1 Constructor

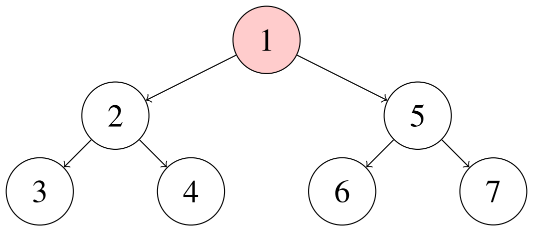
Implement the constructor of the **`DFSearch`** class.

```
public class DFSearch extends Search {
  /**
   * Initialize this search.
   *
   * @param config JPF's configuration.
   * @param vm JPF's virtual machine.
   */
  public DFSearch(Config config, VM vm) {



  }
```

2 Forward and backtrack



For the above state space, provide the sequence of calls to **`forward`** and **`backtrack`** and the value returned by them corresponding to depth first search started in the top most state.

3 Search

Implement a basic **`search`** method using **`forward`** and **`backtrack`** and loops.

```
public void search() {







}
```

4 New states

`public boolean isNewState()`

tests whether the current state has not been visited before.

Incorporate the **`isNewState`** method into the **`search`** method of the **`DFSearch`** class.

```
public void search() {







}
```

5 End states

`public boolean isEndState()`

tests whether the current state is a final state.

Incorporate the **`isEndState`** method into the **`search`** method of the **`DFSearch`** class.

```
public void search() {




}
```

6 Ignored states

`public boolean isIgnoredState()`

tests whether the current state can be ignored in the search.

States can, for example, be ignored by using in the system under test the method **`ignoreIf(boolean)`** of JPF's class **`Verify`** which is part of the package **`gov.nasa.jpf.vm`**.

Incorporate the **`isIgnoredState`** method into the **`search`** method of the **`DFSearch`** class.

```
public void search() {




}
```

7 Done

Other components of JPF can end a search by setting the attribute **`done`** of the class **`Search`** to true.

Modify the **`search`** method of the **`DFSearch`** class to incorporate the **`done`** attribute.

```
public void search() {





}
```

8 Request backtrack

Other components of JPF can request a search to backtrack by means of the method

`public boolean checkAndResetBacktrackRequest()`

Modify the **`search`** method of the **`DFSearch`** class to incorporate the **`checkAndResetBacktrackReques`** method.

```
public void search() {





}
```

9 Depth

The **`Search`** class contains the attribute **`depth`** that can be used to keep track of the depth of the search. It is initialized to zero.

Override the **`forward`** method of the **`Search`** class to keep track of the depth.

```
protected boolean forward() {















}
```

Override the **backtrack** method of the **Search** class to keep track of the depth.

```
protected boolean backtrack() {















}
```

10 Depth limit

JPF can be configured to limit the depth of the search by setting the JPF property **search.depth_limit**. The default value of **search.depth_limit** is **Integer.MAX_VALUE**. The **Search** class provides the method **getDepthLimit** which returns the maximal allowed depth of the search.

We introduce the following method in the **DFSearch** class.

```
private boolean checkDepthLimit() {
  return this.depth < this.getDepthLimit();
}
```

Incorporate **checkDepthLimit** into **forward**.

```
protected boolean forward() {
```

```
}
```

11 Memory usage limit

The JPF property **`search.min_free`** captures the minimal amount of memory, in bytes, that needs to remain free. The default value is $1024 \ll 10 = 1024^2 = 1,048,576B \approx 1MB$. By leaving some memory free, JPF can report that it ran out of memory and provide some useful statistics instead of simply throwing an **`OutOfMemoryError`**. The method **`checkStateSpaceLimit`** of the class **`Search`** checks whether the minimal amount of memory that should be left free is still available.

Modify the **`search`** method of the **`DFSearch`** class to limit the memory usage.

```
public void search() {
```

```
}
```

12 Multiple errors?

The JPF property **`search.multiple_errors`** tells us whether the search should report multiple errors (or just the first one). The **`forward`** method also checks whether any property is violated after the unexplored transition has been traversed. If a violation has been detected then the attribute **`done`** is set to true if and only if JPF has been configured to report at most one error.

The method **hasPropertyTermination** of the class **Search** checks whether a violation was encountered during the last transition. The method returns true if and only if a violation was encountered and the attribute **done** is set to true.

Modify the **search** method of the **DFSearch** class to take **search.multiple_errors** into account.

```
public void search() {











}
```

13 Notification of start and finish

A search should also notify listeners of particular events by invoking to the methods of the interface **SearchListener**, which can be found in the package **gov.nasa.jpf.search**. The **Search** class contains a number of **notify** methods.

Modify the **search** method of the **DFSearch** class to incorporate following notifications.

- **notifySearchStarted**
- **notifySearchFinished**

```
public void search() {











}
```

14 Notification of forward, backtrack and having fully explored a state

Incorporate following notifications into the **`forward`** and **`backtrack`** method.

- **`notifyStateAdvanced`**
- **`notifyStateBacktracked`**
- **`notifyStateProcessed`**

```
protected boolean forward() {







}

protected boolean backtrack() {}







}
```

15 Notification of constraints being violated

Override the **`checkStateSpaceLimit`** method and modify the **`checkDepthLimit`** method to incorporate **`notifySearchConstraintHit(String)`** to notify the following.

- ”memory limit reached”
- ”depth limit reached”

```
public boolean checkStateSpaceLimit() {






}

public boolean checkDepthLimit() {






}
```

16 Notification of property violations

Immediately after an invocation of the **`forward`** method of the **`Search`** class, an invocation of the **`getCurrentError`** method of the **`Search`** class returns **`null`** if and only if no property violation has been detected.

Modify the overridden **`forward`** method of the **`DFSearch`** class to include an invocation of the **`notifyPropertyViolated`** method.

```
protected boolean forward() {








}
```