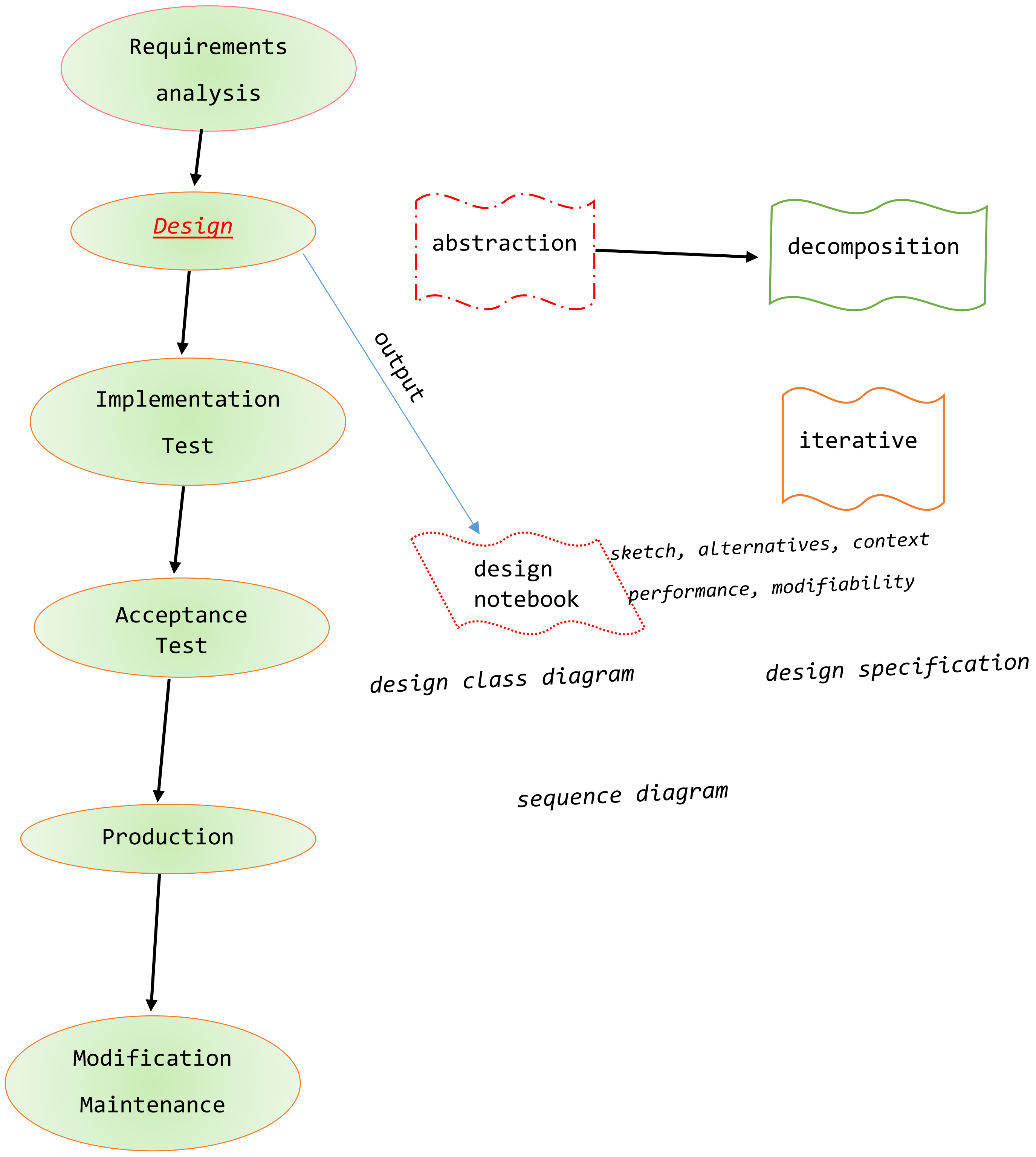
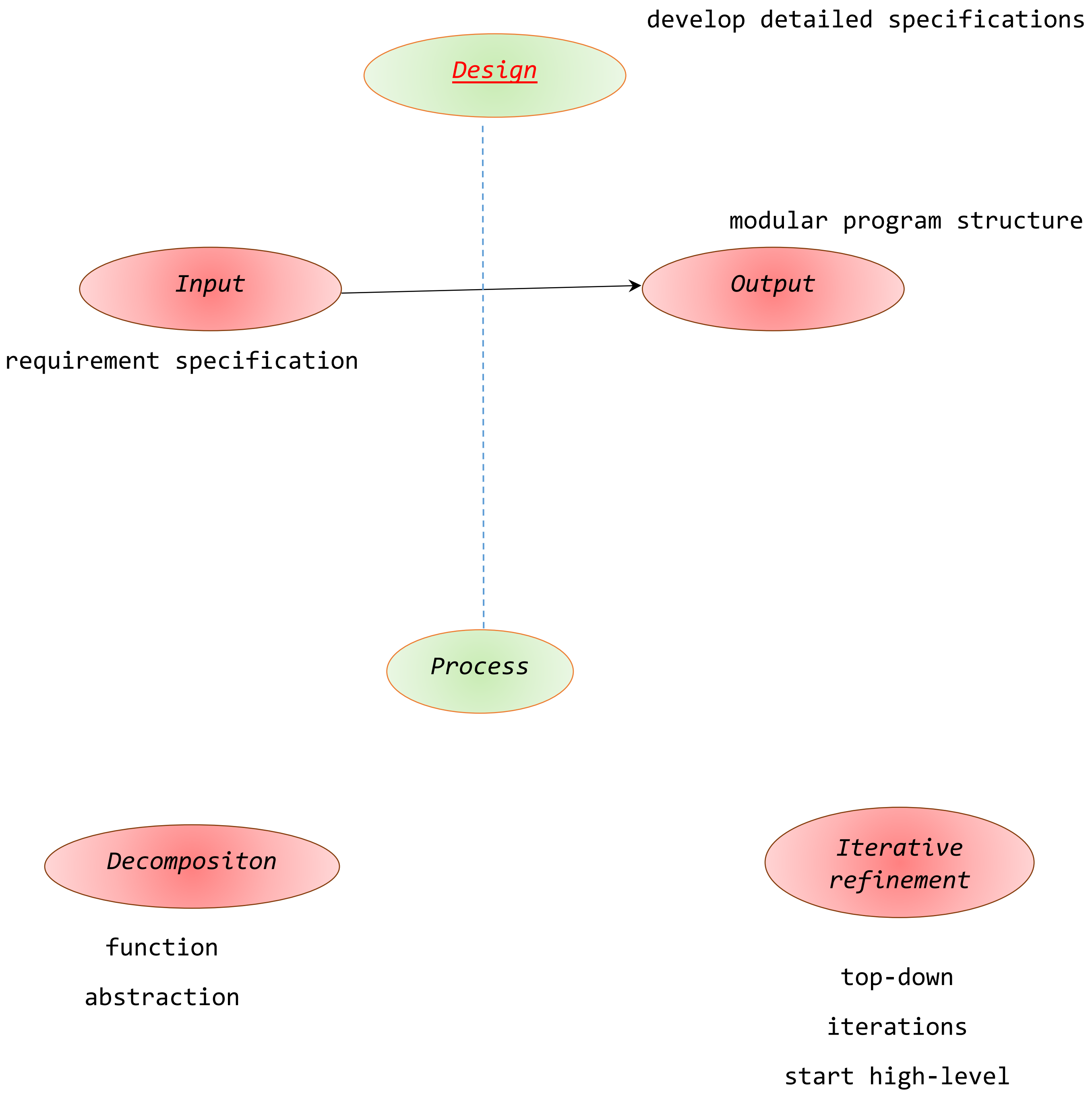
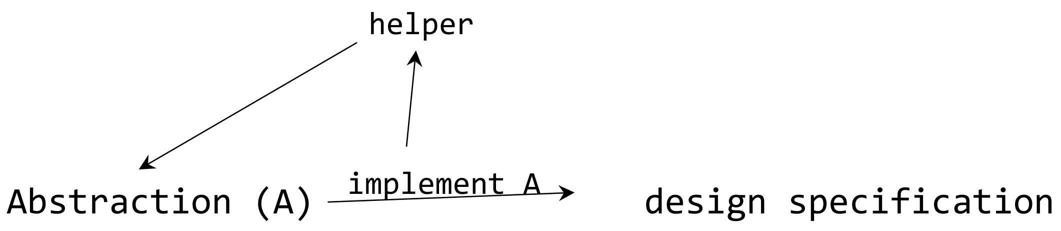
Development Process




develop detailed specifications
Design
modular program structure
Input
Output
requirement specification
Process
Decompositon
function
abstraction
Iterative refinement
top-down
iterations
start high-level

Iterative steps



Iteration 0: initial abstractions

requirements specification: @checks, @effects

construct initial design class diagram association with *dependency* indicators

1: top-level abstractions

analyse design spec. of each initial abstraction → new abstractions

Design class diagram (UML)

concept class diagram : less *refined*

module dependency diagram: less detailed

software classes

↑

domain classes: representation + operations

Word, Keyword, NonKeyword → String

Build ← concept class diagram / not (scratch) initial abstractions of KEngine

```
//startEngine

/**

@overview represents keyword search engines

An engine holds a mutable collection of documents – obtained from some
given URLs

The engine is able to pocess keyword query -> search for documents –
contain keywords


The matching documents are ranked based on frequencies of keywords
found in them

The engine has private file – contain list of uninteresting words

*/

class Engine {

      // need an abstraction -> represent the engine

      ➔ creates abstraction Engine


      /**
      * @effects

      *     If uninteresting words not retrievable

      *           throws NotPossibleException

      *     else

      *           creates NonKeyword

      *           initialises app. state appropriately

      */

      Engine() throws NotPossibleException
```

```
// query
/**
* @checks  w not in NonKeyword
* @effects
*     Sets Keyword = {w}
*     makes Match – contain documents match w, ordered as required
*
*/
query(String w)
// need an abstraction → hold a keyword + store matches
// Keyword, NonKeyword: String
     /**
     * @effects
     *     If WORD(w) = false or w in NonKeyword
     *          throws NotPossibleException
     *     else
     *          sets Keyword = {w}
     *          performs new query
     *          returns result
     */
     Query queryFirst(String w) throws NotPossibleException
```

```
// queryMore

/**
* @checks  Key != {}

*          w not in Keyword & NonKeyword

* @effects

*     adds w → Keyword

*     makes Match – documents already in Match – additionaly match
*     w   (see above)

*     Orders Match properly.

*/

queryMore(String w)

// need an abstraction → hold keywords + store matches

//          → creates abstraction Query

// Keyword, NonKeyword: String

      /**
      * @effects

      * If WORD(w) = false or w in Keyword/ NonKeyword or Key = {}

      *     throws NotPossibleException

      * else

      *     adds w to Keyword

      *     returns query result

      */

      Query queryMore(String w) throws NotPossibleException
```

```
// findDoc
     /**
     * @checks  t is in titles
     * @effects
     *     return d in Document s.t d’s title = t
     *
     */
     findDoc(String t)
     // needs an abstraction → represent Document
     //         → uses abstraction Doc
          /**
          * @effects
          *     If t not in Title
          *           throws NotPossibleException
          *     else
          *           returns document with title t
          */
          Doc findDoc(String t) throws NotPossibleException
```

```
// addDocuments
    /**
    * @checks  u does not name a site in URL
    *          u names a site – provide documents
    * @effects
    *     adds u → URL
    *     adds documents at site u with new titles to Document.
    *     If Keyword – non-empty
    *          adds any documents – match keywords - Match
    */
    addDocuments(String u)
    // need an abstraction → represent Document
    ➔ creates abstraction Doc
         /**
         * @effects
         *  If u not a URL for a site – contain documents or u in URL
         *         throws NotPossibleException
         *  else
         *         adds new documents → Doc
         *                 If no query was in progress
         *                       returns empty query result
         *                 else
         *                       returns query result – include any new
         *matching documents
        */
         Query addDocs(String u) throws NotPossibleException


    // end Engine
```

```
/**
* @overview
*  A textual document – contain a title + some text contents
*/
class Doc     {

}       // end Doc




/**
* @overview
*  A query – consist of keywords - interest
*/
class Query   {

}
```

Top-level data abstractions

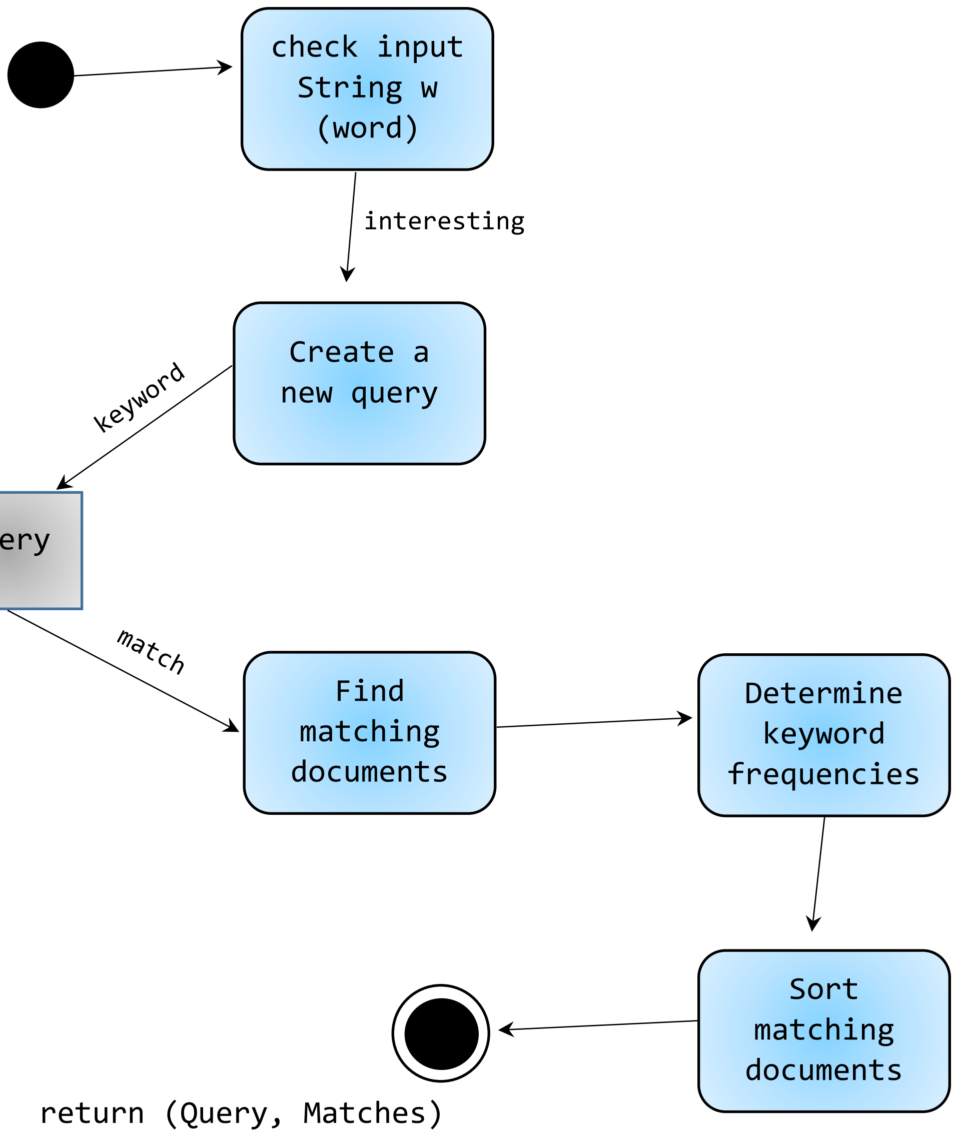
find all top-level abstraction

decomposition

sub-tasks: most significant ones first

Engine.queryFirst

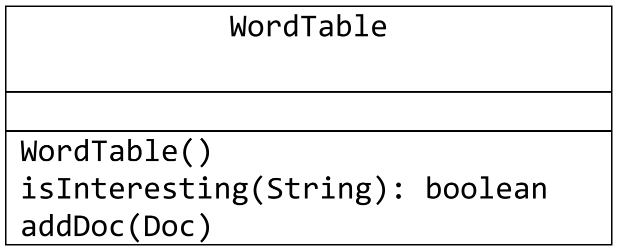
Activity diagram



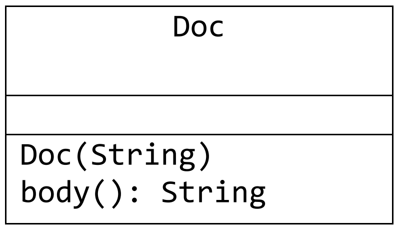
record interesting + uninteresting words in same abstraction (WordTable)

WordTable

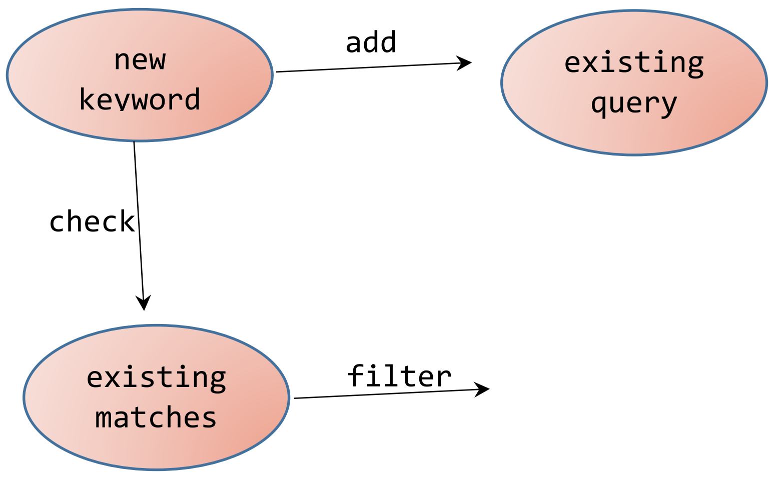
- iteration abstraction
- store words
- check + maintain words set



Doc

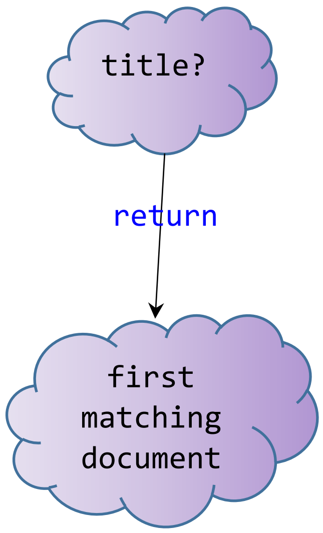


Engine.queryMore

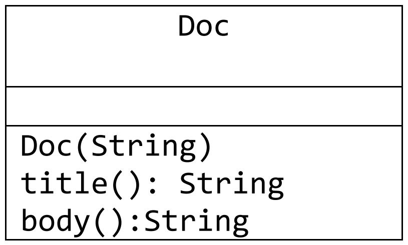


```
                    Query
--------------------------------------------
--------------------------------------------
Query(WordTable, String)
keys(): String[]     // observe keywords
size(): int      // retrieve match
fetch(int): Doc
addKey(String)
```

Engine.findDoc



record documents + titles in *Title Table*

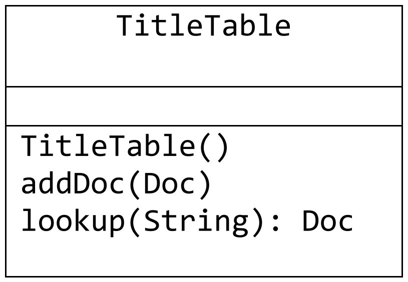


TitleTable

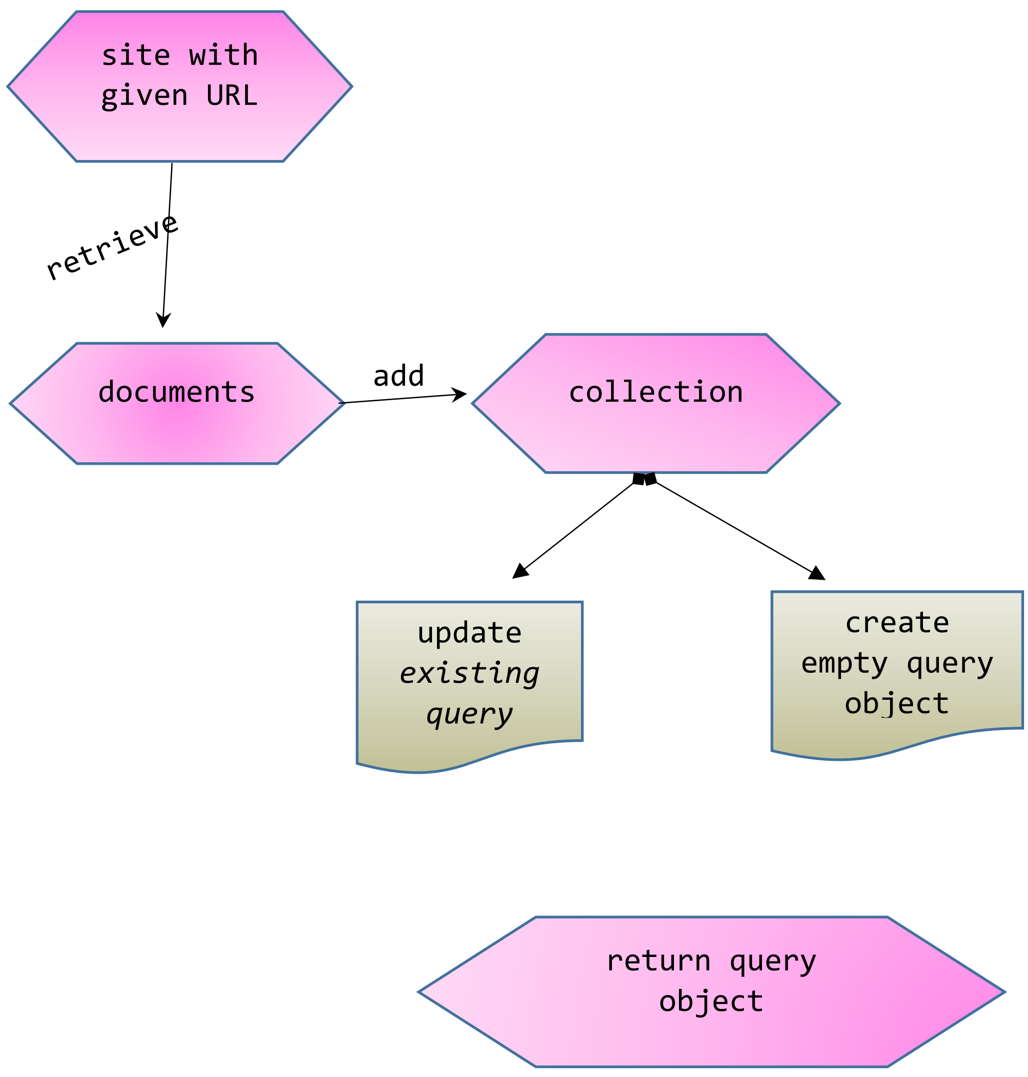
iteration abstraction

store document

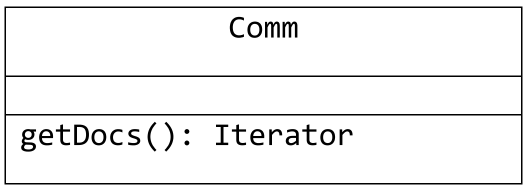
add + look up documents

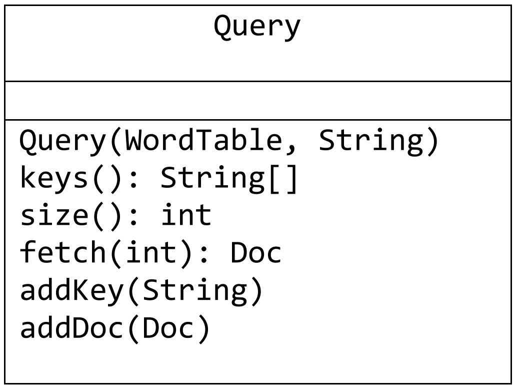


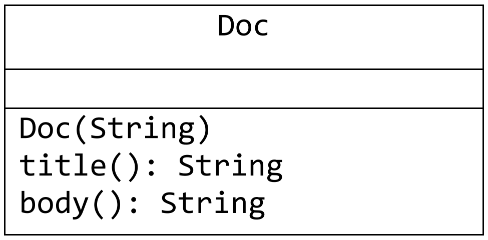
Engine.addDocs



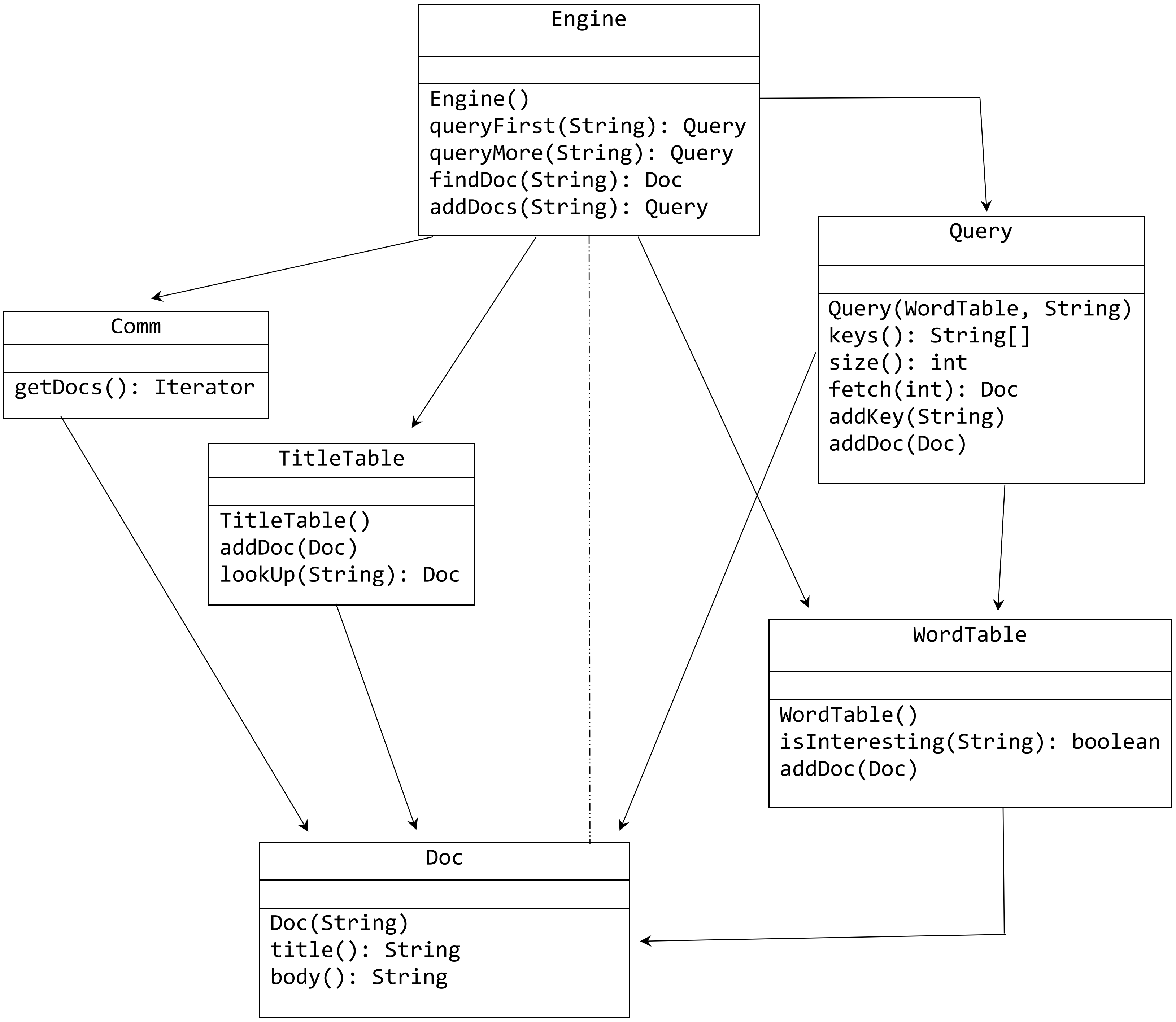
A new abstraction Comm: create a getDocs() → return an Iterator object for documents




Query
Query(WordTable, String)
keys(): String[]
size(): int
fetch(int): Doc
addKey(String)
addDoc(Doc)


Doc
Doc(String)
title(): String
body(): String

Design class diagram



```
Engine
-----------------------------
  -  wt: WordTable
  -  t: TitleTable
  -  q: Query
  -  urls: String[]
  -
-----------------------------
Engine()
queryFirst(String): Query
queryMore(String): Query
findDoc(String): Doc
addDocs(String): Query
```

```
/**
* @overview … (omitted) …
* @version (iteration) 1.0
*/
class Engine {
     @DomainConstraint(type = “WordTable”, optional = false)
     private WordTable wt;
     @DomainConstraint(type = “TitleTable”, optional = false)
     private TitleTable tt;
     @DomainConstraint(type = “Query”)
     private Query q;

     private String[] urls;
     /////      END version 1.0
}    // end Engine
```

```java
/**
* @overview keeps track of interesting + uninteresting words.
*     uninteresting words – obtain from private file
*     records number of times each interesting word occurs in document
* @version (iteration) 1.0
*/
class WordTable {
     /**
     * @effects
     *     If uninteresting-word file cannot be read
     *           throws NotPossibleException
     *     else
     *           initialises this -> contain all words in file
     *
     */
     WordTable() throws NotPossibleException



     /**
     * @effects
     *     If w null/ nonword/ uninteresting word
     *           return false
     *     else
     *           return true
     *
     */
     boolean isInteresting(String w)
/**
* @requires      d not null
* @modifies      this
* @effects
*     add → this interesting words of d with their numbers of
*           occurrences
*
*/
void addDoc(Doc d)
} // end WordTable
```

```
/**
* @overview
*     provides in4 → keywords of query + documents – match those
*     Documents accessed indexes: 0 – size
*     Documents ordered by number of matches they contain
*     document 0th contain the most matches
*
* @version (iteration) 1.0
*/
class Query     {
     /**
     * @effects      returns an empty query
     */
     Query()

     /**
     * @effects      returns a count of documents – match query
     */
     int size()



     /**
     * @effects
     *  If 0 <= i < size
     *     returns ith matching document
     *  else
     *     throws IndexOutOfBoundException
     */
     Doc fetch(int i) throws IndexOutOfBoundException
```

```
    /**
    * @effects      returns keywords of this
    */
    String[] keys()



    /**
    * @requires     w not null
    * @modifies     this
    * @effects
    * If this empty/ w already a keyword in this
    *     throws NotPossibleException
    * else
    *     modifies this → contain w + all keywords in this
    */
    void addKey(String w) throws NotPossibleException



    /**
    * @requires     d not null
    * @modifies     this
    * @effects
    * If this empty & d contain all keywords of this
    *     adds d -> this as query result
    * else
    *     do nothing
    */
    void addDoc(Doc d)
} // end Query
```

```
/**
* @overview     keeps track of documents + titles
*
* @author  dmle
*
* @version (iteration) 1.0
*/
class TitleTable      {

      /**
      * @effects      intialises this to be empty
      */
      TitleTable()


      /**
      * @requires     d not null
      * @modifies     this
      * @effects
      * If a document with d’s title already in this
      *    throws DuplicateException
      * else
      *    adds d with its title to this
      */
      void addDoc(Doc d) throws DuplicateException
```

```
    /**
    * @effects
    * If t null/ no document with title t in this
    *     throws NotPossibleException
    * else
    *     returns document with title t
    */
    Doc lookup(String t) throws NotPossibleException
}   // end TitleTable
```

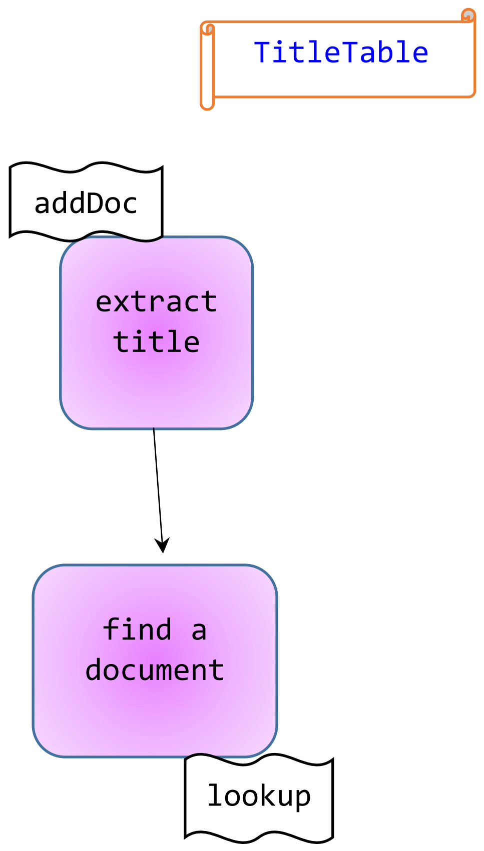
```
/**
* @overview
*    represents communication module responsible → obtain documents
* from remote sites
* @version (iteration) 1.0
*/
public class Comm    {

     /**
     * @effects
     * If u not valid URL/ site it names fails -> respond
     *    throws NotPossibleException
     * else
     *    returns a generator -> documents from site u
     *          (as strings)
     */
     static Iterator getDocs(String u) throws NotPossibleException {
} // end Comm
```

Refinement

Abstraction selection criteria

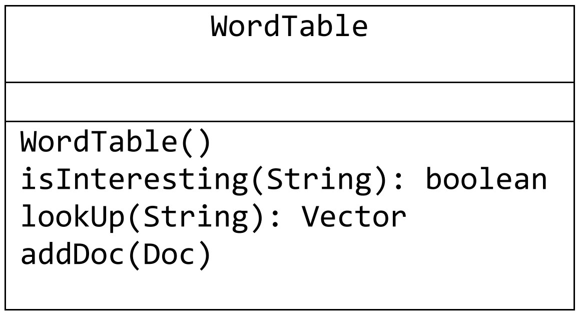
- complete spec. (not yet refined)
- uncertainty
- more → desing

Abstraction: TitleTable   Query   Comm.getDocs(library)

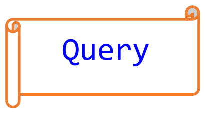


document titles: re-used many times

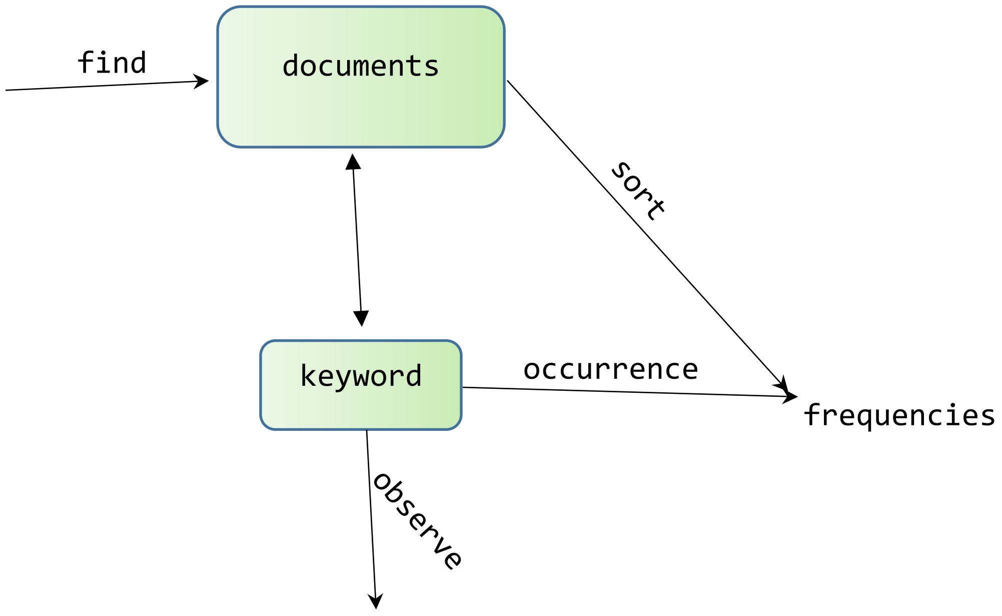
➔ data structure map Docs → Strings
➔ *java.util.Hashtable*



```
WordTable

WordTable()
isInteresting(String): boolean
lookUp(String): Vector
addDoc(Doc)
```



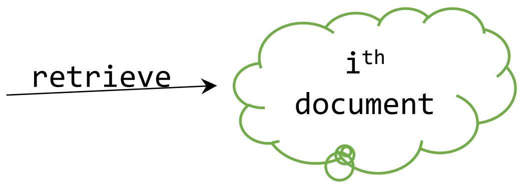
Query(WordTable, String)



```
WordTable
----------------------------------
----------------------------------
WordTable()
isInteresting(String): boolean
lookUp(String): Vector
addDoc(Doc)
```

```
Query
----------------------------------
-k: WordTable
-keys: String      // store keywords
----------------------------------
Query(WordTable, String)
keys(): String[]    // keep track of keywords
size(): int
fetch(int): Doc
addKey(String)
addDoc(Doc)
```

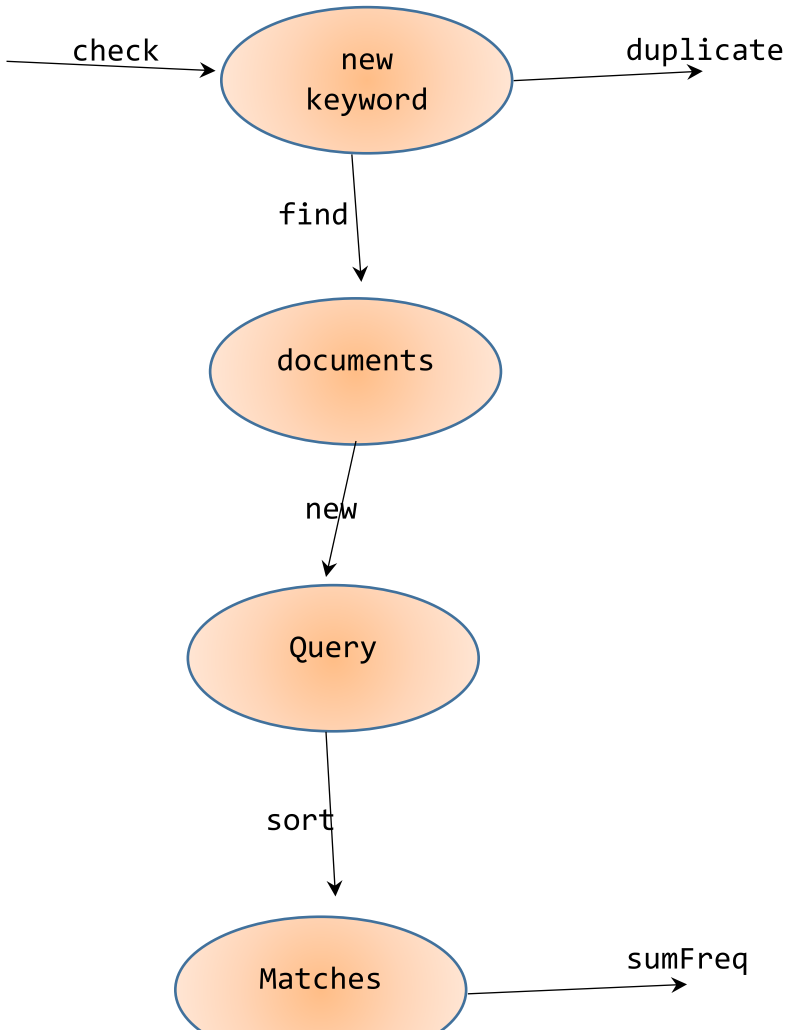
fetch(int):



(current matches)

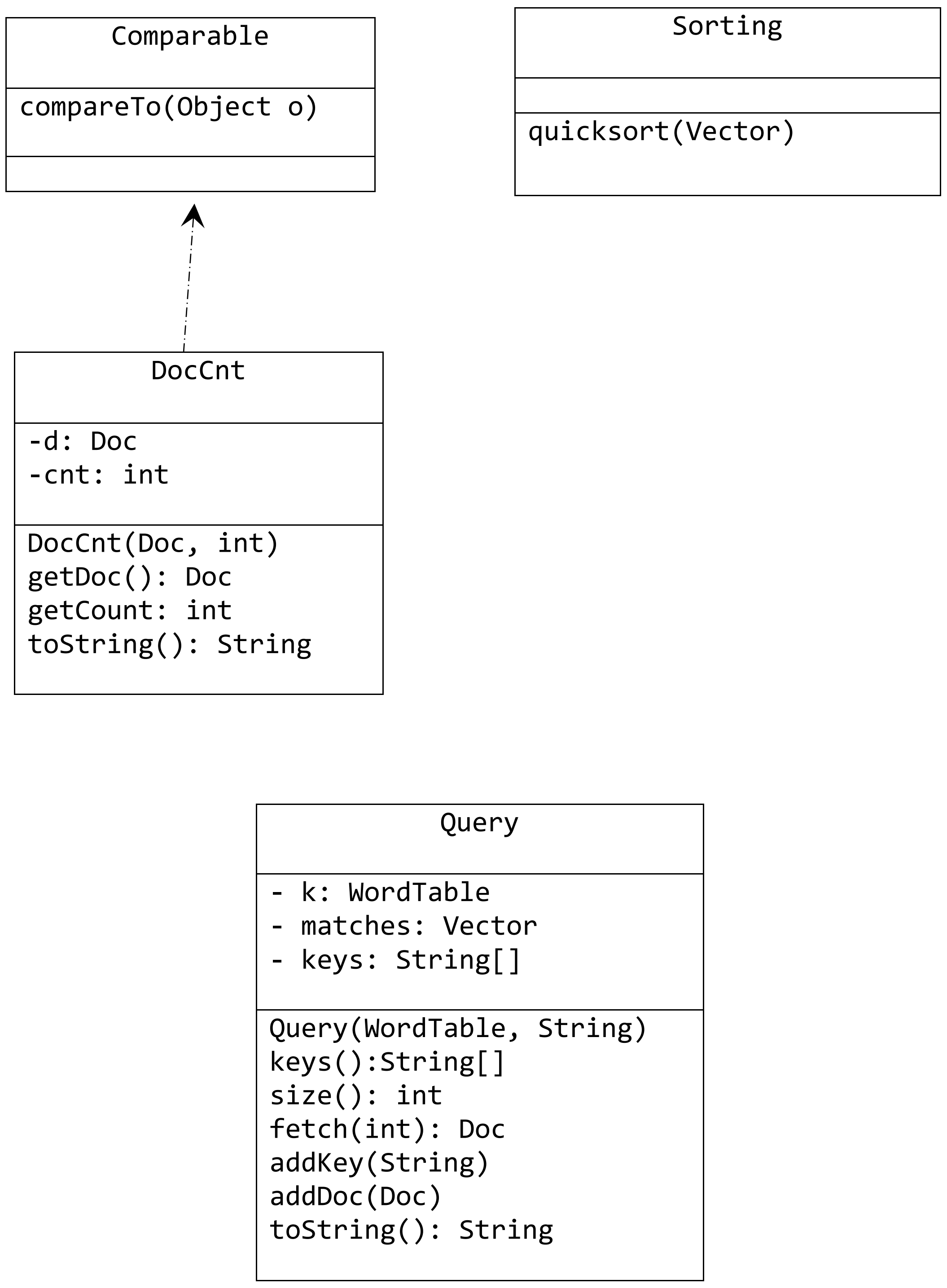
➔ index-based collection → store (Vector)

addKey(String)

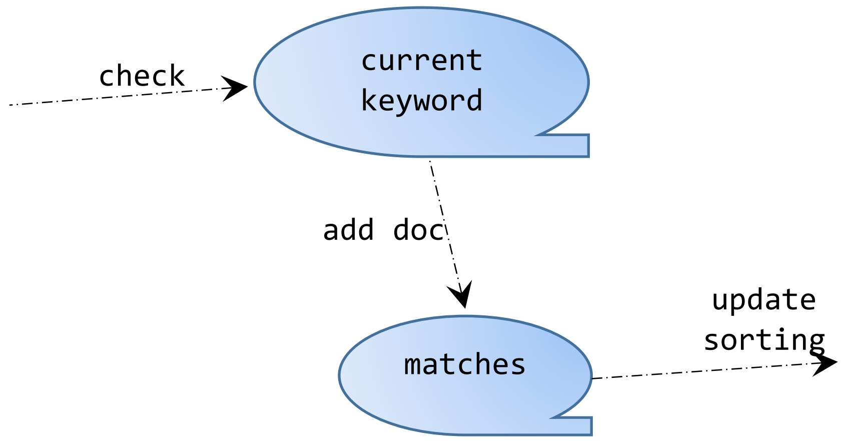


maintain sumFreq → each match → sort matches

➔ DocCnt<Document, Count> abstraction for matches
➔ Vector → store matches (DocCnt objects)
➔ quick-sort



addDoc(Doc)



update WordTable.addDoc → return HashTable

(map keywords – frequencies)

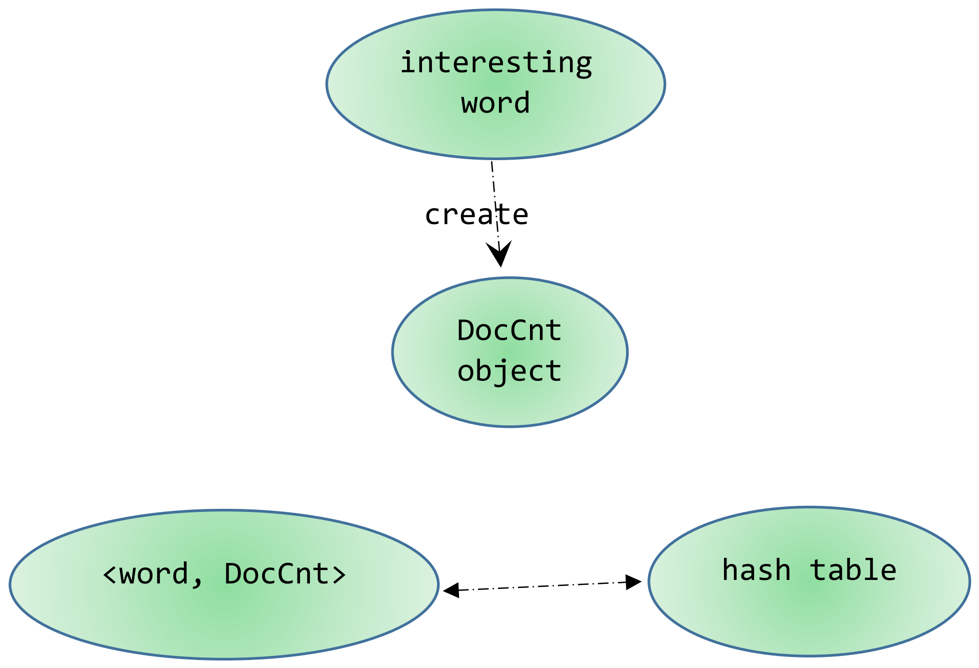
Query.addDoc(Doc) → Query.addDoc(Doc, Hashtable)

```
WordTable
---------------------------------
---------------------------------
WordTable()
isInteresting(String): boolean
lookUp(String): Vector
addDoc(Doc): Hashtable
```

```
Query
---------------------------------
---------------------------------
-k: WordTable
-matches: Vector
-keys: String[]
---------------------------------
Query(WordTable, String)
keys(): String[]
size(): int
fetch(int): Doc
addKey(String)
addDoc(Hashtable, Doc)
```

WordTable

addDoc(Doc)



Doc: iterator method → iterate over all words

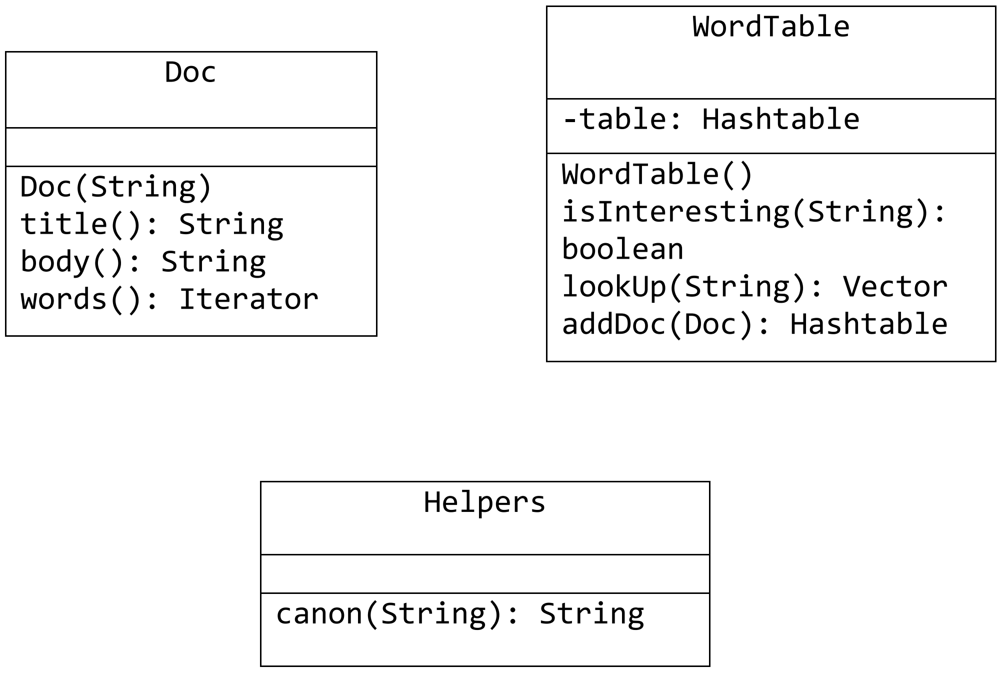
➔ Doc.words(): Iterator method

record each keyword Set of DocCnt objects

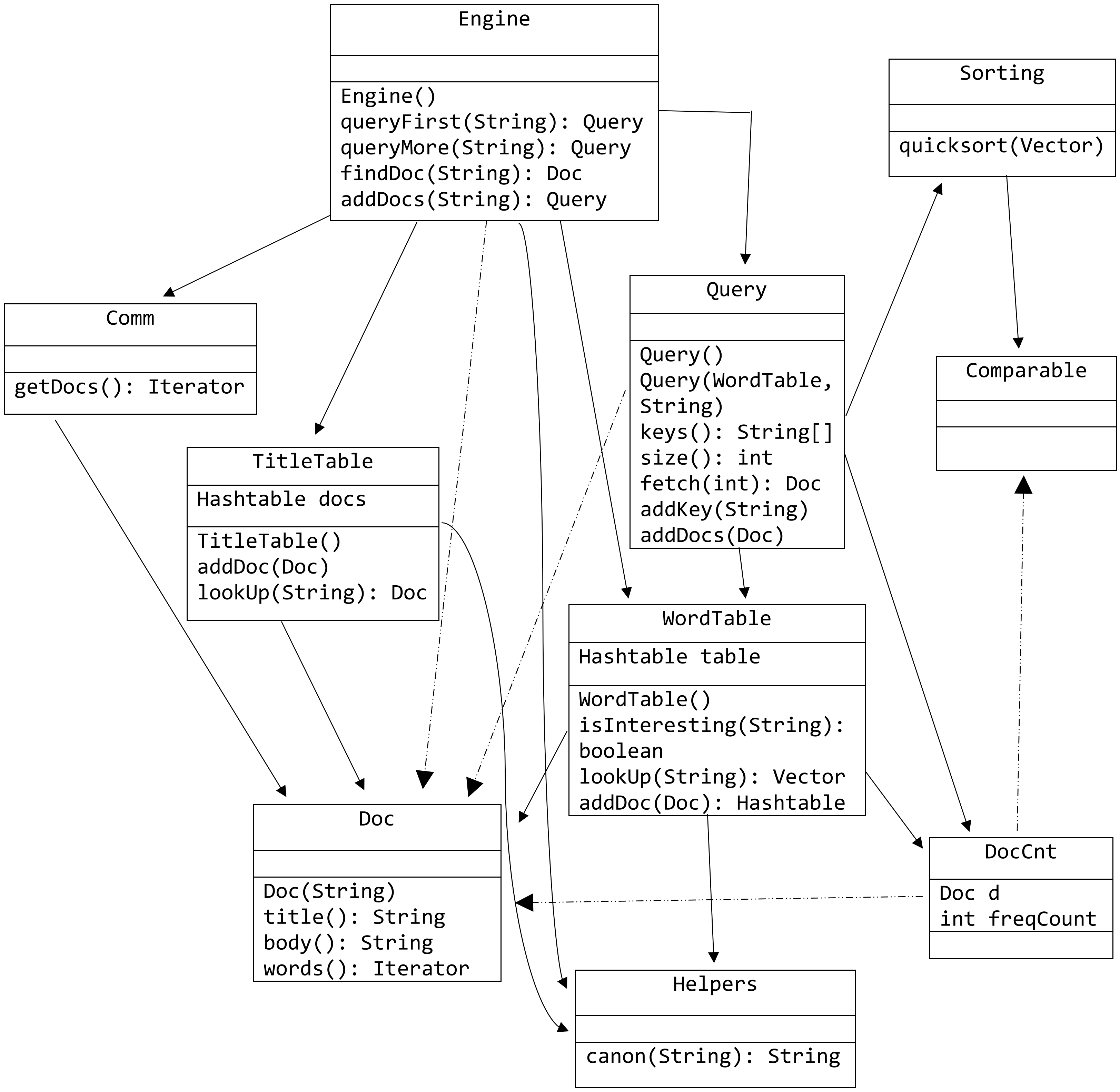
➔ WordTable.table: keyword – Vector DocCnts

canonical word forms

➔ Helpers.canon: convert words → common format


Doc
Doc(String)
title(): String
body(): String
words(): Iterator
WordTable
-table: Hashtable
WordTable()
isInteresting(String): boolean
lookUp(String): Vector
addDoc(Doc): Hashtable
Helpers
canon(String): String

Design class diagram



Query implementation sketches

```
/**
* @requires      wt & w not null

* @effects initialises this – contain w

*

* @pseudocode    <pre> ---   implement sketch      -----

*      lookup key in WordTable

*      sort matches → quicksort

*                <pre>

*/

Query(WordTable wt, String w)
```

```
/**
* @requires …
* @modifies …
* @effects …
*
* @pseudocode    <pre> --- implement sketch -----
      lookup new key in WordTable
      store information → matches in hash table
            for each current match,
                  if document in hash table
                        look up
                        store in vector sort → quicksort
</pre>
*/
void addKey(String w) throws NotPossibleException
```

```
/**
* @requires …
* @modifies …
* @effects …
*
* @pseudo <pre> --- implementation sketch -----
      use argument table → get number of occurrences of each current
key
      if document has all keywords
            compute sum
            insert (doc, sum) pair in vector of matches
      </pre>
*/
void addDoc(Doc d)
```

Design process

Top-down design approach: decomposition by abstraction
(create, refine as needed)

design diagram / sequence diagram → design updates

Design: iterative
(later iterations $\xrightarrow{\text{more details}}$ program structure)

sequence diagram → validated