6. Grundkonzepte der Objektorientierung (4):

Generische Klassen

Java-Beispiele:

StackForChar.java
BuildPairs.java
BuildPairsBounds.java
StackGen.java

Schwerpunkte

- Das Generalisierungsproblem
- Generalisierung durch Klasse ‚Object'
- Wrapper-Klassen
- cast-Operator für Objekte
- Generische Klassen
- Generischer Typ

Das Generalisierungsproblem

Problem: Stack für unterschiedliche Elementtypen

- Für char-Elemente (bisherige Variante)

Stack.java

```
class Stack {
   private char[] stackElements;
   private int top;
      ...
   public void push(char x) {
      top++; stackElements[top] = x;
   }
   ...
```

austauschen

- Für int-Elemente
- Für Zeitangaben: Klasse 'Time'

→ 3 Klassen mit größtenteils identischem Code

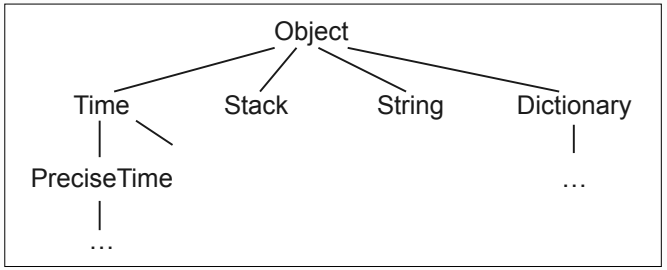
Gibt es eine elegantere Lösung?

Allgemeiner Stack: Elementtyp 'Object'

StackForChar.java

```
class Stack {
   private Object [] stackElements;
   private int top;

   public Stack(int n) {
      stackElements = new Object[n];
      top = -1;
   }

   public void push(Object x) {
      top++;
      stackElements[top] = x;
   }
   ...
}
```


Wiederholung: Kompatibilitätsregel der Klassenhierarchie



Objekte einer Unterklasse dürfen dort stehen, wo Objekte von Oberklassen zugelassen sind.

Beispiele:

```
Time t;
t = new PreciseTime(12, 10, 1);
t.printTime();
```

```
Object o;
o = new Time(12, 10);
o.printTime();
```


Allgemeiner Stack: Anwendung auf 'Time'

```
class Stack {
    private Object [] stackElements;
    private int top;

    public Stack(int n) {
        stackElements = new Object[n];
        top = -1;
    }

    public void push(Object x) {
        top++; stackElements[top] = x;
    }
    ...
}
```

Stack mit Basistyp Object

Was passiert bei `timeStack.push(t1)`?

```
Time t1 = new Time(8, 30);
Stack timeStack = new Stack(10);

timeStack.push(t1.copy());
t1.addMinutes(10);
timeStack.push(t1.copy());
t1.addMinutes(30);
timeStack.push(t1.copy());
```

Statt Object wird Time übergeben

indirekt:
`class Time extends Object`

Wrapper-Klassen

Allgemeiner Stack: Anwendung auf 'char'

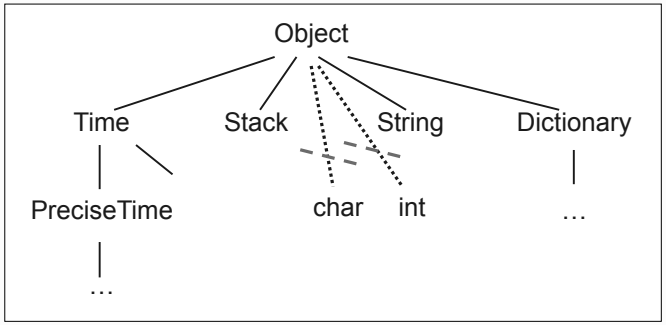
```
class Stack {
     private Object [] stackElements;
     private int top;

     public Stack(int n) {
          stackElements = new Object[n];
          top = -1;
     }

     public void push(Object x) {
          top++; stackElements[top] = x;
     }
     ...
}
```

```
char ch = 'A';

Stack s = new Stack(10);
s.push(ch);
```

erwartet Klasse Object o. Unterklasse

```
Stackchar.java:52: Incompatible type for method.
Can't convert char to java.lang.Object.
```


Klassenhierarchie



Objekte einer Unterklasse dürfen dort stehen, wo Objekte von Oberklassen zugelassen sind:

Aber elementare Typen sind keine Klassen.

Wrapper-Klassen

einfacher Typ → Klasse

einfacher Typ 'verpackt' in Klasse

wrap = verpacken

byte	Byte
short	Short
int	Integer
long	Long
double	Double
float	Float
boolean	Boolean
char	Character
void	Void

Java-API: in java.lang

Jeweils Unterklasse von java.lang.Object
→ Können dort stehen, wo Object erlaubt ist.

Wrapper-Klasse ´Character´

java.lang
Class Character

java.lang.Object
  java.lang.Character
All Implemented Interfaces:
Comparable, Serializable

public final class **Character**
extends Object
implements Serializable, Comparable
The `Character` class wraps a value of the primitive type `char` in an object. An object of type `Character` contains a single field whose type is `char`.

In addition, this class provides several methods for determini

Character information is based on the Unicode Standar

The methods and data of class `Character` are defi — ecifies various properties including name and general categ

The file and its description are available from the U

- http://www.unicode.org

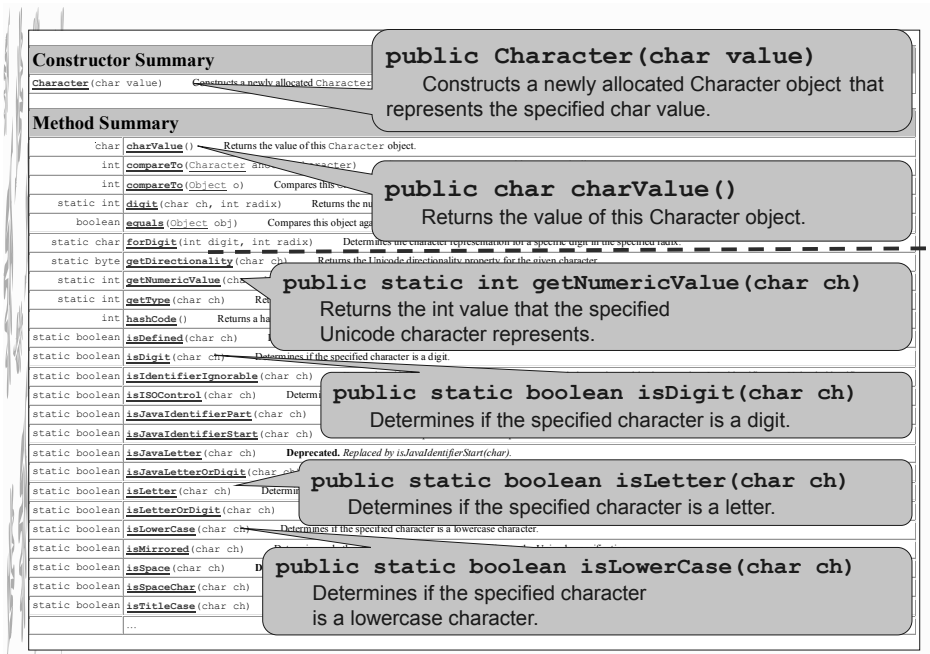
Since:
1.0
See Also:
Serialized Form

Field Summary

static byte	COMBINING_SPACING_MARK
static byte	CONNECTOR_PUNCTUATION
static byte	CONTROL General categor
static byte	CURRENCY_SYMBOL Ge
static byte	DASH_PUNCTUATION G
static byte	DECIMAL_DIGIT_NUMBER
static byte	DIRECTIONALITY_ARABIC_
static byte	DIRECTIONALITY_BOUNDARY
static byte	DIRECTIONALITY_COMMON_NUM
static byte	DIRECTIONALITY_EUROPEAN_NUMBER Weak bidirectional character type "EN" in the Unicode specification.
static byte	DIRECTIONALITY_EUROPEAN_NUMBER_SEPARATOR Weak bidirectional character type "ES" in the Unicode specification.
static byte	DIRECTIONALITY_EUROPEAN_NUMBER_TERMINATOR Weak bidirectional character type "ET" in the Unicode specification.
	…

The Character class wraps a value of the primitive type char in an object. An object of type Character contains a single field whose type is char.

In addition, this class provides several methods for determining a characters's category (lowercase letter, digit, etc.) and for converting characters from uppercase to lowercase and vice versa.



Annahme: Java-API ohne Wrapper-Klassen

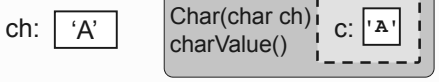
➔ selbst implementieren

Wrapper 'Char' für 'char': selbst implementiert

StackForChar.java

```
class Char {
   private char c;

   public Char(char ch) {
      c = ch;
   }
   public char charValue() {
      return c;
   }
}
```

```
Char ch;

ch = new Char('A');
char c = ch.charValue();
```



Allgemeiner Stack: Anwendung auf Wrapper-Klasse 'Character'

```
class Stack {
     private Object [] stackElements;
     private int top;

     public Stack(int n) {
          stackElements = new Object[n];
          top = -1;
     }

     public void push(Object x) {
          top++; stackElements[top] = x;
     }

     public Object top() {…}
     ...
}
```

```
Character ch;
Stack s = new Stack(10);

ch = new Character(Keyboard.readChar());
s.push(ch);
ch = (Character)s.top();
char c = ch.charValue();
```

Typ 'char'

nach 'Character'

Von ‚Character' nach 'char'

Kompatibilität und Typ-Cast

```
class Stack {
    private Object [] stackElements;
    private int top;

    public Stack(int n) {
        stackElements = new Object[n];
        top = -1;
    }

    public void push(Object x) {
        top++; stackElements[top] = x;
    }

    public Object top() {…}
    ...
}
```

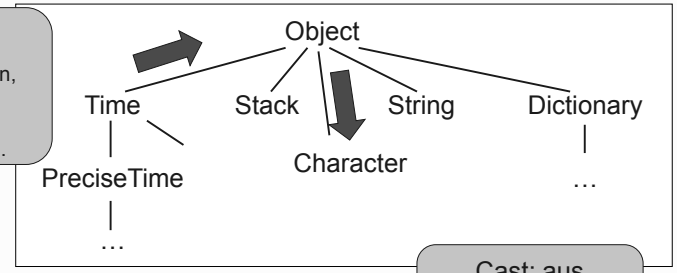
```
Character ch;
Stack s = new Stack(1

ch = new Character(Keyboard.readChar());
s.push(ch);
ch = (Character)s.top();
char c = ch.charValue();
```

Kompatibilitätsregel: Objekte einer Unterklasse dürfen dort stehen, wo Objekte von Oberklassen zugelassen sind.

Umgekehrte Richtung (Oberklasse → Unterklasse): Typ-Cast von 'Object' nach 'Character' notwendig

Kompatibilität: automatisch – mit cast-Opertator

Objekte einer Unterklasse dürfen dort stehen, wo Objekte von Oberklassen zugelassen sind.



Standard: spezieller Typ wird allgemeinem Typ zugeordnet

Cast: aus allgemeinem Typ wird spezieller

```
Time t;
t = new PreciseTime(12, 10, 1);
t.printTime();
```

```
Character ch;
Stack s = new Stack(10);

ch = (Character)s.top();
char c = ch.charValue();
```


Wrapper-Klasse ´Character`

java.lang
Class Character

java.lang.Object
  java.lang.Character
All Implemented Interfaces:
Comparable, Serializable

public final class **Character**
extends Object
implements Serializable, Comparable
The Character class wraps a value of the primitiv
In addition, this class provides several methods for
Character information is based on the Unicode Stan
The methods and data of class Character are def
various properties including name and general categ
The file and its description are available from the U
- http://www.unicode.org

Since: 1.0
See Also: Serialized Form

- The Character class wraps a value of the primitive type char in an object. An object of type Character contains a single field whose type is char.
- In addition, this class provides several methods for determining a characters's category (lowercase letter, digit, etc.) and for converting characters from uppercase to lowercase and vice versa.

Field Summary

static byte	COMBINING_SPACING_MARK General category "Mc" in the Unicode specification.
static byte	CONNECTOR_PUNCTUATION General category "Pc" in the Unicode specification.
static byte	CONTROL General category "Cc" in the Unicode specification.
static byte	CURRENCY_SYMBOL General category "Sc" in the Unicode specification.
static byte	DASH_PUNCTUATION General category "Pd" in the Unicode sp
static byte	DECIMAL_DIGIT_NUMBER General category "Nd" in the U
static byte	DIRECTIONALITY_ARABIC_NUMBER Weak bidire
static byte	DIRECTIONALITY_BOUNDARY_NEUTRAL Weak bidi
static byte	DIRECTIONALITY_COMMON_NUMBER_SEPARATOR
static byte	DIRECTIONALITY_EUROPEAN_NUMBER Weak bidirectional charac
static byte	DIRECTIONALITY_EUROPEAN_NUMBER_SEPARATOR Weak bidirectional character type "ES" in the Unicode specification.
static byte	DIRECTIONALITY_EUROPEAN_NUMBER_TERMINATOR Weak bidirectional character type "ET" in the Unicode specification.
	…

Logische Struktur in Ordnung?

Constructor Summary

Character(char value)	Constructs a newly allocated Character

Method Summary

char	charValue() Returns the value of this Character object.
static byte	getDirectionality(char ch) Returns the Unicode directionality property for the given character.
static int	getNumericValue(char
static boolean	isDigit(char ch)
static boolean	isLetter(char ch)
static boolean	isTitleCase(char ch)
	…

public Character(char value)
Constructs a newly allocated Character object that represents the specified char value.

Wrapper

public char charValue()
Returns the value of this Character object.

Service: Arbeit mit Zeichen

public static int getNumericValue(char ch)
Returns the int value that the specified Unicode character represents.

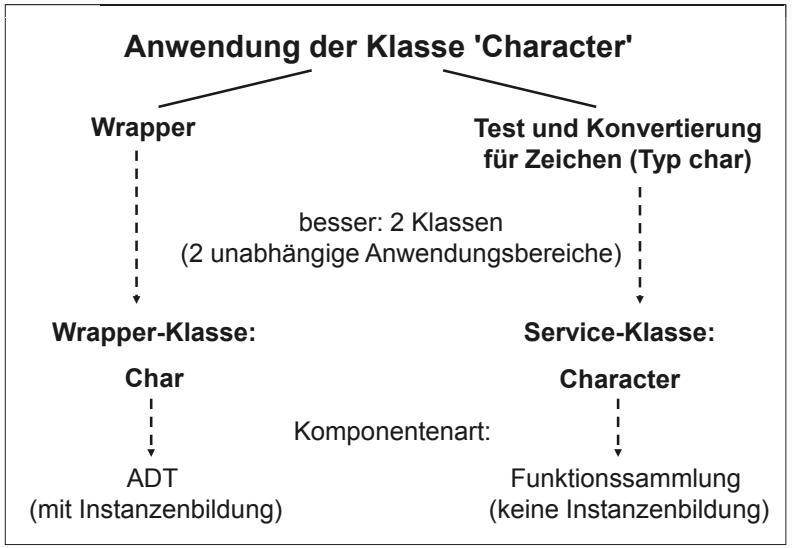
public static boolean isDigit(char ch)
Determines if the specified character is a digit.

public static boolean isLetter(char ch)
Determines if the specified character is a letter.

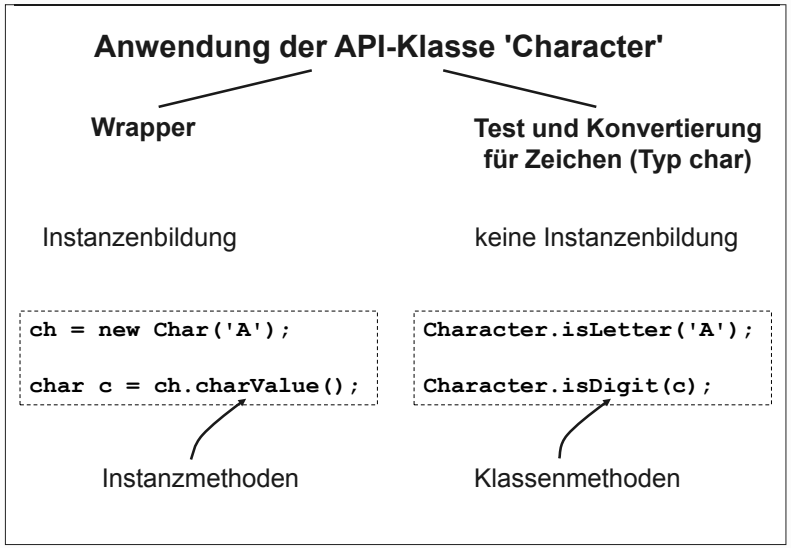
public static boolean isLowerCase(char ch)
Determines if the specified character is a lowercase character.

Die Klasse ‘Charakter‘ spielt keine Rolle.

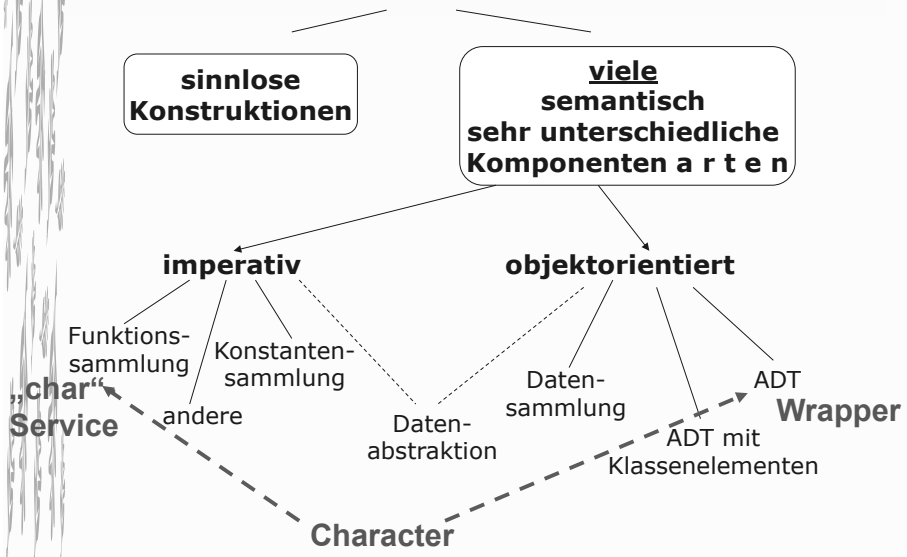
Java-API: logische Struktur ok?



Anwendungen von 'Character'



Platz der API-Klasse ´Character‘



Generische Klassen

Immer "reine" Stacks: derselbe Basistyp garantiert (z.B. Character)?

Allgemeiner Stack: Elementtyp 'Object'

StackForChar.java

```
class Stack {
   private Object [] stackElements;
   private int top;

   public Stack(int n) {
      stackElements = new Object[n];
      top = -1;
   }
   ...
}
```

bisher: Stack von Time, Stack von Character, …

Gemischte Stacks möglich?

"Gemischte" Stacks möglich

```
class Stack {
   private Object [] stackElements;
   private int top;

   public Stack(int n) {
      stackElements = new Object[n];
      top = -1;
   }
   ...
}
```

Problem: Typsicherheit

```
Stack mixedStack = new Stack(10);

mixedStack.push(new Char('A'));
mixedStack.push(new Time(8,30));
mixedStack.push(new Integer(20));
```

Oft will man Stacks mit demselben Basistyp, kann es aber so nicht garantieren.

Schön wäre es, wenn es Typ-Parameter gäbe … (1)

Anstelle von:

```
class Stack {
    private Object [] stackElements;
    private int top;

    public Stack(int n) {
        stackElements = new  Object [n];
        top = -1;
    }

    public void push(Object x) {
        top++; stackElements[top] = x;
    }

    public Object top() {
        . . .
    }
 . . .
}
```


Schön wäre es, wenn es Typ-Parameter gäbe … (2)

nun:

```
class Stack<T> {
    private T [] stackElements;
    private int top;

    public Stack(int n) {
        stackElements = new  T [n];
        top = -1;
    }

    public void push(T x) {
        top++; stackElements[top] = x;
    }

    public T top() {
       . . .
    }
 . . .
}
```

T steht für **beliebigen**, aber **festen** Typ

… mit einer Aktualisierung durch Typargumente

```
Stack<Time> tStack;
Stack<Character> chStack;

tStack = new Stack<Time> ();
chStack = new Stack<Character> ();

tStack.push(new Time(1,20));
chStack.push(new Character('A'));
chStack.push(new Time(7,10));
```

Damit: keine „gemischten“ Stacks erlaubt

Typfehler: Compiler erwartet Parameter vom Typ ‘Character’

Anmerkung:
Dieses Beispiel klappt so nicht ganz.

Generische Klasse: Deklaration

BuildPairs.java

```
class Pair<T> {
    private T first;
    private T second;

    public Pair(T fst, T scd) {
       first = fst;
       second = scd;
    }

    public T getFirst() {
      return first;
    }

    public T getSecond() {
      return second;
    }
  }
```

Typvariable

Generische Klasse

T: beliebiger, aber fester Typ

Damit keine gemischten Tupel: z. B. (Integer, String)

Generische Klassen: Ab Java 2 (Version 1.5)

Generischer Typ: Typvariablen werden aktualisiert

BuildPairs.java

```
class BuildPairs {

  public static void main (String[] args) {
    Pair<Integer> pi;
    Pair<String>  ps;
    Integer i, j;

    i = new Integer(99);
    j = new Integer(100);
    pi = new Pair<Integer> (i, j);
    ps = new Pair<String> ("Hallo", "World");

    System.out.println(ps.getFirst() + " "
           + ps.getSecond());
    System.out.println(pi.getFirst().intValue()
           + " " + pi.getSecond().intValue());
  }
}
```

Generischer Typ

Typargument

Generischer Typ = Generische Klasse + Typargument

Generischer Typ: Verwendung wie normaler Typ

BuildPairs.java

```
class BuildPairs {

  public static void main (String[] args) {
    Pair<Integer> pi;
    Pair<String>  ps;
    Integer i, j;

    i = new Integer(99);
    j = new Integer(100);
    pi = new Pair<Integer> (i, j);
    ps = new Pair<String> ("Hello", "World");

    System.out.println(ps.getFirst() + " "
           + ps.getSecond());
    System.out.println(pi.getFirst().intValue()
           + " " + pi.getSecond().intValue());
  }
}
```

Variablen vereinbaren

Konstruktor aufrufen

Methoden aufrufen

```
% java BuildPairs

Hello World
99 100
```

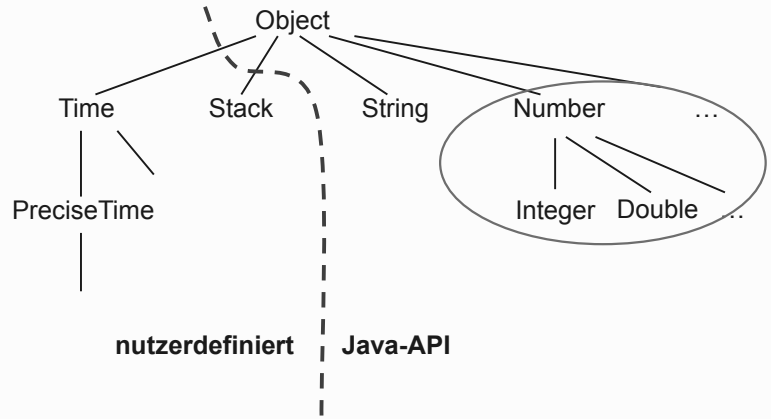
Typbounds: Einschränkung von Typargumenten

BuildPairsBounds.java

```
class PairNumber <T extends Number> {
  private T first;
  private T second;

  PairNumber(T fst, T scd) {
     first = fst;
     second = scd;
  }

  public T getFirst() {
    return first;
  }

  public T getSecond() {
    return second;
  }

  public double add () {
    return first.doubleValue() + second.doubleValue();
  }
}
```

Typargument muss von Number abgeleitet sein: Integer, Double … (Wrapper-Klassen, die Zahlen repräsentieren)

Klasse ‚Number': Oberklasse von „Zahlen"-Wrapperklassen



Typbounds: Einschränkung von Typargumenten

BuildPairsBounds.java

```
class BuildPairsBounds {

  public static void main (String[] args) {
    PairNumber<Integer> pi;
//  PairNumber<String>  ps;
    Integer i, j;

    i = new Integer(99);
    j = new Integer(100);
    pi = new PairNumber<Integer> (i, j);

    System.out.println(pi.getFirst().intValue()
            + " " + pi.getSecond().intValue() + " "
            + pi.add());
  }
}
```

Integer von Number abgeleitet

Fehler!

```
% java BuildPairsBounds

99 100 199.0
```


Erinnerung: Schön wäre es, wenn es Typ-Parameter gäbe …

```
class Stack  <T> {
    private T [] stackElements;
    private int top;

    public Stack(int n) {
        stackElements = new  T [n];
        top = -1;
    }

    public void push(T x) {
        top++; stackElements[top] = x;
    }

    public T top() {
       . . .
    }
 . . .
}
```

Nicht erlaubt: Typvariable als Array-Elementtyp

Ausweg: Statt Arrays verwende man generische API-Klasse ArrayList

ArrayList

StackGen.java

Kombination aus Array und Liste

```
ArrayList<T> stackElements;
```

```
statt: T[] stackElements;
```

- Als Array: Zugriff über Index

  ```
  stackElemements.get(top)
  ```

- Als Liste: beliebige Länge

  Modifikation durch

  ```
  stackElements.set(top,x)
  ```
  existierendes Element ändern

  ```
  stackElements.add(top,x)
  ```
  erweitern an der Stelle top