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3.1 SYMBOL TABLES

- ▶ *API*
- ▶ *elementary implementations*
- ▶ *ordered operations*

Examples of ordered symbol table API

| | <i>keys</i> | <i>values</i> |
|--|-------------|---------------|
| <code>min()</code> → | 09:00:00 | Chicago |
| | 09:00:03 | Phoenix |
| | 09:00:13 | Houston |
| <code>get(09:00:13)</code> → | 09:00:59 | Chicago |
| | 09:01:10 | Houston |
| <code>floor(09:05:00)</code> → | 09:03:13 | Chicago |
| | 09:10:11 | Seattle |
| <code>select(7)</code> → | 09:10:25 | Seattle |
| | 09:14:25 | Phoenix |
| | 09:19:32 | Chicago |
| | 09:19:46 | Chicago |
| <code>keys(09:15:00, 09:25:00)</code> → | 09:21:05 | Chicago |
| | 09:22:43 | Seattle |
| | 09:22:54 | Seattle |
| | 09:25:52 | Chicago |
| <code>ceiling(09:30:00)</code> → | 09:35:21 | Chicago |
| | 09:36:14 | Seattle |
| <code>max()</code> → | 09:37:44 | Phoenix |
| <code>size(09:15:00, 09:25:00) is 5</code> | | |
| <code>rank(09:10:25) is 7</code> | | |

Ordered symbol table API

```
public class ST<Key extends Comparable<Key>, Value>
```

```
...
```

```
Key min()
```

smallest key

```
Key max()
```

largest key

```
Key floor(Key key)
```

largest key less than or equal to key

```
Key ceiling(Key key)
```

smallest key greater than or equal to key

```
int rank(Key key)
```

number of keys less than key

```
Key select(int k)
```

key of rank k

```
void deleteMin()
```

delete smallest key

```
void deleteMax()
```

delete largest key

```
int size(Key lo, Key hi)
```

number of keys between lo and hi

```
Iterable<Key> keys()
```

all keys, in sorted order

```
Iterable<Key> keys(Key lo, Key hi)
```

keys between lo and hi, in sorted order

Binary search: ordered symbol table operations summary

| | sequential search | binary search |
|-------------------|-------------------|---------------|
| search | N | $\log N$ |
| insert / delete | N | N |
| min / max | N | 1 |
| floor / ceiling | N | $\log N$ |
| rank | N | $\log N$ |
| select | N | 1 |
| ordered iteration | $N \log N$ | N |

order of growth of the running time for ordered symbol table operations