Java Fundamentals

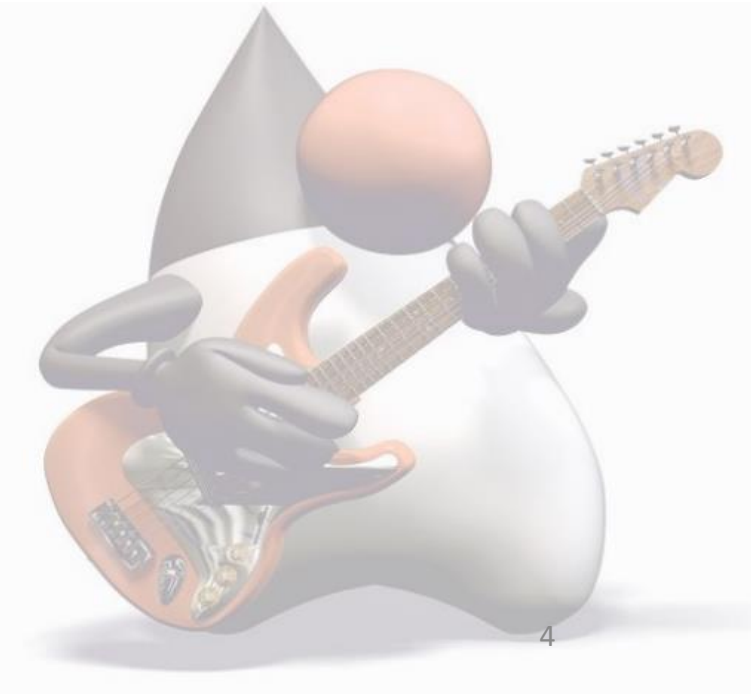
Multithreading

Threads und Runnables

- Multithreading ist fest in Java integriert
- Wird benötigt für
  - Parallelverarbeitung
  - Serveranwendungen

```
public class ThreadStarter {
	public static void main(String[] args) {
		Runnable runnable = () -> {
			for (int i = 0; i < 10;i++) {
				try {
					Thread.sleep(1000L);
					System.out.println("Thread " +
						Thread.currentThread().getName() +
						" counter:" + i);

				} catch (InterruptedException e) {
					e.printStackTrace();
				}
			}
		};

		new Thread(runnable).start();
		new Thread(runnable).start();
		System.out.println("Main thread says good bye");
	}
}
```

```
Main thread says good bye
Thread Thread-1 counter:0
Thread Thread-0 counter:0
Thread Thread-0 counter:1
Thread Thread-1 counter:1
Thread Thread-0 counter:2
Thread Thread-1 counter:2
Thread Thread-1 counter:3
Thread Thread-0 counter:3
Thread Thread-1 counter:4
Thread Thread-0 counter:4
Thread Thread-0 counter:5
Thread Thread-1 counter:5
Thread Thread-1 counter:6
Thread Thread-0 counter:6
Thread Thread-0 counter:7
Thread Thread-1 counter:7
Thread Thread-0 counter:8
Thread Thread-1 counter:8
Thread Thread-0 counter:9
Thread Thread-1 counter:9
```

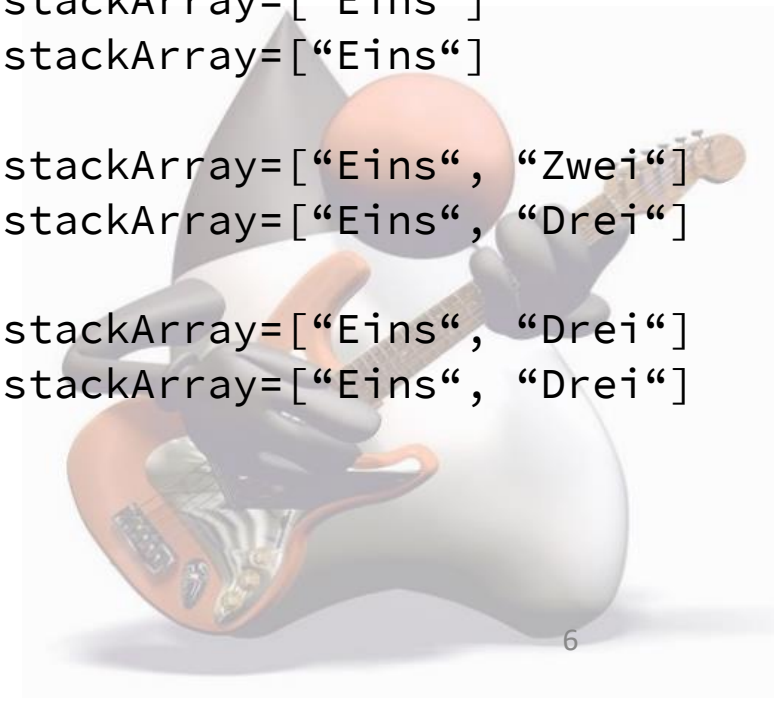


Race Conditions

```
public class Stack {
	int stacksize=0;
	String[] stackArray = new String[10_000];

	public void push(String data) {
		stackArray[stacksize] = data;
		stacksize++;
	}

	public String pop() {
		stacksize--;
		return stackArray[stacksize];
	}
}
```

Race Conditions

```
Stack stack = new Stack();
stack.push(“Eins“); stack.push(“Zwei“); stack.push(“Drei“);

Erwartung: stacksize=3, stackArray=[“Eins“, “Zwei“, “Drei“]

Start                                          ->     stacksize=0, stackArray=[]

Thread 1: push(“Eins“), stackArray[0]=“Eins“ ->     stacksize=0, stackArray=[“Eins“]
Thread 1: push(“Eins“), stacksize++           ->     stacksize=1, stackArray=[“Eins“]

Thread 1: push(“Zwei“), stackArray[1]=“Zwei“ ->     stacksize=1, stackArray=[“Eins“, “Zwei“]
Thread 2: push(“Drei“), stackArray[1]=“Drei“ ->     stacksize=1, stackArray=[“Eins“, “Drei“]

Thread 1: push(“Zwei“), stacksize++           ->     stacksize=2, stackArray=[“Eins“, “Drei“]
Thread 2: push(“Drei“), stacksize++           ->     stacksize=3, stackArray=[“Eins“, “Drei“]

Ergebnis: stacksize=3, stackArray=[“Eins“, “Drei“]
```

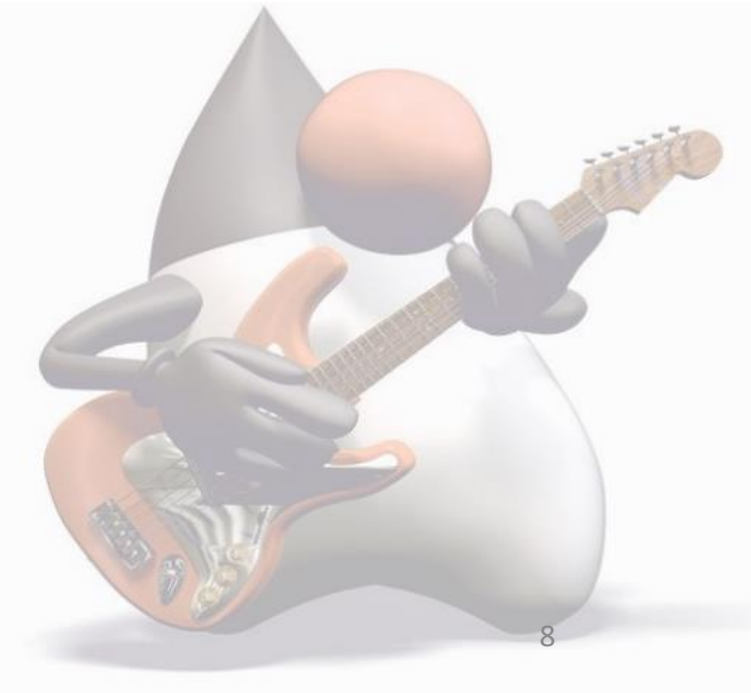


Ein thread-sicherer Stack

```
public class Stack {
        int stacksize=0;
        String[] stackArray = new String[10_000];

        synchronized public void push(String data) {
                stackArray[stacksize] = data;
                stacksize++;
        }

        synchronized public String pop() {
                stacksize--;
                return stackArray[stacksize];
        }
}
```

Ein thread-sicherer Stack

```
public class Stack {
        int stacksize=0;
        String[] stackArray = new String[10_000];

        Object ampel = new Object();

        public void push(String data) {
                synchronized(ampel) {
                        stackArray[stacksize] = data;
                        stacksize++;
                }
        }

        public String pop() {
                synchronized(ampel) {
                        stacksize--;
                        return stackArray[stacksize];
                }
        }
}
```

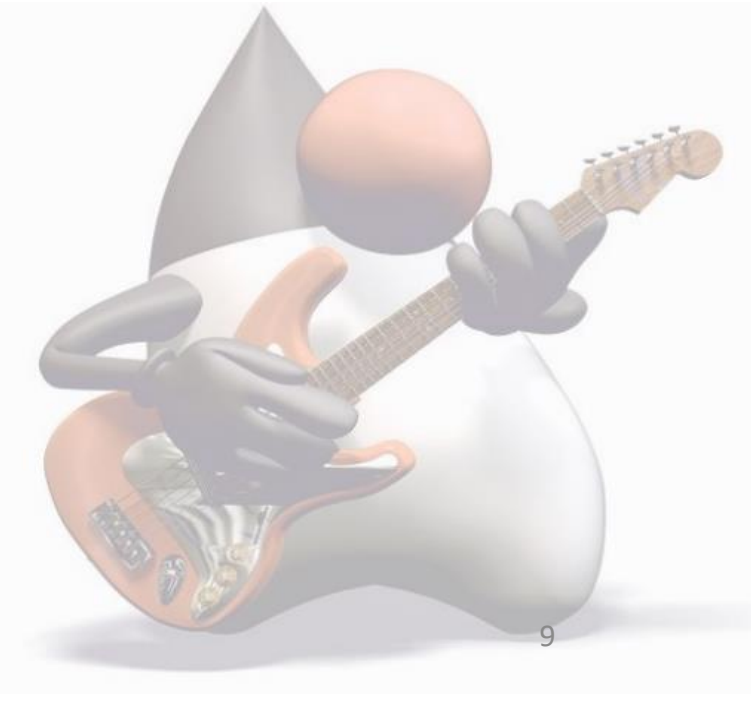


Primitive und Multithreading

- Sind primitive Datentypen thread-sicher?

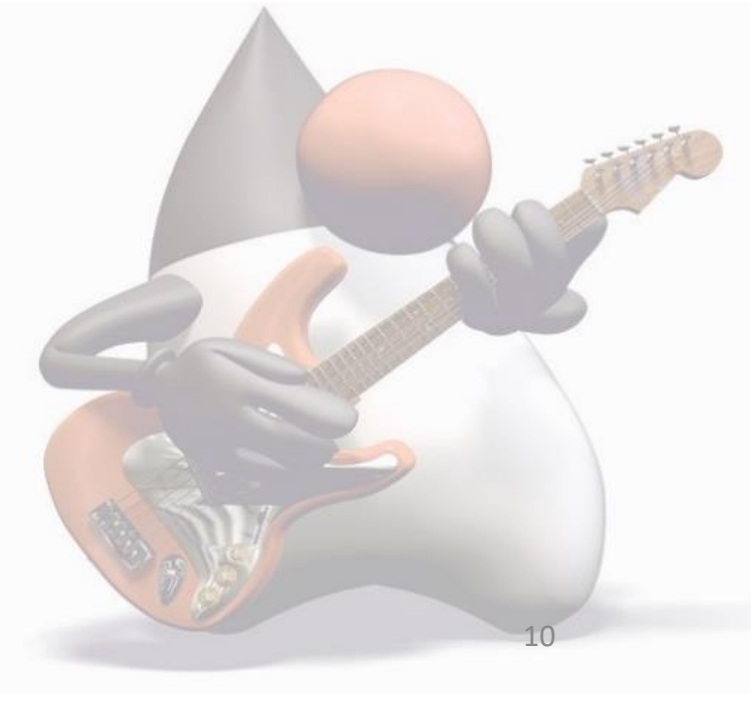
```
public class Counter {
        private int a;

        public int count() {
                return a = a + 1;
        }
}
```

a = a +1 … ist keine atomare Operation auf der CPU



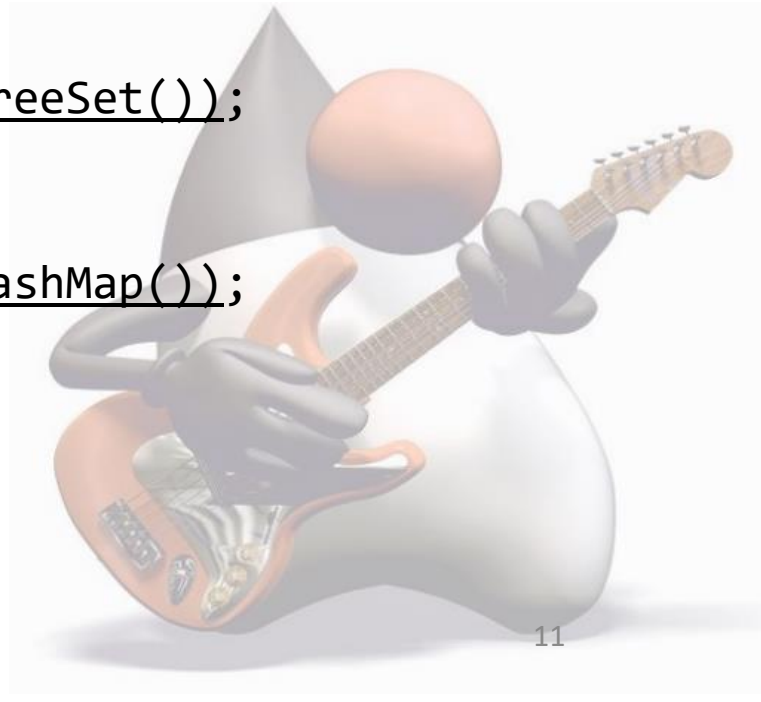
Primitive und Multithreading

```
public class ThreadSafeCounter {
        private AtomicInteger a = new AtomicInteger(0);

        public int count() {
                return a.incrementAndGet();
        }
}
```



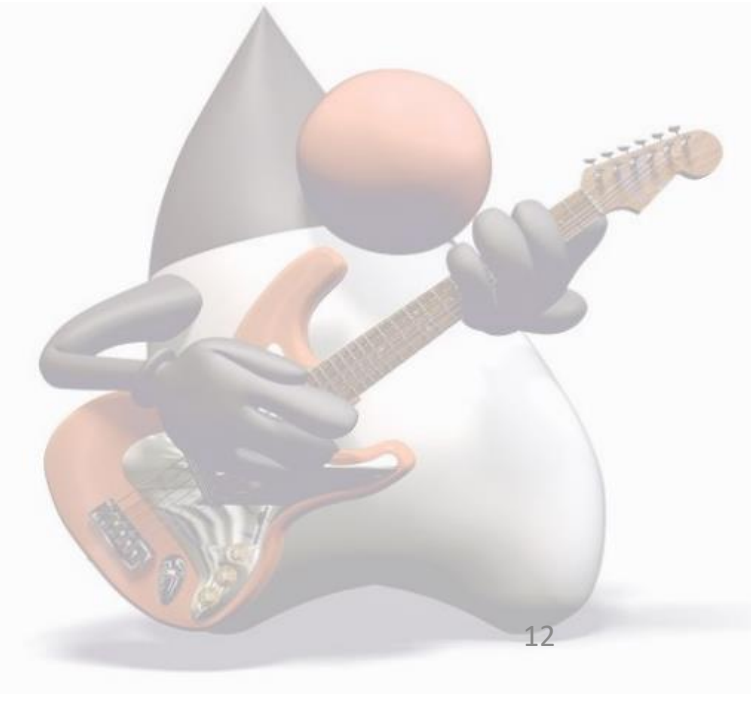
thread-sichere Collections

```
public class TestThreadsafeCollections {
	public static void main(String[] args) {
		List<String> list =
				Collections.synchronizedList(new ArrayList<>());

		Set<String> set =
				Collections.synchronizedSet(new TreeSet());

		Map<Long, String> map =
				Collections.synchronizedMap(new HashMap());

	}
}
```



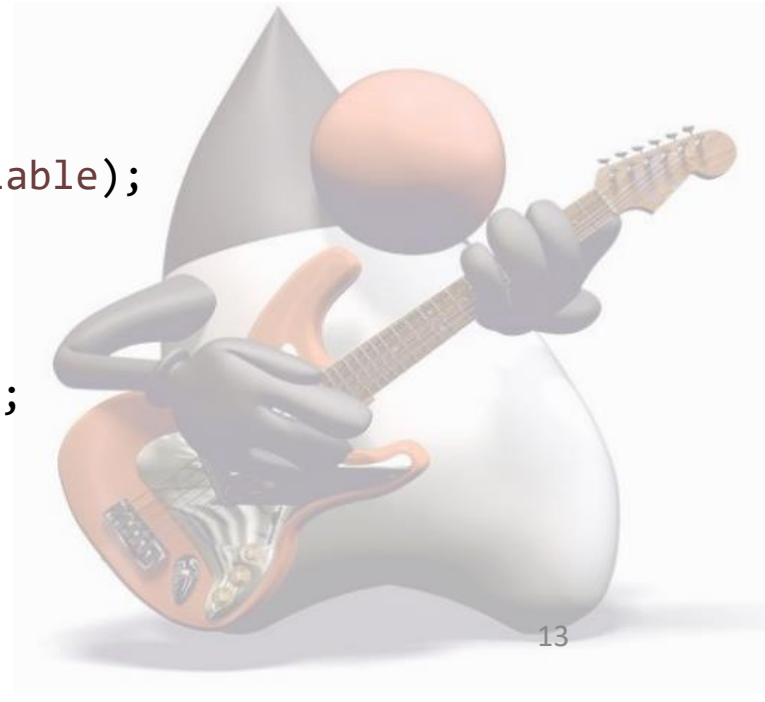
Executor Service

- Die maximale Anzahl der Threads in einem Prozess muss limitiert sein, um die Verfügbarkeit des Servers zu garantieren
- Threads werden deshalb häufig in Pools gehalten
- es gibt vorgefertigte Threadpools



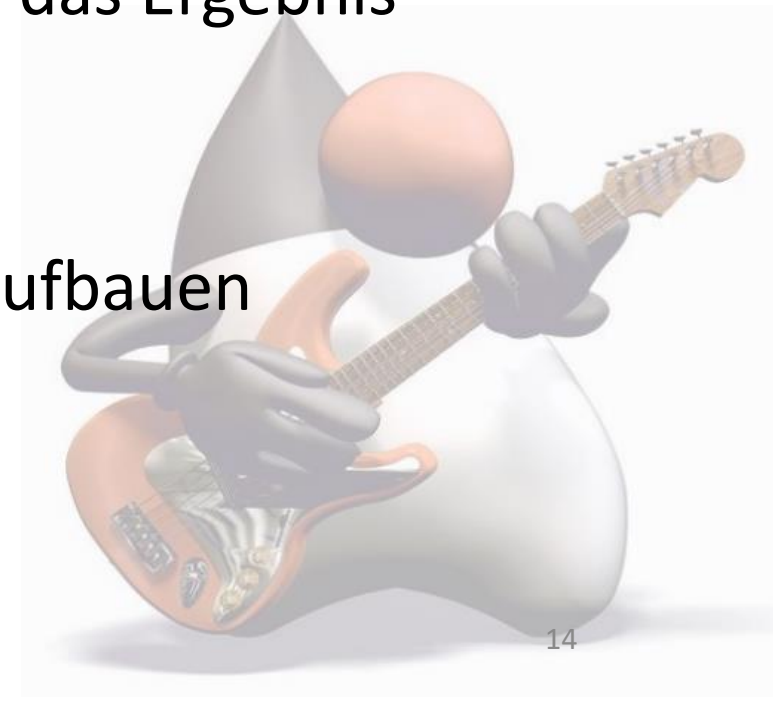
Executor Service

```
public class ExecutorExample {
        public static void main(String[] args) throws InterruptedException {
                int availableProcessors = Runtime.getRuntime().availableProcessors();
                ExecutorService service = Executors.newFixedThreadPool(availableProcessors);

                Runnable runnable = () -> {System.out.print("a");};
                Callable<Long> callable = () -> {return System.currentTimeMillis();};

                for (int i=0;i<Integer.MAX_VALUE;i++) {
                        service.submit(runnable);
                        Future<Long> futureResult = service.submit(callable);
                }

                service.shutdown();
                service.awaitTermination(Long.MAX_VALUE, TimeUnit.DAYS);
        }
}
```



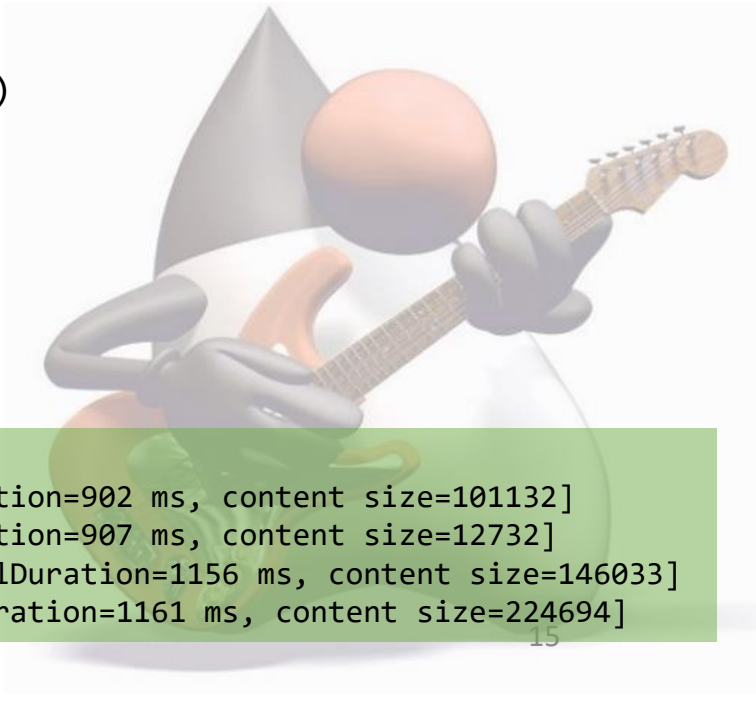
CompletableFuture

- CompletableFuture ist eine Erweiterung der Future Klasse
- Nachteil ist, dass ich warten muss, bis ein Ergebnis da ist
- CompletableFuture erlaubt es, einen Consumer oder eine Function anzugeben, die dann ausgeführt werden soll, wenn das Ergebnis bereitsteht.
- Ich muss nicht warten
- Es lassen sich reaktive Verarbeitungsketten damit aufbauen



CompletableFuture

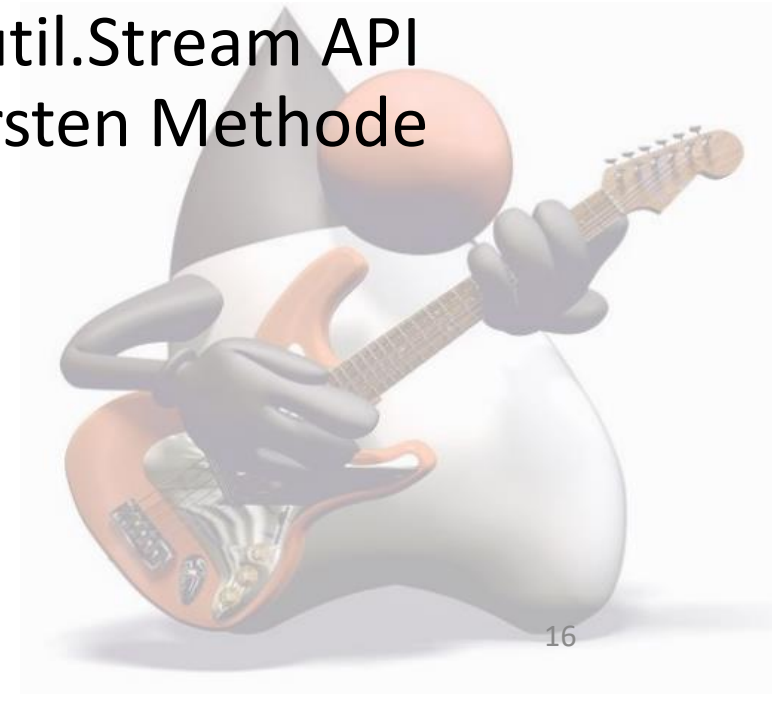
```
public class TestCompletableFuture {
        static String[] pages = { "https://www.vmware.com", "https://www.facebook.com",
                                  "https://www.javatraining.at", "https://www.google.com" };

        public static void main(String[] args) throws InterruptedException, ExecutionException {
                ExecutorService executor = Executors.newFixedThreadPool(10);

                for (String url : pages) {
                        CompletableFuture<WebPageTestResult> cf = CompletableFuture.supplyAsync(() -> {
                                long time = currentTimeMillis();
                                String content = WebPageReader.readWebPage(url); // reads web page
                                return new WebPageTestResult(url, content, currentTimeMillis() - time);
                        }, executor);

                        cf.thenApply((WebPageTestResult wbt) -> wbt.toString())
                          .thenAccept((String s) -> System.out.println(s));
                }

                System.out.println("Main ist zu Ende");

                executor.shutdown();
        }
}
```



```
Main ist zu Ende
WebPageTestResult [page=https://www.vmware.com, callDuration=902 ms, content size=101132]
WebPageTestResult [page=https://www.google.com, callDuration=907 ms, content size=12732]
WebPageTestResult [page=https://www.javatraining.at, callDuration=1156 ms, content size=146033]
WebPageTestResult [page=https://www.facebook.com, callDuration=1161 ms, content size=224694]
```

Übung

- Schreiben Sie eine Klasse Averager mit einer Methode calcAverage, die einen Array von 100.000 Zufallszahlen nimmt und mit 100 parallelen Threads jeweils den Durchschnitt von 1.000 Zahlen errechnet.
- Schreiben Sie eine Methode, die mittels dem java.util.Stream API parallel den Durchschnitt der Ergebniszahlen der ersten Methode errechnet.



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