Educational Objectives

- You can create your own *classes/data types*.
- You understand how *objects* are being instantiated and used.
- You know the term *encapsulation* and are able to your situation.

13. Java Classes

Classes, types, objects, declaration, instantiation, constructors, encapsulation, static fields and methods

Definition: *Classes*

Classes are (user-defined) data types that allow to combine several elements to a new object and to access it by a common name

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Classes - Technical

A class is an entity with a *name* that contains *data* and *functionality*

- A class defines a new *data type*.
- *Data* consists of variables that we call *fields* or *attributes*.
- *Functionality* consists as *methods* that are defined within the class.
- Classes are (typically) separate `.java` files with the same name.

Classes - Conceptual

Classes facilitate to *bundle* the data that *belongs together* content wise.

Classes provide *functionality* that allows to perform *queries* based on the data or *operations* on the data.

Example: Earthquake catalog

Schweizerischer Erdbebendienst
Service Sismologique Suisse
Servizio Sismico Svizzero
Swiss Seismological Service

SED > *Earthquake catalog* > Query the catalogue

Earthquake catalog

link	date	time	appraisal	event type	lat [°N]	lon [°E]	source agencygency	depth	Mw	Ml	Io	Ix	epicentral area
»	2001/01/01	00:03:47.8	certain	earthquake	45.53	6.75	RENASS/BCSF (2009)	5.	1.52	0.9			SSE BEAUFORT(73)
»	2001/01/01	00:20:01.5	uncertain	earthquake	47.51	9.48	LED (2009)	10.	2.17	1.99			
»	2001/01/03	11:11:20.4	certain	earthquake	46.446	9.982	SED (ECOS-09)	4.	2.36	2.3			
»	2001/01/07	18:55:18.3	certain	earthquake	48.05	9.03	LED (2009)	15.	1.82	1.41			
»	2001/01/07	20:55:36.5	certain	earthquake	46.564	10.29	SED (ECOS-	5.	1.94	1.6			

Class for measurement - first try

date	time	appraisal	event type	lat [°N]	lon [°E]	source agencygency	depth	Mw
2001/01/03	11:11:20.4	certain	earthquake	46.446	9.982	SED (ECOS-09)	4.	2.36

File `Measurement.java`

```java
public class Measurement {

    String date;
    String time;

    double latitude;
    double longitude;

    float magnitude;
}
```

Measurement

- String date
- String time
- double latitude
- double longitude
- float magnitude

Definition: *Objects*

Classes are data types. Objects are values of such a type, where the class determines the structure of those objects.

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Objects: Instances of Classes

Classes describe the structure of objects, like a *blueprint*

⇒ Comparable with the *header* of the CSV.

Objects are instantiated according to the blueprint and will contain values

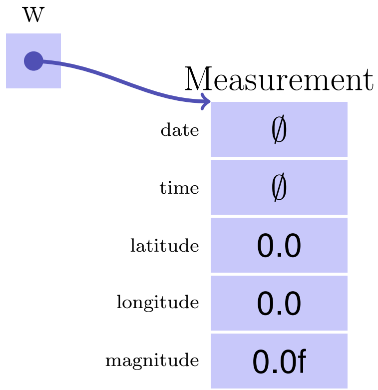
⇒ Comparable with the individual *data-rows* in the CSV.

Object Instantiation: The Keyword `new`

Variable “w” of type “Measurement”

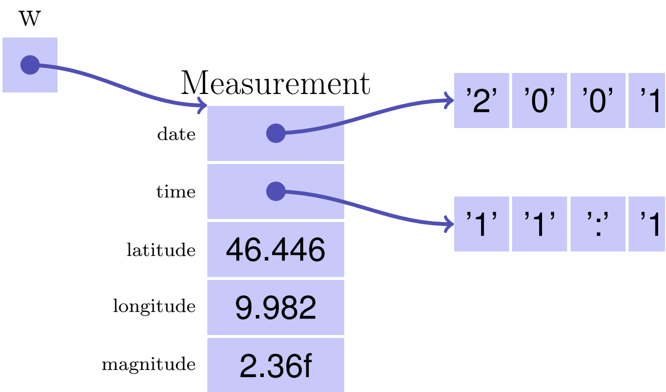
```
Measurement w;

w = new Measurement();
```

Instantiation of an object of type Measurement



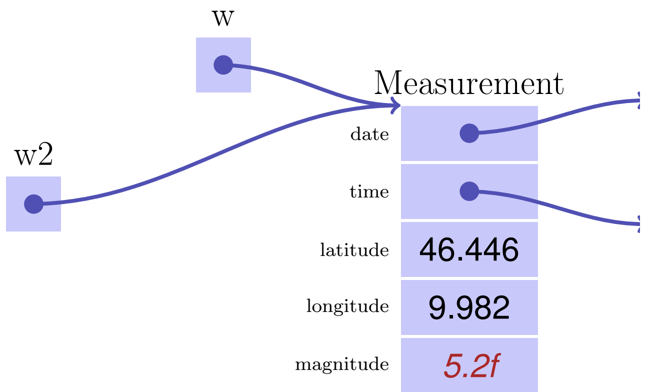
De-referencing: Accessing Fields

```
Measurement w;

w = new Measurement();

w.date = "2001/01/03";
w.time = "11:11:20";
w.latitude = 46.446;
w.longitude = 9.982;
w.magnitude = 2.36f;
```



Objects are Reference-Types: Aliasing

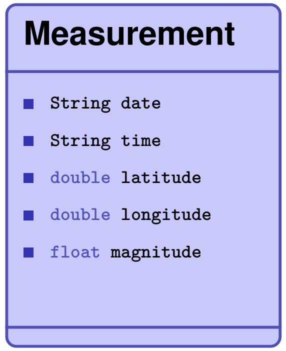
```
Measurement w;

w = new Measurement();

Measurement w2 = w;

w2.magintude = 5.2f;

Out.println(w.magnitude);
```



Wait a second! ...

Classes facilitate to *bundle* the data that *belongs together* content wise.

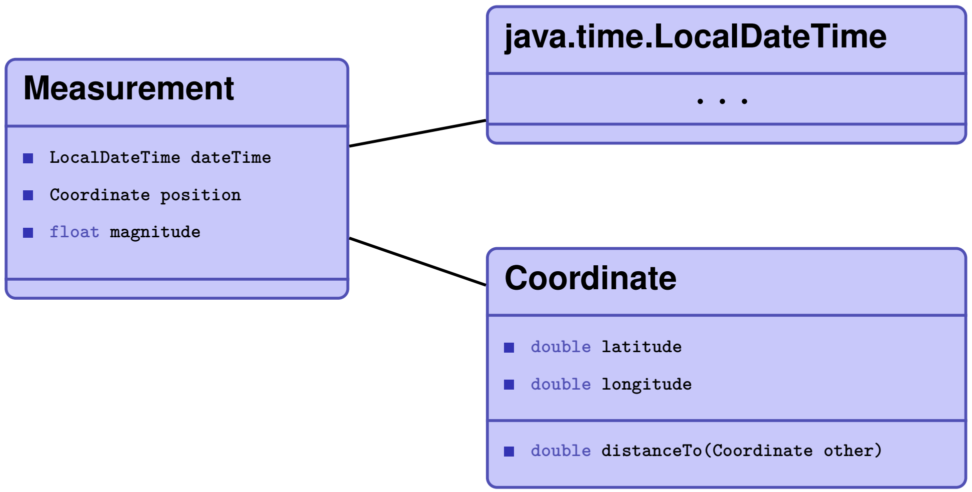
Good Class Design?



We can do better!

- Date and Time belong together in a separate class: Java already offers this: `java.time.LocalDateTime`
- Latitude and longitude belog in their own data type `Coordinate`.

Class Design - second try

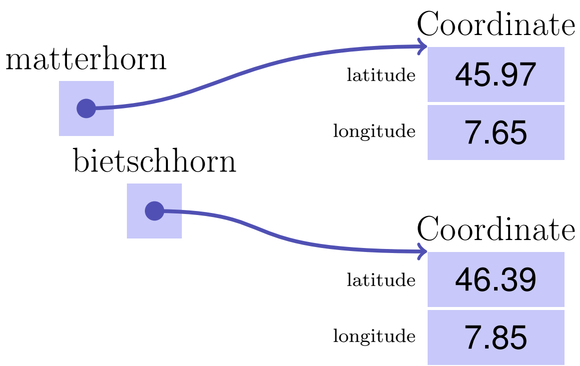


Methods in Classes

```
public class Coordinate {

    double latitude;
    double longitude;

    /**
     * Computes the distance to the provided coordinate 'other'.
     */
    double distanceTo(Coordinate other){
        double dl = this.latitude - other.latitude;
        // complete this as exercise ...
    }
}
```

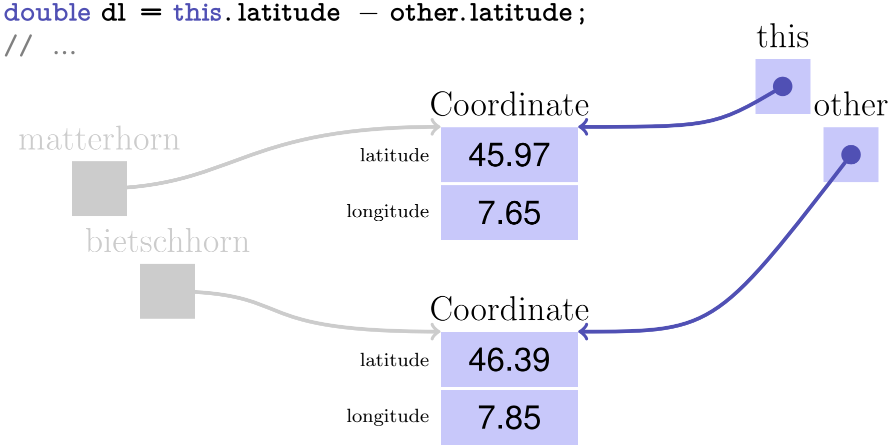
Method calls - Example setup

```
Coordinate matterhorn, bietschhorn;
// ... Instanciate and set values ...
d = matterhorn.distanceTo(bietschhorn);
```



From the context inside the method

```
double distanceTo(Coordinate other){
        double dl = this.latitude - other.latitude;
        // ...
```



Keyword `this`

`this` enables to access the current object from within a method of that class.

Constructors

Creating a `Coordinate` is somewhat cumbersome:

```
Coordinate k = new Coordinate();
k.latitude = 45.97;
k.longitude = 7.65;
```

Constructors facilitate to easily set the initial values of a newly created object.

```
Coordinate k = new Coordinate(45.97, 7.65);
```

In general, the job of the constructor is to establish a reasonable “valid” state.

Constructors - Definition

```
public class Coordinate{
    double latitude;
    double longitude;

    // Constructor for a given coordinates (as a pair of lat/long).
    Coordinate (double lat, double lon){
        this.latitude = lat;
        this.longitude = lon;
    }

}
```


Definition: *Data Encapsulation*

Data encapsulation allows to control access from outside to data and code of the class.

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Data Encapsulation / Information Hiding

Control, what data and what code can be *accessed* from where.

Access modifiers:

- `private`: Visible only from code within the same class
- `protected`: Visible from code in the same class or a subclass (later)
- `public`: Visible from everywhere

Name

- `private field1`
- `protected field2`
- ...

- `private method1`
- `public method2`
- ...

Example: Coordinate

```
public class Coordinate {
    public double latitude;
    public double longitude;

    public double distanceTo(Coordinate other){...}
}
```

Problems:

- Assignment of invalid values
- Consistency checks not possible
- Implementation exposed

Coordinate: Accessor Methods

```
public class Coordinate {
    private double latitude;
    private double longitude;

    public double getLatitude(){
        return latitude;
    }

    public void setLatitude(double lat){
        assert lat >= -90 && lat <= 90;
        this.latitude = lat;
    }
    //...
```


Coordinate: Usage

```
Coordinate position = ...;
position.setLatitude(45);     //This is fine

Out.println(position.getLatitude());     //This is fine


// The following two lines are WRONG
position.setLatitude(100);     //Assertion violation at runtime
Out.print(position.latitude); //Doesn't compile. Invalid access
```


Encapsulation: Exchange implementation

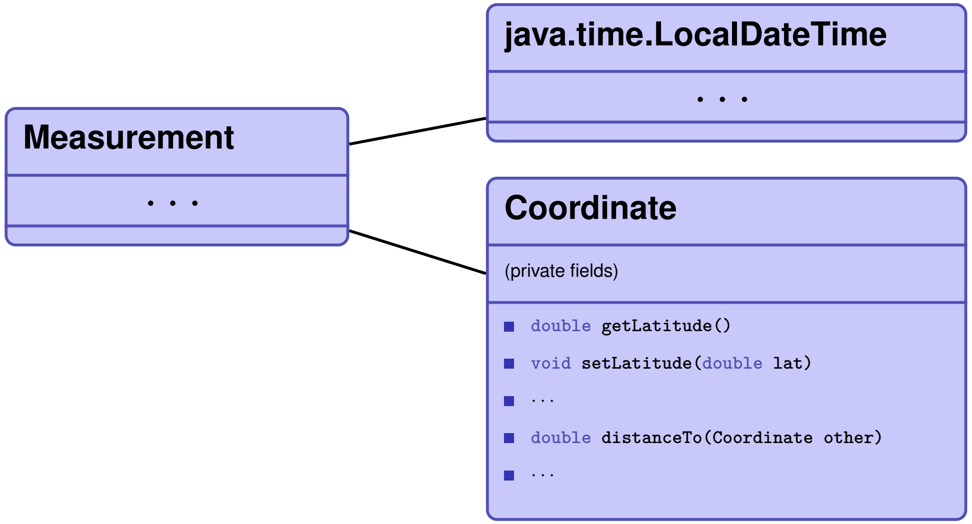
With no direct access to the data, it is easy to change the implementation without making it visible “to the outside”.

Example: Switch to Swiss Coordinate Grid

```
public class Coordinate {
    // Coordinate in LV03 Format (Swiss coordinate grid)
    private int x;
    private int y;

    public double getLatitude(){
        double x_aux = (x - 200_000) / 1_000_000;
        double y_aux = (y - 600_000) / 1_000_000;
        double result = (16.9023892 + (3.238272 * x_aux))
          - (0.270978 * pow(y_aux, 2)) - (0.002528 * pow(x_aux, 2))
          - (0.0447 * pow(y_aux, 2) * x_aux) - (0.0140 * pow(x_aux, 3));
        return (result * 100) / 36;
    }
```

Class Design - third try



Data Encapsulation

- A complex functionality gets defined as abstract as possible semantically and made accessible trough an agreed-upon minimal *interface*
- It should not be visible for the client *how* the state is represented in data fields of the class
- The class provides functionality to the client *independently of its representation*
- This allows to enforce *invariants*

Definition: *Static Fields and Methods*

Static methods and fields are not instantiated per object, but only once per class. They can be accessed directly via the class.

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Static Fields and Methods

Declared with the keyword `static`.

- Exist only once per class
- Are accessed directly via the class name rather than objects of the class. . .
- . . . this is why it’s not possible to access `this` from static methods.
- Observation: the `main` method is static!
  `public static void main(String[] args)`

Example: The `In` class

```
int f = In.readInt()
```

Is defined in class `In` (next slide)

Example: The `In` class

```
/**  This method skips white space and tries to read an integer. If the
 text does not contain an integer or if the number is too big, the
 value 0 is returned and the subsequent call of done() yields false.
 An integer is a sequence of digits, possibly preceded by '−'.
 */
public static int readInt(){
    String s = readDigits();  // read as many digits as possible
    try {
        done = true;
        return Integer.parseInt(s); // trt to interpret string s as int
    } catch (Exception e) {
        done = false;
        return 0; // something other than digits reat, return 0 instead
    }
}
```