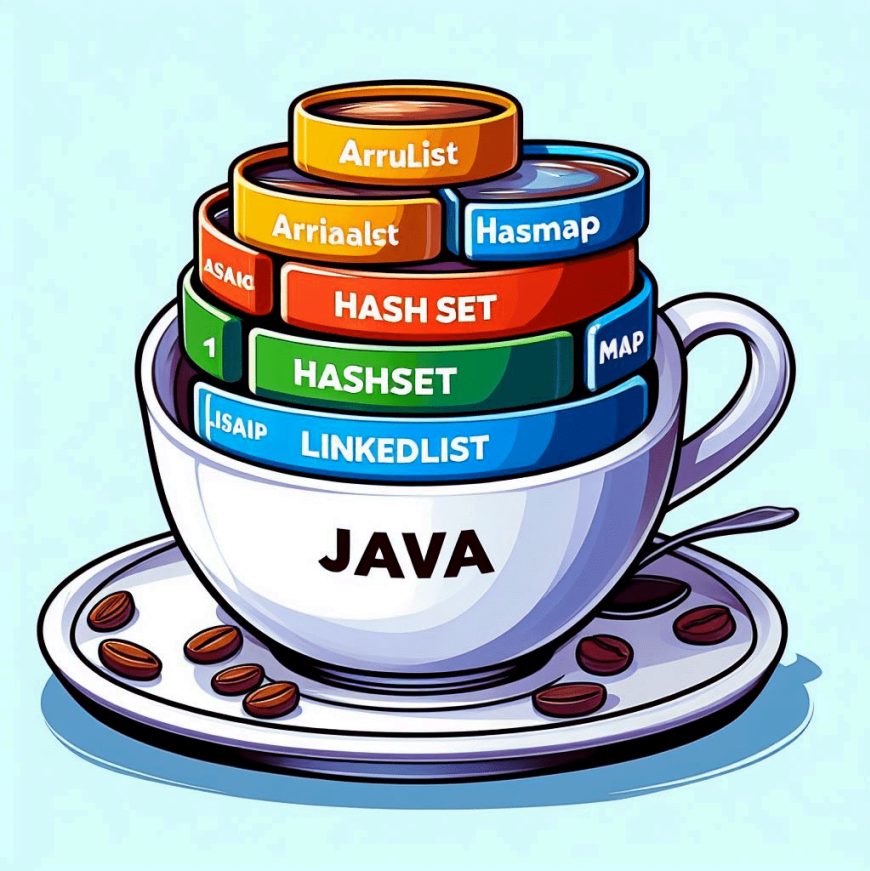
Java Collections and Their Thread-Safe Versions



Java Collections

As a Java developer, understanding collections is essential. Collections provide a way to store, manipulate, and retrieve data efficiently. In this article, we'll explore various Java collections and discuss their thread-safe counterparts. Whether you're a seasoned developer or just starting out, this guide will help you navigate the world of Java collections.

Java provides a rich set of built-in collections classes that cater to different use cases. These classes are part of the `java.util` package and include:

a. Lists

- **ArrayList**: A dynamic array that grows as needed. It's fast for random access but slow for insertions and deletions.

- **LinkedList**: A doubly-linked list that's efficient for insertions and deletions but slower for random access.

Thread-Safe Alternatives:

- **CopyOnWriteArrayList**: A thread-safe version of `ArrayList`. When we perform operations like adding or modifying elements, the **CopyOnWriteArrayList** creates a fresh copy of the underlying array. While this approach can be expensive, it becomes efficient when read operations significantly outnumber mutations.
- **Vector**: Vector is an older thread-safe list implementation. It ensures thread safety by using **synchronized** methods for all operations (such as adding, removing, and accessing elements). While it provides thread safety, this synchronization can impact performance, especially in highly concurrent scenarios.
- **Collections.synchronizedList():** We can create thread safe list using Collections Utility class as well. This function returns a wrapper (SynchronizedList) backed on the specificed list. All of the operations (get, update, remove etc) on the wrapper are synchronized which helps in providing the thread safety but may impact performance due to synchronization.

b. Sets

- **HashSet**: An unordered set that doesn't allow duplicate elements.
- **TreeSet**: A sorted set which maintains elements in their natural order or by a comparator passed during it's creation.

Thread-Safe Alternatives:

- **ConcurrentSkipListSet**: ConcurrentSkipListSet is a thread-safe sorted set based on skip lists.
- **CopyOnWriteArraySet:** The CopyOnWriteArraySet is a thread-safe implementation of the Set interface, backed by a **CopyOnWriteArrayList** i.e. each update operation creates a separate cloned copy of the set.
- **Collections.synchronizedSet():** We can create thread safe set using Collections Utility class as well. This function returns a

wrapper (SynchronizedSet) backed on the specificed set. Similar to SynchronizedList, in SynchronizedSet all of the operations are synchronized.

c. Maps

- **HashMap**: An unordered map that stores key-value pairs. It doesn't allow duplicate keys.
- **TreeMap**: A sorted map which maintains keys in their natural order or by a comparator passed during it's creation.

Thread-Safe Alternatives:

- **ConcurrentHashMap**: A highly efficient thread-safe map. The map is divided into segments, and each segment is independently synchronized. It balances thread safety and performance, making it suitable for multi-threaded applications.
- **ConcurrentSkipListMap**: It is a powerful thread-safe implementation of a sorted map. It is based on skip lists, a data structure that allows efficient search, insertion, and removal operations while maintaining sorted order. Skip lists are similar to balanced trees but use probabilistic balancing rather than strict balancing rules.
- **Collections.synchronizedMap():** We can create thread safe map using Collections Utility class as well. This function returns a wrapper (SynchronizedMap) backed on the specificed Map. Similar to SynchronizedList, in SynchronizedMap all of the operations are synchronized.

In this comprehensive guide, we've explored various Java collections and their thread-safe alternatives. However, it's important to note that we haven't covered every collection available in the Java ecosystem. There are more specialized collections, such as **BlockingQueue**, **ConcurrentLinkedQueue**, and **ConcurrentNavigableMap**, which cater to specific concurrency requirements.

Remember that choosing the right collection depends on your application's needs, performance considerations, and the level of thread safety required. Whether you're a seasoned developer or just

starting out, stay curious and explore the vast world of Java collections!

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