Industrial Programming
Systems Programming & Scripting

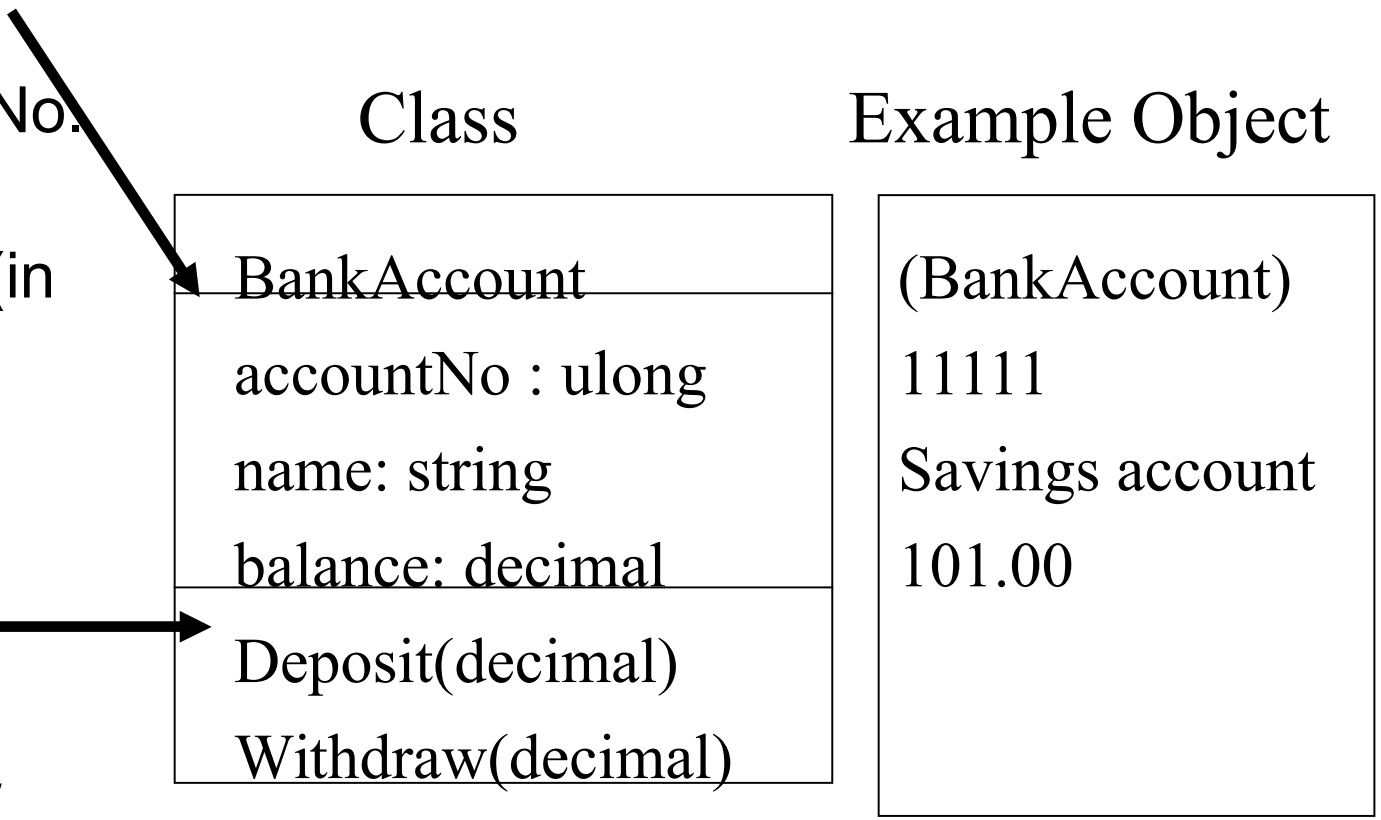
Lecture 12: C# Revision

3 Pillars of Object-oriented Programming

- **Encapsulation**: each class should be self-contained to localise changes. Realised through public and private attributes.
- **Specialisation**: model relationships between classes. Realised through inheritance.
- **Polymorphism**: treat a collection of items as a group. Realised through methods at the right level in the class hierarchy.

Bank Account

- Attribute:
  - Account No.
  - Name
  - Balance (in £'s)
- Methods:
  - Deposit
  - Withdraw



Extending the Example

- Define another class `ProperBankAccount` with an overdraft facility.
- Automatically assign account numbers to new accounts when generating them.
- Keep all field information secure within the account.

Designing the Class

- Fields:
  - Those in `BankAccount` + `overdraft`
- Methods:
  - Those in `BankAccount` but modified
- Invariants:
  - Balance in `ProperBankAccount` is never lower than the negative overdraft.

Revisiting the BankAccount Class

```
class BankAccount {
  protected static ulong latestAccountNo = 1000;
  protected ulong accountNo;
  protected decimal balance;
  protected string name;
```

- We use the access modifier `protected` to hide all fields from other classes, except derived classes.
- We use a `static` field to keep track of the assigned account numbers.

Revisiting the BankAccount Class

```
public BankAccount(string name) {
   latestAccountNo++;
   this.accountNo = latestAccountNo;
   this.name = name;
   this.balance = 0M;
 }

 public BankAccount(ulong no, string name) {
   this.accountNo = no;
   this.name = name;
   this.balance = 0M;
 }
```

- We use *overloading* of the constructor class and the static field to auto assign account numbers.

Revisiting the BankAccount Class

```
public void Deposit(decimal x) {
    this.balance += x;
}
```

- The `Deposit` method is unchanged.
- Its access modifier is `public`.

Revisiting the BankAccount Class

```
public virtual void Withdraw(decimal x) {
    if (this.balance >= x) {
      this.balance -= x;
    } else {
      throw new InsufficientBalance("Balance too low:
{0}", this.balance);
    }
  }
```

- We use *exceptions* to cover the case of an insufficient balance for making a withdrawl.
- The method must be declared *virtual* to allow overriding in a sub-class.

Revisiting the BankAccount Class

```
  public decimal GetBalance() { return this.balance; }

  public void ShowBalance() {
    Console.WriteLine("Current Balance: " + this.balance.ToString());
  }

  public virtual void ShowAccount() {
    Console.WriteLine("Account Number: {0}\tAccount Name: {1}\tCurrent
Balance: {2}",
              this.accountNo, this.name, this.balance.ToString());
  }
```

- `ShowAccount` must be declared virtual to allow overriding in sub-classes.
- The other methods are unchanged.

Invariants

```
// Class invariants:
// invariant: this.balance >= 0
```

- We record the above *class invariants*: this predicate must hold at any point in the lifetime of an object of this class.

Revisiting the BankAccount Class

```
public class InsufficientBalance : System.Exception {
  public InsufficientBalance(string msg, decimal x):base(msg)
{
    Console.WriteLine(" " + x.ToString());
  }
}
```

- The exception class derives from `System.Exception`
- It prints a message by calling the constructor of this base class
- Additionally, it prints the balance.

Implementing the Class

```
class ProperBankAccount: BankAccount {
  public decimal overdraft { get ; set;}
```

- `ProperBankAccount` inherits from `BankAccount`, thus all non-private fields and methods are available.
- The `overdraft` is implemented as a property with default get and set methods.

Implementing the Class (cont'd)

```
public ProperBankAccount(string name) :base(name) {
    // nothing; use set property on overdraft
}

public ProperBankAccount(ulong no, string name)
:base(no,name) {
    // nothing; use set property on overdraft
}
```

- We use overloading to implement 2 constructors for `ProperBankAccount`
- The static field is used to keep track of assigned account numbers.

Implementing the Class

```
 public override void Withdraw(decimal x) {
    if (this.balance+this.overdraft >= x) {
      this.balance -= x;
    } else {
      throw new InsufficientBalance("Balance (including overdraft) too
low", this.balance);
    }
  }
```

- By declaring the `Withdraw` method as override, the instance in `ProperBankAccount` overrides/replaces the one in `BankAccount`

Implementing the Class

```
 public override void ShowAccount() {
    base.ShowAccount();
    Console.WriteLine("\twith an overdraft of {0}",
this.overdraft);
  }
```

- Similarly, the `ShowAccount` method is overridden to additionally show the overdraft for this account.
- `base.ShowAccount()` calls the method in the base class.

Implementing the Class

```
// Class invariants:
 // invariant: this.balance >= - this.overdraft
```

- Finally, we record the class invariants for this class.

Testing the Class

```
 public void RunTransactions(BankAccount acct) {
    // if it has an overdraft facility, initialise its value
    ProperBankAccount pacct = acct as ProperBankAccount;
    if (pacct != null) {
       pacct.overdraft = 200;
    }
    acct.ShowAccount();
    acct.ShowBalance();
    // first, deposit something
    decimal x = 600M;
    Console.WriteLine("Depositing " + x);
    acct.Deposit(x);
    acct.ShowBalance();
    // then, try to withdraw something
    decimal y = 400M;
    Console.WriteLine("Withdrawing " + y);
    try {
      acct.Withdraw(y);
    } catch (InsufficientBalance e) {
     Console.WriteLine("InsufficientBalance {0} for withdrawl of {1}", acct.GetBalance(), y);
    }
    acct.ShowBalance();
    // then, try to withdraw the same amount again
    ...
  }
}
```

The Main Method

```
 public static void Main(){
    RunTester t = new RunTester();

    // create a basic account
    BankAccount mine = new BankAccount("MyAccount");
    // create a proper account
    ProperBankAccount mineOvdft = new ProperBankAccount("MyProperAccount");
    // collect them in an array
    BankAccount[] accts = new  BankAccount[2] { mine, mineOvdft };

    for (int i=0; i<accts.Length; i++) {
      t.RunTransactions(accts[i]);
    }
}
```

- We can use the same `RunTransactions` method for both accounts.
- We use polymorphism in defining the array `accts`, holding both types of accounts.

Running the Program

```
Account Number: 1001    Account Name: MyAccount Current Balance: 0
Current Balance: 0
Depositing 600
Current Balance: 600
Withdrawing 400
Current Balance: 200
Withdrawing 400
 200
InsufficientBalance 200 for withdrawl of 400
Current Balance: 200
Account Number: 1001    Account Name: MyAccount Current Balance: 200
Account Number: 1002    Account Name: MyProperAccount   Current Balance: 0
        with an overdraft of 200
Current Balance: 0
Depositing 600
Current Balance: 600
Withdrawing 400
Current Balance: 200
Withdrawing 400
Current Balance: -200
Account Number: 1002    Account Name: MyProperAccount   Current Balance: -200
        with an overdraft of 200
```

Concepts used in the Example

- *Overloading* to have several constructors with different numbers of arguments.
- *Inheritance* of methods is used to share code.
- *Overriding* of methods is used to modify the behaviour of methods in sub-classes.
- *Polymorphism* is used to collect (sub-)classes.
- *Exceptions* are used for error handling.
- *Access modifiers* are used to hide fields.
- *Properties* are used for convenience.
- *Static fields* are used to count instances.