

September 2020,  
Programming in Java

# Core Data Structures & Generics

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# About me



## Trayan Iliev

- CEO of IPT – Intellectual Products & Technologies
- Oracle® certified programmer 15+ Y
- end-to-end reactive fullstack apps with Java, ES6/7, TypeScript, Angular, React and Vue.js
- 12+ years IT trainer
- Voxxed Days, jPrime, jProfessionals, BGOUG, BGJUG, DEV.BG speaker
- Organizer RoboLearn hackathons and IoT enthusiast

# Course Schedule

- ❖ Block 1: 13:40 – 15:10
  - ❖ Pause: 15:10 – 15:20
  - ❖ Block 2: 15:20 – 16:50
  - ❖ Lunch: 16:50 – 17:00
  - ❖ Block 3: 17:00 – 19:00 (18:00 on 14.09 and 17.09)
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- ❖ Dates: 09 (Wed), 10 (Thu), 14 (Mon), 15 (Tue), 17 (Thu), 18 (Fri) September, 2020
  - ❖ Project demonstrations: 23.09, 30.09, 18:00 - 19:30h

# Where to Find the Code?

Java Web Development projects and examples are available @ GitHub:

<https://github.com/iproduct/course-java-fd>

# Agenda for This Session

- **Arrays** – immutability, manipulating elements, using utility methods of the class Arrays – sort, reverse, fill, copy, max, min, binarySearch, etc.
- **List/ArrayList** methods – get(), add(), remove(), set(), isEmpty(), size(), clear(), contains(), equals()
- **Set/HashSet** methods
- **Map/HashMap** methods
- **Generic Types**



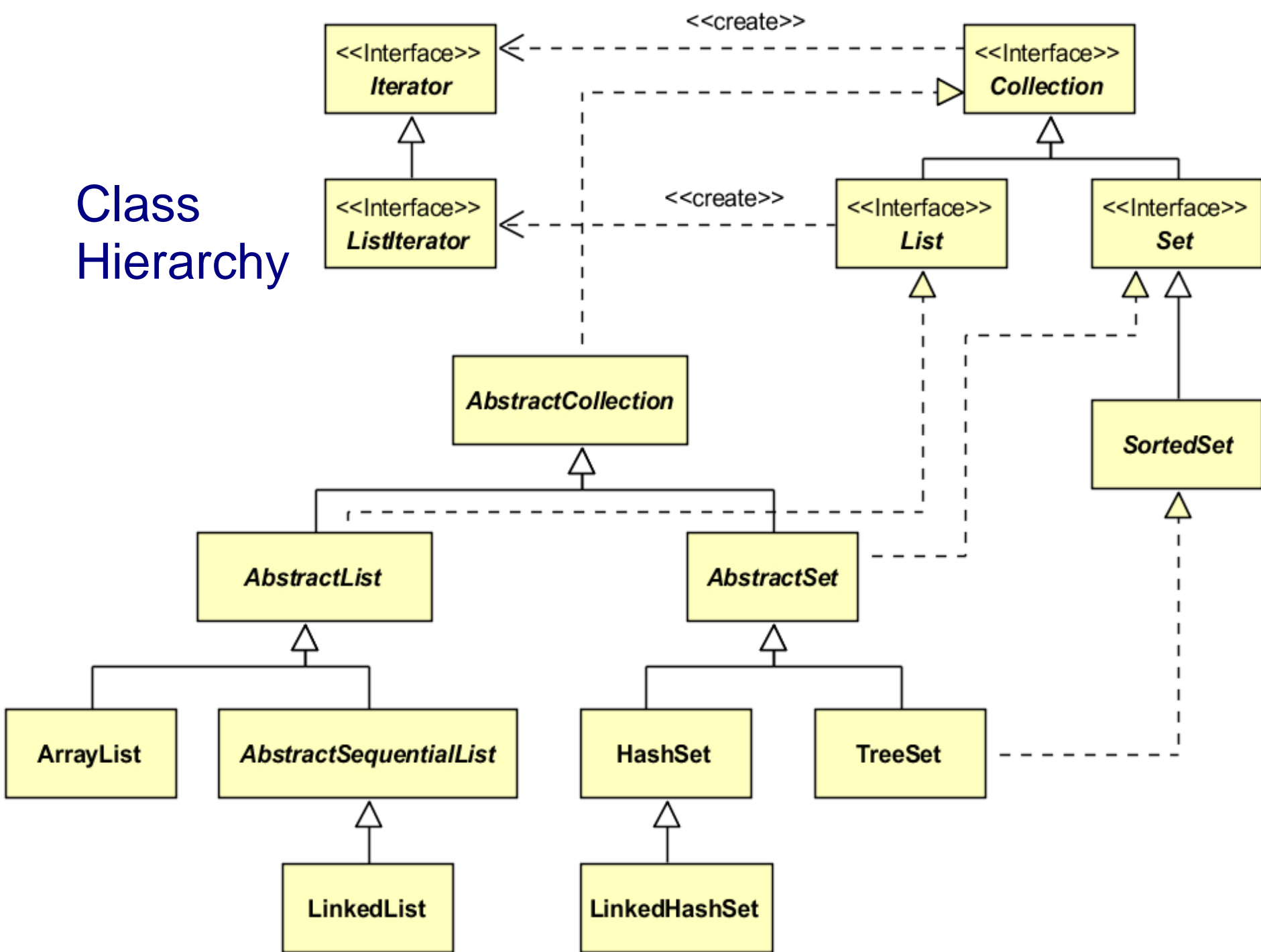
# Arrays. Comparing and Sorting

- Arrays and working with them
- Utility methods of the class **Arrays**:
  - `equals()`
  - `fill()`
  - `copyOf()` и `copyOfRange()`
  - `binarySearch()`
  - `sort()`
- Comparing objects – interfaces **Comparable** and **Comparator**

# Container Classes and Interfaces. Iterators.

- Колекции – интерфейс **Collection**
- Списъци – интерфейс **List**, реализации – **ArrayList**, **LinkedList**, ...
- Множества – интерфейс **Set**, реализации – **HashSet**, **TreeSet**, ...
- Асоциативни списъци – интерфейс **Map**, реализации – **HashMap**, **TreeMap**, **LinkedHashMap**, **WeakHashMap**, ...
- Обхождане на колекция с итератор.
- Реализиране на структури от данни стек, опашка, дек – интерфейси **Queue** и **Deque**. Реализации.

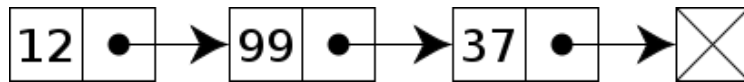
# Class Hierarchy



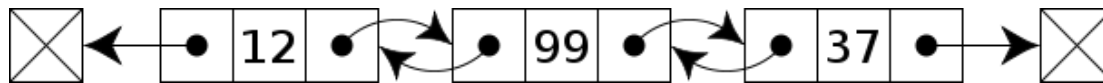


# Data Structures

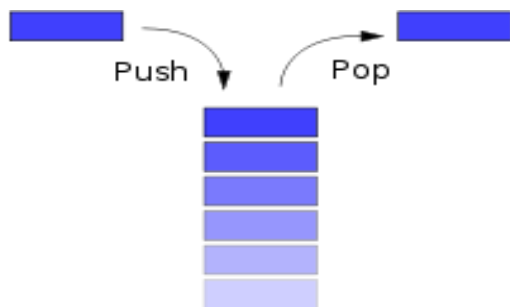
- Linked list:



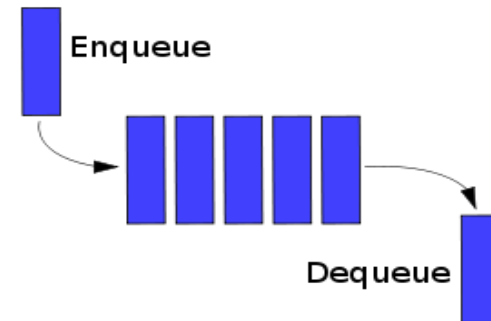
- Doubly-linked list:



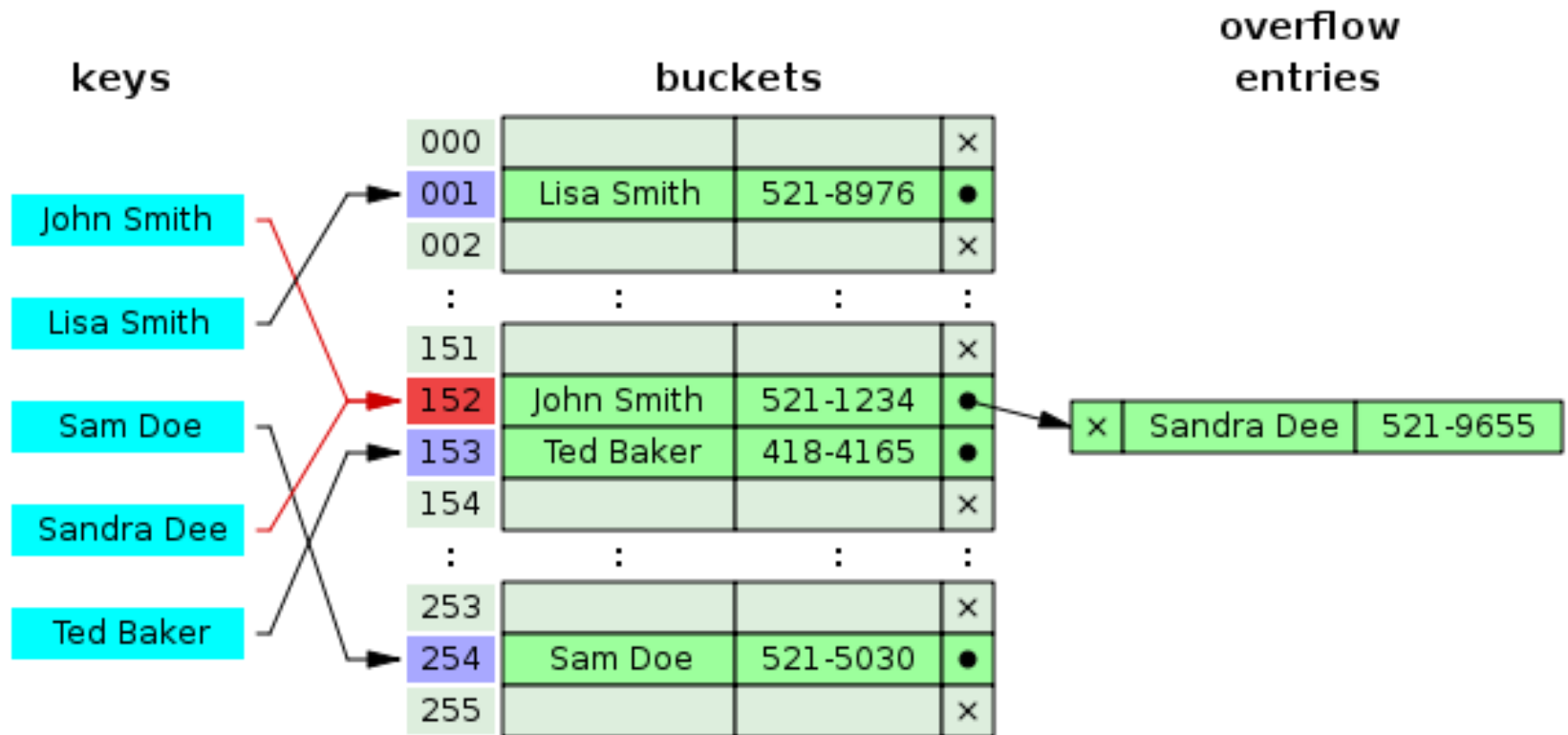
- Stack:



- Queue:



# Hashing. Hash-Functions. Hash Tables



# Parameterized Types: Generics (1)

- Collections and their methods before Java 5 were limited to handle a single type of elements.
- If we want to create typed containers we had to implement different container types for each entity type.
- *Example:* In a e-Bookstore we want to sell **Books** and want the container to contain only **Books** (being strongly typed) --> we should implement separate class **BookList**, as well as for each **Book** we want to keep a list of **Authors** --> we should implement **AuthorList** too, and so on.

# Parameterized Types: Generics (2)

- *Solution:* We can skip writing multiple similar classes (e.g. typed containers for each type of elements) using **Generic types**

- *Generic type invocation:*

```
List<Book> books = new ArrayList<Book>()
```

```
List<Author> authors = new ArrayList<Author>()
```

- **<>** – **Diamond** operator – new in Java™ 7, allows automatic inference of the generic type:

```
List<Book> books = new ArrayList<>()
```

```
List<Author> authors = new ArrayList<>()
```

# Parameterized Types: Generics (3)

- *Generic type declaration:*

```
public class Position<T extends Product> {  
    private T product;  
    ...  
    public Position(T product, double quantity) {  
        this.product = product;  
        this.quantity = quantity;  
        price = product.getPrice();  
    }  
    public T getProduct() {  
        return product;  
    }  
    ...  
}
```

Generic data type

# Conventions Naming Generic Parameters

- Generic parameters naming conventions:

**T** – type parameter (if there are more – **S**, **U**, **V**, **W** ...)

**E** – element of a collection – e.g.: `List<E>`

**K** – key in associative pair – e.g.: `Map<K,V>`

**V** – value in associative pair – e.g.: `Map<K,V>`

**N** – number value

*Example:*

```
public class Invoice <T extends Product> {  
    ...  
    private List<Position<T>> positions = new ArrayList<>();  
    ...  
}
```



# Generic Methods (1)

- We can implement generic methods and constructors too:

```
public static <U extends Product> String
getPositionsAsString (List<Position<U>> positions) {
    StringBuilder posStr = new StringBuilder();
    int n = 0;
    for(Position<U> p: positions){
        posStr.append( String.format(
"\n| %1$3s | %2$30s | %3$6s | %4$4s | %5$6s |%6$8s |",
++n, p.getProduct().getName(), p.getQuantity(),
p.getProduct().getMeasure(),p.getPrice(), p.getTotal()
        ));
    }
    return posStr.toString();
} ...
```

# Generic Methods (2)

- Invoking generic method / constructor:

```
result += Invoice.<T> getPositionsAsString(positions);
```

- OR we can let Java to automatically infer the generic type:

```
result += Invoice.getPositionsAsString(positions);
```

# Bounded Type Parameters

- We can define upper bound constraint for the possible types that can be allowed as actual generic type parameters of the class / method / constructor:

```
public static <U extends Product> String  
getPositionsAsString (List<Position<U>> positions) { ... }
```

- OR

```
public static <U extends Product & Printable> String  
getPositionsAsString (List<Position<U>> positions) {  
    ...  
    p.getProduct().print();  
    ...  
}
```

# Generics Sub-typing

- If the class **Product** extends class **Item**, can we say that **List<Product>** extends **List<Item>** too? Can we substitute the first with the second?
- The answer is „**NOT**“, because the basic generic type is not designed to reflect the specifics of of the **Products**.
- Dos and donts when using generics inheritance:

```
interface Service extends Item; Service s = new Service( ...);
```

```
Collection<Service> services = ...; services.add(s); // OK
```

```
interface Product extends Item; Product p = new Product( ...);
```

```
Collection<Product> products = ...; products.add(p); // OK
```

```
Collection<Item> items = ...; items.add(s); items.add(p); // OK
```

```
items = products; // NOT OK
```

```
items = services; // NOT OK
```

# Using ? as Type Specifier (Wildcards)

- If we want to declare that we expect specific, but not pre-determined type, which for example extends the class **Item**, we could use **?**:

```
Collection<? extends Item> items; // Upper bound is Item
```

```
items = products; // OK
```

```
items = services; // OK
```

```
Items.add(p); // NOT OK – Can not write into it – it is not safe!
```

```
Items.add(s); // NOT OK – Can not write into it – it is not safe!
```

```
for(Item i: items) { // OK – Can read it – it is known to be at least Item.
```

```
    System.out.println( i.getName() + „:“ + i.getPrice() );
```

```
}
```

```
List<? super Product> products; // Lower bound is Product
```

```
products.add(p); // OK – Can write into it – it is now safe.
```

```
Product p = products.get(0); //NOT OK may be superclass of Product
```

- Producer extends and Consumer super (PECS) principle

# Type Erasure & Reification

- **Type Erasure** – chosen in java as backward-compatibility alternative – information about generic type parameters is erased during compilation, and is NOT available in runtime – the generic type becomes compiled to its basic raw type:

`Collection<Product> products; --(runtime)--> Collection products;`

This design decision creates problems if we want to create generic type instance with **new**, or to convert to the generic type, or to check the generic type using **instanceof**.

- **Reification** – better alternative strategy, implemented in languages such as C++, Ada и Eiffel, using which the generic type information is accessible in runtime.



# Generic Containers

- Allow compile time type checking – earlier error detection
- Remove unnecessary typecasting to more specific types – less `ClassCastException`s
- Examples:

```
Collection <String> s = new ArrayList <String>();
```

```
Map <Integer, String> table = new HashMap <Integer,  
String>()
```

- New **for** loop – for each element of a Collection :  

```
for(String i: s) { System.out.println(i) }
```

# Main Implementing Classes. Examples

- Associative lists (dictionaries) – interface **Map**
- Comparing different implementations:
  - ❖ **HashMap**
  - ❖ **TreeMap**
  - ❖ **LinkedHashMap**
  - ❖ **WeakHashMap**
- Hashing.
- Cash implementations – **Reference, SoftReference, WeakReference и PhantomReference**
- Choosing a container implementation

# Литература и интернет ресурси

- Oracle Generics tutorial –  
<https://docs.oracle.com/javase/tutorial/extra/generics/index.html>

# Thank's for Your Attention!



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