. **jms:** JMS backend. Index updates are send to a JMS queue to be processed by an indexing master. See [JMS backend configuration](#) for additional configuration options and [JMS Master/Slave backend](#) for a more detailed description of this setup. **jgroupsMaster, jgroupsSlave** or **jgroups:** Backend using JGroups as communication layer. See [JGroups Master/Slave backend](#) for a more detailed description of this setup. **blackhole:** Mainly a test/developer setting which ignores all indexing work. You can also specify the fully qualified name of a class implementing BackendQueueProcessor. This way you can implement your own communication layer. The implementation is responsible for returning a Runnable instance which on execution will process the index work.

<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>hibernate.search.&lt;indexName&gt;.worker.jndi.*</td>
<td>Defines the JNDI properties to initiate the InitialContext (if needed). JNDI is only used by the JMS back end.</td>
</tr>
<tr>
<td>hibernate.search.&lt;indexName&gt;.worker.jms.connection_factory</td>
<td>Mandatory for the JMS back end. Defines the JNDI name to lookup the JMS connection factory from (/ConnectionFactory by default in JBoss AS)</td>
</tr>
<tr>
<td>hibernate.search.&lt;indexName&gt;.worker.jms.queue</td>
<td>Mandatory for the JMS back end. Defines the JNDI name to lookup the JMS queue from. The queue will be used to post work messages.</td>
</tr>
<tr>
<td>hibernate.search.&lt;indexName&gt;.worker.jms.login</td>
<td>Optional for the JMS slaves. Use it when your queue requires login credentials to define your login.</td>
</tr>
<tr>
<td>hibernate.search.&lt;indexName&gt;.worker.jms.login</td>
<td>Optional for the JMS slaves. Use it when your queue requires login credentials to define your password.</td>
</tr>
</tbody>
</table>

As you probably noticed, some of the shown properties are correlated which means that not all combinations of property values make sense. In fact you can end up with a non-functional configuration. This is especially true for the case that you provide your own implementations of some of the shown interfaces. Make sure to study the existing code before you write your own Worker or BackendQueueProcessor implementation.
3.4.1. JMS Master/Slave back end

This section describes in greater detail how to configure the Master/Slave Hibernate Search architecture.

JMS back end configuration.

Slave nodes

Every index update operation is sent to a JMS queue. Index querying operations are executed on a local index copy.

Example 14. JMS Slave configuration

```plaintext
### slave configuration

#### DirectoryProvider

# (remote) master location
hibernate.search.default.sourceBase = /mnt/mastervolume/lucenedirs/mastercopy

# local copy location
hibernate.search.default.indexBase = /Users/prod/lucenedirs

# refresh every half hour
hibernate.search.default.refresh = 1800

# appropriate directory provider
hibernate.search.default.directory_provider = filesystem-slave

#### Backend configuration

hibernate.search.default.worker.backend = jms
hibernate.search.default.worker.jms.connection_factory = /ConnectionFactory
hibernate.search.default.worker.jms.queue = queue/hibernatesearch

# optionally authentication credentials:
hibernate.search.default.worker.jms.login = myname
hibernate.search.default.worker.jms.password = wonttellyou

# optional jndi configuration (check your JMS provider for more information)

#### Enqueue indexing tasks within an XA transaction with the database

hibernate.search.worker.enlist_in_transaction = true
```

The `enlist_in_transaction` option can be enabled if you need strict guarantees of indexing work to be stored in the queue within the same transaction of the database changes, however this will require both the RDBMs datasource and the JMS queue to be XA enabled.

Make sure to use a XA JMS queue and that your database supports XA as we are talking about coordinated transactional systems.
The default for `enlist_in_transaction` is `false` as often it is desirable to not have the database transaction fail in case there are issues with indexing.

It is possible to apply compensating operations to the index by implementing a custom `ErrorHandler` (see Exception handling), or simply re-synchronize the whole index state by starting the MassIndexer (see Using a MassIndexer).

💡 A file system local copy is recommended for faster search results.

### Master node

Every index update operation is taken from a JMS queue and executed. The master index is copied on a regular basis.

**Example 15. JMS Master configuration**

```yaml
### master configuration
## DirectoryProvider
# (remote) master location where information is copied to
hibernate.search.default.sourceBase = /mnt/mastervolume/lucenedirs/mastercopy

# local master location
hibernate.search.default.indexBase = /Users/prod/lucenedirs

# refresh every half hour
hibernate.search.default.refresh = 1800

# appropriate directory provider
hibernate.search.default.directory_provider = filesystem-master

## Backend configuration
#The backend is not set: use the default one which is 'local'
```

It is recommended that the refresh period be higher than the expected copy time; if a copy operation is still being performed when the next refresh triggers, the second refresh is skipped: it’s safe to set this value low even when the copy time is not known.

In addition to the Hibernate Search framework configuration, a Message Driven Bean has to be written and set up to process the index works queue through JMS.
Example 16. Message Driven Bean processing the indexing queue

```java
@MessageDriven(activationConfig = {
    @ActivationConfigProperty(propertyName="destinationType", propertyValue="javax.jms.Queue"),
    @ActivationConfigProperty(propertyName="destination", propertyValue="queue/hibernatesearch")
  })
public class MDBSearchController extends AbstractJMSHibernateSearchController implements MessageListener {

    @PersistenceContext
    EntityManager em;

    @Override
    protected SearchIntegrator getSearchIntegrator() {
        FullTextEntityManager fullTextEntityManager = Search.getFullTextEntityManager(em);
        return fullTextEntityManager.getSearchFactory().unwrap(SearchIntegrator.class);
    }
}
```

This example inherits from the abstract JMS controller class available in the Hibernate Search source code and implements a JavaEE MDB. This implementation is given as an example and can be adjusted to make use of non Java EE Message Driven Beans. Essentially what you need to do is to connect the specific JMS Queue with the `SearchFactory` instance of the EntityManager. As an advanced alternative, you can implement your own logic by not extending `AbstractJMSHibernateSearchController` but rather to use it as an implementation example.

### 3.4.2. JGroups Master/Slave back end

This section describes how to configure the JGroups Master/Slave back end. The master and slave roles are similar to what is illustrated in JMS Master/Slave back end, only a different backend (hibernate.search.default.worker.backend) needs to be set.

A specific backend can be configured to act either as a slave using `jgroupsSlave`, as a master using `jgroupsMaster`, or can automatically switch between the roles as needed by using `jgroups`.

Either you specify a single `jgroupsMaster` and a set of `jgroupsSlave` instances, or you specify all instances as `jgroups`. Never mix the two approaches!

All backends configured to use JGroups share the same channel. The JGroups JChannel is the main communication link across all nodes participating in the same cluster group; since it is
convenient to have just one channel shared across all backends, the Channel configuration properties are not defined on a per-worker section but are defined globally. See JGroups channel configuration.

Table JGroups backend configuration properties contains all configuration options which can be set independently on each index backend. These apply to all three variants of the backend: jgroupsSlave, jgroupsMaster, jgroups. It is very unlikely that you need to change any of these from their defaults.

Table 7. JGroups backend configuration properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>hibernate.search.&lt;indexName&gt;.jgroups.block_waiting_ack</td>
<td>Set to either true or false. False is more efficient but will not wait for the operation to be delivered to the peers. Defaults to true when the backend is synchronous, to false when the backend is async.</td>
</tr>
<tr>
<td>hibernate.search.&lt;indexName&gt;.jgroups.messages_timeout</td>
<td>The timeout of waiting for a single command to be acknowledged and executed when block_waiting_ack is true, or just acknowledged otherwise. Value in milliseconds, defaults to 20000.</td>
</tr>
<tr>
<td>hibernate.search.&lt;indexName&gt;.jgroups.delegate_backend</td>
<td>The master node receiving indexing operations forwards them to a standard backend to be performed. Defaults to lucene. See also Backend configuration for other options, but probably the only useful option is blackhole, or a custom implementation, to help isolating network latency problems.</td>
</tr>
</tbody>
</table>

Slave nodes

Every index update operation is sent through a JGroups channel to the master node. Index querying operations are executed on a local index copy. Enabling the JGroups worker only makes sure the index operations are sent to the master, you still have to synchronize configuring an appropriate directory (See filesystem-master, filesystem-slave or infinispan options in Directory configuration).

Example 17. JGroups Slave configuration

```java
### slave configuration
hibernate.search.default.worker.backend = jgroupsSlave
```
Master node

Every index update operation is taken from a JGroups channel and executed. The master index is copied on a regular basis.

Example 18. JGroups Master configuration

```java
### master configuration
hibernate.search.default.worker.backend = jgroupsMaster
```

Automatic master election

This feature is considered experimental. In particular during a re-election process there is a small window of time in which indexing requests could be lost.

In this mode the different nodes will autonomously elect a master node. When a master fails, a new node is elected automatically.

When setting this backend it is expected that all Hibernate Search instances in the same cluster use the same backend for each specific index: this configuration is an alternative to the static `jgroupsMaster` and `jgroupsSlave` approach so make sure to not mix them.

To synchronize the indexes in this configuration avoid `filesystem-master` and `filesystem-slave` directory providers as their behaviour cannot be switched dynamically; use the Infinispan Directory instead, which has no need for different configurations on each instance and allows dynamic switching of writers; see also Infinispan Directory configuration.

Example 19. JGroups configuration for automatic master configuration

```java
### automatic configuration
hibernate.search.default.worker.backend = jgroups
```

Should you use `jgroups` or the couple `jgroupsMaster, jgroupsSlave`?

The dynamic `jgroups` backend is better suited for environments in which your master is more likely to need to failover to a different machine, as in clouds. The static configuration has the benefit of keeping the master at a well known location: your architecture might take advantage of it by sending most write requests to the known master. Also optimisation and MassIndexer operations need to be triggered on the master node.
JGroups channel configuration

Configuring the JGroups channel essentially entails specifying the transport in terms of a network protocol stack. To configure the JGroups transport, point the configuration property hibernate.search.services.jgroups.configurationFile to a JGroups configuration file; this can be either a file path or a Java resource name.

If no property is explicitly specified it is assumed that the JGroups default configuration file `flush-udp.xml` is used. This example configuration is known to work in most scenarios, with the notable exception of Amazon AWS; refer to the JGroups manual for more examples and protocol configuration details.

The default cluster name is Hibernate Search Cluster which can be configured as seen in JGroups cluster name configuration.

Example 20. JGroups cluster name configuration

```
hibernate.search.services.jgroups.clusterName = My-Custom-Cluster-Id
```

The cluster name is what identifies a group: by changing the name you can run different clusters in the same network in isolation.

JGroups channel instance injection

For programmatic configurations, one additional option is available to configure the JGroups channel: to pass an existing channel instance to Hibernate Search directly using the property `hibernate.search.services.jgroups.providedChannel`, as shown in the following example.

```
import org.hibernate.search.backend.impl.jgroups.JGroupsChannelProvider;
org.jgroups.JChannel channel = ...
Map<String,String> properties = new HashMap<String,String>(1);
properties.put(JGroupsChannelProvider.CHANNEL_INJECT, channel);
EntityManagerFactory emf = Persistence.createEntityManagerFactory("userPU", properties);
```

3.5. Reader strategy configuration

The different reader strategies are described in Reader strategy. Out of the box strategies are:
• **shared**: share index readers across several queries. This strategy is very efficient.

• **not-shared**: create an index reader for each individual query. Very simple implementation.

• **async**: only opens a new index reader periodically. This is the most efficient implementation, but queries might return out of date values.

The default reader strategy is **shared**.

You can pick the reader strategy by changing the `.reader.strategy` configuration property, scoped to the "default" index or to a specific index.

For example:

```properties
hibernate.search.[default]<indexname>.reader.strategy = async
hibernate.search.[default]<indexname>.reader.async_refresh_period_ms = 8000
```

Adding the above properties switches to the **async** strategy, and configures it to refresh the index reader each 8 seconds.

Alternatively you can use a custom implementation of a `org.hibernate.search.indexes.spi.ReaderProvider`:

```properties
hibernate.search.[default]<indexname>.reader.strategy = my.corp.myapp.CustomReaderProvider
```

where `my.corp.myapp.CustomReaderProvider` is the custom strategy implementation.

### 3.6. Serialization

When using clustering features, Hibernate Search needs to find an implementation of the `SerializationProvider` service on the classpath.

An implementation of the service based on Apache Avro can be found using the following GAV coordinates:

```text
org.hibernate:hibernate-search-serialization-avro:5.7.3.Final
```

You can add the coordinates to your pom file or download all the required dependencies and add them to your classpath. Hibernate Search will find the service implementation without any additional configuration.
Alternatively, you can create a custom service implementation:

**Example 21. Serialization strategy definition**

```java
package example.provider.serializer

import org.hibernate.search.indexes.serialization.spi.Deserializer;
import org.hibernate.search.indexes.serialization.spi.SerializationProvider;
import org.hibernate.search.indexes.serialization.spi.Serializer;

public class ExampleOfSerializationProvider implements SerializationProvider {
    @Override
    public Serializer getSerializer() {
        Serializer serializer = ...
        return serializer;
    }

    @Override
    public Deserializer getDeserializer() {
        Deserializer deserializer = ...
        return deserializer;
    }
}
```

Hibernate Search uses the Java ServiceLoader mechanism to transparently discover services. In this case you will add the following file in your classpath:

**Example 22. Service file for the SerializationProvider service**

```text
/META-INF/services/org.hibernate.search.indexes.serialization.spi.SerializationProvider
```

**Example 23. Content of /META-INF/services/org.hibernate.search.indexes.serialization.spi.SerializationProvider**

```text
example.provider.serializer.ExampleOfSerializationProvider
```

You will find more details about services in the section Using external services.
3.7. Exception handling

Hibernate Search allows you to configure how exceptions are handled during the indexing process. If no configuration is provided then exceptions are logged to the log output by default. It is possible to explicitly declare the exception logging mechanism as seen below:

```java
hibernate.search.error_handler = log
```

The default exception handling occurs for both synchronous and asynchronous indexing. Hibernate Search provides an easy mechanism to override the default error handling implementation.

In order to provide your own implementation you must implement the ErrorHandler interface, which provides the handle(ErrorContext context) method. ErrorContext provides a reference to the primary LuceneWork instance, the underlying exception and any subsequent LuceneWork instances that could not be processed due to the primary exception.

```java
public interface ErrorContext {
    List<LuceneWork> getFailingOperations();
    LuceneWork getOperationAtFault();
    Throwable getThrowable();
    boolean hasErrors();
}
```

To register this error handler with Hibernate Search you must declare the fully qualified classname of your ErrorHandler implementation in the configuration properties:

```java
hibernate.search.error_handler = CustomerErrorHandler
```

Alternatively, an ErrorHandler instance may be passed via the configuration value map used when bootstrapping Hibernate Search programmatically.

3.8. Lucene configuration

Even though Hibernate Search will try to shield you as much as possible from Lucene specifics, there are several Lucene specifics which can be directly configured, either for performance reasons or for satisfying a specific use case. The following sections discuss these configuration options.
3.8.1. Tuning indexing performance

Hibernate Search allows you to tune the Lucene indexing performance by specifying a set of parameters which are passed through to underlying Lucene IndexWriter such as mergeFactor, maxMergeDocs and maxBufferedDocs. You can specify these parameters either as default values applying for all indexes, on a per index basis, or even per shard.

There are several low level IndexWriter settings which can be tuned for different use cases. These parameters are grouped by the indexwriter keyword:

```
hibernate.search.[default|<indexname>].indexwriter.<parameter_name>
```

If no value is set for an indexwriter value in a specific shard configuration, Hibernate Search will look at the index section, then at the default section.

**Example 24. Example performance option configuration**

```
hibernate.search.Animals.2.indexwriter.max_merge_docs = 10
hibernate.search.Animals.2.indexwriter.merge_factor = 20
hibernate.search.Animals.2.indexwriter.max_buffered_docs = default
hibernate.search.default.indexwriter.max_merge_docs = 100
hibernate.search.default.indexwriter.ram_buffer_size = 64
```

The configuration in Example performance option configuration will result in these settings applied on the second shard of the Animal index:

- max_merge_docs = 10
- merge_factor = 20
- ram_buffer_size = 64MB
- max_buffered_docs = Lucene default

All other values will use the defaults defined in Lucene.

The default for all values is to leave them at Lucene’s own default. The values listed in List of indexing performance and behavior properties depend for this reason on the version of Lucene you are using. The values shown are relative to version 2.4. For more information about Lucene indexing performance, please refer to the Lucene documentation.

**Table 8. List of indexing performance and behavior properties**
<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
<th>Default Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>hibernate.search.[default</td>
<td>&lt;indexname&gt;:exclusive_index_use</td>
<td>Set to <strong>true</strong> when no other process will need to write to the same index. This will enable Hibernate Search to work in exclusive mode on the index and improve performance when writing changes to the index.</td>
</tr>
<tr>
<td>hibernate.search.[default</td>
<td>&lt;indexname&gt;].max_queue_length</td>
<td>Each index has a separate &quot;pipeline&quot; which contains the updates to be applied to the index. When this queue is full adding more operations to the queue becomes a blocking operation. Configuring this setting doesn't make much sense unless the <code>worker.execution</code> is configured as <code>async</code>.</td>
</tr>
<tr>
<td>hibernate.search.[default</td>
<td>&lt;indexname&gt;].index_flush_interval</td>
<td>The interval in milliseconds between flushes of write operations to the index storage. Ignored unless <code>worker.execution</code> is configured as <code>async</code>.</td>
</tr>
<tr>
<td>hibernate.search.[default</td>
<td>&lt;indexname&gt;].indexwriter.max_buffered_delete_terms</td>
<td>Determines the minimal number of delete terms required before the buffered in-memory delete terms are applied and flushed. If there are documents buffered in memory at the time, they are merged and a new segment is created.</td>
</tr>
<tr>
<td>hibernate.search.[default</td>
<td>&lt;indexname&gt;].indexwriter.max_buffered_docs</td>
<td>Controls the amount of documents buffered in memory during indexing. The bigger the more RAM is consumed.</td>
</tr>
<tr>
<td>hibernate.search.[default</td>
<td>&lt;indexname&gt;].indexwriter.max_merge_docs</td>
<td>Defines the largest number of documents allowed in a segment. Smaller values perform better on frequently changing indexes, larger values provide better search performance if the index does not change often.</td>
</tr>
<tr>
<td>Property</td>
<td>Description</td>
<td>Default Value</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>--------------</td>
</tr>
<tr>
<td>hibernate.search.[default</td>
<td>&lt;indexname&gt;].indexwriter.merge_factor</td>
<td>Controls segment merge frequency and size. Determines how often segment indexes are merged when insertion occurs. With smaller values, less RAM is used while indexing, and searches on unoptimized indexes are faster, but indexing speed is slower. With larger values, more RAM is used during indexing, and while searches on unoptimized indexes are slower, indexing is faster. Thus larger values (&gt; 10) are best for batch index creation, and smaller values (&lt; 10) for indexes that are interactively maintained. The value must not be lower than 2.</td>
</tr>
<tr>
<td>hibernate.search.[default</td>
<td>&lt;indexname&gt;].indexwriter.merge_min_size</td>
<td>Controls segment merge frequency and size. Segments smaller than this size (in MB) are always considered for the next segment merge operation. Setting this too large might result in expensive merge operations, even tough they are less frequent. See also org.apache.lucene.index.LogDocMergePolicy.minMergeSize.</td>
</tr>
<tr>
<td>hibernate.search.[default</td>
<td>&lt;indexname&gt;].indexwriter.merge_max_size</td>
<td>Controls segment merge frequency and size. Segments larger than this size (in MB) are never merged in bigger segments. This helps reduce memory requirements and avoids some merging operations at the cost of optimal search speed. When optimizing an index this value is ignored. See also org.apache.lucene.index.LogDocMergePolicy.maxMergeSize.</td>
</tr>
<tr>
<td>hibernate.search.[default</td>
<td>&lt;indexname&gt;].indexwriter.merge_max_optimize_size</td>
<td>Controls segment merge frequency and size. Segments larger than this size (in MB) are not merged in bigger segments even when optimizing the index (see merge_max_size setting as well). Applied to org.apache.lucene.index.LogDocMergePolicy.maxMergeSizeForOptimze.</td>
</tr>
<tr>
<td>Property</td>
<td>Description</td>
<td>Default Value</td>
</tr>
<tr>
<td>----------</td>
<td>-------------</td>
<td>---------------</td>
</tr>
<tr>
<td>hibernate.search.[default</td>
<td>&lt;indexname&gt;.indexwriter.merge_calibrate_by_deletes</td>
<td>Controls segment merge frequency and size. Set to <code>false</code> to not consider deleted documents when estimating the merge policy. Applied to <code>org.apache.lucene.index.LogMergePolicy.calibrateSizeByDeletes</code>.</td>
</tr>
<tr>
<td>hibernate.search.[default</td>
<td>&lt;indexname&gt;.indexwriter.ram_buffer_size</td>
<td>Controls the amount of RAM in MB dedicated to document buffers. When used together <code>max_buffered_docs</code> a flush occurs for whichever event happens first. Generally for faster indexing performance it's best to flush by RAM usage instead of document count and use as large a RAM buffer as you can.</td>
</tr>
<tr>
<td>hibernate.search.enable_dirty_check</td>
<td>Not all entity changes require an update of the Lucene index. If all of the updated entity properties (dirty properties) are not indexed Hibernate Search will skip the re-indexing work. Disable this option if you use a custom <code>FieldBridge</code> which need to be invoked at each update event (even though the property for which the field bridge is configured has not changed). This optimization will not be applied on classes using a <code>@ClassBridge</code> or a <code>@DynamicBoost</code>. Boolean parameter, use &quot;true&quot; or &quot;false&quot;.</td>
<td>true</td>
</tr>
<tr>
<td>hibernate.search.[default</td>
<td>&lt;indexname&gt;.indexwriter.infostream</td>
<td>Enable low level trace information about Lucene's internal components. Will cause significant performance degradation: should only be used for troubleshooting purposes.</td>
</tr>
</tbody>
</table>

When your architecture permits it, always keep `hibernate.search.default.exclusive_index_use=true` as it greatly improves efficiency in index writing. This is the default since Hibernate Search version 4.
To tune the indexing speed it might be useful to time the object loading from database in isolation from the writes to the index. To achieve this set the blackhole as worker backend and start your indexing routines. This backend does not disable Hibernate Search: it will still generate the needed changesets to the index, but will discard them instead of flushing them to the index. In contrast to setting the hibernate.search.indexing_strategy to manual, using blackhole will possibly load more data from the database because associated entities are re-indexed as well.

hibernate.search.[default|<indexname>].worker.backend
blackhole

The recommended approach is to focus first on optimizing the object loading by enabling the blackhole backend, and then use the timings you achieve as a baseline to tune the indexing process.

The blackhole backend is not meant to be used in production, only as a tool to identify indexing bottlenecks.

Control segment size

The options merge_max_size, merge_max_optimize_size, merge_calibrate_by_deletes give you control on the maximum size of the segments being created, but you need to understand how they affect file sizes. If you need to hard limit the size, consider that merging a segment is about adding it together with another existing segment to form a larger one, so you might want to set the max_size for merge operations to less than half of your hard limit. Also segments might initially be generated larger than your expected size at first creation time: before they are ever merged. A segment is never created much larger than ram_buffer_size, but the threshold is checked as an estimate.

Example:

//to be fairly confident no files grow above 15MB, use:
hibernate.search.default.indexwriter.ram_buffer_size = 10
hibernate.search.default.indexwriter.merge_max_optimize_size = 7
hibernate.search.default.indexwriter.merge_max_size = 7
When using the Infinispan Directory to cluster indexes make sure that your segments are smaller than the chunk_size so that you avoid fragmenting segments in the grid. Note that the chunk_size of the Infinispan Directory is expressed in bytes, while the index tuning options are in MB.

**Troubleshooting: enable Lucene's Infostream**

Apache Lucene allows to log a very detailed trace log from its internals using a feature called "infostream". To access these details, Hibernate Search can be configured to capture this internal trace from Apache Lucene and redirect it to your logger.

- Enable TRACE level logging for the category org.hibernate.search.backend.lucene.infostream
- Activate the feature on the index you want to inspect: hibernate.search.[default|<indexname>].indexwriter.infostream=true

Keep in mind that this feature has a performance cost, and although most logger frameworks allow the TRACE level to be reconfigured at runtime, enabling the infostream property will slow you down even if the logger is disabled.

### 3.8.2. LockFactory configuration

Lucene Directorys have default locking strategies which work generally good enough for most cases, but it's possible to specify for each index managed by Hibernate Search a specific LockingFactory you want to use. This is generally not needed but could be useful.

Some of these locking strategies require a filesystem level lock and may be used even on RAM based indexes, this combination is valid but in this case the indexBase configuration option usually needed only for filesystem based Directory instances must be specified to point to a filesystem location where to store the lock marker files.

To select a locking factory, set the hibernate.search.<index>.locking_strategy option to one of simple, native, single or none. Alternatively set it to the fully qualified name of an implementation of org.hibernate.search.store.LockFactoryProvider.

*Table 9. List of available LockFactory implementations*

<table>
<thead>
<tr>
<th>name</th>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>simple</td>
<td>org.apache.lucene.store.SimpleFSLockFactory</td>
<td>Safe implementation based on Java's File API, it marks the usage of the index by creating a marker file. If for some reason you had to kill your application, you will need to remove this file before restarting it.</td>
</tr>
<tr>
<td>name</td>
<td>Class</td>
<td>Description</td>
</tr>
<tr>
<td>--------</td>
<td>-----------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>native</td>
<td>org.apache.lucene.store.NativeFSLockFactory</td>
<td>As does simple this also marks the usage of the index by creating a marker file, but this one is using native OS file locks so that even if the JVM is terminated the locks will be cleaned up. This implementation has known problems on NFS, avoid it on network shares. native is the default implementation for the filesystem, filesystem-master and filesystem-slave directory providers.</td>
</tr>
<tr>
<td>single</td>
<td>org.apache.lucene.store.SingleInstanceLockFactory</td>
<td>This LockFactory doesn’t use a file marker but is a Java object lock held in memory; therefore it’s possible to use it only when you are sure the index is not going to be shared by any other process. This is the default implementation for the ram directory provider.</td>
</tr>
<tr>
<td>none</td>
<td>org.apache.lucene.store.NoLockFactory</td>
<td>All changes to this index are not coordinated by any lock; test your application carefully and make sure you know what it means.</td>
</tr>
</tbody>
</table>

Configuration example:

```java
hibernate.search.default.locking_strategy = simple
hibernate.search.Animals.locking_strategy = native
```

The Infinispan Directory uses a custom implementation; it’s still possible to override it but make sure you understand how that will work, especially with clustered indexes.

### 3.8.3. Index format compatibility

While Hibernate Search strives to offer a backwards compatible API making it easy to port your application to newer versions, it still delegates to Apache Lucene to handle the index writing and searching. This creates a dependency to the Lucene index format. The Lucene developers of course attempt to keep a stable index format, but sometimes a change in the format can not be avoided. In those cases you either have to re-index all your data or use an index upgrade tool.
Sometimes Lucene is also able to read the old format so you don’t need to take specific actions (besides making backup of your index).

While an index format incompatibility is a rare event, it can happen more often that Lucene’s Analyzer implementations might slightly change its behavior. This can lead to a poor recall score, possibly missing many hits from the results.

Hibernate Search exposes a configuration property `hibernate.search.lucene_version` which instructs the analyzers and other Lucene classes to conform to their behavior as defined in an (older) specific version of Lucene. See also `org.apache.lucene.util.Version` contained in the `lucene-core.jar`. Depending on the specific version of Lucene you're using you might have different options available. When this option is not specified, Hibernate Search will instruct Lucene to use the default version, which is usually the best option for new projects. Still it's recommended to define the version you’re using explicitly in the configuration so that when you happen to upgrade Lucene the analyzers will not change behavior. You can then choose to update this value at a later time, when you for example have the chance to rebuild the index from scratch.

**Example 25. Force Analyzers to be compatible with a Lucene 4.7 created index**

```java
hibernate.search.lucene_version = LUCENE_47
```

This option is global for the configured SearchFactory and affects all Lucene APIs having such a parameter, as this should be applied consistently. So if you are also making use of Lucene bypassing Hibernate Search, make sure to apply the same value too.

### 3.9. Metadata API

After looking at all these different configuration options, it is time to have a look at an API which allows you to programmatically access parts of the configuration. Via the metadata API you can determine the indexed types and also how they are mapped (see Mapping entities to the index structure) to the index structure. The entry point into this API is the SearchFactory. It offers two methods, namely `getIndexedTypes()` and `getIndexedTypeDescriptor(Class<?>).` The former returns a set of all indexed type, where as the latter allows to retrieve a so called IndexedTypeDescriptor for a given type. This descriptor allows you determine whether the type is indexed at all and, if so, whether the index is for example sharded or not (see Sharding indexes). It also allows you to determine the static boost of the type (see Static index time boosting) as well as its dynamic boost strategy (see Dynamic index time boosting). Most importantly, however, you get information about the indexed properties and generated Lucene Document fields. This is exposed via PropertyDescriptors respectively FieldDescriptors. The easiest way to get to know the API is to explore it via the IDE or its javadocs.
All descriptor instances of the metadata API are read only. They do not allow to change any runtime configuration.

## 3.10. Hibernate Search as a WildFly module

Hibernate Search is included in the WildFly application server, and since WildFly 10 the module is automatically activated (added to the classpath of your deployment) if you have any indexed entities.

Alternatively you can opt to use a different version of the module by downloading and unzipping a different moduleset and setting the `wildfly.jpa.hibernate.search.module` property in your `persistence.xml`.

The modules system in WildFly allows to safely run multiple versions of Hibernate ORM and Hibernate Search in parallel, but if you download an alternative version make sure the Hibernate Search version you choose is compatible with the Hibernate ORM version you choose.

This version of Hibernate Search **5.7.3.Final** requires an Hibernate ORM version **5.2.3.Final** or a later version of the 5.2 branch, such as **5.2.8.Final**.

WildFly includes an older version of Hibernate ORM, so you will need to upgrade this dependency as well. The Hibernate ORM / WildFly update instructions can be found [here](#).

Not least, as the same guide explains you might need to exclude the Javassist version.

### 3.10.1. Use the Hibernate Search version included in WildFly

The activation of the Hibernate Search modules in wildfly is automatic, provided you're having at least one entity annotated with `org.hibernate.search.annotations.Indexed`.

You can control this behaviour of the JPA deployer explicitly; for example to make sure Hibernate Search and Apache Lucene classes are available to your application even though you haven't annotated any entity, set the following property in your `persistence.xml`:

```xml
wildfly.jpa.hibernate.search.module=org.hibernate.search.orm:main
```
3.10.2. Update and activate latest Hibernate Search version in WildFly

You can also download the latest Hibernate Search provided module and install it. This is often the best approach as you will benefit from all the latest improvements of Hibernate Search. Because of the modular design in WildFly, these additional modules can coexist with the embedded modules and won’t affect any other application, unless you explicitly reconfigure it to use the newer module.

You can download the latest pre-packaged Hibernate Search modules from Sourceforge. As a convenience these zip files are also distributed as Maven artifacts: org.hibernate:hibernate-search-modules-5.7.3.Final-wildfly-10-dist:zip.

Unpack the modules in your WildFly modules directory: this will create modules for Hibernate Search and Apache Lucene. The Hibernate Search modules are:

- org.hibernate.search.orm, for users of Hibernate Search with Hibernate; this will transitively include Hibernate ORM.
- org.hibernate.search.engine, for projects depending on the internal indexing engine that don’t require other dependencies to Hibernate.
- org.hibernate.search.backend-jms, in case you want to use the JMS backend described in JMS Architecture.

Next you will need to make sure the JPA deployer of WildFly provides you with the version you have chosen, instead of the default version bundled with the application server. Set the following property in your persistence.xml:

```xml
<wildfly.jpa.hibernate.search.module=org.hibernate.search.orm:5.7.3.Final
```

See also the WildFly JPA configuration

3.10.3. More about modules

More information about the modules configuration in WildFly can be found in the Class Loading in WildFly 10 wiki.
Modular classloading is a feature of JBoss EAP 7 as well, but if you are using JBoss EAP, you're reading the wrong version of the user guide! JBoss EAP subscriptions include official support for Hibernate Search and come with a different edition of this guide specifically tailored for EAP users.

See the Chapter 14 of the Red Hat JBoss Enterprise Application Platform 7 Development Guide.

3.10.4. Using Infinispan with Hibernate Search on WildFly

If you are updating the version of Hibernate Search in WildFly as described in the previous paragraph, you might need to update Infinispan as well. The process is very similar: download the modules from Infinispan project downloads, picking a compatible version, and decompress the modules into the modules directory of your WildFly installation.

Hibernate Search version 5.7.3.Final was compiled and tested with Infinispan version 8.2.4.Final; generally a more recent version of either project is expected to be backwards compatible for cross-project integration purposes as long as they have the same "major.minor" family version.

For example for a version of Hibernate Search depending on Infinispan 8.2.4.Final it should be safe to upgrade Infinispan to 8.2.6.Final, but an upgrade to 8.3.0.Final might not work.
Chapter 4. Mapping entities to the index structure

4.1. Mapping an entity

In Getting started you have already seen that all the metadata information needed to index entities is described through annotations. There is no need for XML mapping files. You can still use Hibernate mapping files for the basic Hibernate configuration, but the Hibernate Search specific configuration has to be expressed via annotations.

There is no XML configuration available for Hibernate Search but we provide a programmatic mapping API that elegantly replaces this kind of deployment form (see Programmatic API for more information).

If you want to contribute the XML mapping implementation, see HSEARCH-210.

4.1.1. Basic mapping

Let's start with the most commonly used annotations when mapping an entity.

@Indexed

Foremost you must declare a persistent class as indexable by annotating the class with @Indexed. All entities not annotated with @Indexed will be ignored by the indexing process.

Example 26. Making a class indexable with @Indexed

```java
@Entity
@Indexed
public class Essay {

...}
```

You can optionally specify the Indexed.index attribute to change the default name of the index. For more information regarding index naming see Directory configuration.

You can also specify an optional indexing interceptor. For more information see conditional indexing.
For each property of your entity, you have the ability to describe whether and how it will be indexed. Adding the \texttt{@Field} annotation declares a property as indexed and allows you to configure various aspects of the indexing process. Without \texttt{@Field} the property is ignored by the indexing process.

Hibernate Search tries to determine the best way to index your property. In most cases this will be as string, but for the types int, long, double and float (and their respective Java wrapper types) Lucene’s numeric field encoding (see \texttt{@NumericField}) is used. This numeric encoding uses a so-called Trie structure which allows for efficient range queries and sorting, resulting in query response times being orders of magnitude faster than with the plain string encoding. Byte and short properties will only be encoded in numeric fields if explicitly marked with the \texttt{@NumericField} annotation.

Prior to Search 5, numeric field encoding was only chosen if explicitly requested via \texttt{@NumericField}. As of Search 5 this encoding is automatically chosen for numeric types. To avoid numeric encoding you can explicitly specify a non-numeric field bridge via \texttt{@Field.bridge} or \texttt{@FieldBridge}. The package \texttt{org.hibernate.search.bridge.builtin} contains a set of bridges which encode numbers as strings, for example \texttt{org.hibernate.search.bridge.builtin.IntegerBridge}.

The following attributes of the \texttt{@Field} annotation help you control the indexing outcome:

- **name**: describes under which name the property should be stored in the Lucene Document. The default value is the property name (following the JavaBeans convention).

- **store**: describes whether or not the property is stored in the Lucene index. You can store the value \texttt{Store.YES} (consuming more space in the index but allowing projection), store it in a compressed way \texttt{Store.COMPRESS} (this does consume more CPU), or avoid any storage \texttt{Store.NO} (this is the default value). When a property is stored, you can retrieve its original value from the Lucene Document. Storing the property has no impact on whether the value is searchable or not.

- **index**: describes whether the property is indexed or not. The different values are \texttt{Index.NO} (no indexing, meaning the value cannot be found by a query), \texttt{Index.YES} (the element gets indexed and is searchable). The default value is \texttt{Index.YES}. \texttt{Index.NO} can be useful for cases where a property is not required to be searchable, but needed for projection.

  \texttt{Index.NO} in combination with \texttt{Analyze.YES} or \texttt{Norms.YES} is not useful, since analyze and norms require the property to be indexed.

- **analyze**: determines whether the property is analyzed (\texttt{Analyze.YES}) or not.
Analyze.NO). The default value is Analyze.YES.

Whether or not you want to analyze a property depends on whether you wish to search the element as is, or by the words it contains. It makes sense to analyze a text field, but probably not a date field.

Fields used for sorting or faceting must not be analyzed.

• norms: describes whether index time boosting information should be stored (Norms.YES) or not (Norms.NO). Not storing the norms can save a considerable amount of memory, but index time boosting will not be available in this case. The default value is Norms.YES.

• termVector: describes collections of term-frequency pairs. This attribute enables the storing of the term vectors within the documents during indexing. The default value is TermVector.NO.

The different values of this attribute are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>TermVector.YES</td>
<td>Store the term vectors of each document. This produces two synchronized arrays, one contains document terms and the other contains the term’s frequency.</td>
</tr>
<tr>
<td>TermVector.NO</td>
<td>Do not store term vectors.</td>
</tr>
<tr>
<td>TermVector.WITH_OFFSETS</td>
<td>Store the term vector and token offset information. This is the same as TermVector.YES plus it contains the starting and ending offset position information for the terms.</td>
</tr>
<tr>
<td>TermVector.WITH_POSITIONS</td>
<td>Store the term vector and token position information. This is the same as TermVector.YES plus it contains the ordinal positions of each occurrence of a term in a document.</td>
</tr>
<tr>
<td>TermVector.WITH_POSITION_OFFSETS</td>
<td>Store the term vector, token position and offset information. This is a combination of the YES, WITH_OFFSETS and WITH_POSITIONS.</td>
</tr>
</tbody>
</table>

• indexNullAs: Per default null values are ignored and not indexed. However, using indexNullAs you can specify a string which will be inserted as token for the null value. Per default this value is set to org.hibernate.search.annotations.Field.DO_NOT_INDEX_NULL indicating that null values should not be indexed. You can set this value to DEFAULT_NULL_TOKEN to indicate that a default null token should be used. This default null token can be specified in the configuration using hibernate.search.default_null_token. If this property is not
set the string _null_ will be used as default. When the field is of a Numeric Type (see @NumericField), the token will be encoded as the respective numeric type: the indexNullAs value needs to be set to a value which can be parsed into a number of the matching type, for example "-1".

When indexNullAs is used, it is important to use the chosen null token in search queries (see Querying) in order to find null values. It is also advisable to use this feature only with un-analyzed fields (analyze=Analyze.NO).

When implementing a custom FieldBridge or TwoWayFieldBridge it is up to the developer to handle the indexing of null values (see JavaDocs of LuceneOptions.indexNullAs()).

- **boost**: Refer to section about boosting
- **bridge**: Refer to section about field bridges

@NumericField

@NumericField is a companion annotation to @Field. It can be specified in the same scope as @Field, but only on properties of numeric type like byte, short, int, long, double and float (and their respective Java wrapper types). It allows to define a custom precisionStep for the numeric encoding of the property value.

@NumericField accepts the following parameters:

<table>
<thead>
<tr>
<th>Value</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>forField</td>
<td>(Optional) Specify the name of the related @Field that will be indexed numerically. It's only mandatory when the property contains more than a @Field declaration</td>
</tr>
<tr>
<td>precisionStep</td>
<td>(Optional) Change the way that the Trie structure is stored in the index. Smaller precisionSteps lead to more disk space usage and faster range and sort queries. Larger values lead to less space used and range query performance more close to the range query using string encoding. Default value is 4.</td>
</tr>
</tbody>
</table>

Lucene supports the numeric types: Double, Long, Integer and Float. For properties of types Byte and Short, an Integer field will be used in the index. Other numeric types should use the default string encoding (via @Field), unless the application can deal with a potential loss in precision, in which case a custom NumericFieldBridge can be used. See Defining a custom
**Example 27. Defining a custom NumericFieldBridge for BigDecimal**

```java
public class BigDecimalNumericFieldBridge extends NumericFieldBridge {
    private static final BigDecimal storeFactor = BigDecimal.valueOf(100);

    @Override
    public void set(String name, Object value, Document document, LuceneOptions luceneOptions) {
        if (value != null) {
            BigDecimal decimalValue = (BigDecimal) value;
            long tmpLong = decimalValue.multiply(storeFactor).longValue();
            Long indexedValue = Long.valueOf(tmpLong);
            luceneOptions.addNumericFieldToDocument(name, indexedValue, document);
        }
    }

    @Override
    public Object get(String name, Document document) {
        String fromLucene = document.get(name);
        BigDecimal storedBigDecimal = new BigDecimal(fromLucene);
        return storedBigDecimal.divide(storeFactor);
    }
}
```

You would use this custom bridge like seen in **Use of BigDecimalNumericFieldBridge**. In this case three annotations are used - @Field, @NumericField and @FieldBridge. @Field is required to mark the property for being indexed (a standalone @NumericField is never allowed). @NumericField might be omitted in this specific case, because the used @FieldBridge annotation refers already to a NumericFieldBridge instance. However, the use of @NumericField makes the use of the property as numeric value explicit.
Example 28. Use of `BigDecimalNumericFieldBridge`:

```java
@Entity
@Indexed
public class Item {
  @Id
  @GeneratedValue
  private int id;

  @Field
  @NumericField
  @FieldBridge(impl = BigDecimalNumericFieldBridge.class)
  private BigDecimal price;

  public int getId() {
    return id;
  }

  public BigDecimal getPrice() {
    return price;
  }

  public void setPrice(BigDecimal price) {
    this.price = price;
  }
}
```

@SortableField

As of Lucene 5 (and thus Hibernate Search 5.5) it is highly recommended to create a so-called "doc value field" for each field to sort on. Hibernate Search provides the `@SortableField` annotation for that purpose. This is an extension annotation to `@Field` and marks a field as sortable (internally, the required doc value field will be added to the index).

Example 29. Use of `@SortableField`:

```java
@Entity
@Indexed
public class Book {
  @Id
  @GeneratedValue
  private int id;

  @Field(name="Abstract", analyze=Analyze.NO)
  @SortableField
  private String summary;

  // ...
}
```
If there is a single `@Field` declared for a given property, `@SortableField` implicitly applies to this field. In case several fields exist for a single property, the `@Field` to be marked as sortable can be specified via `@SortableField#forField()`. Several sortable fields can be defined as the `@SortableField` annotation is repeatable.

The field to be marked as sortable must not be analyzed.

Note that sorting also works if a property is not explicitly marked with `@SortableField`. This has negative runtime performance and memory consumption implications, though. Therefore it is highly recommended to explicitly mark each field to be used for sorting.

Should you want to make a property sortable but not searchable, still an `@Field` needs to be declared (so its field bridge configuration can be inherited). It can be marked with `store = Store.NO` and `index = Index.NO`, causing only the doc value field required for sorting to be added, but not a regular index field.

Fields added through class-level bridges or custom field-level bridges (when not using the default field name) cannot be marked as sortable by means of the `@SortableField` annotation. Instead the field bridge itself has to add the required doc value fields, in addition to the document fields it adds. Furthermore such bridge needs to implement the `MetadataProvidingFieldBridge` interface which defines a method `configureFieldMetadata()` for marking the fields created by this bridge as sortable:
Example 30. Marking fields as sortable via a custom field bridge

```java
/**
 * Custom field bridge for a Map property which creates sortable fields
 * with the values of two keys from the map.
 */
public class MyClassBridge implements MetadataProvidingFieldBridge {

    @Override
    public void set(String name, Object value, Document document, LuceneOptions luceneOps) {
        Map<String, String> map = (Map<String, String>) value;
        String firstName = map.get("firstName");
        String lastName = map.get("lastName");
        // add regular document fields
        luceneOps.addFieldToDocument( name + "_firstName", lastName, document );
        luceneOps.addFieldToDocument( name + "_lastName", lastName, document );
        // add doc value fields to allow for sorting
        document.addSortedDocValuesFieldToDocument( name + "_firstName", firstName );
        document.addSortedDocValuesFieldToDocument( name + "_lastName", lastName );
    }

    @Override
    public void configureFieldMetadata(String name, FieldMetadataBuilder builder) {
        builder
            .field( name + "_firstName", FieldType.STRING )
            .sortable( true )
            .field( name + "_lastName", FieldType.STRING )
            .sortable( true );
    }
}
```

The meta-data configured through `configureFieldMetadata()` will be used for sort validation upon query execution. The name passed to the method is the default field name also passed to `set()`. It needs to be used consistently with `set()`, e.g. as a prefix for all custom fields added.

The `MetadataProvidingFieldBridge` contract is under active development and considered experimental at this time. It may be altered in future revisions, e.g. by adding further methods, thus breaking existing implementations.
Flagging uncovered sorts

By default Hibernate Search will transparently create an uninverting index reader when running a query with sorts not covered by the sortable fields configured as described above. While this allows to execute the query, relying on index uninverting negatively impacts performance.

You thus can optionally advice Hibernate Search to raise an exception when detecting uncovered sorts. To do so, specify the following option:

Example 31. Disabling automatic index uninverting for uncovered sorts

```java
hibernate.search.index_uninverting_allowed = false
```

You e.g. may set this to `false` during testing to identify the sortable fields required for your queries and set it to `true` in production environments to fall back to index uninverting for uncovered sorts accidentally left over.

@id

Finally, the id property of an entity is a special property used by Hibernate Search to ensure index unicity of a given entity. By design, an id has to be stored and must not be tokenized. It is also always string encoded, even if the id is a number. To mark a property as index id, use the `@DocumentId` annotation. If you are using JPA and you are using `@Id` you can omit `@DocumentId`. The chosen entity id will also be used as document id.

Example 32. Specifying indexed properties

```java
@Entity
@Indexed
public class Essay {
    ...
    @Id
    @DocumentId
    public Long getId() { return id; }

    @Field(name="Abstract", store=Store.YES)
    public String getSummary() { return summary; }

    @Lob
    @Field
    public String getText() { return text; }

    @Field
    @NumericField(precisionStep = 6)
    public float getGrade() { return grade; }
}
```
Specifying indexed properties defines an index with four fields: id, Abstract, text and grade. Note that by default the field name is de-capitalized, following the JavaBean specification. The grade field is annotated as numeric with a slightly larger precisionStep than the default.

It is not recommended to sort on the id field as it will lead to erratic behaviors. If you want to sort on your document id, it is recommended to declare another field specifically for sorting using the @Field annotation.

4.1.2. Mapping properties multiple times

Sometimes one has to map a property multiple times per index, with slightly different indexing strategies. For example, sorting a query by field requires the field to be un-analyzed. If one wants to search by words in this property and still sort it, one need to index it twice - once analyzed and once un-analyzed. The @Field is repeatable, which allows to achieve this goal. Alternatively you can use the legacy, explicit plural form @Fields.

Example 33. Using @Field repeatedly to map a property multiple times

```java
@Entity
@Indexed(index = "Book")
public class Book {

    @Field
    @Field(name = "summary_forSort", analyze = Analyze.NO, store = Store.YES)
    @SortableField(forField = "summary_forSort")
    public String getSummary() {
        return summary;
    }

    // ...
}
```

In Using @Field repeatedly to map a property multiple times the field summary is indexed twice, once as summary in a tokenized way, and once as summary_forSort in an un-tokenized way. @Field supports two attributes which are particularly useful when the annotation is repeated:

- **analyzer**: defines a @Analyzer annotation per field rather than per property
- **bridge**: defines a @FieldBridge annotation per field rather than per property

See below for more information about analyzers and field bridges.
4.1.3. Embedded and associated objects

Associated objects as well as embedded objects can be indexed as part of the root entity index. This is useful if you expect to search a given entity based on properties of the associated objects.

In the example Indexing associations the aim is to return places where the associated city is Atlanta (in Lucene query parser language, it would translate into address.city:Atlanta). All place fields are added to the Place index, but also the address related fields address.street, and address.city will be added and made queryable. The embedded object id, address.id, is not added per default. To include it you need to also set @IndexedEmbedded(includeEmbeddedObjectId=true, ...).

Only actual indexed fields (properties annotated with @Field) are added to the root entity index when embedded objects are indexed. The embedded object identifiers are treated differently and need to be included explicitly.
Example 34. Indexing associations

```java
@Entity
@Indexed
public class Place {
    @Id
    @GeneratedValue
    private Long id;

    @Field
    private String name;

    @OneToOne(cascade = { CascadeType.PERSIST, CascadeType.REMOVE })
    @IndexedEmbedded
    private Address address;
    ...
}

@Entity
public class Address {
    @Id
    @GeneratedValue
    private Long id;

    @Field
    private String street;

    @Field
    private String city;

    @ContainedIn
    @OneToMany(mappedBy = "address")
    private Set<Place> places;
    ...
}
```

Be careful. Because the data is de-normalized in the Lucene index when using the `@IndexedEmbedded` technique, Hibernate Search needs to be aware of any change in the `Place` object and any change in the `Address` object to keep the index up to date. To make sure the `Place` Lucene document is updated when it’s `Address` changes, you need to mark the other side of the bidirectional relationship with `@ContainedIn`.

- `@ContainedIn` is useful on both associations pointing to entities and on embedded (collection of) objects.

Let’s make `Indexing associations` a bit more complex by nesting `@IndexedEmbedded` as seen in `Nested usage of @IndexedEmbedded and @ContainedIn`.

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Example 35. Nested usage of @IndexedEmbedded and @ContainedIn

```java
@Entity
@Indexed
public class Place {
    @Id
    @GeneratedValue
    private Long id;

    @Field
    private String name;

    @OneToOne(cascade = { CascadeType.PERSIST, CascadeType.REMOVE })
    @IndexedEmbedded
    private Address address;
    // ...
}

@Entity
public class Address {
    @Id
    @GeneratedValue
    private Long id;

    @Field
    private String street;

    @Field
    private String city;

    @IndexedEmbedded(depth = 1, prefix = "ownedBy_")
    private Owner ownedBy;

    @ContainedIn
    @OneToMany(mappedBy="address")
    private Set<Place> places;
    // ...
}

@Embeddable
public class Owner {
    @Field
    private String name;
    // ...
}
```

As you can see, any @*ToMany, @*ToOne or @Embedded attribute can be annotated with @IndexedEmbedded. The attributes of the associated class will then be added to the main entity index. In Nested usage of @IndexedEmbedded and @ContainedIn the index will contain the following fields
• id
• name
• address.street
• address.city
• address.ownedBy_name

The default prefix is propertyName, following the traditional object navigation convention. You can override it using the prefix attribute as it is shown on the ownedBy property.

The prefix cannot be set to the empty string.

The depth property is necessary when the object graph contains a cyclic dependency of classes (not instances). For example, if Owner points to Place. Hibernate Search will stop including indexed embedded attributes after reaching the expected depth (or the object graph boundaries are reached). A class having a self reference is an example of cyclic dependency. In our example, because depth is set to 1, any @IndexedEmbedded attribute in Owner (if any) will be ignored.

Using @IndexedEmbedded for object associations allows you to express queries (using Lucene’s query syntax) such as:

• Return places where name contains JBoss and where address city is Atlanta. In Lucene query this would be

+name:jboss +address.city:atlanta

• Return places where name contains JBoss and where owner’s name contain Joe. In Lucene query this would be

+name:jboss +address.ownedBy_name:joe

In a way it mimics the relational join operation in a more efficient way (at the cost of data duplication). Remember that, out of the box, Lucene indexes have no notion of association, the join operation is simply non-existent. It might help to keep the relational model normalized while benefiting from the full text index speed and feature richness.

An associated object can itself (but does not have to) be @Indexed

When @IndexedEmbedded points to an entity, the association has to be directional and the other side has to be annotated with @ContainedIn. If not, Hibernate Search has no way to update the root index when the associated entity is updated (in our example, a Place index document has to be updated when the associated Address instance is updated).
Sometimes, the object type annotated by `@IndexedEmbedded` is not the object type targeted by Hibernate and Hibernate Search. This is especially the case when interfaces are used in lieu of their implementation. For this reason you can override the object type targeted by Hibernate Search using the `targetElement` parameter.

**Example 36. Using the `targetElement` property of `@IndexedEmbedded`**

```java
@Entity
@Indexed
public class Address {
  @Id
  @GeneratedValue
  private Long id;

  @Field
  private String street;

  @IndexedEmbedded(depth = 1, prefix = "ownedBy_", targetElement = Owner.class)
  @Target(Owner.class)
  private Person ownedBy;

  // ...
}

@Embeddable
public class Owner implements Person {
  ...
}
```

**Limiting object embedding to specific paths**

The `@IndexedEmbedded` annotation provides also an attribute `includePaths` which can be used as an alternative to `depth`, or in combination with it.

When using only `depth` all indexed fields of the embedded type will be added recursively at the same depth; this makes it harder to pick only a specific path without adding all other fields as well, which might not be needed.

To avoid unnecessarily loading and indexing entities you can specify exactly which paths are needed. A typical application might need different depths for different paths, or in other words it might need to specify paths explicitly, as shown in **Using the `includePaths` property of `@IndexedEmbedded`**

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Example 37. Using the `includePaths` property of `@IndexedEmbedded`

```java
@Entity
@Indexed
public class Person {
    @Id
    public int getId() {
        return id;
    }

    @Field
    public String getName() {
        return name;
    }

    @Field
    public String getSurname() {
        return surname;
    }

    @OneToMany
    @IndexedEmbedded(includePaths = { "name" })
    public Set<Person> getParents() {
        return parents;
    }

    @ContainedIn
    @ManyToOne
    public Human getChild() {
        return child;
    }

    // ... other fields omitted
}
```

Using a mapping as in Using the `includePaths` property of `@IndexedEmbedded`, you would be able to search on a `Person` by `name` and/or `surname`, and/or the `name` of the parent. It will not index the `surname` of the parent, so searching on parent’s surnames will not be possible but speeds up indexing, saves space and improve overall performance.

The `@IndexedEmbedded.includePaths` will include the specified paths in addition to what you would index normally specifying a limited value for depth. Using `includePaths` with a undefined (default) value for `depth` is equivalent to setting `depth=0`: only the included paths are indexed.
Example 38. Using the `includePaths` property of `@IndexedEmbedded`

```java
@Entity
@Indexed
public class Human {

    @Id
    public int getId() {
        return id;
    }

    @Field
    public String getName() {
        return name;
    }

    @Field
    public String getSurname() {
        return surname;
    }

    @OneToMany
    @IndexedEmbedded(depth = 2, includePaths = { "parents.parents.name" })
    public Set<Human> getParents() {
        return parents;
    }

    @ContainedIn
    @ManyToOne
    public Human getChild() {
        return child;
    }

    // ... other fields omitted
```

In **Using the `includePaths` property of `@IndexedEmbedded`**, every human will have it's name and surname attributes indexed. The name and surname of parents will be indexed too, recursively up to second line because of the `depth` attribute. It will be possible to search by name or surname, of the person directly, his parents or of his grand parents. Beyond the second level, we will in addition index one more level but only the name, not the surname.

This results in the following fields in the index:

- **id** - as primary key
- **_hibernate_class** - stores entity type
- **name** - as direct field
- **surname** - as direct field
- **parents.name** - as embedded field at depth 1
- **parents.surname** - as embedded field at depth 1
- `parents.parents.name` - as embedded field at depth 2
- `parents.parents.surname` - as embedded field at depth 2
- `parents.parents.parents.name` - as additional path as specified by includePaths. The first `parents` is inferred from the field name, the remaining path is the attribute of includePaths

You can explicitly include the id of the embedded object using `includePath`, for example `@IndexedEmbedded(includePaths = { "parents.id" })`. This will work regardless of the `includeEmbeddedObjectId` attribute. However, it is recommended to just set `includeEmbeddedObjectId=true`.

Having explicit control of the indexed paths might be easier if you're designing your application by defining the needed queries first, as at that point you might know exactly which fields you need, and which other fields are unnecessary to implement your use case.

### Indexing null embeddeds

Per default null values are ignored and not indexed. However, using `indexNullAs` you can specify that a field should be added when the embedded is null, with a value of your choice.

Per default `indexNullAs` is set to `org.hibernate.search.annotations.IndexedEmbedded.DO_NOT_INDEX_NULL`, indicating that null values should not be indexed. You can set this value to `IndexedEmbedded.DEFAULT_NULL_TOKEN` to indicate that a default null token should be used. This default null token can be specified in the configuration using `hibernate.search.default_null_token`. If this property is not set the string `_null_` will be used as default.

The field name used when indexing null values depend on the `prefix`:

- if the `prefix` is not set, the field name will be the Java property name
- if the `prefix` is set, the field name will be the prefix with the trailing dot (if any) removed. For instance with the prefix `my_embedded`, the null field name will be `my_embedded` (without dot).

When `indexNullAs` is used, it is important to use the chosen null token in search queries (see Querying) in order to find null values.
4.1.4. Associated objects: building a dependency graph with @ContainedIn

While @ContainedIn is often seen as the counterpart of @IndexedEmbedded, it can also be used on its own to build an indexing dependency graph.

When an entity is reindexed, all the entities pointed by @ContainedIn are also going to be reindexed.

4.2. Boosting

Lucene has the notion of boost\(ing\) which allows you to give certain documents or fields more or less importance than others. Lucene differentiates between index and search time boosting. The following sections show you how you can achieve index time boosting using Hibernate Search.

4.2.1. Static index time boosting

To define a static boost value for an indexed class or property you can use the @Boost annotation. You can use this annotation within @Field or specify it directly on method or class level.

Example 39. Different ways of using @Boost

```java
@Entity
@Indexed
@Boost(1.7f)
public class Essay {

@Id
@Column
public Long getId() { return id; }

@Field(name="Abstract", store=Store.YES, boost=@Boost(2f))
@Boost(1.5f)
public String getSummary() { return summary; }

@Lob
@Field(boost=@Boost(1.2f))
public String getText() { return text; }

@Field
public String getISBN() { return isbn; }
}
```

In Different ways of using @Boost, Essay’s probability to reach the top of the search list will be multiplied by 1.7. The summary field will be 3.0 (2 * 1.5, because @Field.boost and @Boost on a property are cumulative) more important than the isbn field. The text field will be 1.2 times
more important than the isbn field. Note that this explanation is wrong in strictest terms, but it is simple and close enough to reality for all practical purposes. Please check the Lucene documentation or the excellent Lucene In Action from Otis Gospodnetic and Erik Hatcher.

### 4.2.2. Dynamic index time boosting

The @Boost annotation used in Static index time boosting defines a static boost factor which is independent of the state of the indexed entity at runtime. However, there are use cases in which the boost factor may depend on the actual state of the entity. In this case you can use the @DynamicBoost annotation together with an accompanying custom BoostStrategy.

**Example 40. Dynamic boost example**

```java
public enum PersonType {
    NORMAL,
    VIP
}

@Entity
@Indexed
@DynamicBoost(impl = VIPBoostStrategy.class)
public class Person {
    private PersonType type;
    // ...
}

public class VIPBoostStrategy implements BoostStrategy {
    public float defineBoost(Object value) {
        Person person = (Person) value;
        if (person.getType().equals(PersonType.VIP)) {
            return 2.0f;
        } else {
            return 1.0f;
        }
    }
}
```

In Dynamic boost example a dynamic boost is defined on class level specifying VIPBoostStrategy as implementation of the BoostStrategy interface to be used at indexing time. You can place the @DynamicBoost either at class or field level. Depending on the placement of the annotation either the whole entity is passed to the defineBoost method or just the annotated field/property value. It’s up to you to cast the passed object to the correct type. In the example all indexed values of a VIP person would be double as important as the values of a normal person.
The specified BoostStrategy implementation must define a public no-arg constructor.

Of course you can mix and match @Boost and @DynamicBoost annotations in your entity. All defined boost factors are cumulative.

4.3. Analysis

Analysis is the process of converting text into single terms (words) and can be considered as one of the key features of a fulltext search engine. Lucene uses the concept of Analyzers to control this process. In the following section we cover the multiple ways Hibernate Search offers to configure the analyzers.

4.3.1. Default analyzer and analyzer by class

The default analyzer class used to index tokenized fields is configurable through the hibernate.search.analyzer property. The default value for this property is org.apache.lucene.analysis.standard.StandardAnalyzer.

You can also define the analyzer class per entity, property and even per @Field (useful when multiple fields are indexed from a single property).

Example 41. Different ways of using @Analyzer

```java
@Entity
@Indexed
@Analyzer(impl = EntityAnalyzer.class)
public class MyEntity {
    @Id
    @GeneratedValue
    @DocumentId
    private Integer id;

    @Field
    private String name;

    @Field
    @Analyzer(impl = PropertyAnalyzer.class)
    private String summary;

    @Field(analyzer = @Analyzer(impl = FieldAnalyzer.class)
    private String body;

    ...
}
```

In this example, EntityAnalyzer is used to index all tokenized properties (eg. name), except
summary and body which are indexed with PropertyAnalyzer and FieldAnalyzer respectively.

Mixing different analyzers in the same entity is most of the time a bad practice. It makes query building more complex and results less predictable (for the novice), especially if you are using a QueryParser (which uses the same analyzer for the whole query). As a rule of thumb, for any given field the same analyzer should be used for indexing and querying.

4.3.2. Named analyzers

Analyzers can become quite complex to deal with. For this reason introduces Hibernate Search the notion of analyzer definitions. An analyzer definition can be reused by many @Analyzer declarations and is composed of:

- a name: the unique string used to refer to the definition
- a list of char filters: each char filter is responsible to pre-process input characters before the tokenization. Char filters can add, change or remove characters; one common usage is for characters normalization
- a tokenizer: responsible for tokenizing the input stream into individual words
- a list of filters: each filter is responsible to remove, modify or sometimes even add words into the stream provided by the tokenizer

This separation of tasks - a list of char filters, and a tokenizer followed by a list of filters - allows for easy reuse of each individual component and let you build your customized analyzer in a very flexible way (just like Lego). Generally speaking the char filters do some pre-processing in the character input, then the Tokenizer starts the tokenizing process by turning the character input into tokens which are then further processed by the TokenFilters. Hibernate Search supports this infrastructure by utilizing the advanced analyzers provided by Lucene; this is often referred to as the Analyzer Framework.

Some of the analyzers and filters will require additional dependencies. For example to use the snowball stemmer you have to also include the lucene-snowball jar and for the PhoneticFilterFactory you need the commons-codec jar. Your distribution of Hibernate Search provides these dependencies in its lib/optional directory. Have a look at Example of available tokenizers and Examples of available filters to see which analyzers and filters have additional dependencies.

Prior to Hibernate Search 5 it was required to add the Apache Solr dependency to your project as well; this is no longer required.

Let’s have a look at a concrete example now - @AnalyzerDef and the Analyzer Framework. First
a char filter is defined by its factory. In our example, a mapping char filter is used, and will replace characters in the input based on the rules specified in the mapping file. Next a tokenizer is defined. This example uses the standard tokenizer. Last but not least, a list of filters is defined by their factories. In our example, the StopFilter filter is built reading the dedicated words property file. The filter is also expected to ignore case.

**Example 42. @AnalyzerDef and the Analyzer Framework**

```java
@AnalyzerDef(name="customanalyzer",
    charFilters = {
        @CharFilterDef(factory = MappingCharFilterFactory.class, params = {
            @Parameter(name = "mapping",
                value = "org/hibernate/search/test/analyzer/mapping-chars.properties")
        })
    },
    tokenizer = @TokenizerDef(factory = StandardTokenizerFactory.class),
    filters = {
        @TokenFilterDef(factory = ASCII FoldingFilterFactory.class),
        @TokenFilterDef(factory = LowerCaseFilterFactory.class),
        @TokenFilterDef(factory = StopFilterFactory.class, params = {
            @Parameter(name="words",
                value = "org/hibernate/search/test/analyzer/stoplist.properties")
        }),
        @Parameter(name="ignoreCase", value="true")
    }
)

public class Team {
    // ...
}
```

Filters and char filters are applied in the order they are defined in the @AnalyzerDef annotation. Order matters!

Some tokenizers, token filters or char filters load resources like a configuration or metadata file. This is the case for the stop filter and the synonym filter.
Example 43. Use a specific charset to load the property file

```java
@AnalyzerDef(name="customanalyzer",
    charFilters = {
        @CharFilterDef(factory = MappingCharFilterFactory.class, params = {
            @Parameter(name = "mapping",
                value = "org/hibernate/search/test/analyzer/mapping-chars.properties")
        })
    },
    tokenizer = @TokenizerDef(factory = StandardTokenizerFactory.class),
    filters = {
        @TokenFilterDef(factory = ASCIIFoldingFilterFactory.class),
        @TokenFilterDef(factory = LowerCaseFilterFactory.class),
        @TokenFilterDef(factory = StopFilterFactory.class, params = {
            @Parameter(name="words",
                value = "org/hibernate/search/test/analyzer/stoplist.properties")
        }),
        @Parameter(name="ignoreCase", value="true")
    })
public class Team {
    // ...
}
```

Once defined, an analyzer definition can be reused by an `@Analyzer` declaration as seen in Referencing an analyzer by name.

Example 44. Referencing an analyzer by name

```java
@Entity
@Indexed
@AnalyzerDef(name="customanalyzer", ...)
public class Team {
    @Id
    @DocumentId
    @GeneratedValue
    private Integer id;

    @Field
    private String name;

    @Field
    private String location;

    @Field
    @Analyzer(definition = "customanalyzer")
    private String description;
}
```

Analyzer instances declared by `@AnalyzerDef` are also available by their name in the
**SearchFactory** which is quite useful when building queries.

```
Analyzer analyzer = fullTextSession.getSearchFactory().getAnalyzer("customanalyzer");
```

Fields in queries should be analyzed with the same analyzer used to index the field so that they speak a common "language": the same tokens are reused between the query and the indexing process. This rule has some exceptions but is true most of the time. Respect it unless you know what you are doing.

**Available analyzers**

Apache Lucene comes with a lot of useful default char filters, tokenizers and filters. You can find a complete list of char filter factories, tokenizer factories and filter factories at [http://wiki.apache.org/solr/AnalyzerFactoryTokenizersTokenFilters](http://wiki.apache.org/solr/AnalyzerFactoryTokenizersTokenFilters). Let’s check a few of them.

**Table 10. Example of available char filters**

<table>
<thead>
<tr>
<th>Factory</th>
<th>Description</th>
<th>Parameters</th>
<th>Additional dependencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>MappingCharFilterFactory</td>
<td>Replaces one or more characters with one or more characters, based on mappings specified in the resource file</td>
<td><code>mapping</code>: points to a resource file containing the mappings using the format: &quot;á&quot; ⇒ &quot;a&quot; &quot;ñ&quot; ⇒ &quot;n&quot; &quot;ø&quot; ⇒ &quot;o&quot;</td>
<td>lucene-analyzers-common</td>
</tr>
<tr>
<td>HTMLStripCharFilterFactory</td>
<td>Remove HTML standard tags, keeping the text</td>
<td>none</td>
<td>lucene-analyzers-common</td>
</tr>
</tbody>
</table>

**Table 11. Example of available tokenizers**

<table>
<thead>
<tr>
<th>Factory</th>
<th>Description</th>
<th>Parameters</th>
<th>Additional dependencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>StandardTokenizerFactory</td>
<td>Use the Lucene StandardTokenizer</td>
<td>none</td>
<td>lucene-analyzers-common</td>
</tr>
<tr>
<td>HTMLStripCharFilterFactory</td>
<td>Remove HTML tags, keep the text and pass it to a StandardTokenizer.</td>
<td>none</td>
<td>lucene-analyzers-common</td>
</tr>
<tr>
<td>PatternTokenizerFactory</td>
<td>Breaks text at the specified regular expression pattern.</td>
<td><code>pattern</code>: the regular expression to use for tokenizing group: says which pattern group to extract into tokens</td>
<td>lucene-analyzers-common</td>
</tr>
<tr>
<td>Factory</td>
<td>Description</td>
<td>Parameters</td>
<td>Additional dependencies</td>
</tr>
<tr>
<td>------------------------------</td>
<td>------------------------------------------------------------------------------</td>
<td>-------------------------------------------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td><strong>StandardFilterFactory</strong></td>
<td>Remove dots from acronyms and 's from words</td>
<td>none</td>
<td>lucene-analyzers-common</td>
</tr>
<tr>
<td><strong>LowerCaseFilterFactory</strong></td>
<td>Lowercases all words</td>
<td>none</td>
<td>lucene-analyzers-common</td>
</tr>
<tr>
<td><strong>StopFilterFactory</strong></td>
<td>Remove words (tokens) matching a list of stop words</td>
<td>words: points to a resource file containing the stop words, ignoreCase: true if case should be ignore when comparing stop words, false otherwise</td>
<td>lucene-analyzers-common</td>
</tr>
<tr>
<td><strong>SnowballPorterFilterFactory</strong></td>
<td>Reduces a word to it's root in a given language. (eg. protect, protects, protection share the same root). Using such a filter allows searches matching related words.</td>
<td>language: Danish, Dutch, English, Finnish, French, German, Italian, Norwegian, Portuguese, Russian, Spanish, Swedish and a few more</td>
<td>lucene-analyzers-common</td>
</tr>
<tr>
<td><strong>ASCIIFoldingFilterFactory</strong></td>
<td>Remove accents for languages like French</td>
<td>none</td>
<td>lucene-analyzers-common</td>
</tr>
<tr>
<td><strong>PhoneticFilterFactory</strong></td>
<td>Inserts phonetically similar tokens into the token stream</td>
<td>encoder: One of DoubleMetaphone, Metaphone, Soundex or RefinedSoundex inject: true will add tokens to the stream, false will replace the existing token maxCodeLength: sets the maximum length of the code to be generated. Supported only for Metaphone and DoubleMetaphone encodings</td>
<td>lucene-analyzers-phonetic and commons-codec</td>
</tr>
</tbody>
</table>
### Factory Description Parameters Additional dependencies

<table>
<thead>
<tr>
<th>Factory</th>
<th>Description</th>
<th>Parameters</th>
<th>Additional dependencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>CollationKeyFilterFactory</td>
<td>Converts each token into its java.text.CollationKey, and then encodes the CollationKey with IndexableBinaryStringTools, to allow it to be stored as an index term.</td>
<td>custom, language, country, variant, strength, decomposition</td>
<td>lucene-analyzers-common and commons-io</td>
</tr>
</tbody>
</table>

We recommend to check out the implementations of org.apache.lucene.analysis.util.TokenizerFactory and org.apache.lucene.analysis.util.TokenFilterFactory in your IDE to see the implementations available.

### 4.3.3. Dynamic analyzer selection

So far all the introduced ways to specify an analyzer were static. However, there are use cases where it is useful to select an analyzer depending on the current state of the entity to be indexed, for example in a multilingual applications. For an BlogEntry class for example the analyzer could depend on the language property of the entry. Depending on this property the correct language specific stemmer should be chosen to index the actual text.

To enable this dynamic analyzer selection Hibernate Search introduces the @AnalyzerDiscriminator annotation. Usage of @AnalyzerDiscriminator demonstrates the usage of this annotation.
Example 45. Usage of @AnalyzerDiscriminator

```java
@Entity
@Indexed
@AnalyzerDef(name = "en",
    tokenizer = @TokenizerDef(factory = StandardTokenizerFactory.class),
    filters = {
        @TokenFilterDef(factory = LowerCaseFilterFactory.class),
        @TokenFilterDef(factory = EnglishPorterFilterFactory.class)
    })
@AnalyzerDef(name = "de",
    tokenizer = @TokenizerDef(factory = StandardTokenizerFactory.class),
    filters = {
        @TokenFilterDef(factory = LowerCaseFilterFactory.class),
        @TokenFilterDef(factory = GermanStemFilterFactory.class)
    })
public class BlogEntry {
    @Id
    @GeneratedValue
    @DocumentId
    private Integer id;

    @Field
    @AnalyzerDiscriminator(impl = LanguageDiscriminator.class)
    private String language;

    @Field
    private String text;

    private Set<BlogEntry> references;
    // standard getter/setter
    // ... 
}

public class LanguageDiscriminator implements Discriminator {
    public String getAnalyzerDefinitionName(Object value, Object entity, String field) {
        if (value == null || !(entity instanceof Article)) {
            return null;
        }
        return (String) value;
    }
}
```

The prerequisite for using @AnalyzerDiscriminator is that all analyzers which are going to be used dynamically are predefined via @AnalyzerDef definitions. If this is the case, one can place the @AnalyzerDiscriminator annotation either on the class or on a specific property of the entity for which to dynamically select an analyzer. Via the impl parameter of the
@AnalyzerDiscriminator you specify a concrete implementation of the Discriminator interface. It is up to you to provide an implementation for this interface. The only method you have to implement is `getAnalyzerDefinitionName()` which gets called for each field added to the Lucene document. The entity which is getting indexed is also passed to the interface method. The value parameter is only set if the AnalyzerDiscriminator is placed on property level instead of class level. In this case the value represents the current value of this property.

An implementation of the Discriminator interface has to return the name of an existing analyzer definition or null if the default analyzer should not be overridden. Usage of @AnalyzerDiscriminator assumes that the language parameter is either 'de' or 'en' which matches the specified names in the @AnalyzerDefs.

### 4.3.4. Retrieving an analyzer

In some situations retrieving analyzers can be handy. For example, if your domain model makes use of multiple analyzers (maybe to benefit from stemming, use phonetic approximation and so on), you need to make sure to use the same analyzers when you build your query.

This rule can be broken but you need a good reason for it. If you are unsure, use the same analyzers. If you use the Hibernate Search query DSL (see Building a Lucene query with the Hibernate Search query DSL), you don’t have to think about it. The query DSL does use the right analyzer transparently for you.

Whether you are using the Lucene programmatic API or the Lucene query parser, you can retrieve the scoped analyzer for a given entity. A scoped analyzer is an analyzer which applies the right analyzers depending on the field indexed. Remember, multiple analyzers can be defined on a given entity each one working on an individual field. A scoped analyzer unifies all these analyzers into a context-aware analyzer. While the theory seems a bit complex, using the right analyzer in a query is very easy.
Example 46. Using the scoped analyzer when building a full-text query

```java
org.apache.lucene.queryparser.classic.QueryParser parser = new
QueryParser(  
    "title",  
    fullTextSession.getSearchFactory().getAnalyzer( Song.class ) 
);
/org.apache.lucene.search.Query luceneQuery =  
parser.parse( "title:sky Or title_stemmed:diamond" );
/org.hibernate.Query fullTextQuery =  
fullTextSession.createFullTextQuery( luceneQuery, Song.class );

List result = fullTextQuery.list();  //return a list of managed objects
```

In the example above, the song title is indexed in two fields: the standard analyzer is used in the field `title` and a stemming analyzer is used in the field `title_stemmed`. By using the analyzer provided by the search factory, the query uses the appropriate analyzer depending on the field targeted.

You can also retrieve analyzers defined via `@AnalyzerDef` by their definition name using `searchFactory.getAnalyzer(String)`.

4.4. Bridges

When discussing the basic mapping for an entity one important fact was so far disregarded. In Lucene all index fields have to be represented as strings. All entity properties annotated with `@Field` have to be converted to strings to be indexed. The reason we have not mentioned it so far is, that for most of your properties Hibernate Search does the translation job for you thanks to a set of built-in bridges. However, in some cases you need a more fine grained control over the translation process.

4.4.1. Built-in bridges

Hibernate Search comes bundled with a set of built-in bridges between a Java property type and its full text representation.

null

Per default null elements are not indexed. Lucene does not support null elements. However, in some situation it can be useful to insert a custom token representing the null value. See `@Field` for more information.

java.lang.String

Strings are indexed as are
short, Short, integer, Integer, long, Long, float, Float, double, Double

Are per default indexed numerically using a Trie structure. You need to use a NumericRangeQuery to search for values. See also @Field and @NumericField

BigInteger, BigDecimal

BigInteger and BigDecimal are converted into their string representation and indexed. Note that in this form the values cannot be compared by Lucene using for example a TermRangeQuery. For that the string representation would need to be padded. An alternative using numeric encoding with a potential loss in precision can be seen in Defining a custom NumericFieldBridge for BigDecimal.

java.util.Date, java.util.Calendar

Dates are indexed as long value representing the number of milliseconds since January 1, 1970, 00:00:00 GMT. You shouldn’t really bother with the internal format. It is important, however, to query a numerically indexed date via a NumericRangeQuery.

Usually, storing the date up to the millisecond is not necessary. @DateBridge defines the appropriate resolution you are willing to store in the index.

java.time.Year

converts the year to the integer representation.

java.time.Duration

converts the duration to the total length in nanoseconds.

java.time.Instant

converts the instant to the number of milliseconds from Epoch. Note that these values are indexed with a precision to the millisecond.

Note that it must be possible to convert the Instant or the Duration to a Long. If these values are too big or too small an exception is thrown.

LocalDate, LocalTime, LocalDateTime, LocalTime, MonthDay, OffsetDateTime, OffsetTime, Period, YearMonth, ZoneDateTime, ZoneId, ZoneOffset

the bridges for these classes in the java.time package store the values as string padded with 0 when required to allow sorting.
@Entity
@Indexed
public class Meeting {
  @Field(analyze=Analyze.NO)
  @DateBridge(resolution=Resolution.MINUTE)
  private Date date;
  // ...
}

You can also choose to encode the date as string using the encoding=EncodingType.STRING of DateBridge. In this case the dates are stored in the format yyyyMMddHHmmssSSS (using GMT time).

⚠️ A Date whose resolution is lower than MILLISECOND cannot be a @DocumentId

⚠️ The default date bridge uses Lucene’s DateTools to convert from Date or Calendar to its indexed value. This means that all dates are expressed in GMT time. If your requirements are to store dates in a fixed time zone you have to implement a custom date bridge.

java.net.URI, java.net.URL

URI and URL are converted to their string representation

java.lang.Class

Classes are converted to their fully qualified class name. The thread context classloader is used when the class is rehydrated

### 4.4.2. Tika bridge

Hibernate Search allows you to extract text from various document types using the built-in TikaBridge which utilizes Apache Tika to extract text and metadata from the provided documents. The @TikaBridge annotation can be used with String, URI, byte[] or java.sql.Blob properties. In the case of String and URI the bridge interprets the values are file paths and tries to open a file to parse the document. In the case of byte[] and Blob the values are directly passed to Tika for parsing.

Tika uses metadata as in- and output of the parsing process and it also allows to provide additional context information. This process is described in Parser interface. The Hibernate Search Tika bridge allows you to make use of these additional configuration options by providing two interfaces in conjunction with TikaBridge. The first interface is the TikaParseContextProvider. It allows you to create a custom ParseContext for the document parsing. The second interface is TikaMetadataProcessor which has two methods -
prepareMetadata() and set(String, Object, Document, LuceneOptions, Metadata metadata). The former allows to add additional metadata to the parsing process (for example the file name) and the latter allows you to index metadata discovered during the parsing process.

Sortable fields with Tika

If you want to add multiple fields in your TikaMetadataProcessor, and also want to make those fields sortable, you should make your processor implement the MetadataProvidingTikaMetadataProcessor. This is similar to implementing MetadataProvidingFieldBridge on a regular field bridge: see @SortableField.

Like MetadataProvidingFieldBridge, the MetadataProvidingTikaMetadataProcessor contract is under active development and considered experimental at this time. It may be altered in future revisions, e.g. by adding further methods, thus breaking existing implementations.

TikaParseContextProvider as well as TikaMetadataProcessor implementation classes can both be specified as parameters on the TikaBridge annotation.

Example 47. Example mapping with Apache Tika

```java
@Entity
@Indexed
public class Song {
    @Id
    @GeneratedValue
    long id;
    
    @Field
    @TikaBridge(metadataProcessor = Mp3TikaMetadataProcessor.class)
    String mp3FileName;
    // ...
}
```

```java
QueryBuilder queryBuilder = fullTextSession.getSearchFactory().
    .buildQueryBuilder()
    .forEntity(Song.class)
    .get();

Query query = queryBuilder.keyword().
    .onField("mp3FileName")
    .ignoreFieldBridge() //mandatory
    .matching("Apes")
    .createQuery();

List result = fullTextSession.createFullTextQuery(query).list();
```
In the Example mapping with Apache Tika the property `mp3FileName` represents a path to an MP3 file; the headers of this file will be indexed and so the performed query will be able to match the MP3 metadata.

**Example mapping with Apache Tika**

To avoid issues with the `TikaBridge` not implementing `TwoWayFieldBridge`, queries built using the DSL (as in the Example mapping with Apache Tika) need to explicitly enable the option `ignoreFieldBridge()`.

4.4.3. Custom bridges

Sometimes, the built-in bridges of Hibernate Search do not cover some of your property types, or the `String` representation used by the bridge does not meet your requirements. The following paragraphs describe several solutions to this problem.

**StringBridge**

The simplest custom solution is to give Hibernate Search an implementation of your expected `Object` to `String` bridge. To do so you need to implement the `org.hibernate.search.bridge.StringBridge` interface. All implementations have to be thread-safe as they are used concurrently.

**Example 48. Custom StringBridge implementation**

```java
/**
 * Padding Integer bridge.
 * All numbers will be padded with 0 to match 5 digits
 * @author Emmanuel Bernard
 */
public class PaddedIntegerBridge implements StringBridge {
    private int padding = 5;

    public String objectToString(Object object) {
        String rawInteger = ((Integer) object).toString();
        if (rawInteger.length() > padding)
            throw new IllegalArgumentException("Number too big to be padded");
        StringBuilder paddedInteger = new StringBuilder();
        for (int padIndex = rawInteger.length(); padIndex < padding; padIndex++) {
            paddedInteger.append('0');
        }
        return paddedInteger.append(rawInteger).toString();
    }
}
```

Given the string bridge defined in Custom StringBridge implementation, any property or field
can use this bridge thanks to the @FieldBridge annotation:

```java
@FieldBridge(impl = PaddedIntegerBridge.class)
private Integer length;
```

**Parameterized bridge**

Parameters can also be passed to the bridge implementation making it more flexible. Passing parameters to your bridge implementation implements a ParameterizedBridge interface and parameters are passed through the @FieldBridge annotation.

**Example 49. Passing parameters to your bridge implementation**

```java
public class PaddedIntegerBridge implements StringBridge, ParameterizedBridge {

    public static String PADDING_PROPERTY = "padding";
    private int padding = 5; //default

    public void setParameterValues(Map<String,String> parameters) {
        String padding = parameters.get( PADDING_PROPERTY );
        if (padding != null) this.padding = Integer.parseInt( padding );
    }

    public String objectToString(Object object) {
        String rawInteger = ((Integer) object).toString();
        if (rawInteger.length() > padding)
            throw new IllegalArgumentException("Number too big to be padded");
        StringBuilder paddedInteger = new StringBuilder( );
        for (int padIndex = rawInteger.length(); padIndex < padding;
            padIndex++) {
            paddedInteger.append('0');
        }
        return paddedInteger.append(rawInteger).toString();
    }
}
```

```
//on the property:
@FieldBridge(impl = PaddedIntegerBridge.class,
    params = @Parameter(name="padding", value="10")
)
private Integer length;
```

The ParameterizedBridge interface can be implemented by StringBridge, TwoWayStringBridge, FieldBridge implementations.

All implementations have to be thread-safe, but the parameters are set during initialization and
no special care is required at this stage.

**Type aware bridge**

It is sometimes useful to get the type the bridge is applied on:

- the return type of the property for field/getter-level bridges
- the class type for class-level bridges

An example is a bridge that deals with enums in a custom fashion but needs to access the actual enum type. Any bridge implementing `AppliedOnTypeAwareBridge` will get the type the bridge is applied on injected. Like parameters, the type injected needs no particular care with regard to thread-safety.

**Two-way bridge**

If you expect to use your bridge implementation on an id property (ie annotated with `@DocumentId`), you need to use a slightly extended version of `StringBridge` named `TwoWayStringBridge`. Hibernate Search needs to read the string representation of the identifier and generate the object out of it. There is no difference in the way the `@FieldBridge` annotation is used.
Example 50. Implementing a TwoWayStringBridge usable for id properties

```java
public class PaddedIntegerBridge implements TwoWayStringBridge, ParameterizedBridge {
    public static String PADDING_PROPERTY = "padding";
    private int padding = 5; //default

    public void setParameterValues(Map parameters) {
        Object padding = parameters.get(PADDING_PROPERTY);
        if (padding != null) this.padding = (Integer) padding;
    }

    public String objectToString(Object object) {
        String rawInteger = ((Integer) object).toString();
        if (rawInteger.length() > padding)
            throw new IllegalArgumentException("Number too big to be padded");
        StringBuilder paddedInteger = new StringBuilder();
        for (int padIndex = rawInteger.length(); padIndex < padding; padIndex++) {
            paddedInteger.append('0');
        }
        return paddedInteger.append(rawInteger).toString();
    }

    public Object stringToObject(String stringValue) {
        return new Integer(stringValue);
    }
}
```

//On an id property:
@DocumentId
@FieldBridge(impl = PaddedIntegerBridge.class, params = @Parameter(name="padding", value="10")
private Integer id;

It is important for the two-way process to be idempotent (ie object = stringToObject(objectToString(object))).

FieldBridge

Some use cases require more than a simple object to string translation when mapping a property to a Lucene index. To give you the greatest possible flexibility you can also implement a bridge as a FieldBridge. This interface gives you a property value and let you map it the way you want in your Lucene Document. You can for example store a property in two different document fields. The interface is very similar in its concept to the Hibernate ORM UserType.
Example 51. Implementing the FieldBridge interface

```java
/**
 * Store the date in 3 different fields - year, month, day - to ease the creation of RangeQuery per
 * year, month or day (eg get all the elements of December for the last 5 years).
 * @author Emmanuel Bernard
 */
public class DateSplitBridge implements FieldBridge {
    private final static TimeZone GMT = TimeZone.getTimeZone("GMT");

    public void set(String name, Object value, Document document,
                    LuceneOptions luceneOptions) {
        Date date = (Date) value;
        Calendar cal = GregorianCalendar.getInstance(GMT);
        cal.setTime(date);
        int year = cal.get(Calendar.YEAR);
        int month = cal.get(Calendar.MONTH) + 1;
        int day = cal.get(Calendar.DAY_OF_MONTH);

        // set year
        luceneOptions.addFieldToDocument(
            name + ".year",
            String.valueOf( year ),
            document );

        // set month and pad it if needed
        luceneOptions.addFieldToDocument(
            name + ".month",
            month < 10 ? "0" : "" + String.valueOf( month ),
            document );

        // set day and pad it if needed
        luceneOptions.addFieldToDocument(
            name + ".day",
            day < 10 ? "0" : "" + String.valueOf( day ),
            document );
    }

    //property
    @FieldBridge(impl = DateSplitBridge.class)
    private Date date;
```

In Implementing the FieldBridge interface the fields are not added directly to Document. Instead the addition is delegated to the LuceneOptions helper; this helper will apply the options you have selected on @Field, like Store or TermVector, or apply the chosen @Boost value. It is especially useful to encapsulate the complexity of COMPRESS implementations. Even though it is recommended to delegate to LuceneOptions to add fields to the Document, nothing stops you from editing the Document directly and ignore the LuceneOptions in case you need to.
Classes like `LuceneOptions` are created to shield your application from changes in Lucene API and simplify your code. Use them if you can, but if you need more flexibility you're not required to.

**ClassBridge**

It is sometimes useful to combine more than one property of a given entity and index this combination in a specific way into the Lucene index. The `@ClassBridge` and `@ClassBridges` annotations can be defined at class level (as opposed to the property level). In this case the custom field bridge implementation receives the entity instance as the value parameter instead of a particular property. Though not shown in Implementing a class bridge, `@ClassBridge` supports the `termVector` attribute discussed in section Basic mapping.
Example 52. Implementing a class bridge

```java
@Entity
@Indexed
@ClassBridge(
    name="branchnetwork",
    store=Store.YES,
    impl = CatFieldsClassBridge.class,
    params = @Parameter( name="sepChar", value=" " ) )

public class Department {
    private int id;
    private String network;
    private String branchHead;
    private String branch;
    private Integer maxEmployees
    // ...
}

public class CatFieldsClassBridge implements FieldBridge, ParameterizedBridge {
    private String sepChar;

    public void setParameterValues(Map parameters) {
        this.sepChar = (String) parameters.get( "sepChar" );
    }

    public void set(String name, Object value, Document document, LuceneOptions luceneOptions) {
        // In this particular class the name of the new field was passed
        // from the name field of the ClassBridge Annotation. This is not
        // a requirement. It just works that way in this instance. The
        // actual name could be supplied by hard coding it below.
        Department dep = (Department) value;
        String fieldValue1 = dep.getBranch();
        if ( fieldValue1 == null ) {
            fieldValue1 = "";
        }
        String fieldValue2 = dep.getNetwork();
        if ( fieldValue2 == null ) {
            fieldValue2 = "";
        }
        String fieldValue = fieldValue1 + sepChar + fieldValue2;
        Field field = new Field( name, fieldValue, luceneOptions.
            getStore(),
            luceneOptions.getIndex(), luceneOptions.getTermVector() );
        field.setBoost( luceneOptions.getBoost() );
        document.add( field );
    }
}
```

In this example, the particular CatFieldsClassBridge is applied to the department instance, the field bridge then concatenate both branch and network and index the concatenation.
4.4.4. BridgeProvider: associate a bridge to a given return type

Custom field bridges are very flexible, but it can be tedious and error prone to apply the same custom @FieldBridge annotation every time a property of a given type is present in your domain model. That is what BridgeProviders are for.

Let's imagine that you have a type Currency in your application and that you want to apply your very own CurrencyFieldBridge every time an indexed property returns Currency. You can do it the hard way:

Example 53. Applying the same @FieldBridge for a type the hard way

```java
@Entity @Indexed
public class User {
    @FieldBridge(impl=CurrencyFieldBridge.class)
    public Currency getDefaultCurrency();
    // ...
}

@Entity @Indexed
public class Account {
    @FieldBridge(impl=CurrencyFieldBridge.class)
    public Currency getCurrency();
    // ...
}

// continue to add @FieldBridge(impl=CurrencyFieldBridge.class)
everywhere Currency is
```

Or you can write your own BridgeProvider implementation for Currency.
**Example 54. Writing a `BridgeProvider`**

```java
public class CurrencyBridgeProvider implements BridgeProvider {
    // needs a default no-arg constructor
    @Override
    public FieldBridge provideFieldBridge(BridgeContext bridgeProviderContext) {
        if (bridgeProviderContext.getReturnType().equals(Currency.class)) {
            return CurrencyFieldBridge.INSTANCE;
        }
        return null;
    }
}
```

# service file named META-INF/services/org.hibernate.search.bridge.spi.BridgeProvider
com.acme.myapps.hibernate.search.CurrencyBridgeProvider

You need to implement `BridgeProvider` and create a service file named `META-INF/services/org.hibernate.search.bridge.spi.BridgeProvider`. This file must contain the fully qualified class name(s) of the `BridgeProvider` implementations. This is the classic Service Loader discovery mechanism.

Now, any indexed property of type `Currency` will use `CurrencyFieldBridge` automatically.

**Example 55. An explicit @FieldBridge is no longer needed**

```java
@Entity @Indexed
public class User {
    @Field
    public Currency getDefaultCurrency();
    // ...
}

@Entity @Indexed
public class Account {
    @Field
    public Currency getCurrency();
    // ...
}
```

// `CurrencyFieldBridge` is applied automatically everywhere `Currency` is found on an indexed property
A few more things you need to know:

- A `BridgeProvider` must have a no-arg constructor
- If a `BridgeProvider` only returns `FieldBridge` instances if it is meaningful for the calling context. Null otherwise. In our example, the return type must be `Currency` to be meaningful to our provider.
- If two or more bridge providers return a `FieldBridge` instance for a given return type, an exception will be raised.

**What is a calling context**

A calling context is represented by the `BridgeProviderContext` object and represents the environment for which we are looking for a bridge. `BridgeProviderContext` gives access to the return type of the indexed property as well as the `ServiceManager` which gives access to the `ClassLoaderService` for everything class loader related.

```java
ClassLoaderService classLoaderService = serviceManager.getClassLoaderService();
CustomBridge cb = classLoaderService.className("com.package.CustomBridge");
```

### 4.5. Conditional indexing

This feature is considered experimental. More operation types might be added in the future depending on user feedback.

In some situations, you want to index an entity only when it is in a given state, for example:

- Only index blog entries marked as published
- No longer index invoices when they are marked archived

This serves both functional and technical needs. You don't want your blog readers to find your draft entries and filtering them off the query is a bit annoying. Very few of your entities are actually required to be indexed and you want to limit indexing overhead and keep indexes small and fast.

Hibernate Search lets you intercept entity indexing operations and override them. It is quite simple:

- Write an `EntityIndexingInterceptor` class with your entity state based logic
- Mark the entity as intercepted by this implementation
Let’s look at the blog example at Index blog entries only when they are published and remove them when they are in a different state

Example 56. Index blog entries only when they are published and remove them when they are in a different state

```java
/**
 * Only index blog when it is in published state
 *
 * @author Emmanuel Bernard <emmanuel@hibernate.org>
 */
public class IndexWhenPublishedInterceptor implements EntityIndexingInterceptor<Blog> {
    @Override
    public IndexingOverride onAdd(Blog entity) {
        if (entity.getStatus() == BlogStatus.PUBLISHED) {
            return IndexingOverride.APPLY_DEFAULT;
        }
        return IndexingOverride.SKIP;
    }

    @Override
    public IndexingOverride onUpdate(Blog entity) {
        if (entity.getStatus() == BlogStatus.PUBLISHED) {
            return IndexingOverride.UPDATE;
        }
        return IndexingOverride.REMOVE;
    }

    @Override
    public IndexingOverride onDelete(Blog entity) {
        return IndexingOverride.APPLY_DEFAULT;
    }

    @Override
    public IndexingOverride onCollectionUpdate(Blog entity) {
        return onUpdate(entity);
    }
}
```
We mark the `Blog` entity with `@Indexed.interceptor`. As you can see, `IndexWhenPublishedInterceptor` implements `EntityIndexingInterceptor` and accepts `Blog` entities (it could have accepted super classes as well - for example `Object` if you create a generic interceptor.

You can react to several planned indexing events:

- when an entity is added to your datastore
- when an entity is updated in your datastore
- when an entity is deleted from your datastore
- when a collection own by this entity is updated in your datastore

For each occurring event you can respond with one of the following actions:

- **APPLY_DEFAULT**: that’s the basic operation that lets Hibernate Search update the index as expected - creating, updating or removing the document
- **SKIP**: ask Hibernate Search to not do anything to the index for this event - data will not be created, updated or removed from the index in any way
- **REMOVE**: ask Hibernate Search to remove indexing data about this entity - you can safely ask for REMOVE even if the entity has not yet been indexed
- **UPDATE**: ask Hibernate Search to either index or update the index for this entity - it is safe to ask for UPDATE even if the entity has never been indexed
Be careful, not every combination makes sense: for example, asking to **UPDATE** the index upon onDelete. Note that you could ask for **SKIP** in this situation if saving indexing time is critical for you. That’s rarely the case though.

By default, no interceptor is applied on an entity. You have to explicitly define an interceptor via the [@Indexed](#) annotation (see [@Indexed](#)) or programmatically (see Programmatic API). This class and all its subclasses will then be intercepted. You can stop or change the interceptor used in a subclass by overriding [@Indexed.interceptor](#). Hibernate Search provides **DontInterceptEntityInterceptor** which will explicitly not intercept any call. This is useful to reset interception within a class hierarchy.

Dirty checking optimization is disabled when interceptors are used. Dirty checking optimization does check what has changed in an entity and only triggers an index update if indexed properties are changed. The reason is simple, your interceptor might depend on a non indexed property which would be ignored by this optimization.

An EntityIndexingInterceptor can never override an explicit indexing operation such as `index(T)`, `purge(T, id)` or `purgeAll(class)`.

### 4.6. Providing your own id

You can provide your own id for Hibernate Search if you are extending the internals. You will have to generate a unique value so it can be given to Lucene to be indexed. This will have to be given to Hibernate Search when you create an `org.hibernate.search.Work` object - the document id is required in the constructor.

### 4.6.1. The ProvidedId annotation

Unlike [@DocumentId](#) which is applied on field level, [@ProvidedId](#) is used on the class level. Optionally you can specify your own bridge implementation using the bridge property. Also, if you annotate a class with [@ProvidedId](#), your subclasses will also get the annotation - but it is not done by using the `java.lang.annotations.@Inherited`. Be sure however, to not use this annotation with [@DocumentId](#) as your system will break.
Example 57. Providing your own id

```java
@ProvidedImage(bridge = org.my.own.package.MyCustomBridge)
@Indexed
public class MyClass{
    @Field
    String MyString;
    ...
}
```

### 4.7. Programmatic API

Although the recommended approach for mapping indexed entities is to use annotations, it is sometimes more convenient to use a different approach:

- the same entity is mapped differently depending on deployment needs (customization for clients)
- some automation process requires the dynamic mapping of many entities sharing common traits

While it has been a popular demand in the past, the Hibernate team never found the idea of an XML alternative to annotations appealing due to its heavy duplication, lack of code refactoring safety, because it did not cover all the use case spectrum and because we are in the 21st century ;)

The idea of a programmatic API was much more appealing and has now become a reality. You can programatically define your mapping using a programmatic API: you define entities and fields as indexable by using mapping classes which effectively mirror the annotation concepts in Hibernate Search. Note that fan(s) of XML approach can design their own schema and use the programmatic API to create the mapping while parsing the XML stream.

In order to use the programmatic model you must first construct a `SearchMapping` object which you can do in two ways:

- directly
- via a factory

You can pass the `SearchMapping` object directly via the property key `hibernate.search.model_mapping` or the constant `Environment.MODEL_MAPPING`. Use the Configuration API or the `Map` passed to the JPA Persistence bootstrap methods.
Example 58. Programmatic mapping

```java
SearchMapping mapping = new SearchMapping();
// ... configure mapping
Configuration config = new Configuration();
config.getProperties().put(Environment.MODEL_MAPPING, mapping);
SessionFactory sf = config.buildSessionFactory();
```

Example 59. Programmatic mapping with JPA

```java
SearchMapping mapping = new SearchMapping();
// ... configure mapping
Map props = new HashMap();
props.put(Environment.MODEL_MAPPING, mapping);
EntityManagerFactory emf = Persistence.createEntityManagerFactory("userPU", props);
```

Alternatively, you can create a factory class (ie hosting a method annotated with @Factory) whose factory method returns the SearchMapping object. The factory class must have a no-arg constructor and its fully qualified class name is passed to the property key hibernate.search.model_mapping or its type-safe representation Environment.MODEL_MAPPING. This approach is useful when you do not necessarily control the bootstrap process like in a Java EE, CDI or Spring Framework container.
The `SearchMapping` is the root object which contains all the necessary indexable entities and fields. From there, the `SearchMapping` object exposes a fluent (and thus intuitive) API to express your mappings: it contextually exposes the relevant mapping options in a type-safe way. Just let your IDE auto-completion feature guide you through.

Today, the programmatic API cannot be used on a class annotated with Hibernate Search annotations, chose one approach or the other. Also note that the same default values apply in annotations and the programmatic API. For example, the `@Field.name` is defaulted to the property name and does not have to be set.

Each core concept of the programmatic API has a corresponding example to depict how the same definition would look using annotation. Therefore seeing an annotation example of the programmatic approach should give you a clear picture of what Hibernate Search will build with the marked entities and associated properties.

### 4.7.1. Mapping an entity as indexable

The first concept of the programmatic API is to define an entity as indexable. Using the annotation approach a user would mark the entity as `@Indexed`, the following example demonstrates how to programmatically achieve this.
Example 61. Marking an entity indexable

```java
SearchMapping mapping = new SearchMapping();

mapping.entity(Address.class)
    .indexed()
    .indexName("Address_Index") //optional
    .interceptor(IndexWhenPublishedInterceptor.class);

//optional
cfg.getProperties().put("hibernate.search.model_mapping", mapping);
```

As you can see you must first create a `SearchMapping` object which is the root object that is then passed to the Configuration object as property. You must declare an entity and if you wish to make that entity as indexable then you must call the `indexed()` method. The `indexed()` method has an optional `indexName(String indexName)` which can be used to change the default index name that is created by Hibernate Search. Likewise, an `interceptor(Class<? extends EntityIndexedInterceptor>)` is available. Using the annotation model the above can be achieved as:

Example 62. Annotation example of indexing entity

```java
@Entity
@Indexed(index="Address_Index", interceptor=IndexWhenPublishedInterceptor.class)
public class Address {
    // ...
}
```

4.7.2. Adding DocumentId to indexed entity

To set a property as a document id:

Example 63. Enabling document id with programmatic model

```java
SearchMapping mapping = new SearchMapping();

mapping.entity(Address.class).indexed()
    .property("addressId", ElementType.FIELD) //field access
    .documentId()
    .name("id");

cfg.getProperties().put("hibernate.search.model_mapping", mapping);
```

The above is equivalent to annotating a property in the entity as `@DocumentId` as seen in the
following example:

Example 64. `@DocumentId` annotation definition

```java
@Entity
@Indexed
public class Address {
    @Id
    @GeneratedValue
    @DocumentId(name = "id")
    private Long addressId;
    // ...
}
```

4.7.3. Defining analyzers

Analyzers can be programmatically defined using the `analyzerDef(String analyzerDef, Class<? extends TokenizerFactory> tokenizerFactory)` method. This method also enables you to define filters for the analyzer definition. Each filter that you define can optionally take in parameters as seen in the following example:

Example 65. Defining analyzers using programmatic model

```java
SearchMapping mapping = new SearchMapping();

mapping
    .analyzerDef("ngram", StandardTokenizerFactory.class)
    .filter(LowerCaseFilterFactory.class)
    .filter(NGramFilterFactory.class)
    .param("minGramSize", "3")
    .param("maxGramSize", "3")
    .analyzerDef("en", StandardTokenizerFactory.class)
    .filter(LowerCaseFilterFactory.class)
    .filter(EnglishPorterFilterFactory.class)
    .analyzerDef("de", StandardTokenizerFactory.class)
    .filter(LowerCaseFilterFactory.class)
    .filter(GermanStemFilterFactory.class)
    .entity(Address.class).indexed()
    .property("addressId", ElementType.METHOD) //getter access
    .documentId()
    .name("id");

cfg.getProperties().put("hibernate.search.model_mapping", mapping);
```

The analyzer mapping defined above is equivalent to the annotation model using `@AnalyzerDef`:

```java
@Entity
@Indexed
public class Address {
    @Id
    @GeneratedValue
    @DocumentId(name = "id")
    private Long addressId;
    // ...
}
```
Example 66. Analyzer definition using annotation

```java
@Indexed
@Entity
@AnalyzerDef(name = "ngram",
    tokenizer = @TokenizerDef(factory = StandardTokenizerFactory.class),
    filters = {
        @TokenFilterDef(factory = LowerCaseFilterFactory.class),
        @TokenFilterDef(factory = NGramFilterFactory.class,
            params = {
                @Parameter(name = "minGramSize", value = "3"),
                @Parameter(name = "maxGramSize", value = "3")
            }
        )
    })

@AnalyzerDef(name = "en",
    tokenizer = @TokenizerDef(factory = StandardTokenizerFactory.class),
    filters = {
        @TokenFilterDef(factory = LowerCaseFilterFactory.class),
        @TokenFilterDef(factory = EnglishPorterFilterFactory.class)
    })

@AnalyzerDef(name = "de",
    tokenizer = @TokenizerDef(factory = StandardTokenizerFactory.class),
    filters = {
        @TokenFilterDef(factory = LowerCaseFilterFactory.class),
        @TokenFilterDef(factory = GermanStemFilterFactory.class)
    })

class Address {
    // ...
}
```

4.7.4. Defining full text filter definitions

The programmatic API provides easy mechanism for defining full text filter definitions which is available via `@FullTextFilterDef` (see Filters). The next example depicts the creation of full text filter definition using the `fullTextFilterDef` method.
Example 67. Defining full text definition programmatically

```java
SearchMapping mapping = new SearchMapping();

mapping
    .analyzerDef("en", StandardTokenizerFactory.class)
    .filter(LowerCaseFilterFactory.class)
    .filter(EnglishPorterFilterFactory.class)
    .fullTextFilterDef("security", SecurityFilterFactory.class)
    .cache(FilterCacheModeType.INSTANCE_ONLY)
    .entity(Address.class)
    .indexed()
    .property("addressId", ElementType.METHOD)
    .documentId()
    .name("id")
    .property("street1", ElementType.METHOD)
    .field()
    .analyzer("en")
    .store(Store.YES)
    .field()
    .name("address_data")
    .analyzer("en")
    .store(Store.NO);

cfg.getProperties().put("hibernate.search.model_mapping", mapping);
```

The previous example can effectively been seen as annotating your entity with `@FullTextFilterDef` like below:
Example 68. Using annotation to define full text filter definition

```java
@Entity
@Indexed
@AnalyzerDef(name = "en",
    tokenizer = @TokenizerDef(factory = StandardTokenizerFactory.class),
    filters = {
        @TokenFilterDef(factory = LowerCaseFilterFactory.class),
        @TokenFilterDef(factory = EnglishPorterFilterFactory.class)
    })
@FullTextFilterDef(name = "security", impl = SecurityFilterFactory.class, cache = FilterCacheModeType.INSTANCE_ONLY)
public class Address {

    @Id
    @GeneratedValue
    @DocumentId(name="id")
    public Long getAddressId() {...);

    @Field(store=Store.YES, analyzer=@Analyzer(definition="en"))
    @Field(name="address_data", analyzer=@Analyzer(definition="en"))
    public String getAddress1() {...};

    // ...
}
```

4.7.5. Defining fields for indexing

When defining fields for indexing using the programmatic API, call `field()` on the `property(String propertyName, ElementType elementType)` method. From `field()` you can specify the `name`, `index`, `store`, `bridge` and `analyzer` definitions.
Example 69. Indexing fields using programmatic API

```java
SearchMapping mapping = new SearchMapping();

mapping
   .analyzerDef( "en", StandardTokenizerFactory.class )
   .filter( LowerCaseFilterFactory.class )
   .filter( EnglishPorterFilterFactory.class )
   .entity(Address.class).indexed()
      .property("addressId", ElementType.METHOD)
         .documentId()
         .name("id")
      .property("street1", ElementType.METHOD)
         .field()
            .analyzer("en")
            .store(Store.YES)
         .field()
            .name("address_data")
            .analyzer("en");

cfg.getProperties().put( "hibernate.search.model_mapping", mapping );
```

The above example of marking fields as indexable is equivalent to defining fields using `@Field` as seen below:

Example 70. Indexing fields using annotation

```java
@Entity
@Indexed
@AnalyzerDef(name = "en",
      tokenizer = @TokenizerDef(factory = StandardTokenizerFactory.class),
      filters = {
         @TokenFilterDef(factory = LowerCaseFilterFactory.class),
         @TokenFilterDef(factory = EnglishPorterFilterFactory.class)
      })
public class Address {

   @Id
   @GeneratedValue
   @DocumentId(name="id")
   private Long getAddressId() {...};

   @Field(store=Store.YES, analyzer=@Analyzer(definition="en"))
   @Field(name="address_data", analyzer=@Analyzer(definition="en"))
   public String getAddress1() {...}

   // ...
}
```
When using a programmatic mapping for a given type $X$, you can only refer to fields defined on $X$. Fields or methods inherited from a super type are not configurable. In case you need to configure a super class property, you need to either override the property in $X$ or create a programmatic mapping for the super class. This mimics the usage of annotations where you cannot annotate a field or method of a super class either, unless it is redefined in the given type.

### 4.7.6. Programmaticaly defining embedded entities

In this section you will see how to programmatically define entities to be embedded into the indexed entity similar to using the @IndexedEmbedded model. In order to define this you must mark the property as `indexEmbedded`. There is the option to add a prefix to the embedded entity definition which can be done by calling `prefix` as seen in the example below:

**Example 71. Programmaticaly defining embedded entities**

```java
SearchMapping mapping = new SearchMapping();
mapping
    .entity(ProductCatalog.class)
    .indexed()
    .property("catalogId", ElementType.METHOD)
    .documentId()
    .name("id")
    .property("title", ElementType.METHOD)
    .field()
        .index(Index.YES)
        .store(Store.NO)
    .property("description", ElementType.METHOD)
    .field()
        .index(Index.YES)
        .store(Store.NO)
    .property("items", ElementType.METHOD)
    .indexEmbedded()
        .prefix("catalog.items"); //optional

cfg.getProperties().put( "hibernate.search.model_mapping", mapping )
```

The next example shows the same definition using annotation (@IndexedEmbedded):
Example 72. Using `@IndexedEmbedded`

```java
@Entity
@Indexed
public class ProductCatalog {
    @Id
    @GeneratedValue
    @DocumentId(name = "id")
    public Long getCatalogId() {...}

    @Field
    public String getTitle() {...}

    @Field
    public String getDescription();

    @OneToMany(fetch = FetchType.LAZY)
    @IndexColumn(name = "list_position")
    @Cascade(org.hibernate.annotations.CascadeType.ALL)
    @IndexedEmbedded(prefix = "catalog.items")
    public List<Item> getItems() {...}
    // ...
}
```

4.7.7. Contained In definition

`@ContainedIn` can be defined as seen in the example below:

Example 73. Programmatically defining `containedIn`

```java
SearchMapping mapping = new SearchMapping();

mapping
    .entity(ProductCatalog.class)
    .indexed()
    .property("catalogId", ElementType.METHOD)
    .documentId()
    .property("title", ElementType.METHOD)
    .field()
    .property("description", ElementType.METHOD)
    .field()
    .property("items", ElementType.METHOD)
    .indexEmbedded()

    .entity(Item.class)
    .property("description", ElementType.METHOD)
    .field()
    .property("productCatalog", ElementType.METHOD)
    .containedIn();

cfg.getProperties().put("hibernate.search.model_mapping", mapping);
```
This is equivalent to defining `@ContainedIn` in your entity:

**Example 74. Annotation approach for `@ContainedIn`**

```java
@Entity
@Indexed
public class ProductCatalog {

    @Id
    @GeneratedValue
    @DocumentId
    public Long getCatalogId() {...}

    @Field
    public String getTitle() {...}

    @Field
    public String getDescription() {...}

    @OneToMany(fetch = FetchType.LAZY)
    @IndexColumn(name = "list_position")
    @Cascade(org.hibernate.annotations.CascadeType.ALL)
    @IndexedEmbedded
    private List<Item> getItems() {...}

    // ...
}

@Entity
public class Item {

    @Id
    @GeneratedValue
    private Long itemId;

    @Field
    public String getDescription() {...}

    @ManyToOne(cascade = { CascadeType.PERSIST, CascadeType.REMOVE })
    @ContainedIn
    public ProductCatalog getProductCatalog() {...}

    // ...
}
```

**4.7.8. Date/Calendar Bridge**

In order to define a calendar or date bridge mapping, call the `dateBridge(Resolution resolution)` or `calendarBridge(Resolution resolution)` methods after you have defined a `field()` in the `SearchMapping` hierarchy.
Example 75. Programmatic model for defining calendar/date bridge

SearchMapping mapping = new SearchMapping();

mapping
.entity(Address.class)
.indexed()
.property("addressId", ElementType.FIELD)
.documentId()
.property("street1", ElementType.FIELD())
.field()
.property("createdOn", ElementType.FIELD())
.field()
.dateBridge(Resolution.DAY)
.property("lastUpdated", ElementType.FIELD())
.calendarBridge(Resolution.DAY);

cfg.getProperties().put("hibernate.search.model_mapping", mapping);

See below for defining the above using @CalendarBridge and @DateBridge:

Example 76. @CalendarBridge and @DateBridge definition

@Entity
@Indexed
public class Address {

@Id
@GeneratedValue
@DocumentId
private Long addressId;

@Field
private String address1;

@Field
@DateBridge(resolution=Resolution.DAY)
private Date createdOn;

@CalendarBridge(resolution=Resolution.DAY)
private Calendar lastUpdated;

// ...
}

4.7.9. Declaring bridges

It is possible to associate bridges to programmatically defined fields. When you define a field() programmatically you can use the bridge(Class<?> impl) to associate a FieldBridge implementation class. The bridge method also provides optional methods to
include any parameters required for the bridge class. The below shows an example of programmatically defining a bridge:

Example 77. Declaring field bridges programmatically

```java
SearchMapping mapping = new SearchMapping();

mapping
    .entity(Address.class)
    .indexed()
    .property("addressId", ElementType.FIELD)
    .documentId()  
    .property("street1", ElementType.FIELD)
    .field()
    .field()
        .name("street1_abridged")
        .bridge( ConcatStringBridge.class )
        .param( "size", "4" );

cfg.getProperties().put("hibernate.search.model_mapping", mapping);
```

The above can equally be defined using annotations, as seen in the next example.

Example 78. Declaring field bridges using annotation

```java
@Entity
@Indexed
public class Address {

@Id
@GeneratedValue
@DocumentId(name="id")
private Long addressId;

@Field
@Field(name="street1_abridged",
        bridge = @FieldBridge( impl = ConcatStringBridge.class, 
                                params = @Parameter( name="size", value="4" )))
private String address1;

// ...
}
```

4.7.10. Mapping class bridge

You can define class bridges on entities programmatically. This is shown in the next example:
Example 79. Defining class bridges using API

```java
SearchMapping mapping = new SearchMapping();

mapping
    .entity(Departments.class)
    .classBridge(CatDeptsFieldsClassBridge.class)
        .name("branchnetwork")
        .index(Index.YES)
        .store(Store.YES)
        .param("sepChar", " ")
    .classBridge(EquipmentType.class)
        .name("equiptype")
        .index(Index.YES)
        .store(Store.YES)
        .param("C", "Cisco")
        .param("D", "D-Link")
        .param("K", "Kingston")
        .param("3", "3Com")
    .indexed();

cfg.getProperties().put("hibernate.search.model_mapping", mapping);
```

The above is similar to using @ClassBridge as seen in the next example:

Example 80. Using @ClassBridge

```java
@Entity
@Indexed
@ClassBridge(name="branchnetwork",
    store= Store.YES,
    impl = CatDeptsFieldsClassBridge.class,
    params = @Parameter( name="sepChar", value=" " ) ),
@ClassBridge(name="equiptype",
    store= Store.YES,
    impl = EquipmentType.class,
    params = @Parameter( name="C", value="Cisco" ),
    @Parameter( name="D", value="D-Link" ),
    @Parameter( name="K", value="Kingston" ),
    @Parameter( name="3", value="3Com" )
))
public class Departments {

    // ...
}
```

4.7.11. Mapping dynamic boost

You can apply a dynamic boost factor on either a field or a whole entity:
Example 81. `dynamicBoost` mapping using programmatic model

```java
SearchMapping mapping = new SearchMapping();
    .entity(DynamicBoostedDescLibrary.class)
    .indexed()
    .dynamicBoost(CustomBoostStrategy.class)
    .property("libraryId", ElementType.FIELD)
    .documentId().name("id")
    .property("name", ElementType.FIELD)
    .dynamicBoost(CustomFieldBoostStrategy.class);
    .field()
    .store(Store.YES)

cfg.getProperties().put("hibernate.search.model_mapping", mapping);
```

The next example shows the equivalent mapping using the `@DynamicBoost` annotation:

Example 82. Using the `@DynamicBoost` annotation

```java
@Entity
@Indexed
@DynamicBoost(impl = CustomBoostStrategy.class)
public class DynamicBoostedDescriptionLibrary {

    @Id
    @GeneratedValue
    @DocumentId
    private int id;

    private float dynScore;

    @Field(store = Store.YES)
    @DynamicBoost(impl = CustomFieldBoostStrategy.class)
    private String name;

    public DynamicBoostedDescriptionLibrary() {
        dynScore = 1.0f;
    }

    // ...
}
```
Chapter 5. Querying

The second most important capability of Hibernate Search is the ability to execute Lucene queries and retrieve entities managed by a Hibernate session. The search provides the power of Lucene without leaving the Hibernate paradigm, giving another dimension to the Hibernate classic search mechanisms (HQL, Criteria query, native SQL query).

Preparing and executing a query consists of four simple steps:

- Creating a `FullTextSession`
- Creating a Lucene query either via the Hibernate Search query DSL (recommended) or by utilizing the Lucene query API
- Wrapping the Lucene query using an `org.hibernate.Query`
- Executing the search by calling for example `list()` or `scroll()`

To access the querying facilities, you have to use a `FullTextSession`. This Search specific session wraps a regular `org.hibernate.Session` in order to provide query and indexing capabilities.

**Example 83. Creating a FullTextSession**

```java
Session session = sessionFactory.openSession();
//...
FullTextSession fullTextSession = Search.getFullTextSession(session);
```

Once you have a `FullTextSession` you have two options to build the full-text query: the Hibernate Search query DSL or the native Lucene query.

If you use the Hibernate Search query DSL, it will look like this:

```java
QueryBuilder b = fullTextSession.getSearchFactory().
.buildQueryBuilder().forEntity(Myth.class).get();
org.apache.lucene.search.Query luceneQuery =
  b.keyword().
  .onField("history").boostedTo(3)
  .matching("storm")
  .createQuery();

org.hibernate.Query fullTextQuery = fullTextSession.createFullTextQuery(luceneQuery);
List result = fullTextQuery.list(); //return a list of managed objects
```
You can alternatively write your Lucene query either using the Lucene query parser or Lucene programmatic API.

**Example 84. Creating a Lucene query via the QueryParser**

```java
SearchFactory searchFactory = fullTextSession.getSearchFactory();
org.apache.lucene.queryparser.classic.QueryParser parser =
    new QueryParser("title", searchFactory.getAnalyzer(Myth.class));
try {
    org.apache.lucene.search.Query luceneQuery = parser.parse("history:storm^3");
} catch (ParseException e) {
    //handle parsing failure
}
org.hibernate.Query fullTextQuery = fullTextSession.createFullTextQuery(luceneQuery);
List result = fullTextQuery.list(); //return a list of managed objects
```

The Hibernate query built on top of the Lucene query is a regular `org.hibernate.Query`, which means you are in the same paradigm as the other Hibernate query facilities (HQL, Native or Criteria). The regular `list()`, `uniqueResult()`, `iterate()` and `scroll()` methods can be used.

In case you are using the Java Persistence APIs of Hibernate, the same extensions exist:

**Example 85. Creating a Search query using the JPA API**

```java
EntityManager em = entityManagerFactory.createEntityManager();
FullTextEntityManager fullTextEntityManager =
    org.hibernate.search.jpa.Search.getFullTextEntityManager(em);
// ...
QueryBuilder b = fullTextEntityManager.getSearchFactory()
    .buildQueryBuilder().forEntity(Myth.class).get();
org.apache.lucene.search.Query luceneQuery = b.keyword()
    .onField("history").boostedTo(3)
    .matching("storm")
    .createQuery();
javax.persistence.Query fullTextQuery =
    fullTextEntityManager.createFullTextQuery( luceneQuery );
List result = fullTextQuery.getResultList(); //return a list of managed objects
```
The following examples we will use the Hibernate APIs but the same example can be easily rewritten with the Java Persistence API by just adjusting the way the FullTextQuery is retrieved.

### 5.1. Building queries

Hibernate Search queries are built on top of Lucene queries which gives you total freedom on the type of Lucene query you want to execute. However, once built, Hibernate Search wraps further query processing using org.hibernate.Query as your primary query manipulation API.

#### 5.1.1. Building a Lucene query using the Lucene API

Using the Lucene API, you have several options. You can use the query parser (fine for simple queries) or the Lucene programmatic API (for more complex use cases). It is out of the scope of this documentation on how to exactly build a Lucene query. Please refer to the online Lucene documentation or get hold of a copy of Lucene In Action or Hibernate Search in Action.

#### 5.1.2. Building a Lucene query with the Hibernate Search query DSL

Writing full-text queries with the Lucene programmatic API is quite complex. It's even more complex to understand the code once written. Besides the inherent API complexity, you have to remember to convert your parameters to their string equivalent as well as make sure to apply the correct analyzer to the right field (a ngram analyzer will for example use several ngrams as the tokens for a given word and should be searched as such).

The Hibernate Search query DSL makes use of a style of API called a fluent API. This API has a few key characteristics:

- it has meaningful method names making a succession of operations reads almost like English
- it limits the options offered to what makes sense in a given context (thanks to strong typing and IDE auto-completion).
- it often uses the chaining method pattern
- it’s easy to use and even easier to read

Let’s see how to use the API. You first need to create a query builder that is attached to a given indexed entity type. This QueryBuilder will know what analyzer to use and what field bridge to apply. You can create several `QueryBuilder` instances (one for each entity type involved in the root of your query). You get the `QueryBulder` from the `SearchFactory`.
You can also override the analyzer used for a given field or fields. This is rarely needed and should be avoided unless you know what you are doing.

Using the query builder, you can then build queries. It is important to realize that the end result of a QueryBuilder is a Lucene query. For this reason you can easily mix and match queries generated via Lucene's query parser or Query objects you have assembled with the Lucene programmatic API and use them with the Hibernate Search DSL. Just in case the DSL is missing some features.

**Keyword queries**

Let's start with the most basic use case - searching for a specific word:

```
Query luceneQuery = mythQB.keyword().onField("history").matching("storm").createQuery();
```

`keyword()` means that you are trying to find a specific word. `onField()` specifies in which Lucene field to look. `matching()` tells what to look for. And finally `createQuery()` creates the Lucene query object. A lot is going on with this line of code.

- The value `storm` is passed through the `history` FieldBridge: it does not matter here but you will see that it's quite handy when dealing with numbers or dates.
- The field bridge value is then passed to the analyzer used to index the field `history`. This ensures that the query uses the same term transformation than the indexing (lower case, n-gram, stemming and so on). If the analyzing process generates several terms for a given word, a boolean query is used with the `SHOULD` logic (roughly an `OR` logic).

We make the example a little more advanced now and have a look at how to search a field that uses ngram analyzers. ngram analyzers index succession of ngrams of your words which helps to recover from user typos. For example the 3-grams of the word hibernate are hib, ibe, ber, rna, nat, ate.
@AnalyzerDef(name = "ngram",
tokenizer = @TokenizerDef(factory = StandardTokenizerFactory.class),
filters = {
    @TokenFilterDef(factory = StandardFilterFactory.class),
    @TokenFilterDef(factory = LowerCaseFilterFactory.class),
    @TokenFilterDef(factory = StopFilterFactory.class),
    @TokenFilterDef(factory = NGramFilterFactory.class,
        params = {
            @Parameter(name = "minGramSize", value = "3"),
            @Parameter(name = "maxGramSize", value = "3")
        })
})
@Entity
@Indexed
public class Myth {
    @Field(analyzer=@Analyzer(definition="ngram")
    public String getName() { return name; }
    public String setName(String name) { this.name = name; }
    private String name;
    ...
}
Query luceneQuery = mythQb.keyword().onField("name").matching("Sisiphus")
    .createQuery();

The matching word "Sisiphus" will be lower-cased and then split into 3-grams: sis, isi, sip, phu, hus. Each of these n-gram will be part of the query. We will then be able to find the Sysiphus myth (with a y). All that is transparently done for you.

If for some reason you do not want a specific field to use the field bridge or the analyzer you can call the ignoreAnalyzer() or ignoreFieldBridge() functions.

To search for multiple possible words in the same field, simply add them all in the matching clause.

//search document with storm or lightning in their history
Query luceneQuery =
    mythQb.keyword().onField("history").matching("storm lightning")
    .createQuery();

To search the same word on multiple fields, use the onFields method.
Sometimes, one field should be treated differently from another field even if searching the same term, you can use the andField() method for that.

In the previous example, only field name is boosted to 5.

**Fuzzy queries**

To execute a fuzzy query (based on the Levenshtein distance algorithm), start like a keyword query and add the fuzzy flag.

Threshold is the limit above which two terms are considering matching. It’s a decimal between 0 and 1 and defaults to 0.5. prefixLength is the length of the prefix ignored by the "fuzzyness": while it defaults to 0, a non zero value is recommended for indexes containing a huge amount of distinct terms.

**Wildcard queries**

You can also execute wildcard queries (queries where some of parts of the word are unknown). The character ? represents a single character and * represents any character sequence. Note
that for performance purposes, it is recommended that the query does not start with either `?` or `*`.

```java
Query luceneQuery = mythQB
    .keyword()
    .wildcard(
    .onField("history")
    .matching("sto*")
    .createQuery();
```

Wildcard queries do not apply the analyzer on the matching terms. Otherwise the risk of `*` or `?` being mangled is too high.

**Phrase queries**

So far we have been looking for words or sets of words, you can also search exact or approximate sentences. Use `phrase()` to do so.

```java
Query luceneQuery = mythQB
    .phrase()
    .onField("history")
    .sentence("Thou shalt not kill")
    .createQuery();
```

You can search approximate sentences by adding a slop factor. The slop factor represents the number of other words permitted in the sentence: this works like a within or near operator

```java
Query luceneQuery = mythQB
    .phrase()
    .withSlop(3)
    .onField("history")
    .sentence("Thou kill")
    .createQuery();
```

**Range queries**

After looking at all these query examples for searching for to a given word, it is time to introduce range queries (on numbers, dates, strings etc). A range query searches for a value in between given boundaries (included or not) or for a value below or above a given boundary (included or not).
Spatial (or geolocation) queries

This set of queries has its own chapter, check out Spatial.

More Like This queries

Have you ever looked at an article or document and thought: "I want to find more like this"? Have you ever appreciated an e-commerce website that gives you similar articles to the one you are exploring?

More Like This queries are achieving just that. You feed it an entity (or its identifier) and Hibernate Search returns the list of entities that are similar.

How does it work?

For each (selected) field of the targeted entity, we look at the most meaningful terms. Then we create a query matching the most meaningful terms per field. This is a slight variation compared to the original Lucene MoreLikeThisQuery implementation.

The query DSL API should be self explaining. Let's look at some usage examples.
QueryBuilder qb = fullTextSession.buildQueryBuilder().forEntity(Coffee.class).build();

Query mltQuery = qb
   .moreLikeThis()
   .comparingAllFields()
   .toEntityWithId(coffeeId)
   .createQuery();

List<Object[]> results = (List<Object[]>) fullTextSession
   .createFullTextQuery(mltQuery, Coffee.class)
   .setProjection(ProjectionConstants.THIS, ProjectionConstants.SCORE)
   .list();

This first example takes the id of an Coffee entity and finds the matching coffees across all fields. To be fair, this is not across all fields. To be included in the More Like This query, fields need to store term vectors or the actual field value. Id fields (of the root entity as well as embedded entities) and numeric fields are excluded. The latter exclusion might change in future versions.

Looking at the Coffee class, the following fields are considered: name as it is stored, description as it stores the term vector. id and internalDescription are excluded.

@Entity @Indexed
public class Coffee {

@Id @GeneratedValue
public Integer getId() { return id; }

@Field(termVector = TermVector.NO, store = Store.YES)
public String getName() { return name; }

@Field(termVector = TermVector.YES)
public String getSummary() { return summary; }

@Column(length = 2000)
@Field(termVector = TermVector.YES)
public String getDescription() { return description; }

public int getIntensity() { return intensity; }

// Not stored nor term vector, i.e. cannot be used for More Like This
@Field
public String getInternalDescription() { return internalDescription;
}

// ...
}
In the example above we used projection to retrieve the relative score of each element. We might use the score to only display the results for which the score is high enough.

💡 For best performance and best results, store the term vectors for the fields you want to include in a More Like This query.

Often, you are only interested in a few key fields to find similar entities. Plus some fields are more important than others and should be boosted.

```java
Query mltQuery = qb
    .moreLikeThis()
    .comparingField("summary").boostedTo(10f)
    .andField("description")
    .toEntityWithId(coffeeId)
    .createQuery();
```

In this example, we look for similar entities by summary and description. But similar summaries are more important than similar descriptions. This is a critical tool to make More Like This meaningful for your data set.

Instead of providing the entity id, you can pass the full entity object. If the entity contains the identifier, we will use it to find the term vectors or field values. This means that we will compare the entity state as stored in the Lucene index. If the identifier cannot be retrieved (for example if the entity has not been persisted yet), we will look at each of the entity properties to find the most meaningful terms. The latter is slower and won't give the best results - avoid it if possible.

Here is how you pass the entity instance you want to compare with:

```java
Coffee coffee = ...; //managed entity from somewhere
Query mltQuery = qb
    .moreLikeThis()
    .comparingField("summary").boostedTo(10f)
    .andField("description")
    .toEntity(coffee)
    .createQuery();
```

By default, the results contain at the top the entity you are comparing with. This is particularly useful to compare relative scores. If you don't need it, you can exclude it.
You can ask Hibernate Search to give a higher score to the very similar entities and downgrade the score of mildly similar entities. We do that by boosting each meaningful terms by their individual overall score. Start with a boost factor of 1 and adjust from there.

Remember, more like this is a very subjective meaning and will vary depending on your data and the rules of your domain. With the various options offered, Hibernate Search arms you with the tools to adjust this weapon. Make sure to continuously test the results against your data set.

**Combining queries**

You can combine queries to create more complex queries. The following aggregation operators are available:

- **SHOULD**: the query should contain the matching elements of the subquery
- **MUST**: the query must contain the matching elements of the subquery
- **MUST NOT**: the query must not contain the matching elements of the subquery

These aggregations have a similar effect as the classic boolean operators AND, OR and NOT, but have different names to emphasise that they will have an impact on scoring.

For example the **SHOULD** operator between two queries will have an effect similar to the boolean **OR**: if either of the two combined queries matches the entry, the entry will be included in the match; though the entries which match both queries will have an higher score than those which only match one of them.

The sub-queries can be any Lucene query including a boolean query itself.
Example 86. Structure of a boolean **AND** query: the **must** method.

```java
Query combinedQuery = querybuilder
    .bool()
    .must(queryA)
    .must(queryB)
    .createQuery();
```

Example 87. Structure of boolean **OR** query: the **should** method.

```java
Query combinedQuery = querybuilder
    .bool()
    .should(queryA)
    .should(queryB)
    .createQuery();
```

Example 88. Structure of a negation query: apply a **not** modifier to a **must**.

```java
Query combinedQuery = querybuilder
    .bool()
    .must(queryA)
    .must(queryB).not()
    .createQuery();
```

Let’s look at a few more practical examples; note how the querybuilder usage can be nested and how 'should', 'must', and 'not' can be combined in many ways:
Example 89. Full example of combining fulltext queries

```java
//look for popular modern myths that are not urban
Date twentiethCentury = ...;
Query luceneQuery = mythQB
    .bool()
    .must( mythQB.keyword().onField("description").matching("urban")
    .createQuery() )
    .not()
    .must( mythQB.range().onField("starred").above(4).createQuery() )
    .must( mythQB
    .range()
    .onField("creationDate")
    .above(twentiethCentury)
    .createQuery() )
    .createQuery();

//look for popular myths that are preferably urban
Query luceneQuery = mythQB
    .bool()
    .should( mythQB.keyword().onField("description").matching("urban")
    .createQuery() )
    .must( mythQB.range().onField("starred").above(4).createQuery() )
    .createQuery();

//look for all myths except religious ones
Query luceneQuery = mythQB
    .all()
    .except( monthQb
    .keyword()
    .onField("description_stem")
    .matching("religion")
    .createQuery()
    )
    .createQuery();
```

Query options

We already have seen several query options in the previous example, but let's summarize again the options for query types and fields:

- **boostedTo** (on query type and on field): boost the whole query or the specific field to a given factor
- **withConstantScore** (on query): all results matching the query have a constant score equals to the boost
- **filteredBy(Filter)** (on query): filter query results using the Filter instance
- **ignoreAnalyzer** (on field): ignore the analyzer when processing this field
- **ignoreFieldBridge** (on field): ignore field bridge when processing this field
Let's check out an example using some of these options

```java
Query luceneQuery = mythQB
    .bool()
    .should( mythQB.keyword().onField("description").matching("urban")
    .createQuery() )
    .should( mythQB
      .keyword()
      .onField("name")
      .boostedTo(3)
      .ignoreAnalyzer()
      .matching("urban").createQuery() )
    .must( mythQB
      .range()
      .boostedTo(5).withConstantScore()
      .onField("starred").above(4).createQuery() )
    .createQuery();
```

As you can see, the Hibernate Search query DSL is an easy to use and easy to read query API and by accepting and producing Lucene queries, you can easily incorporate query types not (yet) supported by the DSL. Please give us feedback!

### 5.1.3. Building a Hibernate Search query

So far we only covered the process of how to create your Lucene query (see Building queries). However, this is only the first step in the chain of actions. Let's now see how to build the Hibernate Search query from the Lucene query.

**Generality**

Once the Lucene query is built, it needs to be wrapped into an Hibernate Query. If not specified otherwise, the query will be executed against all indexed entities, potentially returning all types of indexed classes.

**Example 90. Wrapping a Lucene query into a Hibernate Query**

```java
FullTextSession fullTextSession = Search.getFullTextSession( session );
org.hibernate.Query fullTextQuery = fullTextSession.createFullTextQuery( luceneQuery );
```

It is advised, from a performance point of view, to restrict the returned types:
Example 91. Filtering the search result by entity type

```java
fullTextQuery = fullTextSession
    .createFullTextQuery(luceneQuery, Customer.class);

// or
fullTextQuery = fullTextSession
    .createFullTextQuery(luceneQuery, Item.class, Actor.class);
```

In Filtering the search result by entity type the first example returns only matching Customer instances, the second returns matching Actor and Item instances. The type restriction is fully polymorphic which means that if there are two indexed subclasses Salesman and Customer of the baseclass Person, it is possible to just specify Person.class in order to filter on result types.

Pagination

Out of performance reasons it is recommended to restrict the number of returned objects per query. In fact is a very common use case anyway that the user navigates from one page to another. The way to define pagination is exactly the way you would define pagination in a plain HQL or Criteria query.

Example 92. Defining pagination for a search query

```java
org.hibernate.Query fullTextQuery =
    fullTextSession.createFullTextQuery(luceneQuery, Customer.class);
fullTextQuery.setFirstResult(15); //start from the 15th element
fullTextQuery.setMaxResults(10); //return 10 elements
```

It is still possible to get the total number of matching elements regardless of the pagination via fulltextQuery.getResultSize()

Sorting

Apache Lucene provides a very flexible and powerful way to sort results. While the default sorting (by relevance) is appropriate most of the time, it can be interesting to sort by one or several other properties.

In order to do so, you will have to build a Lucene Sort object, which can be done by using either the Hibernate Search sort DSL or the native Lucene SortField class.

If you use the Hibernate Search sort DSL, it will look like this:
Example 93. Sorting the results with a DSL-built Lucene Sort

```java
QueryBuilder builder = fullTextSession.getSearchFactory()
    .buildQueryBuilder().forEntity(Book.class).get();
Query luceneQuery = /* ... */;
FullTextQuery query = s.createFullTextQuery(luceneQuery, Book.class);
Sort sort = builder
    .sort()
    .byField("author").desc() // Descending order
    .andByField("title") // Default order (ascending)
    .createSort();
query.setSort(sort);
List results = query.list();
```

If you use the Sort DSL (like in the example above) to target fields indexed through custom FieldBridges, then those field bridges must implement `MetadataProvidingFieldBridge`, so as to define the type of those fields and to mention that they are sortable.

Alternatively, you may build your sort using the Lucene `SortField` class directly. Then you will have to always specify the sort field type manually.

Example 94. Sorting the results with a custom-built Lucene Sort

```java
FullTextQuery query = s.createFullTextQuery(luceneQuery, Book.class);
org.apache.lucene.search.Sort sort = new Sort(
    new SortField("author", SortField.Type.STRING),
    new SortField("title", SortField.Type.STRING));
query.setSort(sort);
List results = query.list();
```

Be aware that fields used for sorting must not be tokenized (see `@Field`). Also they should be marked as sortable field using the `@SortableField` annotation (see `@SortableField`).

Handling missing values

By default, Hibernate Search will expect every document to contain exactly one value for the given sort fields. If it's not the case, you may decide whether documents with missing values will end up in first or last position in the result list:
Example 95. Returning documents with missing values in first position when sorting

```java
QueryBuilder builder = fullTextSession.getSearchFactory()
    .buildQueryBuilder().forEntity(Book.class).get();
Query luceneQuery = /* ... */;
FullTextQuery query = s.createFullTextQuery( luceneQuery, Book.class );
Sort sort = builder
    .sort()
    .byField("author")
    .onMissingValue().sortFirst()
    .andByField("title")
    .createSort();
query.setSort(sort);
List results = query.list();
```

For numeric fields (and only numeric fields), you may even provide a default value to be used in case it's missing:

Example 96. Using a default value on a sort field

```java
QueryBuilder builder = fullTextSession.getSearchFactory()
    .buildQueryBuilder().forEntity(Book.class).get();
Query luceneQuery = /* ... */;
FullTextQuery query = s.createFullTextQuery( luceneQuery, Book.class );
Sort sort = builder
    .sort()
    .byField("authorId")
    .onMissingValue().use(42L) // Assume the ID is 42 when it's missing
    .andByField("title")
    .createSort();
query.setSort(sort);
List results = query.list();
```

⚠️ The `use(Object)` method expects a value matching the actual type of the field. Field bridges, if any, are not applied. Thus, in the example above, providing an `Author` instead of the identifier directly would not work.

Using native sorts within the sort DSL

If you happen to find a sorting feature that is supported by Lucene, but not yet implemented in Hibernate Search sort DSL. If so, you may still use the DSL to mix a native `SortField` with DSL-defined sorts:
Example 97. Mixing DSL-defined sorts with native Lucene SortFields

```java
QueryBuilder builder = fullTextSession.getSearchFactory()
    .buildQueryBuilder().forEntity(Book.class).get();
Query luceneQuery = /* ... */;
FullTextQuery query = s.createFullTextQuery(luceneQuery, Book.class);
SortField complexSortField = /* ... */;
Sort sort = builder
    .sort()
    .byField("author")
    .andByNative(complexSortField)
    .createSort();
query.setSort(sort);
List results = query.list();
```

Fetching strategy

When you restrict the return types to one class, Hibernate Search loads the objects using a single query. It also respects the static fetching strategy defined in your domain model.

It is often useful, however, to refine the fetching strategy for a specific use case.

Example 98. Specifying FetchMode on a query

```java
Criteria criteria =
    s.createCriteria(Book.class).setFetchMode("authors", FetchMode.JOIN);
s.createFullTextQuery(luceneQuery).setCriteriaQuery(criteria);
```

In this example, the query will return all Books matching the luceneQuery. The authors collection will be loaded from the same query using an SQL outer join.

When defining a criteria query, it is not necessary to restrict the returned entity types when creating the Hibernate Search query from the full text session: the type is guessed from the criteria query itself.

⚠️ Only fetch mode can be adjusted, refrain from applying any other restriction.

⚠️ While it is known to work as of Hibernate Search 4, using restriction (ie a where clause) on your Criteria query should be avoided when possible. `getResultSize()` will throw a `SearchException` if used in conjunction with a Criteria with restriction.

⚠️ You cannot use setCriteriaQuery if more than one entity type is expected to be returned.
Projection

For some use cases, returning the domain object (including its associations) is overkill. Only a small subset of the properties is necessary. Hibernate Search allows you to return a subset of properties:

Example 99. Using projection instead of returning the full domain object

```java
org.hibernate.search.FullTextQuery query =
    s.createFullTextQuery(luceneQuery, Book.class);
query.setProjection("id", "summary", "body", "mainAuthor.name");
List results = query.list();
Object[] firstResult = (Object[]) results.get(0);
Integer id = firstResult[0];
String summary = firstResult[1];
String body = firstResult[2];
String authorName = firstResult[3];
```

Hibernate Search extracts the properties from the Lucene index and convert them back to their object representation, returning a list of `Object[]`. Projections avoid a potential database round trip (useful if the query response time is critical). However, it also has several constraints:

- the properties projected must be stored in the index (`@Field(store=Store.YES)`), which increases the index size
- the properties projected must use a `FieldBridge` implementing `org.hibernate.search.bridge.TwoWayFieldBridge` or `org.hibernate.search.bridge.TwoWayStringBridge`, the latter being the simpler version.

> All Hibernate Search built-in types are two-way.

- you can only project simple properties of the indexed entity or its embedded associations. This means you cannot project a whole embedded entity.
- projection does not work on collections or maps which are indexed via `@IndexedEmbedded`

Projection is also useful for another kind of use case. Lucene can provide metadata information about the results. By using some special projection constants, the projection mechanism can retrieve this metadata:
Example 100. Using projection in order to retrieve meta data

```java
org.hibernate.search.FullTextQuery query = 
    s.createFullTextQuery(luceneQuery, Book.class);
query.setProjection(
    FullTextQuery.SCORE,
    FullTextQuery.THIS,
    "mainAuthor.name" );
List results = query.list();
Object[] firstResult = (Object[]) results.get(0);
float score = firstResult[0];
Book book = firstResult[1];
String authorName = firstResult[2];
```

You can mix and match regular fields and projection constants. Here is the list of the available constants:

- **FullTextQuery.THIS**: returns the initialized and managed entity (as a non projected query would have done).
- **FullTextQuery.DOCUMENT**: returns the Lucene Document related to the object projected.
- **FullTextQuery.OBJECT_CLASS**: returns the class of the indexed entity.
- **FullTextQuery.SCORE**: returns the document score in the query. Scores are handy to compare one result against an other for a given query but are useless when comparing the result of different queries.
- **FullTextQuery.ID**: the id property value of the projected object.
- **FullTextQuery.DOCUMENT_ID**: the Lucene document id. Careful, Lucene document id can change overtime between two different IndexReader opening.
- **FullTextQuery.EXPLANATION**: returns the Lucene Explanation object for the matching object/document in the given query. Do not use if you retrieve a lot of data. Running explanation typically is as costly as running the whole Lucene query per matching element. Make sure you use projection!

**Customizing object initialization strategies**

By default, Hibernate Search uses the most appropriate strategy to initialize entities matching your full text query. It executes one (or several) queries to retrieve the required entities. This is the best approach to minimize database round trips in a scenario where none / few of the retrieved entities are present in the persistence context (ie the session) or the second level cache.

If most of your entities are present in the second level cache, you can force Hibernate Search to look into the cache before retrieving an object from the database.
Example 101. Check the second-level cache before using a query

```java
FullTextQuery query = session.createFullTextQuery(luceneQuery, User.class);
query.initializeObjectWith(
    ObjectLookupMethod.SECOND_LEVEL_CACHE,
    DatabaseRetrieveMethod.QUERY
);
```

**ObjectLookupMethod** defines the strategy used to check if an object is easily accessible (without database round trip). Other options are:

- **ObjectLookupMethod.PERSISTENCE_CONTEXT**: useful if most of the matching entities are already in the persistence context (ie loaded in the Session or EntityManager)
- **ObjectLookupMethod.SECOND_LEVEL_CACHE**: check first the persistence context and then the second-level cache.

Note that to search in the second-level cache, several settings must be in place:

- the second level cache must be properly configured and active
- the entity must have enabled second-level cache (eg via `@Cacheable`)
- the Session, EntityManager or Query must allow access to the second-level cache for read access (ie CacheMode.NORMAL in Hibernate native APIs or CacheRetrieveMode.USE in JPA 2 APIs).

Avoid using **ObjectLookupMethod.SECOND_LEVEL_CACHE** unless your second level cache implementation is either EHCache or Infinispan; other second level cache providers don’t currently implement this operation efficiently.

You can also customize how objects are loaded from the database (if not found before). Use **DatabaseRetrieveMethod** for that:

- **QUERY** (default): use a (set of) queries to load several objects in batch. This is usually the best approach.
- **FIND_BY_ID**: load objects one by one using the Session.get or EntityManager.find semantic. This might be useful if batch-size is set on the entity (in which case, entities will be loaded in batch by Hibernate Core). QUERY should be preferred almost all the time.

The defaults for both methods, the object lookup as well as the database retrieval can also be configured via configuration properties. This way you don’t have to specify your preferred
methods on each query creation. The property names are
hibernate.search.query.object_lookup_method and
hibernate.search.query.database_retrieval_method respectively. As value use the
name of the method (upper- or lowercase). For example:

Example 102. Setting object lookup and database retrieval methods via configuration properties

```properties
hibernate.search.query.object_lookup_method = second_level_cache
hibernate.search.query.database_retrieval_method = query
```

Limiting the time of a query

You can limit the time a query takes in Hibernate Search in two ways:

- raise an exception when the limit is reached
- limit to the number of results retrieved when the time limit is raised

Raise an exception on time limit

You can decide to stop a query if when it takes more than a predefined amount of time. Note
that this is a best effort basis but if Hibernate Search still has significant work to do and if we are
beyond the time limit, a QueryTimeoutException will be raised
(org.hibernate.QueryTimeoutException or javax.persistence.QueryTimeoutException depending
on your programmatic API).

To define the limit when using the native Hibernate APIs, use one of the following approaches

Example 103. Defining a timeout in query execution

```java
Query luceneQuery = ...;
FullTextQuery query = fullTextSession.createFullTextQuery(luceneQuery, User.class);

//define the timeout in seconds
query.setTimeout(5);

//alternatively, define the timeout in any given time unit
query.setTimeout(450, TimeUnit.MILLISECONDS);

try {
    query.list();
} catch (org.hibernate.QueryTimeoutException e) {
    //do something, too slow
}
```
Likewise `getResultSetSize()`, `iterate()` and `scroll()` honor the timeout but only until the end of the method call. That simply means that the methods of `Iterable` or the `ScrollableResults` ignore the timeout.

`explain()` does not honor the timeout: this method is used for debug purposes and in particular to find out why a query is slow.

When using JPA, simply use the standard way of limiting query execution time.

**Example 104. Defining a timeout in query execution**

```java
Query luceneQuery = ...;
FullTextQuery query = fullTextEM.createFullTextQuery(luceneQuery, User.class);

//define the timeout in milliseconds
query.setHint("javax.persistence.query.timeout", 450);

try {
    query.getResultList();
} catch (javax.persistence.QueryTimeoutException e) {
    //do something, too slow
}
```

Remember, this is a best effort approach and does not guarantee to stop exactly on the specified timeout.

Limit the number of results when the time limit is reached

Alternatively, you can return the number of results which have already been fetched by the time the limit is reached. Note that only the Lucene part of the query is influenced by this limit. It is possible that, if you retrieve managed object, it takes longer to fetch these objects.

This approach is not compatible with the setTimeout approach.

To define this soft limit, use the following approach
Example 105. Defining a time limit in query execution

```java
Query luceneQuery = ...;
FullTextQuery query = fullTextSession.createFullTextQuery(luceneQuery, User.class);

//define the timeout in seconds
query.limitExecutionTimeTo(500, TimeUnit.MILLISECONDS);
List results = query.list();
```

Likewise `getResultSize()`, `iterate()` and `scroll()` honor the time limit but only until the end of the method call. That simply means that the methods of `Iterable` or the `ScrollableResults` ignore the timeout.

You can determine if the results have been partially loaded by invoking the `hasPartialResults` method.

Example 106. Determines when a query returns partial results

```java
Query luceneQuery = ...;
FullTextQuery query = fullTextSession.createFullTextQuery(luceneQuery, User.class);

//define the timeout in seconds
query.limitExecutionTimeTo(500, TimeUnit.MILLISECONDS);
List results = query.list();

if (query.hasPartialResults()) {
    displayWarningToUser();
}
```

If you use the JPA API, `limitExecutionTimeTo` and `hasPartialResults` are also available to you.

### 5.2. Retrieving the results

Once the Hibernate Search query is built, executing it is in no way different than executing a HQL or Criteria query. The same paradigm and object semantic applies. All the common operations are available: `list()`, `uniqueResult()`, `iterate()`, `scroll()`.

#### 5.2.1. Performance considerations

If you expect a reasonable number of results (for example using pagination) and expect to work on all of them, `list()` or `uniqueResult()` are recommended. `list()` work best if the entity `batch-size` is set up properly. Note that Hibernate Search has to process all Lucene Hits elements (within the pagination) when using `list()`, `uniqueResult()` and `iterate()`.
If you wish to minimize Lucene document loading, `scroll()` is more appropriate. Don’t forget to close the `ScrollableResults` object when you’re done, since it keeps Lucene resources. If you expect to use scroll, but wish to load objects in batch, you can use `query.setFetchSize()`. When an object is accessed, and if not already loaded, Hibernate Search will load the next `fetchSize` objects in one pass.

- Pagination is preferred over scrolling.

### 5.2.2. Result size

It is sometimes useful to know the total number of matching documents:

- for the Google-like feature "1-10 of about 888,000,000"
- to implement a fast pagination navigation
- to implement a multi step search engine (adding approximation if the restricted query return no or not enough results)

Of course it would be too costly to retrieve all the matching documents. Hibernate Search allows you to retrieve the total number of matching documents regardless of the pagination parameters. Even more interesting, you can retrieve the number of matching elements without triggering a single object load.

**Example 107. Determining the result size of a query**

```java
gconf hibernate.search.FullTextQuery query = s.createFullTextQuery(luceneQuery, Book.class);
//return the number of matching books without loading a single one
assert 3245 == query.getResultSize();

gconf hibernate.search.FullTextQuery query = s.createFullTextQuery(luceneQuery, Book.class);
query.setMaxResult(10);
List results = query.list();
//return the total number of matching books regardless of pagination
assert 3245 == query.getResultSize();
```

Like Google, the number of results is an approximation if the index is not fully up-to-date with the database (asynchronous cluster for example).

### 5.2.3. ResultTransformer

As seen in `Projection` projection results are returns as Object arrays. This data structure is not always matching the application needs. In this cases it is possible to apply a ResultTransformer which post query execution can build the needed data structure:
Example 108. Using ResultTransformer in conjunction with projections

```java
org.hibernate.search.FullTextQuery query =
    s.createFullTextQuery(luceneQuery, Book.class);
query.setProjection("title", "mainAuthor.name");

query.setResultTransformer(  
    new StaticAliasToBeanResultTransformer(  
        BookView.class,
        "title",
        "author"
    )
);
List<BookView> results = (List<BookView>) query.list();
for (BookView view : results) {
    log.info("Book: " + view.getTitle() + ", " + view.getAuthor());
}
```

Examples of ResultTransformer implementations can be found in the Hibernate Core codebase.

5.2.4. Understanding results

You will find yourself sometimes puzzled by a result showing up in a query or a result not showing up in a query. Luke is a great tool to understand those mysteries. However, Hibernate Search also gives you access to the Lucene Explanation object for a given result (in a given query). This class is considered fairly advanced to Lucene users but can provide a good understanding of the scoring of an object. You have two ways to access the Explanation object for a given result:

- Use the `fullTextQuery.explain(int)` method
- Use projection

The first approach takes a document id as a parameter and return the Explanation object. The document id can be retrieved using projection and the `FullTextQuery.DOCTYPE_ID` constant.

⚠️ The Document id has nothing to do with the entity id. Do not mess up these two notions.

In the second approach you project the Explanation object using the `FullTextQuery.EXPLANATION` constant.
Example 109. Retrieving the Lucene Explanation object using projection

```java
FullTextQuery ftQuery = s.createFullTextQuery( luceneQuery, Dvd.class )
    .setProjection(  
        FullTextQuery.DOCUMENT_ID,  
        FullTextQuery.EXPLANATION,  
        FullTextQuery.THIS );
@SuppressWarnings("unchecked") List<Object[]> results = ftQuery.list();
for (Object[] result : results) {
    Explanation e = (Explanation) result[1];
    display( e.toString() );
}
```

Be careful, building the explanation object is quite expensive, it is roughly as expensive as running the Lucene query again. Don’t do it if you don’t need the object

### 5.3. Filters

Apache Lucene has a powerful feature that allows to filter query results according to a custom filtering process. This is a very powerful way to apply additional data restrictions, especially since filters can be cached and reused. Some interesting use cases are:

- security
- temporal data (eg. view only last month’s data)
- population filter (eg. search limited to a given category)
- and many more

Hibernate Search pushes the concept further by introducing the notion of parameterizable named filters which are transparently cached. For people familiar with the notion of Hibernate Core filters, the API is very similar:

Example 110. Enabling fulltext filters for a given query

```java
fullTextQuery = s.createFullTextQuery(query, Driver.class);  
fullTextQuery.enableFullTextFilter("bestDriver");
fullTextQuery.enableFullTextFilter("security").setParameter("login", "andre");
fullTextQuery.list(); //returns only best drivers where andre has credentials
```

In this example we enabled two filters on top of the query. You can enable (or disable) as many filters as you like.
Declaring filters is done through the @FullTextFilterDef annotation. You can use one or more @FullTextFilterDef on any: * @Indexed entity regardless of the query the filter is later applied to * Parent class of an @Indexed entity * package-info.java of a package containing an @Indexed entity

This implies that filter definitions are global and their names must be unique. A SearchException is thrown in case two different @FullTextFilterDef annotations with the same name are defined. Each named filter has to specify its actual filter implementation.

Example 111. Defining and implementing a Filter

```java
@Entity
@Indexed
@FullTextFilterDef(name = "bestDriver", impl = BestDriversFilter.class),
@FullTextFilterDef(name = "security", impl = SecurityFilterFactory.class)
public class Driver {
    ...
}

public class BestDriversFilter extends QueryWrapperFilter {
    public BestDriversFilter() {
        super(new TermQuery(new Term("score", "5")));
    }
}
```

BestDriversFilter is an example of a simple Lucene filter which reduces the result set to drivers whose score is 5. In this example we use org.apache.lucene.search.QueryWrapperFilter, which extends org.apache.lucene.search.Filter, as it’s a convenient way to wrap a Lucene Query.

Make sure the Filter has a public constructor which does not require any parameter.

If your Filter creation requires additional steps or if the filter you want to use does not have a no-arg constructor, you can use the factory pattern:
Example 112. Creating a filter using the factory pattern

```java
@Entity
@Indexed
@FullTextFilterDef(name = "bestDriver", impl = BestDriversFilterFactory.class)
public class Driver { ... }

public class BestDriversFilterFactory {
    @Factory
    public Filter getFilter() {
        //some additional steps to cache the filter results per
        IndexReader
        Filter bestDriversFilter = new BestDriversFilter();
        return new CachingWrapperFilter(bestDriversFilter);
    }
}
```

Hibernate Search will look for a `@Factory` annotated method and use it to build the filter instance. The factory must have a no-arg constructor.

Named filters come in handy where parameters have to be passed to the filter. For example a security filter might want to know which security level you want to apply:

Example 113. Passing parameters to a defined filter

```java
fullTextQuery = s.createFullTextQuery(query, Driver.class);
fullTextQuery.enableFullTextFilter("security").setParameter("level", 5);
```

Each parameter must have an associated setter on either the filter or filter factory of the targeted named filter definition.
Example 114. Using parameters in the actual filter implementation

```java
public class SecurityFilterFactory {
    private Integer level;

    /**
     * injected parameter
     */
    public void setLevel(Integer level) {
        this.level = level;
    }

    @Factory
    public Filter getFilter() {
        Query query = new TermQuery(new Term("level", level.toString()));
        return new CachingWrapperFilter(new QueryWrapperFilter(query));
    }
}
```

Filters will be cached once created, based on all their parameter names and values. Caching happens using a combination of hard and soft references to allow disposal of memory when needed. The hard reference cache keeps track of the most recently used filters and transforms the ones least used to SoftReferences when needed. Once the limit of the hard reference cache is reached additional filters are cached as SoftReferences. To adjust the size of the hard reference cache, use `hibernate.search.filter.cache_strategy.size` (defaults to 128). For advanced use of filter caching, you can implement your own FilterCachingStrategy. The classname is defined by `hibernate.search.filter.cache_strategy`.

This filter caching mechanism should not be confused with caching the actual filter results. In Lucene it is common practice to wrap filters using the IndexReader around a `CachingWrapperFilter`. The wrapper will cache the DocIdSet returned from the `getDocIdSet(IndexReader reader)` method to avoid expensive recomputation. It is important to mention that the computed DocIdSet is only cachable for the same IndexReader instance, because the reader effectively represents the state of the index at the moment it was opened. The document list cannot change within an opened IndexReader. A different/new IndexReader instance, however, works potentially on a different set of Documents (either from a different index or simply because the index has changed), hence the cached DocIdSet has to be recomputed.

Hibernate Search also helps with this aspect of caching. Per default the cache flag of `@FullTextFilterDef` is set to `FilterCacheModeType.INSTANCE_AND_DOCIDSETRESULTS` which will automatically cache the filter instance as well as wrap the specified filter around a Hibernate specific implementation of `CachingWrapperFilter`. In contrast to Lucene's version of this class `SoftReferences` are used together with a hard reference count (see discussion about filter cache). The hard reference count can be adjusted using `hibernate.search.filter.cache_docidresults.size` (defaults to 5). The wrapping
behavior can be controlled using the `@FullTextFilterDef.cache` parameter. There are three different values for this parameter:

<table>
<thead>
<tr>
<th>Value</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>FilterCacheModeType.NONE</td>
<td>No filter instance and no result is cached by Hibernate Search. For every filter call, a new filter instance is created. This setting might be useful for rapidly changing data sets or heavily memory constrained environments.</td>
</tr>
<tr>
<td>FilterCacheModeType.INSTANCE_ONLY</td>
<td>The filter instance is cached and reused across concurrent Filter.getDocIdSet() calls. DocIdSet results are not cached. This setting is useful when a filter uses its own specific caching mechanism or the filter results change dynamically due to application specific events making DocIdSet caching in both cases unnecessary.</td>
</tr>
<tr>
<td>FilterCacheModeType.INSTANCE_AND_DOCID_SETRESULTS</td>
<td>Both the filter instance and the DocIdSet results are cached. This is the default value.</td>
</tr>
</tbody>
</table>

Last but not least - why should filters be cached? There are two areas where filter caching shines:

- the system does not update the targeted entity index often (in other words, the IndexReader is reused a lot)
- the Filter’s DocIdSet is expensive to compute (compared to the time spent to execute the query)

### 5.3.1. Using filters in a sharded environment

It is possible, in a sharded environment to execute queries on a subset of the available shards. This can be done in two steps:

- create a sharding strategy that does select a subset of IndexManagers depending on some filter configuration
- activate the proper filter at query time

Let’s first look at an example of sharding strategy that query on a specific customer shard if the customer filter is activated.
In this example, if the filter named `customer` is present, we make sure to only use the shard
dedicated to this customer. Otherwise, we return all shards. A given Sharding strategy can react to one or more filters and depends on their parameters.

The second step is simply to activate the filter at query time. While the filter can be a regular filter (as defined in Filters) which also filters Lucene results after the query, you can make use of a special filter that will only be passed to the sharding strategy and otherwise ignored for the rest of the query. Simply use the ShardSensitiveOnlyFilter class when declaring your filter.

```java
@Entity @Indexed
@FullTextFilterDef(name="customer", impl=ShardSensitiveOnlyFilter.class)
public class Customer {
    // ...
}
```

```java
FullTextQuery query = ftEm.createFullTextQuery(luceneQuery, Customer.class);
query.enableFulltextFilter("customer").setParameter("CustomerID", 5);
@SuppressWarnings("unchecked")
List<Customer> results = query.getResultList();
```

Note that by using the ShardSensitiveOnlyFilter, you do not have to implement any Lucene filter. Using filters and sharding strategy reacting to these filters is recommended to speed up queries in a sharded environment.

### 5.4. Faceting

Faceted search is a technique which allows to divide the results of a query into multiple categories. This categorization includes the calculation of hit counts for each category and the ability to further restrict search results based on these facets (categories). Facets Example on Amazon shows a faceting example. The search for 'Hibernate Search' results in fifteen hits which are displayed on the main part of the page. The navigation bar on the left, however, shows the category Computers & Internet with its subcategories Programming, Computer Science, Databases, Software, Web Development, Networking and Home Computing. For each of these subcategories the number of books is shown matching the main search criteria and belonging to the respective subcategory. This division of the category Computers & Internet is one facet of this search. Another one is for example the average customer review rating.
In Hibernate Search the classes `QueryBuilder` and `FullTextQuery` are the entry point to the faceting API. The former allows to create faceting requests whereas the latter gives access to the so-called `FacetManager`. With the help of the `FacetManager` faceting requests can be applied on a query and selected facets can be added to an existing query in order to refine search results. The following sections will describe the faceting process in more detail. The examples will use the entity `Cd` as shown in Example entity for faceting:
In order to facet on a given indexed field, the field needs to be configured with the `@Facet` annotation. Also, the field itself cannot be analyzed.

`@Facet` contains a `name` and `forField` parameter. The `name` is arbitrary and used to identify the facet. Per default it matches the field name it belongs to. `forField` is relevant in case the property is mapped to multiple fields using `@Field` multiple times, as it is a repeatable annotation. In this case `forField` can be used to identify the index field to which it applies. Both `@Field` and `@Facet` are repeatable annotations.

Last but not least, `@Facet` contains a `encoding` parameter. Usually, Hibernate Search automatically selects the encoding:

- String fields are encoded as `FacetEncodingType.STRING`
- `byte`, `short`, `int`, `long` (including corresponding wrapper types) and `Date` as `FacetEncodingType.LONG`
- and `float` and `double` (including corresponding wrapper types) as `FacetEncodingType.DOUBLE`

In some cases it can make sense, however, to explicitly set the encoding. Discrete faceting requests for example only work for string encoded facets. In order to use a discrete facet for
numbers the encoding must be explicitly set to `FacetEncodingType.STRING`.

Pre Hibernate Search 5.2 there was no need to explicitly use a `@Facet` annotation. In 5.2 it became necessary in order to use Lucene’s native faceting API.

### 5.4.1. Creating a faceting request

The first step towards a faceted search is to create the `FacetingRequest`. Currently two types of faceting requests are supported. The first type is called **discrete faceting** and the second type **range faceting** request.

---

**Discrete faceting request**

In the case of a discrete faceting request, you start with giving the request a unique name. This name will later be used to retrieve the facet values (see **Interpreting a Facet result**). Then you need to specify on which index field you want to categorize on and which faceting options to apply. An example for a discrete faceting request can be seen in **Creating a discrete faceting request**:

**Example 116. Creating a discrete faceting request**

```java
QueryBuilder builder = fullTextSession.getSearchFactory().buildQueryBuilder().forEntity(Cd.class).get();

FacetingRequest labelFacetingRequest = builder.facet()
    .name("labelFacetRequest")
    .onField("label")
    .discrete()
    .orderedBy(FacetSortOrder.COUNT_DESC)
    .includeZeroCounts(false)
    .maxFacetCount(3)
    .createFacetingRequest();
```

When executing this faceting request a `Facet` instance will be created for each discrete value for the indexed field `label`. The `Facet` instance will record the actual field value including how often this particular field value occurs within the original query results. Parameters `orderedBy`, `includeZeroCounts` and `maxFacetCount` are optional and can be applied on any faceting request. Parameter `orderedBy` allows to specify in which order the created facets will be returned. The default is `FacetSortOrder.COUNT_DESC`, but you can also sort on the field value. Parameter `includeZeroCount` determines whether facets with a count of 0 will be included in the result (by default they are not) and `maxFacetCount` allows to limit the maximum amount of facets returned.
There are several preconditions an indexed field has to meet in order to categorize (facet) on it:

- The indexed property must be of type `String`, `Date` or of the numeric type byte, short, int, long, double or float (or their respective Java wrapper types).
- The property has to be indexed with `Analyze.NO`.
- `null` values should be avoided.

When you need conflicting options, we suggest to index the property twice and use the appropriate field depending on the use case:

```java
@Field(name="price")
@Field(name="price_facet",
    analyze=Analyze.NO,
    bridge=@FieldBridge(impl = IntegerBridge.class))
private int price;
```

### Creating a range faceting request

The creation of a range faceting request is similar. We also start with a name for the request and the field to facet on. Then we have to specify ranges for the field values. A range faceting request can be seen in Creating a range faceting request. There, three different price ranges are specified. `below` and `above` can only be specified once, but you can specify as many `from`-`to` ranges as you want. For each range boundary you can also specify via `excludeLimit` whether it is included into the range or not.

**Example 117. Creating a range faceting request**

```java
QueryBuilder builder = fullTextSession.getSearchFactory().
    .createQueryBuilder()
    .forEntity(Cd.class)
    .get();
FacetingRequest priceFacetingRequest = builder.facet()
    .name("priceFaceting")
    .onField("price_facet")
    .range()
    .below(1000)
    .from(1001).to(1500)
    .above(1500).excludeLimit()
    .createFacetingRequest();
```
5.4.2. Setting the facet sort order

The result of applying a faceting request is a list of Facet instances as seen in Applying a faceting request. The order within the list is given by the FacetSortOrder parameter specified via orderedBy when creating the faceting request. The default value is FacetSortOrder.COUNT_DESC, meaning facets are ordered by their count in descending order (highest count first). Other values are COUNT_ASC, FIELD_VALUE and RANGE_DEFINITION_ORDER. COUNT_ASC returns the facets in ascending count order whereas FIELD_VALUE will return them in alphabetical order of the facet/category value (see Interpreting a Facet result). RANGE_DEFINITION_ORDER only applies for range faceting request and returns the facets in the same order in which the ranges are defined. For Creating a range faceting request this would mean the facet for the range of below 1000 would be returned first, followed by the facet for the range 1001 to 1500 and finally the facet for above 1500.

5.4.3. Applying a faceting request

In Creating a faceting request we have seen how to create a faceting request. Now it is time to apply it on a query. The key is the FacetManager which can be retrieved via the FullTextQuery (see Applying a faceting request).

Example 118. Applying a faceting request

```java
// create a fulltext query
Query luceneQuery = builder.all().createQuery(); // match all query
FullTextQuery fullTextQuery = fullTextSession.createFullTextQuery(luceneQuery, Cd.class);

// retrieve facet manager and apply faceting request
FacetManager facetManager = fullTextQuery.getFacetManager();
facetManager.enableFaceting(priceFacetingRequest);

// get the list of Cds
List<Cd> cds = fullTextQuery.list();
...

// retrieve the faceting results
List<Facet> facets = facetManager.getFacets("priceFaceting");
...
```

You need to enable the faceting request before you execute the query. You do that via facetManager.enableFaceting(<facetName>). You can enable as many faceting requests as you like. Then you execute the query and retrieve the facet results for a given request via facetManager.getFacets(<facetname>). For each request you will get a list of Facet instances. Facet requests stay active and get applied to the fulltext query until they are either explicitly disabled via disableFaceting(<facetName>) or the query is discarded.
5.4.4. Interpreting a Facet result

Each facet request results in a list of Facet instances. Each instance represents one facet/category value. In the CD example (Creating a discrete faceting request) where we want to categorize on the CD labels, there would for example be a Facet for each of the record labels Universal, Sony and Warner. Facet API shows the API of Facet.

Example 119. Facet API

```java
public interface Facet {
    /**
     * @return the faceting name this Facet belongs to.
     * @see org.hibernate.search.query.facet.FacetingRequest#getFacetingName()
     */
    String getFacetingName();

    /**
     * Return the Document field name this facet is targeting.
     * The field needs to be indexed with Analyze.NO).
     * @return the Document field name this facet is targeting.
     */
    String getFieldName();

    /**
     * @return the value of this facet. In case of a discrete facet it is the actual
     *         Document field value. In case of a range query the value is a
     *         string representation of the range.
     */
    String getValue();

    /**
     * @return the facet count.
     */
    int getCount();

    /**
     * @return a Lucene Query which can be executed to retrieve all
     *         documents matching the value of this facet.
     */
    Query getFacetQuery();
}
```

getFacetingName() and getFieldName() are returning the facet request name and the targeted document field name as specified by the underlying FacetRequest. For example "Creating a discrete faceting request" that would be labelFacetRequest and label respectively. The interesting information is provided by getValue() and getCount(). The
former is the actual facet/category value, for example a concrete record label like Universal. The latter returns the count for this value. To stick with the example again, the count value tells you how many CDs are released under the Universal label. Last but not least, `getFacetQuery()` returns a Lucene query which can be used to retrieve the entities counted in this facet.

### 5.4.5. Restricting query results

A common use case for faceting is a "drill-down" functionality which allows you to narrow your original search by applying a given facet on it. To do this, you can apply any of the returned Facet instances as additional criteria on your original query via FacetSelection. FacetSelection is available via the FacetManager and allow you to select a facet as query criteria (selectFacets), remove a facet restriction (deselectFacets), remove all facet restrictions (clearSelectedFacets) and retrieve all currently selected facets (getSelectedFacets). Restricting query results via the application of a FacetSelection shows an example.

**Example 120. Restricting query results via the application of a FacetSelection**

```java
// create a fulltext query
Query luceneQuery = builder.all().createQuery(); // match all query
FullTextQuery fullTextQuery = fullTextSession.createFullTextQuery(
luceneQuery, clazz);

// retrieve facet manager and apply faceting request
FacetManager facetManager = fullTextQuery.getFacetManager();
facetManager.enableFaceting(priceFacetingRequest);

// get the list of CD
List<Cd> cds = fullTextQuery.list();
assertTrue(cds.size() == 10);

// retrieve the faceting results
List<Facet> facets = facetManager.getFacets("priceFaceting");
assertTrue(facets.get(0).getCount() == 2);

// apply first facet as additional search criteria
FacetSelection facetSelection = facetManager.getFacetGroup("priceFaceting");
facetSelection.selectFacets(facets.get(0));

// re-execute the query
cds = fullTextQuery.list();
assertTrue(cds.size() == 2);
```

Per default selected facets are combined via disjunction (OR). In case a field has multiple values, like a potential Cd.artists association, you can also use conjunction (AND) for the facet selection.
5.5. Optimizing the query process

Query performance depends on several criteria:

- the Lucene query itself: read the literature on this subject.
- the number of loaded objects: use pagination and / or index projection (if needed).
- the way Hibernate Search interacts with the Lucene readers: defines the appropriate Reader strategy.

5.5.1. Logging executed Lucene queries

Knowing the executed queries is vital when working on performance optimizations. This is especially the case if your application accepts queries passed in by the user or e.g. dynamically builds queries using the Hibernate Search query DSL.

In order to log all Lucene queries executed by Hibernate Search, enable DEBUG logging for the log category org.hibernate.search.fulltext_query.
Chapter 6. Manual index changes

As Hibernate core applies changes to the Database, Hibernate Search detects these changes and will update the index automatically (unless the EventListeners are disabled). Sometimes changes are made to the database without using Hibernate, as when backup is restored or your data is otherwise affected; for these cases Hibernate Search exposes the Manual Index APIs to explicitly update or remove a single entity from the index, or rebuild the index for the whole database, or remove all references to a specific type.

All these methods affect the Lucene Index only, no changes are applied to the Database.

6.1. Adding instances to the index

Using `FullTextSession.index(T entity)` you can directly add or update a specific object instance to the index. If this entity was already indexed, then the index will be updated. Changes to the index are only applied at transaction commit.

Example 122. Indexing an entity via `FullTextSession.index(T entity)`

```java
FullTextSession fullTextSession = Search.getFullTextSession(session);
Transaction tx = fullTextSession.beginTransaction();
Object customer = fullTextSession.load(Customer.class, 8);
fullTextSession.index(customer);
tx.commit(); //index only updated at commit time
```

In case you want to add all instances for a type, or for all indexed types, the recommended approach is to use a MassIndexer: see Using a MassIndexer for more details.

The method `FullTextSession.index(T entity)` is considered an explicit indexing operation, so any registered EntityIndexingInterceptor won’t be applied in this case. For more information on EntityIndexingInterceptor see Conditional indexing.

6.2. Deleting instances from the index

It is equally possible to remove an entity or all entities of a given type from a Lucene index without the need to physically remove them from the database. This operation is named purging and is also done through the `FullTextSession`.
Example 123. Purging a specific instance of an entity from the index

```java
FullTextSession fullTextSession = Search.getFullTextSession(session);
Transaction tx = fullTextSession.beginTransaction();
for (Customer customer : customers) {
    fullTextSession.purge(Customer.class, customer.getId());
}
tx.commit(); //index is updated at commit time
```

Purging will remove the entity with the given id from the Lucene index but will not touch the database.

If you need to remove all entities of a given type, you can use the purgeAll method. This operation removes all entities of the type passed as a parameter as well as all its subtypes.

Example 124. Purging all instances of an entity from the index

```java
FullTextSession fullTextSession = Search.getFullTextSession(session);
Transaction tx = fullTextSession.beginTransaction();
fullTextSession.purgeAll(Customer.class);
//optionally optimize the index
//fullTextSession.getSearchFactory().optimize(Customer.class);
tx.commit(); //index changes are applied at commit time
```

As in the previous example, it is suggested to optimize the index after many purge operation to actually free the used space.

As is the case with method `FullTextSession.index(T entity)`, also `purge` and `purgeAll` are considered explicit indexing operations: any registered `EntityIndexingInterceptor` won't be applied. For more information on `EntityIndexingInterceptor` see Conditional indexing.

Methods `index`, `purge` and `purgeAll` are available on `FullTextEntityManager` as well.

All manual indexing methods (index, purge and purgeAll) only affect the index, not the database, nevertheless they are transactional and as such they won't be applied until the transaction is successfully committed, or you make use of `flushToIndexes`. 
6.3. Rebuilding the whole index

If you change the entity mapping to the index, chances are that the whole index needs to be updated; for example if you decide to index an existing field using a different analyzer you’ll need to rebuild the index for affected types. Also if the Database is replaced (like restored from a backup, imported from a legacy system) you’ll want to be able to rebuild the index from existing data. Hibernate Search provides two main strategies to choose from:

- Using `FullTextSession.flushToIndexes()` periodically, while using `FullTextSession.index()` on all entities.
- Use a MassIndexer.

When you change the entity mapping to the index, if you don’t know whether the changes require a full reindexing or not, you can follow this rule of thumb:

- Rebuilding the whole index is **not** required if all you did was:
  - **adding** new indexed entities that will not have any persisted instance, e.g. adding an `@Indexed` annotation on an entity which has no rows in database.
  - **adding** new fields that will be empty for all currently persisted entities, e.g. adding a new property on an entity type and mapping it to a field, but with the guarantee that this property will initially be null for every instance of this entity;
  - and/or **removing** data from existing indexes/fields, e.g. removing an index field, or removing the need for a field to be stored.

- Rebuilding the whole index is **required** if you made any change to the mapping that is not mentioned above.

6.3.1. Using flushToIndexes()

This strategy consists in removing the existing index and then adding all entities back to the index using `FullTextSession.purgeAll()` and `FullTextSession.index()`, however there are some memory and efficiency constraints. For maximum efficiency Hibernate Search batches index operations and executes them at commit time. If you expect to index a lot of data you need to be careful about memory consumption since all documents are kept in a queue until the transaction commit. You can potentially face an `OutOfMemoryException` if you don’t empty the queue periodically: to do this you can use `fullTextSession.flushToIndexes()`. Every time `fullTextSession.flushToIndexes()` is called (or if the transaction is committed), the batch queue is processed applying all index changes. Be aware that, once flushed, the changes cannot be rolled back.
Example 125. Index rebuilding using index() and flushToIndexes()

```java
fullTextSession.setFlushMode(FlushMode.MANUAL);
fullTextSession.setCacheMode(CacheMode.IGNORE);
transaction = fullTextSession.beginTransaction();
//Scrollable results will avoid loading too many objects in memory
ScrollableResults results = fullTextSession.createCriteria(Email.class)
    .setFetchSize(BATCH_SIZE)
    .scroll(ScrollMode.FORWARD_ONLY);
int index = 0;
while(results.next()) {
    index++;
    fullTextSession.index(results.get(0)); //index each element
    if (index % BATCH_SIZE == 0) {
        fullTextSession.flushToIndexes(); //apply changes to indexes
        fullTextSession.clear(); //free memory since the queue is processed
    }
}
transaction.commit();
```

Try to use a batch size that guarantees that your application will not run out of memory: with a bigger batch size objects are fetched faster from database but more memory is needed.

### 6.3.2. Using a MassIndexer

Hibernate Search's MassIndexer uses several parallel threads to rebuild the index; you can optionally select which entities need to be reloaded or have it reindex all entities. This approach is optimized for best performance but requires to set the application in maintenance mode: making queries to the index is not recommended when a MassIndexer is busy.

Example 126. Index rebuilding using a MassIndexer

```java
fullTextSession.createIndexer().startAndWait();
```

This will rebuild the index, deleting it and then reloading all entities from the database. Although it's simple to use, some tweaking is recommended to speed up the process: there are several parameters configurable.

⚠️ During the progress of a MassIndexer the content of the index is undefined! If a query is performed while the MassIndexer is working most likely some results will be missing.
Example 127. Using a tuned MassIndexer

```java
cREATE INDEXER (User.class) 
  .batchSizeToLoadObjects(25) 
  .cacheMode(CacheMode.NORMAL) 
  .threadsToLoadObjects(12) 
  .idFetchSize(150) 
  .transactionTimeout(1800) 
  .progressMonitor(monitor) //a MassIndexerProgressMonitor implementation 
.startAndWait();
```

This will rebuild the index of all User instances (and subtypes), and will create 12 parallel threads to load the User instances using batches of 25 objects per query; these same 12 threads will also need to process indexed embedded relations and custom FieldBridges or ClassBridges, to finally output a Lucene document. In this conversion process these threads are likely going to need to trigger lazy loading of additional attributes, so you will probably need a high number of threads working in parallel. When run in a JTA environment such as the WildFly application server, the mass indexer will use a timeout of 1800 seconds (= 30 minutes) for its transactions. Configure a timeout value which is long enough to load and index all entities of the type with the most instances, taking into account the configured batch size and number of threads to load objects. Note that these transactions are read-only, so choosing a substantially large value should pose no problem in general.

As of Hibernate Search 4.4.0, instead of indexing all the types in parallel, the MassIndexer is configured by default to index only one type in parallel. It prevents resource exhaustion especially database connections and usually does not slow down the indexing. You can however configure this behavior using `MassIndexer.typesToIndexInParallel(int threadsToIndexObjects)`:

Example 128. Configuring the MassIndexer to index several types in parallel

```java
cREATE INDEXER (User.class, Customer.class) 
  .typesToIndexInParallel(2) 
  .batchSizeToLoadObjects(25) 
  .cacheMode(CacheMode.NORMAL) 
  .threadsToLoadObjects(5) 
  .idFetchSize(150) 
  .progressMonitor(monitor) //a MassIndexerProgressMonitor implementation 
.startAndWait();
```

Generally we suggest to leave cacheMode to CacheMode.IGNORE (the default), as in most reindexing situations the cache will be a useless additional overhead; it might be useful to
enable some other CacheMode depending on your data: it could increase performance if the main entity is relating to enum-like data included in the index.

The MassIndexer was designed for speed and is unaware of transactions, so there is no need to begin one or committing. Also because it is not transactional it is not recommended to let users use the system during its processing, as it is unlikely people will be able to find results and the system load might be too high anyway.

MassIndexer using threads and JDBC connections

The MassIndexer was designed to finish the re-indexing task as quickly as possible, but this requires a bit of care in its configuration to behave fairly with your server resources.

There is a simple formula to understand how the different options applied to the MassIndexer affect the number of used worker threads and connections: each thread will require a JDBC connection.

```
threads = typesToIndexInParallel * (threadsToLoadObjects + 1);
required JDBC connections = threads;
```

Let's see some suggestions for a roughly sane tuning starting point:

1. Option `typesToIndexInParallel` should probably be a low value, like 1 or 2, depending on how much of your CPUs have spare cycles and how slow a database round trip will be.

2. Before tuning a parallel run, experiment with options to tune your primary indexed entities in isolation.

3. Making `threadsToLoadObjects` higher increases the pre-loading rate for the picked entities from the database, but also increases memory usage and the pressure on the threads working on subsequent indexing.

4. Increasing parallelism usually helps as the bottleneck usually is the latency to the database connection: it’s probably worth it to experiment with values significantly higher than the number of actual cores available, but make sure your database can handle all the multiple requests.

5. This advice might not apply to you: always measure the effects! We’re providing this as a means to help you understand how these options are related.
Running the MassIndexer with many threads will require many connections to the database. If you don't have a sufficiently large connection pool, the MassIndexer itself and/or your other applications could starve being unable to serve other requests: make sure you size your connection pool accordingly to the options as explained in the above paragraph.

The "sweet spot" of number of threads to achieve best performance is highly dependent on your overall architecture, database design and even data values. All internal thread groups have meaningful names so they should be easily identified with most diagnostic tools, including simply thread dumps.

Using a custom MassIndexer implementation

The provided MassIndexer is quite general purpose, and while we believe it's a robust approach, you might be able to squeeze some better performance by writing a custom implementation. To run your own MassIndexer instead of using the one shipped with Hibernate Search you have to:

1. create an implementation of the org.hibernate.search.spi.MassIndexerFactory interface;
2. set the property hibernate.search.massindexer.factoryclass with the qualified class name of the factory implementation.

Example 129. Custom MassIndexerFactory example

```java
package org.myproject
import org.hibernate.search.spi.MassIndexerFactory

public class CustomIndexerFactory implements MassIndexerFactory {

    public void initialize(Properties properties) {
    }

    public MassIndexer createMassIndexer(...) {
        return new CustomIndexer();
    }
}

hibernate.search.massindexer.factoryclass = org.myproject.CustomIndexerFactory
```
6.3.3. Useful parameters for batch indexing

Other parameters which affect indexing time and memory consumption are:

- `hibernate.search.[default|<indexname>].exclusive_index_use`
- `hibernate.search.[default|<indexname>].indexwriter.max_buffered_docs`
- `hibernate.search.[default|<indexname>].indexwriter.max_merge_docs`
- `hibernate.search.[default|<indexname>].indexwriter.merge_factor`
- `hibernate.search.[default|<indexname>].indexwriter.merge_min_size`
- `hibernate.search.[default|<indexname>].indexwriter.merge_max_size`
- `hibernate.search.[default|<indexname>].indexwriter.merge_maximize_size`
- `hibernate.search.[default|<indexname>].indexwriter.merge_calibrate_by_deletes`
- `hibernate.search.[default|<indexname>].indexwriter.ram_buffer_size`

Previous versions also had a `max_field_length` but this was removed from Lucene, it's possible to obtain a similar effect by using a `LimitTokenCountAnalyzer`. All `.indexwriter` parameters are Lucene specific and Hibernate Search is just passing these parameters through - see Tuning indexing performance for more details.

The MassIndexer uses a forward only scrollable result to iterate on the primary keys to be loaded, but MySQL's JDBC driver will load all values in memory; to avoid this "optimization" set `idFetchSize` to `Integer.MIN_VALUE`. 
Chapter 7. Index Optimization

This section explains some low level tricks to keep your indexes at peak performance. We cover some Lucene details which in most cases you don't have to know about: Hibernate Search will handle these operations optimally and transparently in most cases without the need for further configuration. Still, it is good to know that there are ways to configure the behavior, if the need arises.

The index is physically stored in several smaller segments. Each segment is immutable and represents a generation of index writes. Index segments are periodically compacted, both to merge smaller segments and to remove stale entries; this merging process happens constantly in the background and can be tuned with the options specified in Tuning indexing performance, but you can also define policies to fully run index optimizations when it is most suited for your specific workload.

With older versions of Lucene it was important to frequently optimize the index to maintain good performance, but with current Lucene versions this doesn’t apply anymore. The benefit of explicit optimization is very low, and in certain cases even counter-productive. During an explicit optimization the whole index is processed and rewritten inflicting a significant performance cost. Optimization is for this reason a double-edged sword.

Another reason to avoid optimizing the index too often is that an optimization will, as a side effect, invalidate cached filters and field caches and internal buffers need to be refreshed.

Optimizing the index is often not needed, does not benefit write (update) performance at all, and is a slow operation: make sure you need it before activating it.

Of course optimizing the index does not only present drawbacks: after the optimization process is completed and new IndexReader instances have loaded their buffers, queries will perform at peak performance and you will have reclaimed all disk space potentially used by stale entries.

It is recommended to not schedule any optimization, but if you wish to perform it periodically you should run it:

- on an idle system or when the searches are less frequent
- after a lot of index modifications

When using a MassIndexer (see Using a MassIndexer) it will optimize involved indexes by default at the start and at the end of processing; you can change this behavior by using MassIndexer.optimizeAfterPurge and MassIndexer.optimizeOnFinish respectively. The initial optimization is actually very cheap as it is performed on an empty index: its purpose is to release the storage space occupied by the old index.
7.1. Automatic optimization

While in most cases this is not needed, Hibernate Search can automatically optimize an index after:

- a certain amount of write operations
- or after a certain amount of transactions

The configuration for automatic index optimization can be defined on a global level or per index:

Example 130. Defining automatic optimization parameters

```plaintext
hibernate.search.default.optimizer.operation_limit.max = 1000
hibernate.search.default.optimizer.transaction_limit.max = 100
hibernate.search.Animal.optimizer.transaction_limit.max = 50
```

With the above example an optimization will be triggered to the Animal index as soon as either:

- the number of additions and deletions reaches 1000
- the number of transactions reaches 50

(hibernate.search.Animal.optimizer.transaction_limit.max having priority over hibernate.search.default.optimizer.transaction_limit.max)

If none of these parameters are defined, no optimization is processed automatically.

The default implementation of OptimizerStrategy can be overridden by implementing org.hibernate.search.store.optimization.OptimizerStrategy and setting the optimizer.implementation property to the fully qualified name of your implementation. This implementation must implement the interface, be a public class and have a public constructor taking no arguments.

Example 131. Loading a custom OptimizerStrategy

```plaintext
hibernate.search.default.optimizer.implementation = com.acme.worlddomination.SmartOptimizer
hibernate.search.default.optimizer.SomeOption = CustomConfigurationValue
hibernate.search.humans.optimizer.implementation = default
```

The keyword default can be used to select the Hibernate Search default implementation; all properties after the .optimizer key separator will be passed to the implementation’s initialize method at start.
7.2. Manual optimization

You can programmatically optimize (defragment) a Lucene index from Hibernate Search through the SearchFactory:

**Example 132. Programmatic index optimization**

```java
FullTextSession fullTextSession = Search.getFullTextSession(regularSession);
SearchFactory searchFactory = fullTextSession.getSearchFactory();

searchFactory.optimize(Order.class);
// or
searchFactory.optimize();
```

The first example optimizes the Lucene index holding Orders; the second, optimizes all indexes.

*searchFactory.optimize()* has no effect on a JMS or JGroups backend: you must apply the optimize operation on the Master node.

7.3. Adjusting optimization

The Lucene index is constantly being merged in the background to keep a good balance between write and read performance; in a sense this is a form of background optimization which is always applied.

The following match attributes of Lucene's IndexWriter and are commonly used to tune how often merging occurs and how aggressive it is applied. They are exposed by Hibernate Search via:

- `hibernate.search.[default|<indexname>].indexwriter.max_buffered_docs`
- `hibernate.search.[default|<indexname>].indexwriter.max_merge_docs`
- `hibernate.search.[default|<indexname>].indexwriter.merge_factor`
- `hibernate.search.[default|<indexname>].indexwriter.ram_buffer_size`

See [Tuning indexing performance](#) for a description of these properties.
Chapter 8. Monitoring

Hibernate Search offers access to a Statistics object via SearchFactory.getStatistics(). It allows you for example to determine which classes are indexed and how many entities are in the index. This information is always available. However, by specifying the hibernate.search.generate_statistics property in your configuration you can also collect total and average Lucene query and object loading timings.

8.1. JMX

You can also enable access to the statistics via JMX. Setting the property hibernate.search.jmx_enabled will automatically register the StatisticsInfoMBean. Depending on your the configuration the IndexControlMBean and IndexingProgressMonitorMBean will also be registered. In case you are having more than one JMX enabled Hibernate Search instance running within a single JVM, you should also set hibernate.search.jmxBean_suffix to a different value for each of the instances. The specified suffix will be used to distinguish between the different MBean instances. Let’s have a closer look at the mentioned MBeans.

If you want to access your JMX beans remotely via JConsole make sure to set the system property com.sun.management.jmxremote to true.

8.1.1. StatisticsInfoMBean

This MBean gives you access to Statistics object as described in the previous section.

8.1.2. IndexControlMBean

This MBean allows to build, optimize and purge the index for a given entity. Indexing occurs via the mass indexing API (see Using a MassIndexer). A requirement for this bean to be registered in JMX is, that the Hibernate SessionFactory is bound to JNDI via the hibernate.session_factory_name property. Refer to the Hibernate Core manual for more information on how to configure JNDI. The IndexControlMBean and its API are for now experimental.

8.1.3. IndexingProgressMonitorMBean

This MBean is an implementation MassIndexerProgressMonitor interface. If hibernate.search.jmx_enabled is enabled and the mass indexer API is used the indexing progress can be followed via this bean. The bean will only be bound to JMX while indexing is in progress. Once indexing is completed the MBean is not longer available.
Chapter 9. Spatial

With the spatial extensions you can combine full-text queries with distance restrictions, filter results based on distances or sort results on such a distance criteria.

The spatial support of Hibernate Search has the following goals:

- Enable spatial search on entities: find entities within x km from a given location (latitude, longitude) on Earth
- Provide an easy way to enable spatial indexing via expressive annotations
- Provide a simple way for querying
- Hide geographical complexity

For example, you might search for restaurants somewhere in a 2 km radius around your office.

In order to use the spatial extensions for an indexed entity, you need to add the `@Spatial` annotation (org.hibernate.search.annotations.Spatial) and specify one or more sets of coordinates.

9.1. Enable indexing of Spatial Coordinates

There are different techniques to index point coordinates. Hibernate Search Spatial offers a choice between two strategies:

- index as numbers
- index as labeled spatial hashes

We will now describe both methods, so you can make a suitable choice. You can pick a different strategy for each set of coordinates. The strategy is selected by specifying the `spatialMode` attribute of the `@Spatial` annotation.

9.1.1. Indexing coordinates for range queries

When setting the `@Spatial.spatialMode` attribute to `SpatialMode.RANGE` (which is the default) coordinates are indexed as numeric fields, so that range queries can be performed to narrow down the initial area of interest.

Pros:

- Is quick on small data sets (< 100k entities)
- Is very simple: straightforward to debug/analyze
• Impact on index size is moderate

Cons:

• Poor performance on large data sets

• Poor performance if your data set is distributed across the whole world (for example when indexing points of interest in the United States, in Europe and in Asia, large areas collide because they share the same latitude. The latitude range query returns large amounts of data that need to be cross checked with those returned by the longitude range).

To index your entities for range querying you have to:

• add the @Spatial annotation on your entity

• add the @Latitude and @Longitude annotations on your properties representing the coordinates; these must be of type Double

Example 133. Sample Spatial indexing: Hotel class

```java
import org.hibernate.search.annotations.*;
@Entity
@Indexed
@Spatial
public class Hotel {

    @Latitude
    Double latitude

    @Longitude
    Double longitude

    // ...
```

9.1.2. Indexing coordinates in a grid with spatial hashes

When setting @Spatial.spatialMode to SpatialModeHASH the coordinates are encoded in several fields representing different zoom levels. Each box for each level is labeled so coordinates are assigned matching labels for each zoom level. This results in a grid encoding of labels called spatial hashes.

Pros:

• Good performance even with large data sets

• World wide data distribution independent

Cons:
To index your entities you have to:

- add the @Spatial annotation on the entity with the SpatialMode set to GRID:
  @Spatial(spatialMode = SpatialMode.HASH)

- add the @Latitude and @Longitude annotations on the properties representing your coordinates; these must be of type Double

Example 134. Indexing coordinates in a grid using spatial hashes

```java
@Spatial(spatialMode = SpatialMode.HASH)
@Indexed
@Entity
public class Hotel {

    @Latitude
    Double latitude;

    @Longitude
    Double longitude;

    // ...
```

9.1.3. Implementing the Coordinates interface

Instead of using the @Latitude and @Longitude annotations you can choose to implement the org.hibernate.search.spatial.Coordinates interface.
Example 135. Implementing the Coordinates interface

```java
import org.hibernate.search.annotations.*;
import org.hibernate.search.spatial.Coordinates;

@Entity
@Indexed
@Spatial
public class Song implements Coordinates {

    @Id
    long id;
    double latitude;
    double longitude;
    // ...

    @Override
    Double getLatitude() {
        return latitude;
    }

    @Override
    Double getLongitude() {
        return longitude;
    }
    // ...
}
```

As we will see in the section Multiple Coordinate pairs, an entity can have multiple @Spatial annotations; when having the entity implement Coordinates, the implemented methods refer to the default @Spatial annotation with the default pair of coordinates.

The default (field) name in case @Spatial is placed on the entity level is org.hibernate.search.annotations.Spatial.COORDINATES_DEFAULT_FIELD.

An alternative is to use properties implementing the Coordinates interface; this way you can have multiple Spatial instances:
Example 136. Using attributes of type Coordinates

```java
@Entity
@Indexed
public class Event {
    @Id
    Integer id;

    @Field(store = Store.YES)
    String name;

double latitude;

double longitude;

    @Spatial(spatialMode = SpatialMode.HASH)
    public Coordinates getLocation() {
        return new Coordinates()
        {
            @Override
            public Double getLatitude() {
                return latitude;
            }

            @Override
            public Double getLongitude() {
                return longitude;
            }
        };
    }

    // ...
}
```

When using this form the `@Spatial.name` automatically defaults to the property name. In the above case to `location`.

9.2. Performing Spatial Queries

You can use the Hibernate Search query DSL to build a query to search around a pair of coordinates (latitude, longitude) or around a bean implementing the `Coordinates` interface.

As with any full-text query, the spatial query creation flow looks like:

1. retrieve a `QueryBuilder` from the `SearchFactory`
2. use the DSL to build a spatial query, defining search center and radius
3. optionally combine the resulting `Query` with other filters
4. call the `createFullTextQuery()` and use the resulting query like any standard Hibernate or JPA query
Example 137. Search for an Hotel by distance

```java
QueryBuilder builder = fullTextSession.getSearchFactory()
   .buildQueryBuilder().forEntity( Hotel.class ).get();

org.apache.lucene.search.Query luceneQuery = builder
   .spatial()
   .within( radius, Unit.KM )
   .ofLatitude( centerLatitude )
   .andLongitude( centerLongitude )
   .createQuery();

org.hibernate.Query hibQuery = fullTextSession
   .createFullTextQuery( luceneQuery, Hotel.class );
List results = hibQuery.list();
```

In the above example we did not explicitly specify the field name to use. The default coordinates field name was used implicitly. To target an alternative pair of coordinates at query time, we need to specify the field name as well. See Multiple Coordinate pairs.

A fully working example can be found in the test-suite of the source code. Refer to SpatialIndexingTest.testSpatialAnnotationOnClassLevel() and its corresponding Hotel test class.

Alternatively to passing separate latitude and longitude values, you can also pass an instance implementing the Coordinates interface:

Example 138. DSL example with Coordinates

```java
Coordinates coordinates = Point.fromDegrees(24d, 31.5d);
Query query = builder
   .spatial()
   .within( 51, Unit.KM )
   .ofCoordinates( coordinates )
   .createQuery();

List results = fullTextSession.createFullTextQuery( query, POI.class )
   .list();
```

9.2.1. Returning distance to query point in the search results

Returning distance to the center in the results

To retrieve the actual distance values (in kilometers) you need to use projection (see Projection):
Example 139. Distance projection example

```java
double centerLatitude = 24.0d;
double centerLongitude = 32.0d;

QueryBuilder builder = fullTextSession.getSearchFactory()
    .buildQueryBuilder().forEntity(POI.class).get();
org.apache.lucene.search.Query luceneQuery = builder
    .spatial()
    .onField("location")
    .within(100, Unit.KM)
    .ofLatitude(centerLatitude)
    .andLongitude(centerLongitude)
    .createQuery();

FullTextQuery hibQuery = fullTextSession.createFullTextQuery(luceneQuery, POI.class);
hibQuery.setProjection(FullTextQuery.SPATIAL_DISTANCE, FullTextQuery.THIS);
hibQuery.setSpatialParameters(centerLatitude, centerLongitude, "location");
List results = hibQuery.list();
```

- Use `FullTextQuery.setProjection` with `FullTextQuery.SPATIAL_DISTANCE` as one of the projected fields.
- Call `FullTextQuery.setSpatialParameters` with the latitude, longitude and the name of the spatial field used to build the spatial query. Note that using coordinates different than the center used for the query will have unexpected results.

The default (field) name in case `@Spatial` is placed on the entity level is `org.hibernate.search.annotations.Spatial.COORDINATES_DEFAULT_FIELD`.

### Distance projection and null values

When a spatial field on an entity has a `null` value for either its latitude or longitude (or both), the resulting projected distance will always be `null`.

### Sorting by distance

To sort the results by distance to the center of the search you will have to build a `Sort` instance using Hibernate Search sort DSL:
Example 140. Distance sort example using the sort DSL

```java
double centerLatitude = 24.0d;
double centerLongitude = 32.0d;

QueryBuilder builder = fullTextSession.getSearchFactory()
    .buildQueryBuilder().forEntity(POI.class).get();
org.apache.lucene.search.Query luceneQuery = builder
    .spatial()
    .onField("location")
    .within(100, Unit.KM)
    .ofLatitude(centerLatitude)
    .andLongitude(centerLongitude)
    .createQuery();

FullTextQuery hibQuery = fullTextSession.createFullTextQuery(luceneQuery, POI.class);
List results = query.list();
Sort distanceSort = qb
    .sort()
    .byDistance()
    .onField("location")
    .fromLatitude(centerLatitude)
    .andLongitude(centerLongitude)
    .createSort();
hibQuery.setSort(distanceSort);
```

The sort must be constructed using the same coordinates on the same spatial field used to build the spatial query, otherwise the sorting will occur with another center than the query. This repetition is needed to allow you to define Queries with any tool.

### Sorting and null values

When a spatial field on an entity has a **null** value for either its latitude or longitude (or both):

- if you are filtering the results using a distance query, the entity with missing coordinates will not appear in the query results and its rank in the sort is irrelevant.
- otherwise, the resulting distance will always be the greatest possible value, which means the entity will be ranked last if the sort is ascending, or first if the sort is descending.

Alternatively, you may also use a `DistanceSortField` directly, as it was done before the introduction of Hibernate Search sort DSL:
Example 141. Distance sort example without using the sort DSL

```java
double centerLatitude = 24.0d;
double centerLongitude = 32.0d;

QueryBuilder builder = fullTextSession.getSearchFactory()
    .buildQueryBuilder().forEntity(POI.class).get();
org.apache.lucene.search.Query luceneQuery = builder
    .spatial()
    .onField("location")
    .within(100, Unit.KM)
    .ofLatitude(centerLatitude)
    .andLongitude(centerLongitude)
    .createQuery();

FullTextQuery hibQuery = fullTextSession.createFullTextQuery(luceneQuery, POI.class);
Sort distanceSort = new Sort(
    new DistanceSortField(centerLatitude, centerLongitude, "location"));
hibQuery.setSort(distanceSort);
```

9.3. Multiple Coordinate pairs

You can associate multiple pairs of coordinates to the same entity, as long as each pair is uniquely identified by using a different name. This is achieved by stacking multiple `@Spatial` annotations and specifying the `name` attribute on the individual `@Spatial` annotation. At most one of them will be allowed to use the default name.
Example 142. Multiple sets of coordinates

```java
import org.hibernate.search.annotations.*;

@Entity
@Indexed
@Spatial
@Spatial(name="work", spatialMode = SpatialMode.HASH)
public class UserEx {
    @Id
    Integer id;

    @Latitude
    Double homeLatitude;

    @Longitude
    Double homeLongitude;

    @Latitude(of="work")
    Double workLatitude;

    @Longitude(of="work")
    Double workLongitude;
}
```

To target an alternative pair of coordinates at query time, we need to specify the pair by name using `onField(String)`:

Example 143. Querying on non-default coordinate set

```java
QueryBuilder builder = fullTextSession.getSearchFactory()
    .buildQueryBuilder().forEntity(UserEx.class).get();

org.apache.lucene.search.Query luceneQuery = builder
    .spatial()
    .onField("work")
    .within( radius, Unit.KM )
    .ofLatitude( centerLatitude )
    .andLongitude( centerLongitude )
    .createQuery();

org.hibernate.Query hibQuery = fullTextSession.createFullTextQuery( luceneQuery,
    Hotel.class );
List results = hibQuery.list();
```
9.4. Insight: implementation details of spatial hashes indexing

The following chapter is meant to provide a technical insight in spatial hash (grid) indexing. It discusses how coordinates are mapped to the index and how queries are implemented.

9.4.1. At indexing level

When Hibernate Search indexes an entity annotated with `@Spatial`, it instantiates a `SpatialFieldBridge` to transform the latitude and longitude fields accessed via the `Coordinates` interface to the multiple index fields stored in the Lucene index.

Principle of the spatial index: the spatial index used in Hibernate Search is a grid based spatial index where grid ids are hashes derived from latitude and longitude.

To make computations easier the latitude and longitude field values will be projected into a flat coordinate system with the help of a sinusoidal projection. Origin value space is:

\[-90 \rightarrow +90\], \[-180 \rightarrow +180\]

for latitude, longitude coordinates and projected space is:

\[-\pi \rightarrow +\pi\], \[-\pi/2 \rightarrow +\pi/2\]

for Cartesian x, y coordinates (beware of fields order inversion: x is longitude and y is latitude).

The index is divided into n levels labeled from 0 to n-1.

At the level 0 the projected space is the whole Earth. At the level 1 the projected space is divided into 4 rectangles (called boxes as in bounding box):

\[-\pi,-\pi/2\]→[0,0], \[-\pi,0\]→[0,+\pi/2], \[0,-\pi/2\]→[+\pi,0] and \[0,0\]→[+\pi,+\pi/2]

At level n+1 each box of level n is divided into 4 new boxes and so on. The numbers of boxes at a given level is 4^n.

Each box is given an id, in this format: [Box index on the X axis]|[Box index on the Y axis]. To calculate the index of a box on an axis we divide the axis range in 2^n slots and find the slot the box belongs to. At the n level the indexes on an axis are from -(2^n)/2 to (2^n)/2. For instance, the 5th level has 4^5 = 1024 boxes with 32 indexes on each axis (32x32 is 1024) and the box of Id "0|8" is covering the \[0,8/32*\pi/2\]→[1/32*\pi,9/32*\pi/2] rectangle is projected space.

Beware! The boxes are rectangles in projected space but the related area on Earth is not rectangular!
Now that we have all these boxes at all these levels, we index points "into" them.

For a point (lat,long) we calculate its projection (x,y) and then we calculate for each level of the spatial index, the ids of the boxes it belongs to.

At each level the point is in one and only one box. For points on the edges the box are considered exclusive on the left side and inclusive on the right i-e [start,end] (the points are normalized before projection to [-90,+90],[-180,+180]).

We store in the Lucene document corresponding to the entity to index one field for each level of the spatial hash grid. The field is named: HSSI[n]. [spatial index fields name] is given either by the parameter at class level annotation or derived from the name of the spatial annotated method of the entity, HSSI stands for Hibernate Search Spatial Index and n is the level of the spatial hashes grid.

We also store the latitude and longitude as a numeric field under [spatial index fields name]_HSSI_Latitude and [spatial index fields name]_HSSI_Longitude fields. They will be used to filter precisely results by distance in the second stage of the search.

9.4.2. At search level

Now that we have all these fields, what are they used for?

When you ask for a spatial search by providing a search discus (center+radius) we will calculate the box ids that do cover the search discus in the projected space, fetch all the documents that belong to these boxes (thus narrowing the number of documents for which we will have to calculate distance to the center) and then filter this subset with a real distance calculation. This is called two level spatial filtering.

**Step 1: Compute the best spatial hashes grid level for the search discus**

For a given search radius there is an optimal hash grid level where the number of boxes to retrieve shall be minimal without bringing back to many documents (level 0 has only 1 box but retrieve all documents). The optimal hash grid level is the maximum level where the width of each box is larger than the search area. Near the equator line where projection deformation is minimal, this will lead to the retrieval of at most 4 boxes. Towards the poles where the deformation is more significant, it might need to examine more boxes but as the sinusoidal projection has a simple Tissot's indicatrix (see Sinusoidal projection) in populated areas, the overhead is minimal.

**Step 2: Compute ids of the corresponding covering boxes at that level**

Now that we have chosen the optimal level, we can compute the ids of the boxes covering the search discus (which is not a discus in projected space anymore).
This is done by org.hibernate.search.spatial.impl.SpatialHelper.getSpatialHashCellsIds(Point center, double radius, int spatialHashLevel)

It will calculate the bounding box of the search discus and then call org.hibernate.search.spatial.impl.SpatialHelper.getSpatialHashCellsIds(Point lowerLeft, Point upperRight, int spatialHashLevel) that will do the actual computation. If the bounding box crosses the meridian line it will cut the search in two and make two calls to getSpatialHashCellsIds(Point lowerLeft, Point upperRight, int spatialHashLevel) with left and right parts of the box.

There are some geo related hacks (search radius too large, search radius crossing the poles) that are handled in bounding box computations done by Rectangle.fromBoundingCircle(Coordinates center, double radius) (see http://janmatuschek.de/LatitudeLongitudeBoundingCoordinates for reference on those subjects).

The SpatialHelper.getSpatialHashCellsIds(Point lowerLeft, Point upperRight, int spatialHashLevel) project the defining points of the bounding box and compute the boxes they belong to. It returns all the box Ids between the lower left to the upper right corners, thus covering the area.

**Step 3: Lucene index lookup**

The query is built with theses Ids searching for documents having a HSSI[n] (n the level found at Step 1) field valued with one of the ids of Step 2.

See also the implementation of org.hibernate.search.spatial.impl.SpatialHashFilter.

This query will return all documents in the boxes covering the projected bounding box of the search discus. So it is too large and needs refining. But we have narrowed the distance calculation problems to a subset of our data.

**Step 4: Refine**

A distance calculation filter is set after the Lucene index lookup query of Step 3 to exclude false candidates from the result list.

See SpatialQueryBuilderFromCoordinates.buildSpatialQuery(Coordinates center, double radius, String fieldName)
Chapter 10. Advanced features

In this final chapter we are offering a smörgåsbord of tips and tricks which might become useful as you dive deeper and deeper into Hibernate Search.

10.1. Accessing the SearchFactory

The `SearchFactory` object keeps track of the underlying Lucene resources for Hibernate Search. It is a convenient way to access Lucene natively. The `SearchFactory` can be accessed from a `FullTextSession`:

Example 144. Accessing the SearchFactory

```java
FullTextSession fullTextSession = Search.getFullTextSession(regularSession);
SearchFactory searchFactory = fullTextSession.getSearchFactory();
```

10.2. Accessing the SearchIntegrator

The interface `SearchIntegrator` gives access to lower level APIs of Hibernate Search. You can access the `SearchIntegrator` SPI using the `SearchFactory` (Accessing the `SearchFactory`):

Example 145. Accessing the SearchIntegrator

```java
SearchIntegrator searchIntegrator = searchFactory.unwrap(SearchIntegrator.class);
```

10.3. Using an IndexReader

Queries in Lucene are executed on an `IndexReader`. Hibernate Search caches index readers to maximize performance and implements other strategies to retrieve updated `IndexReaders` in order to minimize IO operations. Your code can access these cached resources, but you have to follow some "good citizen" rules.
Example 146. Accessing an IndexReader

```java
IndexReader reader = searchFactory.getIndexReaderAccessor().open(Order.class);
try {
    //perform read-only operations on the reader
}
finally {
    searchFactory.getIndexReaderAccessor().close(reader);
}
```

In this example the SearchFactory figures out which indexes are needed to query this entity. Using the configured ReaderProvider (described in Reader strategy) on each index, it returns a compound IndexReader on top of all involved indexes. Because this IndexReader is shared amongst several clients, you must adhere to the following rules:

- Never call `indexReader.close()`, but always call `readerProvider.closeReader(reader)`, using a finally block.
- Don’t use this IndexReader for modification operations: it’s a read-only instance, you would get an exception.

Aside from those rules, you can use the IndexReader freely, especially to do native Lucene queries. Using this shared IndexReaders will be more efficient than by opening one directly from - for example - the filesystem.

As an alternative to the method `open(Class... types)` you can use `open(String... indexNames)` in this case you pass in one or more index names; using this strategy you can also select a subset of the indexes for any indexed type if sharding is used.

Example 147. Accessing an IndexReader by index names

```java
IndexReader reader = searchFactory
    .getIndexReaderAccessor()
    .open("Products.1", "Products.3");
```

10.4. Accessing a Lucene Directory

A Directory is the most common abstraction used by Lucene to represent the index storage; Hibernate Search doesn’t interact directly with a Lucene Directory but abstracts these interactions via an IndexManager: an index does not necessarily need to be implemented by a Directory.

If you are certain that your index is represented as a Directory and need to access it, you can get
a reference to the Directory via the IndexManager. You will have to cast the IndexManager instance to a DirectoryBasedIndexManager and then use getDirectoryProvider().getDirectory() to get a reference to the underlying Directory. This is not recommended, if you need low level access to the index using Lucene APIs we suggest to see Using an IndexReader instead.

10.5. Sharding indexes

In some cases it can be useful to split (shard) the data into several Lucene indexes. There are two main use use cases:

- A single index is so big that index update times are slowing the application down. In this case static sharding can be used to split the data into a pre-defined number of shards.
- Data is naturally segmented by customer, region, language or other application parameter and the index should be split according to these segments. This is a use case for dynamic sharding.

💡 By default sharding is not enabled.

10.5.1. Static sharding

To enable static sharding set the hibernate.search.<indexName>.sharding_strategy.nbr_of_shards property as seen in Enabling index sharding.

Example 148. Enabling index sharding

```
hibernate.search.[default|<indexName>].sharding_strategy.nbr_of_shards = 5
```

The default sharding strategy which gets enabled by setting this property, splits the data according to the hash value of the document id (generated by the FieldBridge). This ensures a fairly balanced sharding. You can replace the default strategy by implementing a custom IndexShardingStrategy. To use your custom strategy you have to set the hibernate.search.[default|<indexName>].sharding_strategy property to the fully qualified class name of your custom IndexShardingStrategy.
Example 149. Registering a custom IndexShardingStrategy

```java
hibernate.search.[default|<indexName>].sharding_strategy =
my.custom.RandomShardingStrategy
```

10.5.2. Dynamic sharding

Dynamic sharding allows you to manage the shards yourself and even create new shards on the fly. To do so you need to implement the interface ShardIdentifierProvider and set the hibernate.search.[default|<indexName>].sharding_strategy property to the fully qualified name of this class. Note that instead of implementing the interface directly, you should rather derive your implementation from org.hibernate.search.store.ShardIdentifierProviderTemplate which provides a basic implementation. Let’s look at Custom ShardIdentifierProvider for an example.
Example 150. Custom ShardIdentifierProvider

```java
public static class AnimalShardIdentifierProvider extends ShardIdentifierProviderTemplate {
    @Override
    public String getShardIdentifier(Class<? extends Animal> entityType, Serializable id, String idAsString, Document document) {
        if (entityType.equals(Animal.class)) {
            String typeValue = document.getField("type").stringValue();
            addShard(typeValue);
            return typeValue;
        }
        throw new RuntimeException("Animal expected but found " + entityType);
    }

    @Override
    protected Set<String> loadInitialShardNames(Properties properties, BuildContext buildContext) {
        ServiceManager serviceManager = buildContext.getServiceManager();
        SessionFactory sessionFactory = serviceManager.requestService(HibernateSessionFactoryService.class).getSessionFactory();
        Session session = sessionFactory.openSession();
        try {
            Criteria initialShardsCriteria = session.createCriteria(Animal.class);
            initialShardsCriteria.setProjection(Projections.distinct(Property.forName("type")));
            List<String> initialTypes = initialShardsCriteria.list();
            return new HashSet<String>(initialTypes);
        } finally {
            session.close();
        }
    }
}
```

The are several things happening in AnimalShardIdentifierProvider. First off its purpose is to create one shard per animal type (e.g. mammal, insect, etc.). It does so by inspecting the class type and the Lucene document passed to the getShardIdentifier() method. It extracts the type field from the document and uses it as shard name. getShardIdentifier() is called for every addition to the index and a new shard will be created with every new animal type encountered. The base class ShardIdentifierProviderTemplate maintains a set with all known shards to which any identifier must be added by calling addShard().

It is important to understand that Hibernate Search cannot know which shards already exist when the application starts. When using ShardIdentifierProviderTemplate as base class of a ShardIdentifierProvider implementation, the initial set of shard identifiers must be returned by the loadInitialShardNames() method. How this is done will depend on the use case. However, a common case in combination with Hibernate ORM is that the initial shard set is
defined by the distinct values of a given database column. Custom ShardIdentifierProvider shows how to handle such a case. AnimalShardIdentifierProvider makes in its loadInitialShardNames() implementation use of a service called HibernateSessionFactoryService (see also Using external services) which is available within an ORM environment. It allows to request a Hibernate SessionFactory instance which can be used to run a Criteria query in order to determine the initial set of shard identifiers.

Last but not least, the ShardIdentifierProvider also allows for optimizing searches by selecting which shard to run a query against. By activating a filter (see Using filters in a sharded environment), a sharding strategy can select a subset of the shards used to answer a query (getShardIdentifiersForQuery(), not shown in the example) and thus speed up the query execution.

This ShardIdentifierProvider is considered experimental. We might need to apply some changes to the defined method signatures to accommodate for unforeseen use cases. Please provide feedback if you have ideas, or just to let us know how you’re using this API.

10.6. Sharing indexes

It is technically possible to store the information of more than one entity into a single Lucene index. There are two ways to accomplish this:

- Configuring the underlying directory providers to point to the same physical index directory. In practice, you set the property hibernate.search.[fully qualified entity name].indexName to the same value. As an example, let’s use the same index (directory) for the Furniture and Animal entities. We just set indexName for both entities to "Animal". Both entities will then be stored in the Animal directory:

  hibernate.search.org.hibernate.search.test.shards.Furniture.indexName = Animal
  hibernate.search.org.hibernate.search.test.shards.Animal.indexName = Animal

- Setting the @Indexed annotation’s index attribute of the entities you want to merge to the same value. If we again wanted all Furniture instances to be indexed in the Animal index along with all instances of Animal we would specify @Indexed(index="Animal") on both Animal and Furniture classes.

  This is only presented here so that you know the option is available. There is really not much benefit in sharing indexes.
10.7. Using external services

A Service in Hibernate Search is a class implementing the interface `org.hibernate.search.engine.service.spi.Service` and providing a default no-arg constructor. Theoretically that's all that is needed to request a given service type from the Hibernate Search `ServiceManager`. In practice you want probably want to add some service life cycle methods (implement `Startable` and `Stoppable`) as well as actual methods providing some functionality.

Hibernate Search uses the service approach to decouple different components of the system. Let's have a closer look at services and how they are used.

10.7.1. Using a Service

Many of the pluggable contracts of Hibernate Search can use services. Services are accessible via the `BuildContext` interface as in the following example.

*Example 151. Example of a custom DirectoryProvider using a ClassLoaderService*

```java
public CustomDirectoryProvider implements DirectoryProvider<RAMDirectory> {
    private ServiceManager serviceManager;
    private ClassLoaderService classLoaderService;

    public void initialize(
        String directoryProviderName,
        Properties properties,
        BuildContext context) {
        // get a reference to the ServiceManager
        this.serviceManager = context.getServiceManager();
    }

    public void start() {
        // get the current ClassLoaderService
        classLoaderService = serviceManager.requestService(ClassLoaderService.class);
    }

    public RAMDirectory getDirectory() {
        // use the ClassLoaderService
    }

    public stop() {
        // make sure to release all services
        serviceManager.releaseService(ClassLoaderService.class);
    }
}
```

When you request a service, an instance of the requested service type is returned to you. Make sure release the service via `ServiceManager.releaseService` once you don’t need it.
anymore. Note that the service can be released in the `DirectoryProvider.stop` method if the `DirectoryProvider` uses the service during its lifetime or could be released right away if the service is only needed during initialization time.

### 10.7.2. Implementing a Service

To implement a service, you need to create an interface which identifies it and extends `org.hibernate.search.engine.service.spi.Service`. You can then add additional methods to your service interface as needed.

Naturally you will also need to provide an implementation of your service interface. This implementation must have a public no-arg constructor. Optionally your service can also implement the life cycle methods `org.hibernate.search.engine.service.spi.Startable` and/or `org.hibernate.search.engine.service.spi.Stoppable`. These methods will be called by the `ServiceManager` when the service is created respectively the last reference to a requested service is released.

Services are retrieved from the `ServiceManager.requestService` using the `Class` object of the interface you define as a key.

#### Managed services

To transparently discover services Hibernate Search uses the Java ServiceLoader mechanism. This means you need to add a service file to your jar under `/META-INF/services/` named after the fully qualified classname of your service interface. The content of the file contains the fully qualified classname of your service implementation.

*Example 152. Service file for the Infinispan CacheManagerService service*

```properties
/META-INF/services/org.infinispan.hibernate.search.spi.CacheManagerService
```

*Example 153. Content of META-INF/services/org.infinispan.hibernate.search.spi.CacheManagerService*

```properties
org.infinispan.hibernate.search.impl.DefaultCacheManagerService
```
Hibernate Search only supports a single service implementation of a given service. There is no mechanism to select between multiple versions of a service. It is an error to have multiple jars defining each a different implementation for the same service. If you want to override the implementation of an already existing service at runtime you will need to look at Provided services.

Provided services

Provided services are usually used by frameworks integrating with Hibernate Search and not by library users themselves.

As an alternative to manages services, a service can be provided by the environment bootstrapping Hibernate Search. For example, Infinispan which uses Hibernate Search as its internal search engine, passes the CacheContainer to Hibernate Search. In this case, the CacheContainer instance is not managed by Hibernate Search and the start/stop methods defined by optional Stoppable and Startable interfaces will be ignored.

A Service implementation which is only used as a Provided Service doesn’t need to have a public constructor taking no arguments.

Provided services have priority over managed services. If a provided service is registered with the same ServiceManager instance as a managed service, the provided service will be used.

The provided services are passed to Hibernate Search via the SearchConfiguration interface: as implementor of method getProvidedServices you can return a Map of all services you need to provide.

When implementing a custom org.hibernate.search.cfg.spi.SearchConfiguration we recommend you extend the base class org.hibernate.search.cfg.spi.SearchConfigurationBase: that will improve compatibility by not breaking your code when we need to add new methods to this interface.

10.8. Customizing Lucene’s scoring formula

Lucene allows the user to customize its scoring formula by extending org.apache.lucene.search.similarities.Similarity. The abstract methods defined in this class match the factors of the following formula calculating the score of query q for document d:
score(q,d) = coord(q,d) · queryNorm(q) · ∑ _t in q~ ( tf(t in d) · idf(t) · t.getBoost() · norm(t,d) )

<table>
<thead>
<tr>
<th>Factor</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>tf(t ind)</td>
<td>Term frequency factor for the term (t) in the document (d).</td>
</tr>
<tr>
<td>idf(t)</td>
<td>Inverse document frequency of the term.</td>
</tr>
<tr>
<td>coord(q,d)</td>
<td>Score factor based on how many of the query terms are found in the specified document.</td>
</tr>
<tr>
<td>queryNorm(q)</td>
<td>Normalizing factor used to make scores between queries comparable.</td>
</tr>
<tr>
<td>t.getBoost()</td>
<td>Field boost.</td>
</tr>
<tr>
<td>norm(t,d)</td>
<td>Encapsulates a few (indexing time) boost and length factors.</td>
</tr>
</tbody>
</table>

It is beyond the scope of this manual to explain this formula in more detail. Please refer to Similarity's Javadoc for more information.

Hibernate Search provides two ways to modify Lucene’s similarity calculation.

First you can set the default similarity by specifying the fully specified classname of your Similarity implementation using the property hibernate.search.similarity. The default value is org.apache.lucene.search.similarities.ClassicSimilarity.

Secondly, you can override the similarity used for a specific index by setting the similarity property for this index (see Directory configuration for more information about index configuration):

```
hibernate.search.[default|<indexname>].similarity = my.custom.Similarity
```

As an example, let’s assume it is not important how often a term appears in a document. Documents with a single occurrence of the term should be scored the same as documents with multiple occurrences. In this case your custom implementation of the method `tf(float freq)` should return 1.0.

When two entities share the same index they must declare the same Similarity implementation.

10.9. Multi-tenancy
10.9.1. What is multi-tenancy?

The term multi-tenancy in general is applied to software development to indicate an architecture in which a single running instance of an application simultaneously serves multiple clients (tenants). Isolating information (data, customizations, etc) pertaining to the various tenants is a particular challenge in these systems. This includes the data owned by each tenant stored in the database. You will find more details on how to enable multi-tenancy with Hibernate in the Hibernate ORM developer’s guide.

10.9.2. Using a tenant-aware `FullTextSession`

Hibernate Search supports multi-tenancy on top of Hibernate ORM, it stores the tenant identifier in the document and automatically filters the query results.

The `FullTextSession` will be bound to the specific tenant ("client-A" in the example) and the mass indexer will only index the entities associated to that tenant identifier.

**Example 154. Bind the session to a tenant**

```java
Session session = getSessionFactory()
    .withOptions()
    .tenantIdentifier( "client-A" )
    .openSession();

FullTextSession session = Search.getFullTextSession( session );
```

The use of a tenant identifier will have the following effects:

1. Every document saved or updated in the index will have an additional field `__HSearch_TenantId` containing the tenant identifier.
2. Every search will be filtered using the tenant identifier.
3. The MassIndexer (see Using a MassIndexer) will only affect the currently selected tenant.

Note that not using a tenant will return all the matching results for all the tenants in the index.
Chapter 11. Integration with Elasticsearch

11.1. Status

⚠️ This feature is a work in progress. Make sure to read the Limitations section!

The integration with Elasticsearch is in development and should be considered experimental. We do think we have the basics covered and we are looking for feedback.

Patches can be sent as pull requests to the Github repository, but also general feedback, suggestions and questions are very welcome. To get in touch or find other interesting links for contributors, see the Community page of the Hibernate website.

11.2. Goal of the Elasticsearch integration

The goal of integrating with Elasticsearch is to allow Hibernate Search users to benefit from the full-text capabilities integrated with Hibernate ORM but replacing the local Lucene based index with a remote Elasticsearch service.

There could be various reasons to prefer this over an "embedded Lucene" approach:

• wish to separate the service running your application from the Search service
• integrate with an existing Elasticsearch instance
• benefit from Elasticsearch’s out of the box horizontal scalability features
• explore the data updated by an Hibernate powered application using the Elasticsearch dashboard integrations such as Kibana

There are a couple of drawbacks compared to the embedded Lucene approach though:

• incur a performance penalty of remote RPCs both for index updates and to run queries
• need to manage an additional service
• possibly need to buy and manage additional servers

Which solution is best will depend on the specific needs of your system and your organization.
Why not use Elasticsearch directly

The #1 reason is that Hibernate Search integrates perfectly with Hibernate ORM. All changes done to your objects will trigger the necessary index changes transparently.

- it will honor the transaction boundary - i.e. not do the indexing work if the transaction ends up in rollback
- changes to cascaded objects are handled
- changes to nested object embedded in a root indexed entity are handled
- changes will be sent in bulk - i.e. optimized systematically for you
- etc.

There is no more paradigm shift in your code. You are working on Hibernate ORM managed objects, doing your queries on object properties with a nice DSL.

11.3. Getting started and configuration

To experiment with the Elasticsearch integration you will have to download Elasticsearch and run it: Hibernate Search connects to an Elasticsearch node but does not provide one.

One option is to use the Elasticsearch Docker image.

Start an Elasticsearch node via Docker

docker pull elasticsearch
docker run -p 9200:9200 -d -v "$PWD/plugin_dir":/usr/share/elasticsearch/plugins 
-v "$PWD/config/elasticsearch.yml":/usr/share/elasticsearch/config/elasticsearch.yml 
elasticsearch

Elasticsearch version

Hibernate Search expects an Elasticsearch node version 2.0 at least. 5.0 is not supported yet. Hibernate Search internal tests run against Elasticsearch 2.4.4.

11.3.1. Dependencies in your Java application

In addition to the usual dependencies like Hibernate ORM and Hibernate Search, you will need
the new hibernate-search-elasticsearch jar.

Example 155. Maven dependencies for Hibernate Search with Elasticsearch

```xml
<dependency>
    <groupId>org.hibernate</groupId>
    <artifactId>hibernate-search-elasticsearch</artifactId>
    <version>5.7.3.Final</version>
</dependency>
```

11.3.2. Elasticsearch configuration

Hibernate Search can work with an Elasticsearch server without altering its configuration. However some features offered by Hibernate Search require specific configuration:

- if you want to be able to use the Hibernate Search MassIndexer with purgeAllOnStart enabled - which is enabled by default -, or to use FullTextSession.purge() or FullTextSession.purgeAll(), install the delete-by-query plugin
- if you want to retrieve the distance in a geolocation query, enable the lang-groovy plugin, see Elasticsearch Spatial queries
- if you want to use paging (as opposed to scrolling) on result sets larger than 10000 elements (for instance access the 10001st result), you may increase the value of the index.max_result_window property (default is 10000).

11.3.3. Hibernate Search configuration

Configuration is minimal. Add the configuration properties to your persistence.xml or where you put the rest of your Hibernate Search configuration.

Select Elasticsearch as the backend

```xml
hibernate.search.default.indexmanager elasticsearch
```

Hostname and port for Elasticsearch

```xml
hibernate.search.default.elasticsearch.host http://127.0.0.1:9200
```

(default)

You may also select multiple hosts (separated by whitespace characters), so that they are assigned requests in turns (load balancing):

```xml
hibernate.search.default.elasticsearch.host
```
In the example above, the first request will go to \texttt{es1}, the second to \texttt{es2}, the third to \texttt{es1}, and so on.

**Username for Elasticsearch connection**

\texttt{hibernate.search.default.elasticsearch.username} \texttt{ironman} (default is empty, meaning anonymous access)

**Password for Elasticsearch connection**

\texttt{hibernate.search.default.elasticsearch.password} \texttt{j@rVIs} (default is empty)

If you used HTTP instead of HTTPS in any of the Elasticsearch host URLs (see above), your password will be transmitted in clear text over the network.

**Select the index creation strategy**

\texttt{hibernate.search.default.elasticsearch.index_schema_management_strategy} \texttt{CREATE} (default)

Let’s see the options for the \texttt{index_schema_management_strategy} property:

<table>
<thead>
<tr>
<th>Value</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>\texttt{NONE}</td>
<td>The index, its mappings and the analyzer definitions will not be created, deleted nor altered. Hibernate Search will <strong>not even check</strong> that the index already exists.</td>
</tr>
<tr>
<td>\texttt{VALIDATE}</td>
<td>The index, its mappings and analyzer definitions will be checked for conflicts with Hibernate Search’s metamodel. The index, its mappings and analyzer definitions will not be created, deleted nor altered.</td>
</tr>
<tr>
<td>\texttt{MERGE}</td>
<td>The index, its mappings and analyzer definitions will be created, existing mappings will be updated if there are no conflicts. + Caution: if analyzer definitions have to be updated, the index will be closed automatically during the update.</td>
</tr>
<tr>
<td>\texttt{CREATE}</td>
<td><strong>The default</strong>: an existing index will not be altered, a missing index will be created along with their mappings and analyzer definitions.</td>
</tr>
<tr>
<td>\texttt{RECREATE}</td>
<td>Indexes will be deleted if existing and then created along with their mappings and analyzer definitions. This will delete all content from the indexes!</td>
</tr>
<tr>
<td>\texttt{RECREATE_DELETE}</td>
<td>Similarly to \texttt{RECREATE} but will also delete the index at shutdown. Commonly used for tests.</td>
</tr>
</tbody>
</table>
Strategies in production environments

It is strongly recommended to use either NONE or VALIDATE in a production environment. RECREATE and RECREATE_DELETE are obviously unsuitable in this context (unless you want to reindex everything upon every startup), and MERGE may leave your mapping half-merged in case of conflict.

To be precise, if your mapping changed in an incompatible way, such as a field having its type changed, merging may be impossible. In this case, the MERGE strategy will prevent Hibernate Search from starting, but it may already have successfully merged another index, making a rollback difficult at best.

Also, when updating analyzer definitions, Hibernate Search will stop the affected indexes during the update. This means the MERGE strategy should be used with caution when multiple clients use Elasticsearch indexes managed by Hibernate Search: those clients should be synchronized in such a way that while Hibernate Search is starting, no other client tries to use the index.

For these reasons, migrating your mapping should be considered a part of your deployment process and be planned cautiously.

Mapping validation is as permissive as possible. Fields or mappings that are unknown to Hibernate Search will be ignored, and settings that are more powerful than required (e.g. a field annotated with @Field(index = Index.NO) in Search but marked as "index": analyzed in Elasticsearch) will be deemed valid.

One exception should be noted, though: date formats must match exactly the formats specified by Hibernate Search, due to implementation constraints.

Maximum time to wait for a connection to the Elasticsearch server before failing (in ms)

hibernate.search.default.elasticsearch.connection_timeout 3000 (default)

Maximum time to wait for a response from the Elasticsearch server before failing (in ms)

hibernate.search.default.elasticsearch.read_timeout 60000 (default)

Maximum number of simultaneous connections to the Elasticsearch cluster

hibernate.search.default.elasticsearch.max_total_connection 20 (default)

Maximum number of simultaneous connections to a single Elasticsearch server
Whether to enable automatic discovery of servers in the Elasticsearch cluster (true or false)
hibernate.search.default.elasticsearch.discovery.enabled false (default)

Whether to perform an explicit refresh after a set of operations has been executed against a specific index (true or false)
hibernate.search.default.elasticsearch.refresh_after_write false (default)

Status an index must at least have in order for Hibernate Search to work with it (one of "green", "yellow" or "red")
hibernate.search.default.elasticsearch.required_index_status green (default)

Maximum time to wait for the indexes to become available before failing (in ms)
hibernate.search.default.elasticsearch.index_management_wait_timeout 10000 (default)

Time interval between two executions of the automatic discovery (in seconds)
hibernate.search.default.elasticsearch.discovery.refresh_interval 10 (default)

Whether to enable automatic discovery of servers in the Elasticsearch cluster (true or false)
This is useful in unit tests to ensure that a write is visible by a query immediately without delay. This keeps unit tests simpler and faster. But you should not rely on the synchronous behaviour for your production code. Leave at `false` for optimal performance of your Elasticsearch cluster.

*When scrolling, the minimum number of previous results kept in memory at any time*

```
hibernate.search.elasticsearch.scroll_backtracking_window_size 10000
```

(default)

*When scrolling, the number of results fetched by each Elasticsearch call*

```
hibernate.search.elasticsearch.scroll_fetch_size 1000
```

(default)

*When scrolling, the maximum duration `ScrollableResults` will be usable if no other results are fetched from Elasticsearch, in seconds*

```
hibernate.search.elasticsearch.scroll_timeout 60
```

(default)

Properties prefixed with `hibernate.search.default` can be given globally as shown above and/or be given for specific indexes:

```
hibernate.search.someindex.elasticsearch.index_schema_management_strategy MERGE
```

This excludes properties related to the internal Elasticsearch client, which at the moment is common to every index manager (but this will change in a future version). Excluded properties are `host`, `username`, `password`, `read_timeout`, `connection_timeout`, `max_total_connection`, `max_total_connection_per_route`, `discovery.enabled`, `discovery.refresh_interval` and `discovery.scheme`.

### 11.4. Mapping and indexing

Like in Lucene embedded mode, indexes are transparently updated when you create or update entities mapped to Hibernate Search. Simply use familiar annotations from Mapping entities to the index structure.

The name of the index will be the lowercased name provided to `@Indexed` (non qualified class name by default). Hibernate Search will map the fully qualified class name to the Elasticsearch type.

#### 11.4.1. Annotation specificities
Field.indexNullAs

The org.hibernate.search.annotations.Field annotation allows you to provide a replacement value for null properties through the indexNullAs attribute (see @Field), but this value must be provided as a string.

In order for your value to be understood by Hibernate Search (and Elasticsearch), the provided string must follow one of those formats:

- For string values, no particular format is required.
- For numeric values, use formats accepted by Double.parseDouble, Integer.parseInt, etc., depending on the actual type of your field.
- For booleans, use either true or false.
- For dates (java.util.Calendar, java.util.Date, java.time.*), use the ISO-8601 format.

The full format is yyyy-MM-dd'T'HH:mm:ss.nZ[ZZZ] (for instance 2016-11-26T16:41:00.006+01:00[CET]). Please keep in mind that part of this format must be left out depending on the type of your field, though. For a java.time.LocalDateTime field, for instance, the provided string must not include the zone offset (+01:00) or the zone ID ([UTC]), because those don’t make sense.

Even when they make sense for the type of your field, the time and time zone may be omitted (if omitted, the time zone will be interpreted as the default JVM time zone).

Dynamic boosting

The org.hibernate.search.annotations.DynamicBoost annotation is not (and cannot be) supported with Elasticsearch, because the platform lacks per-document, index-time boosting capabilities. Static boosts (@Boost) are, however, supported.

11.4.2. Analyzers

Analyzers are treated differently than in Lucene embedded mode.

Built-in or server-defined analyzers

Using the definition attribute in the @Analyzer annotation, you can refer to the name of the built-in Elasticsearch analyzer, or custom analyzers already registered on your Elasticsearch instances.

More information on analyzers, in particular those already built in Elasticsearch, can be found in the Elasticsearch documentation.
Example of custom analyzers defined in the elasticsearch.yml

```
# Custom analyzer
index.analysis:
analyzer.custom-analyzer:
  type: custom
tokenizer: standard
filter: [custom-filter, lowercase]
filter.custom-filter:
  type: stop
  stopwords : [test1, close]
```

From there, you can use the custom analyzers by name in your entity mappings.

*Example of mapping that refers to custom and built-in analyzers on Elasticsearch*

```
@Entity
@Indexed(index = "tweet")
public class Tweet {

  @Id
  @GeneratedValue
  private Integer id;

  @Field
  @Analyzer(definition = "english") // Elasticsearch built-in analyzer
  private String englishTweet;

  @Field
  @Analyzer(definition = "whitespace") // Elasticsearch built-in analyzer
  private String whitespaceTweet;

  @Field(name = "tweetNotAnalyzed", analyzer = Analyze.NO, store = Store.YES)
  // Custom analyzer:
  @Field(
    name = "tweetWithCustom",
    analyzer = @Analyzer(definition = "custom-analyzer")
  )
  private String multipleTweets;
}
```

You may also reference a built-in Lucene analyzer implementation using the `@Analyzer.impl` attribute: Hibernate Search will translate the implementation to an equivalent Elasticsearch built-in type, if possible.
Using the `@Analyzer.impl` attribute is not recommended with Elasticsearch because it will never allow you to take full advantage of Elasticsearch analysis capabilities. You cannot, for instance, use custom analyzer implementations: only built-in Lucene implementations are supported.

It should only be used when migrating an application that already used Hibernate Search, moving from an embedded Lucene instance to an Elasticsearch cluster.

**Example of mapping that refers to a built-in analyzer on Elasticsearch using a Lucene implementation class**

```java
@Entity
@Indexed(index = "tweet")
public class Tweet {

    @Id
    @GeneratedValue
    private Integer id;

    @Field
    @Analyzer(impl = EnglishAnalyzer.class) // Elasticsearch built-in "english" analyzer
    private String englishTweet;

    @Field
    @Analyzer(impl = WhitespaceAnalyzer.class) // Elasticsearch built-in "whitespace" analyzer
    private String whitespaceTweet;
}
```

**Custom analyzers**

You can also define analyzers within your Hibernate Search mapping using the `@AnalyzerDef` annotation, like you would do with an embedded Lucene instance. When Hibernate Search creates the Elasticsearch indexes, the relevant definitions will then be automatically added as a custom analyzer in the index settings.

Two different approaches allow you to define your analyzers with Elasticsearch.

The first, recommended approach is to use the factories provided by the `hibernate-search-elasticsearch` module:

- `org.hibernate.search.elasticsearch.analyzer.ElasticsearchCharFilterFactory`
- `org.hibernate.search.elasticsearch.analyzer.ElasticsearchTokenFilterFactory`
• `org.hibernate.search.elasticsearch.analyzer.ElasticsearchTokenizerFactory`

Those classes can be passed to the `factory` attribute of the `@CharFilterDef`, `@TokenFilterDef` and `@TokenizerDef` annotations.

The `params` attribute may be used to define the `type` parameter and any other parameter accepted by Elasticsearch for this type.

The parameter values will be interpreted as JSON. The parser is not strict, though:

• quotes around strings may be left out in some cases, as when a string only contains letters.
• when quotes are required (e.g. your string may be interpreted as a number, and you don’t want that), you may use single quotes instead of double quotes (which are painful to write in Java).

You may use the `name` attribute of the `@CharFilterDef`, `@TokenFilterDef` and `@TokenizerDef` annotations to define the exact name to give to that definition in the Elasticsearch settings.
Example of mapping that defines analyzers on Elasticsearch using the Elasticsearch*Factory types

```java
@Entity
@Indexed(index = "tweet")
@AnalyzerDef(
    name = "tweet_analyzer",
    charFilters = {
        @CharFilterDef(
            name = "custom_html_strip",
            factory = ElasticsearchCharFilterFactory.class,
            params = {
                @Parameter(name = "type", value = "html_strip"),
                // One can use Json arrays
                @Parameter(name = "escaped_tags", value = "['br', 'p']")
            }
        ),
        @CharFilterDef(
            name = "p_br_as_space",
            factory = ElasticsearchCharFilterFactory.class,
            params = {
                @Parameter(name = "type", value = "pattern_replace"),
                @Parameter(name = "pattern", value = "\p{p}\|\p{br}\")",
                @Parameter(name = "replacement", value = "' '"),
                @Parameter(name = "tags", value = "CASE_INSENSITIVE")
            }
        )
    },
    tokenizer = @TokenizerDef(
        factory = ElasticsearchTokenizerFactory.class,
        params = {
            @Parameter(name = "type", value = "whitespace")
        })
)

public class Tweet {
    @Id
    @GeneratedValue
    private Integer id;

    @Field
    @Analyzer(definition = "tweet_analyzer")
    private String content;
}
```

The second approach is to configure everything as if you were using Lucene: use the Lucene factories, their parameter names, and format the parameter values as required in Lucene. Hibernate Search will automatically convert these definitions to the Elasticsearch equivalent.
Referencing Lucene factories is not recommended with Elasticsearch because it will never allow you to take full advantage of Elasticsearch analysis capabilities.

Here are the known limitations of the automatic translation:

- a few factories have unsupported parameters, because those have no equivalent in Elasticsearch. An exception will be raised on startup if a parameter is not supported.

- the **hyphenator** parameter for *HyphenatedWordsFilterFactory* must refer to a file on the Elasticsearch servers, on the contrary to other factories where the files are accessed by Hibernate Search directly. This is due to an Elasticsearch limitation (there is no way to forward the content of a local hyphenation pattern file).

- some built-in Lucene factories are not (and cannot) be translated, because of incompatible parameters between the Lucene factory and the Elasticsearch equivalent. This is in particular the case for *HunspellStemFilterFactory*.

Therefore, Lucene factories should only be referenced within analyzer definitions when migrating an application that already used Hibernate Search, moving from an embedded Lucene instance to an Elasticsearch cluster.
**Example of mapping that defines analyzers on Elasticsearch using Lucene factories**

```java
@Entity
@Indexed(index = "tweet")
@AnalyzerDef(
    name = "tweet_analyzer",
    charFilters = {
        @CharFilterDef(
            name = "custom_html_strip",
            factory = HTMLStripCharFilterFactory.class,
            params = {
                @Parameter(name = "escapedTags", value = "br,p")
            }
        ),
        @CharFilterDef(
            name = "p_br_as_space",
            factory = PatternReplaceCharFilterFactory.class,
            params = {
                @Parameter(name = "pattern", value = "<p/>|<br/>")
            }
        )
    },
    tokenizer = @TokenizerDef(
        factory = WhitespaceTokenizerFactory.class
    )
)

public class Tweet {

    @Id
    @GeneratedValue
    private Integer id;

    @Field
    @Analyzer(definition = "tweet_analyzer")
    private String content;
}
```

### 11.4.3. Custom field bridges

You can write custom field bridges and class bridges. For class bridges and field bridges creating multiple fields, make sure to make your bridge implementation also implement the `MetadataProvidingFieldBridge` contract.
Creating sub-fields in custom field bridges is not supported.

You create a sub-field when your `MetadataProvidingFieldBridge` registers a field whose name is the name of an existing field, with a dot and another string appended, like `name + ".mySubField"`.

This lack of support is due to Elasticsearch not allowing a field to have multiple types. In the example above, the field would have both the `object` datatype and whatever datatype the original field has (`string` in the most common case).

As an alternative, you may append a suffix to the original field name in order to create a sibling field, e.g. use `name + "_mySubField"` or `name + "_more.mySubField"` instead of `name + ".mySubField"`.

This limitation is true in particular for field bridges applied to the `@DocumentId`: fields added to the document must not be in the form `name + ".mySubField"`, in order to avoid mapping conflicts with the ID field.
/**
 * Used as class-level bridge for creating the "firstName" and "middleName"
document and doc value fields.
 */
public static class FirstAndMiddleNamesFieldBridge implements
MetadataProvidingFieldBridge {
    @Override
    public void set(String name, Object value, Document document,
                     LuceneOptions luceneOptions) {
        Explorer explorer = (Explorer) value;
        String firstName = explorer.getNameParts().get("firstName");
        luceneOptions.addFieldToDocument( name + "_firstName", firstName,
                                           document );
        document.add( new SortedDocValuesField( name + "_firstName", new
                                                  BytesRef( firstName ) ) );
        String middleName = explorer.getNameParts().get("middleName");
        luceneOptions.addFieldToDocument( name + "_middleName", middleName,
                                           document );
        document.add( new SortedDocValuesField( name + "_middleName", new
                                                  BytesRef( middleName ) ) );
    }
    @Override
    public void configureFieldMetadata(String name, FieldMetadataBuilder builder) {
        builder
            .field( name + "_firstName", FieldType.STRING )
                .sortable( true )
            .field( name + "_middleName", FieldType.STRING )
                .sortable( true );
    }
}

This interface and FieldBridge in general are likely going to evolve in the
next major version of Hibernate Search to remove its adherence to Lucene
specific classes like Document.

11.4.4. Tika bridges

If your metadata processors create fields with a different name from the one passed as a
parameter, make sure to make your processor also implement the
MetadataProvidingTikaMetadataProcessor contract.

11.5. Queries

You can write queries like you usually do in Hibernate Search: native Lucene queries and DSL
queries (see Querying). We do automatically translate the most common types of Apache
Lucene queries and all queries generated by the Hibernate Search DSL except more like this
Unsupported Query DSL features

Queries written via the DSL work. Open a JIRA otherwise.

The notable exception is more like this queries. Hibernate Search has a more advanced algorithm than Lucene (or Elasticsearch/Solr) which is not easily portable with what Elasticsearch exposes.

If you need this feature, contact us.

On top of translating Lucene queries, you can directly create Elasticsearch queries by using either its String format or a JSON format:

Example 156. Creating an Elasticsearch native query from a string

```java
FullTextSession fullTextSession = Search.getFullTextSession(session);
QueryDescriptor query = ElasticsearchQueries.fromString("title:tales");
List<?> result = fullTextSession.createFullTextQuery(query, ComicBook.class).list();
```

Example 157. Creating an Elasticsearch native query from JSON

```java
FullTextSession fullTextSession = Search.getFullTextSession(session);
QueryDescriptor query = ElasticsearchQueries.fromJson("{"query": { "match": { "lastName": "Brand" } } }");
List<?> result = session.createFullTextQuery(query, GolfPlayer.class).list();
```

Date/time in native Elasticsearch queries

By default Elasticsearch interprets the date/time strings lacking the time zone as if they were represented using the UTC time zone. If overlooked, this can cause your native Elasticsearch queries to be completely off.

The simplest way to avoid issues is to always explicitly provide time zones IDs or offsets when building native Elasticsearch queries. This may be achieved either by directly adding the time zone ID or offset in date strings, or by using the `time_zone` parameter (range queries only). See Elasticsearch documentation for more information.
11.5.1. Spatial queries

The Elasticsearch integration supports spatial queries by using either the DSL or native Elasticsearch queries.

For regular usage, there are no particular requirements for spatial support.

However, if you want to calculate the distance from your entities to a point without sorting by the distance to this point, you need to enable the Groovy plugin by adding the following snippet to your Elasticsearch configuration:

**Enabling Groovy support in your elasticsearch.yml**

```yaml
script.engine.groovy.inline.search: on
```

11.5.2. Paging and scrolling

You may handle large result sets in two different ways, with different limitations.

For (relatively) smaller result sets, you may use the traditional offset/limit querying provided by the `FullTextQuery` interfaces: `setFirstResult(int)` and `setMaxResults(int)`. Limitations:

- This will only get you as far as the 10000 first documents, i.e. when requesting a window that includes documents beyond the 10000th result, Elasticsearch will return an error. If you want to raise this limit, see the `index.max_result_window` property in Elasticsearch’s settings.

If your result set is bigger, you may take advantage of scrolling by using the `scroll` method on `org.hibernate.search.FullTextQuery`. Limitations:

- This method is not available in `org.hibernate.search.jpa.FullTextQuery`.
- The Elasticsearch implementation has poor performance when an offset has been defined (i.e. `setFirstResult(int)` has been called on the query before calling `scroll()`). This is because Elasticsearch does not provide such feature, thus Hibernate Search has to scroll through every previous result under the hood.
- The Elasticsearch implementation allows only limited backtracking. Calling `scrollableResults.setRowNumber(4)` when currently positioned at index 1006, for example, may result in a `SearchException` being thrown, because only 1000 previous elements had been kept in memory. You may work this around by tweaking the property: `hibernate.search.elasticsearch.scroll_backtracking_window_size` (see Elasticsearch integration configuration).
- The `ScrollableResults` will become stale and unusable after a given period of time spent without fetching results from Elasticsearch. You may work this around by tweaking two
properties: `hibernate.search.elasticsearch.scroll_timeout` and `hibernate.search.elasticsearch.scroll_fetch_size` (see Elasticsearch integration configuration). Typically, you will solve timeout issues by reducing the fetch size and/or increasing the timeout limit, but this will also increase the performance hit on Elasticsearch.

11.5.3. Sorting

Sorting is performed the same way as with the Lucene backend.

If you happen to need an advanced Elasticsearch sorting feature that is not natively supported in `SortField` or in Hibernate Search sort DSL, you may still create a sort from JSON, and even mix it with DSL-defined sorts:

*Example 158. Mixing DSL-defined sorts with native Elasticsearch JSON sorts*

```java
QueryBuilder qb = fullTextSession.getSearchFactory().
    .buildQueryBuilder().forEntity(Book.class).get();
Query luceneQuery = /* ... */;
FullTextQuery query = s.createFullTextQuery( luceneQuery, Book.class );
Sort sort = qb.sort()
    .byNative( "authors.name", "{\'order":"asc\', \'mode":"min\'}" )
    .andByField("title")
    .createSort();
query.setSort(sort);
List results = query.list();
```

11.5.4. Projections

All fields are stored by Elasticsearch in the JSON document it indexes, there is no specific need to mark fields as stored when you want to project them. The downside is that to project a field, Elasticsearch needs to read the whole JSON document. If you want to avoid that, use the `Store.YES` marker.

You can also retrieve the full JSON document by using `org.hibernate.search.elasticsearch.ElasticsearchProjectionConstants.SOURCE`.
query = ftm.createFullTextQuery(
  qb.keyword()
  .onField( "tags" )
  .matching( "round-based" )
  .createQuery(),
  VideoGame.class
)
  .setProjection( ElasticsearchProjectionConstants.SCORE,
  ElasticsearchProjectionConstants.SOURCE );
projection = (Object[]) query.getSingleResult();

If you're looking for information about execution time, you may also use org.hibernate.search.elasticsearch.ElasticsearchProjectionConstants.TOOK and org.hibernate.search.elasticsearch.ElasticsearchProjectionConstants.TIMED_OUT:

query = ftm.createFullTextQuery(
  qb.keyword()
  .onField( "tags" )
  .matching( "round-based" )
  .createQuery(),
  VideoGame.class
)
  .setProjection(
    ElasticsearchProjectionConstants.SOURCE,
    ElasticsearchProjectionConstants.TOOK,
    ElasticsearchProjectionConstants.TIMED_OUT
  );
projection = (Object[]) query.getSingleResult();
Integer took = (Integer) projection[1]; // Execution time (milliseconds)
Boolean timedOut = (Boolean) projection[2]; // Whether the query timed out

11.5.5. Filters

The Elasticsearch integration supports the definition of full text filters.

Your filters need to implement the ElasticsearchFilter interface.
public class DriversMatchingNameElasticsearchFilter implements ElasticsearchFilter {
    private String name;
    public DriversMatchingNameElasticsearchFilter() {
    }
    public void setName(String name) {
        this.name = name;
    }
    @Override
    public String getJsonFilter() {
        return "{ 'term': { 'name': ' + name + ' } }";
    }
}

You can then declare the filter in your entity.

@Entity
@Indexed
@FullTextFilterDef(name = "namedDriver",
    impl = DriversMatchingNameElasticsearchFilter.class)
public class Driver {
    @Id
    @DocumentId
    private int id;

    @Field(analyze = Analyze.YES)
    private String name;
    ...
}

From then you can use it as usual.

ftQuery.enableFullTextFilter( "namedDriver" ).setParameter( "name", "liz" );

For static filters, you can simply extend the SimpleElasticsearchFilter and provide an Elasticsearch filter in JSON form.

11.6. Index optimization

The optimization features documented in Index Optimization are only partially implemented. That kind of optimization is rarely needed with recent versions of Lucene (on which Elasticsearch is based), but some of it is still provided for the very specific case of indexes meant to stay read-only for a long period of time:
• The automatic optimization is not implemented and most probably never will be.
• The manual optimization (searchFactory.optimize()) is implemented.

11.7. Limitations

Not everything is implemented yet. Here is a list of known limitations.

Please check with JIRA and the mailing lists for updates, but at the time of writing this at least the following features are known to not work yet:

• Query timeouts: HSEARCH-2399
• MoreLikeThis queries: HSEARCH-2395
• @IndexedEmbedded.indexNullAs: HSEARCH-2389
• Statistics: HSEARCH-2421
• @AnalyzerDiscriminator: HSEARCH-2428
• Mixing Lucene based indexes and Elasticsearch based indexes (partial support is here though)
• Hibernate Search does not make use of nested objects nor parent child relationship mapping HSEARCH-2263. This is largely mitigated by the fact that Hibernate Search does the denormalization itself and maintain data consistency when nested objects are updated.
• There is room for improvements in the performances of the MassIndexer implementation
• There is no failover to the next host when multiple hosts are configured and one host happens to fail: HSEARCH-2469
• Our new Elasticsearch integration module does not work in OSGi environments. If you need this, please vote for: HSEARCH-2524.

11.8. Known bugs in Elasticsearch

Depending on the Elasticsearch version you use, you may encounter bugs that are specific to that version. Here is a list of known Elasticsearch bugs, and what to do about it.

• Mapping java.time.ZonedDateTime won’t work with Elasticsearch 2.4.1 because of a JodaTime bug affecting Elasticsearch: HSEARCH-2414.

  Fix: Upgrade to Elasticsearch 2.4.2.
11.9. Acknowledgment

More information about Elasticsearch can be found on the Elasticsearch website and its reference documentation.

Hibernate Search uses Jest to communicate with Elasticsearch.
Chapter 12. Further reading

Last but not least, a few pointers to further information. We highly recommend you to get a copy of Hibernate Search in Action. This excellent book covers Hibernate Search in much more depth than this online documentation can and has a great range of additional examples. If you want to increase your knowledge of Lucene we recommend Lucene in Action (Second Edition).

Because Hibernate Search’s functionality is tightly coupled to Hibernate ORM it is a good idea to understand Hibernate. Start with the online documentation or get hold of a copy of Java Persistence with Hibernate, Second Edition.

If you have any further questions regarding Hibernate Search or want to share some of your use cases have a look at the Hibernate Search Wiki and the Hibernate Search Forum. We are looking forward hearing from you.

In case you would like to report a bug use the Hibernate Search JIRA instance. Feedback is always welcome!