Outline

1. Object-Oriented Design
   - unified modeling language
   - managing a library
   - modeling diagrams
2. Object-Oriented Programming in Python
   - class definitions and instantiations
   - data and functional attributes
   - classes for library manager
3. Summary + Assignments

MCS 260 Lecture 24
Introduction to Computer Science
Jan Verschelde, 7 March 2016

object-oriented design
OOP in Python

Object-Oriented Design

UML: Unified Modeling Language

Object-Oriented Programming (OOP) enables us to create our own high level data types, called abstract data types.
Real-world entities (such as books, people) are represented in the software by objects and classes.

UML is a graphical language to model, design and construct object-oriented software.
UML 2.1 defines 13 basic diagram types.
Umbrello UML Modeller is a program for KDE on Knoppix.

Two types of modeling diagrams:

1. structural ones define the static architecture;
2. behavioral ones captures interactions and states.

Running example: library management system.

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Managing a Library

a case study

Goal: manage a library of books.

Two types of users: librarians and patrons.

Patrons when logged on may view the catalog,
check out books, and return books.

After logging in, in addition to what is available to all,
a librarian may

1. add and delete books;
2. add, search, and delete persons.

Still very simple management:
only one person uses the program at any given time.

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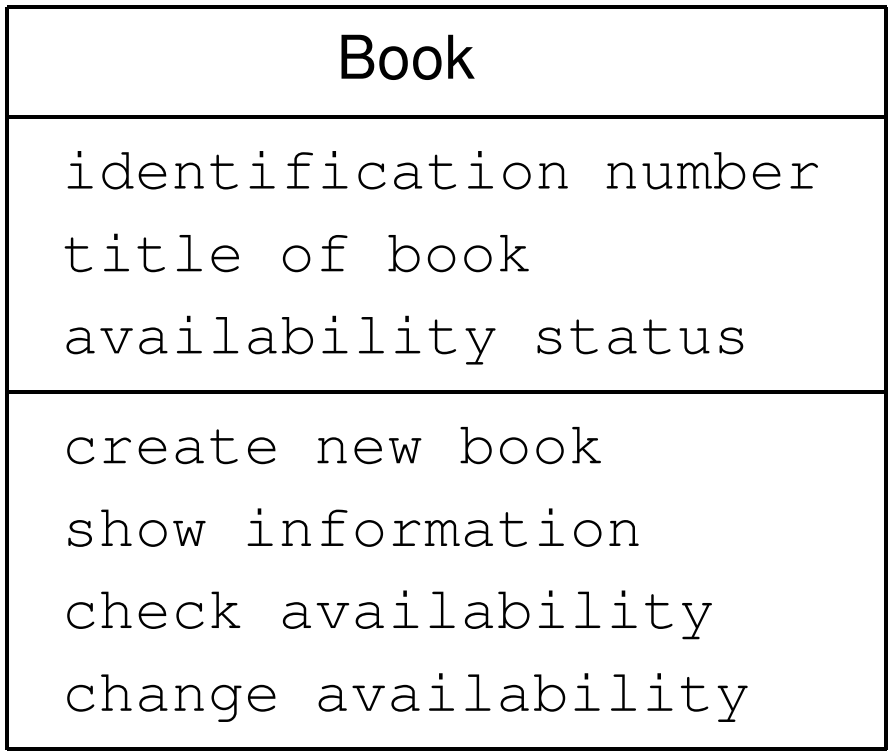
the class Book

class diagram

An object of the class Book has three attributes:
`identification number`, `title`, `availability`.

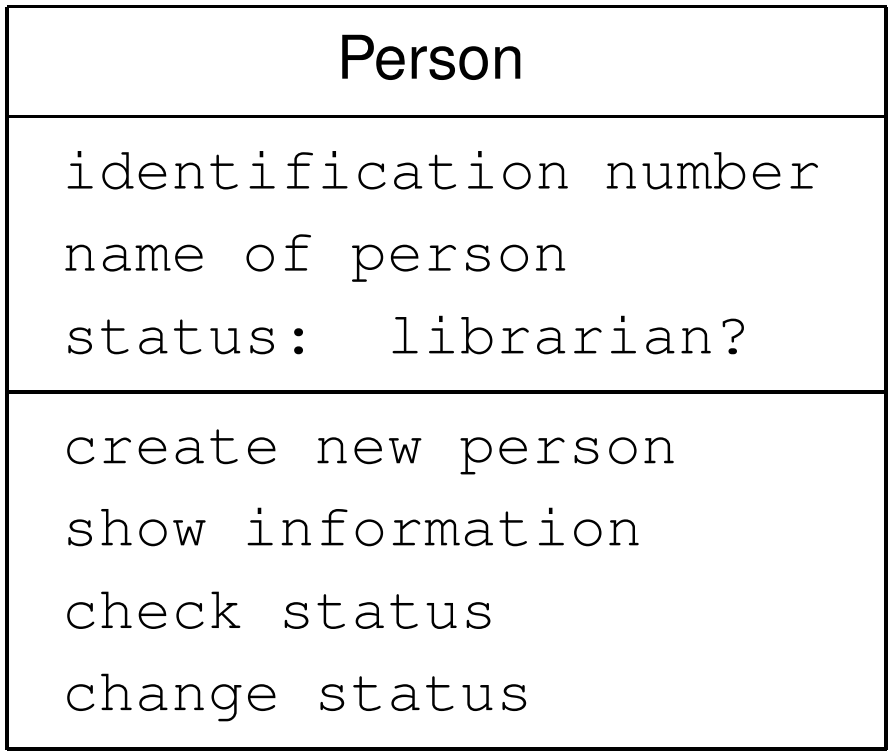


Four methods: `__init__()`, `__str__()`, `check()`, `change()`.

the class Person

class diagram

An object of the class Person has three attributes:
`identification number`, `name`, `status`.



Four methods: `__init__()`, `__str__()`, `check()`, `change()`.

the class Catalog

class diagram

The collection of books is an object of the class Catalog.
Its one attribute `collection` is a list of books.

Catalog
`list of books`

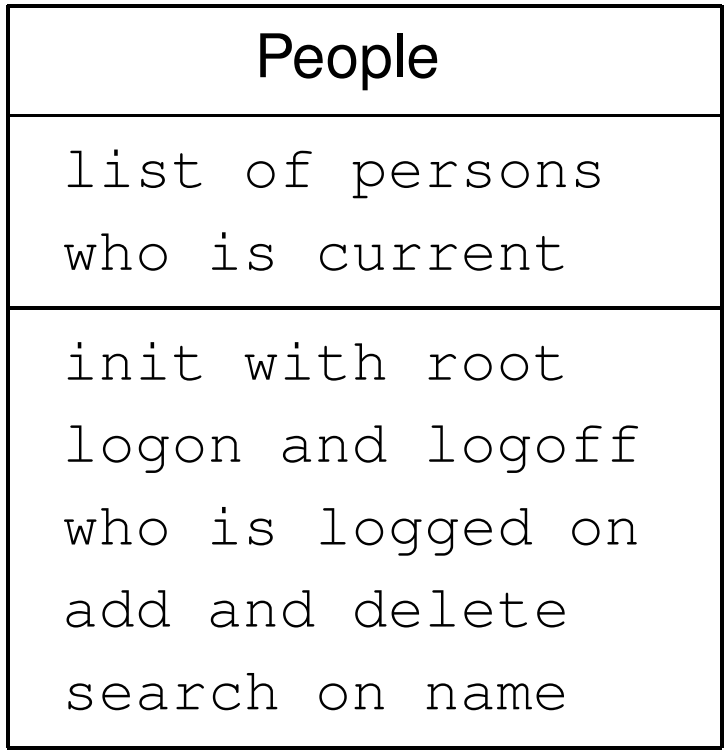
`add and delete`
`checkin and checkout`
`show the collection`
`search on key`

In addition to `__init__()` and `__str__()` we have five methods:
`add()`, `delete()`, `checkin()`, `checkout()`, and `search()`.
The class Catalog imports from the class Book.

the class People

class diagram

An object of the class People has a list as first attribute.
Its second attribute is who is currently logged on.

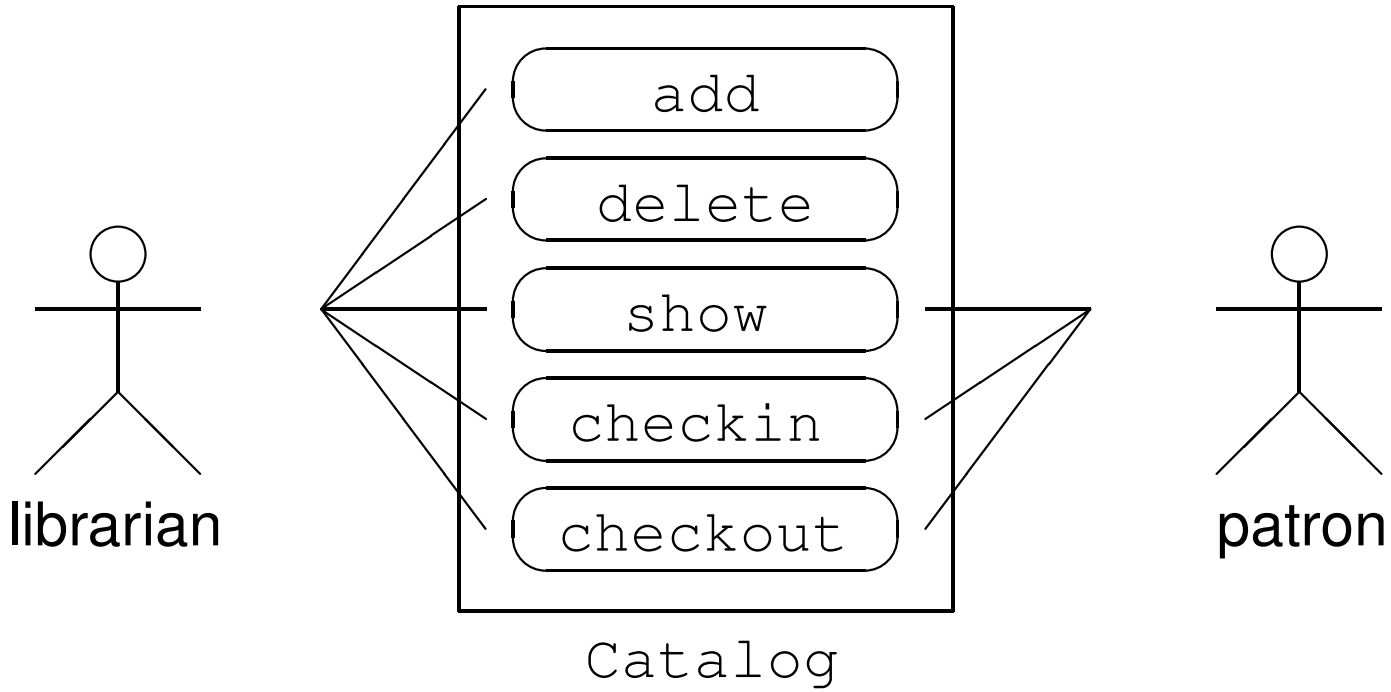


seven methods: `init()`, `logon()`, `logoff()`, `who()`, `add()`, `delete()` and `search()`.

Use Case Diagram for Catalog

a behavior modeling diagram

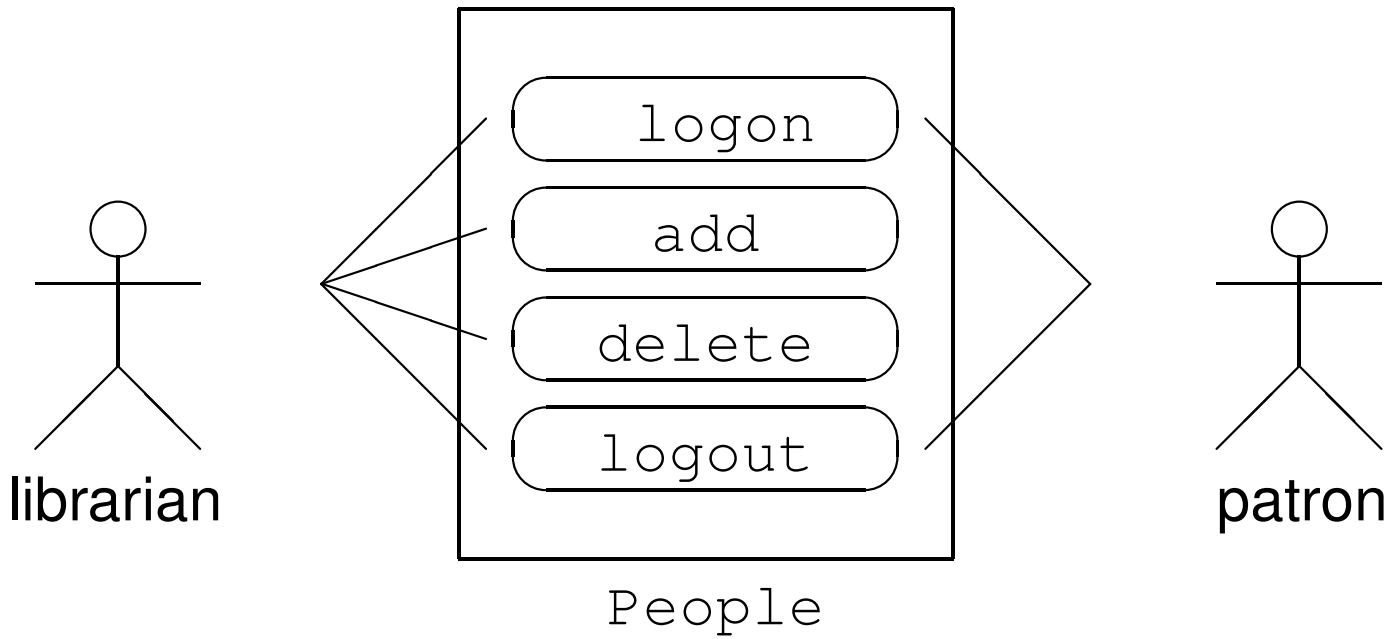
Librarians and patrons differ in their use of the Catalog:



Use Case Diagram for People

a behavior modeling diagram

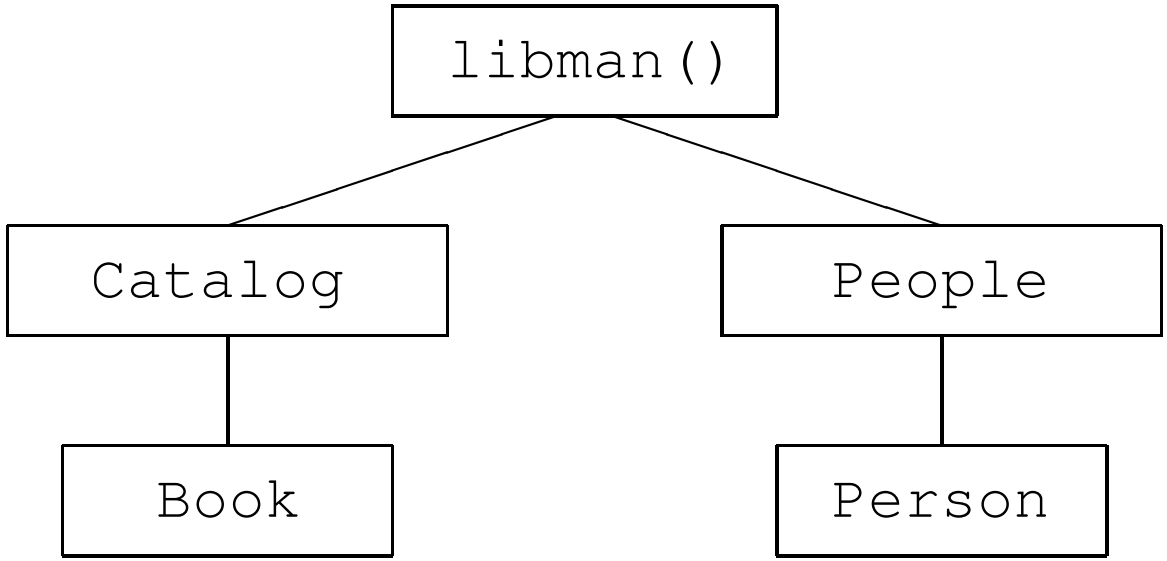
Librarians and patrons differ in their use of the People:



Design of a Library Manager

OOP follows bottom up design

Object-oriented design is typically bottom up, starting at the classes `Book` and `Person`.



The program libman() imports from `Catalog` and `People`.
The class `Catalog` imports from `Book`
and the class `People` imports from `Person`.

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class definitions and instantiations

The general syntax is

```
class < class name > :
    < documentation string >
    < class data attributes >
    < methods >
```

As a general style rule, we will place a class definition in a separate file and treat it as a module.

Creating an instance of a class is called instantiation:

```
< name of object > = < class name >()
```

Calling the class name as a function executes `__init__()` and returns an object.

We name this object by assigning it to a variable.

interactive usage of the class Book

If we store the definition of the class Book in the file `classbook.py`, then we work with objects as

```
>>> from classbook import Book
>>> b1 = Book('one')
>>> print(b1)
 1: one is available
>>> b2 = Book('two')
>>> print(b2)
 2: two is available
>>> b3 = Book()
Give title : three
>>> print(b3)
 3: three is available
```

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data attributes: the class variables

Every object of our class Book has three data attributes:
`key`, `title`, `available`.

```
class Book:
    "Objects of the class Book represent books."
```

Referencing an attribute goes like

```
< object >.< attribute name >
```

Session on previous slide continued:

```
>>> b1.key
1
>>> b1.title
'one'
```

class wide data attributes

To give each book a unique key, we count the number of books.
Each time a new object is created, the counter is augmented by one, and the new object receives as key the new value of the counter.

```
class Book(object):
    """
    Objects of the class Book represent books.
    """
    count = [0]  # class wide attribute

    def __init__(self, *title):
        "constructor a a book"
        self.count[0] = self.count[0] + 1
        self.key = self.count[0]
```

The class wide attribute `count` is a list. Every object has a different list `count` as a data attribute, but the content of that list is the same.

functional attributes: the methods of a class

The constructor `__init__()` has an optional argument:

```
def __init__(self, *title):
    "constructor a a book"
    self.count[0] = self.count[0] + 1
    self.key = self.count[0]
    if len(title) > 0:
        self.title = title[0]
    else:
        self.title = input('Give title : ')
    self.available = True
```

The parameter `self` of `__init__()` is the instance itself.

We do not give an actual value for `self` as with other parameters. Instead:

```
>>> from classbook import Book
>>> b = Book()
Give title :
```

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documentation strings of the class Book

```
class Book(object):
    """
    Objects of the class Book represent books.
    """
    def __init__(self, *title):
        "constructor a a book"

    def __str__(self):
        "string representation of book"

    def check(self):
        "returns the status of the book"

    def change(self):
        "flips the status of the book"
```

documentation strings of the class Person

```
class Person(object):
    """
    An object of the class Person is either
    a librarian or a patron of the library.
    """
    def __init__(self, **nps):
        """
        The arguments of the construct are name, PIN,
        and status, given in the dictionary nps.
        For each key not in nps, the user is prompted.
        """
    def __str__(self):
        "string representation of a person"

    def check(self):
        "returns the status of the person"

    def change(self):
        "prompts for a new PIN and status"
```

the method `__init__()` of Person

First part of the definition:

```
def __init__(self, **nps):
    """
    The arguments of the construct are name, PIN,
    and status, given in the dictionary nps.
    For each key not in nps, the user is prompted.
    """
    if 'name' in nps:
        self.name = nps['name']
    else:
        self.name = input('Give your name : ')
```

The `name` is the key of the dictionary, used as

```
>>> from classperson import Person
>>> p = Person(name='me', PIN=1234, status=True)
```

the method `__init__()` continued

Adding the value for `pin` and `librarian`:

```
if 'PIN' in nps:
    self.pin = nps['PIN']
else:
    rawpin = input('Give your PIN : ')
    self.pin = int(rawpin)
if 'status' in nps:
    self.librarian = nps['status']
else:
    answer = input('Librarian ? (y/n) ')
    if answer == 'y':
        self.librarian = True
    else:
        self.librarian = False
```

interactive usage of the class Person

```
>>> p = Person(name='me', PIN=1234, status=True)
>>> str(p)
'me with PIN 1234 is a librarian'
>>> p.name
'me'
>>> p.pin
1234
>>> p.librarian
True
>>> q = Person()
Give your name : you
Give your PIN : 4321
Librarian ? (y/n) n
>>> print(q)
you with PIN 4321 is a patron
```

the class Catalog encapulates a list

```
from classbook import Book

class Catalog(object):
    """
    The class Catalog holds the book collection.
    """
    def __init__(self):
        "sets the data attribute"
        self.collection = []

    def __str__(self):
        "returns the string representation"
        result = ""
        for book in self.collection:
            result += str(book) + '\n'
        return result

    def add(self, book):
        "adds the book to the catalog"
        self.collection.append(book)
```

interactive usage of the Catalog

```
>>> from classcatalog import Catalog
>>> from classbook import Book
>>> b = Book()
Give title : one
>>> c = Catalog()
>>> c.add(b)
>>> print(c)
 1: one is available

>>>
```

We add a method to search on the key:

```
>>> print(c.search_on_key(1))
 1: one is available
>>>
```

search on the key

```
def search_on_key(self, key):
    """
    Returns the book with the key if it in
    the collection, else None is returned.
    """
    for book in self.collection:
        if book.key == key:
            return book
    return None
```

check out a book

```
def checkout(self, key):
    "Checks out the book with key."
    book = self.search_on_key(key)
    if book == None:
        print('no book with key = ', key)
    else:
        if not book.check():
            print(book)
        else:
            book.change()
```

check in a book

```
def checkin(self, key):
    "Checks in the book with key."
    book = self.search_on_key(key)
    if book == None:
        print('no book with key = ', key)
    elif isinstance(book, Book):
        if not book.check():
            book.change()
```

deleting a book

```
def delete(self, key):
    "Deletes the book with key."
    for k in range(0, len(self.collection)):
        book = self.collection[k]
        if book.key == key:
            popped = self.collection.pop(k)
            print(popped)
            print('has been deleted')
            break
```

the class People

Data attributes: a list and the name of the current user.

```
from classperson import Person

class People(object):
    """
    The class People collects information of
    all librarians and patrons of the library.
    """
    def __init__(self):
        "Creates a root user."
        root = Person(name='root', PIN=0, status=True)
        self.whoswho = [root]
        self.current = ''
```

The _ _init_ _ constructor method is invoked at the time of instantiation: it initializes the object.

the class People continued

```
def search(self, name):
    """
    Returns None if name not in self.whoswho,
    else the person object is returned.
    """
    for person in self.whoswho:
        if person.name == name:
            return person
    return None

def logon(self):
    """
    Prompts for name and PIN, and returns
    -1 if access is not granted;
     0 if the user is a patron;
    +1 if the user is a librarian.
    """
```

the method `logon()` defined

```
name = input('Give your name : ')
member = self.search(name)
if member == None:
    print('you are not a member')
    return -1
else:
    rawpin = input('Give your PIN : ')
    intpin = int(rawpin)
    if intpin == member.pin:
        print('welcome ' + member.name)
        self.current = member
        if member.librarian:
            return +1
        else:
            return 0
    else:
        print('wrong PIN')
        return -1
```

who is logged in and logoff

```
def who(self):
    "Shows who is currently logged in."
    if self.current == '':
        print('nobody is logged in')
    else:
        print(self.current.name + ' is logged in')

def logoff(self):
    "The current user is logged off."
    if self.current != '':
        print('bye bye, ' + self.current.name)
        self.current = ''
```

adding and deleting persons

```
def add(self, *person):
    "Adds a new person to the collection."
    if len(person) > 0:
        toadd = person[0]
    else:
        toadd = Person()
    self.whoswho.append(toadd)

def delete(self):
    "Prompts for a name and then deletes."
    name = input('Give name : ')
    for k in range(0, len(self.whoswho)):
        person = self.whoswho[k]
        if person.name == name:
            popped = self.whoswho.pop(k)
            print(popped, 'has been deleted')
            break
```

main program: libclassman.py

```
from classcatalog import Catalog
from classpeople import People

def show_menu(who):
    """
    Shows the menu to the user
    and returns the choice made.
    """
def act(pep, cat, chc, who):
    "Performs the requested action."

def main():
    "Main library management program."
    cat = Catalog()
    people = People()
    who = -1
    print('Welcome to our library!')
    while True:
        choice = show_menu(who)
        if choice == 9:
            break
        who = act(people, cat, choice, who)
```

the function show_menu

```
def show_menu(who):
    """
    Shows the menu to the user
    and returns the choice made.
    """
    if who == -1:  # no one logged on
        print('Please log on')
        return 0
    else: # who == 0 is patron
        print('choose from the menu :')
        print('  1. log off')
        print('  2. show the collection')
        print('  3. check out a book')
        print('  4. return a book')
        if who == +1: # librarian
            print('  5. add a new book')
            print('  6. delete a book')
            print('  7. add a new user')
            print('  8. delete a user')
            print('  9. shut down')
        ansraw = input('Make your choice : ')
        return int(ansraw)
```

the function act

```
def act(pep, cat, chc, who):
    "Performs the requested action."
    result = who
    if chc == 0:
        result = pep.logon()
    elif chc == 1:
        pep.logoff()
        result = -1
    elif chc == 2:
        cat.show()
    elif chc == 3:
        cat.checkout()
    elif chc == 4:
        cat.checkin()
    elif chc == 5:
        cat.add()
    elif chc == 6:
        cat.delete()
    elif chc == 7:
        pep.add()
    elif chc == 8:
        pep.delete()
    return result
```

Summary + Assignments

We started chapter 10 in *Python Programming*,
see §6.5 in *Computer Science, an overview*
for UML, see online tutorials, at `www.uml.org`.

Assignments:

1. Make a class `Counter` which initializes to zero. The method `add` increments the counter by one. The string representation returns the value of the counter, that is: the value of the data attribute stored by the object instantiated from the class `Counter`.
2. Design a class `Rational` to compute with rational numbers. Ensure that a rational number is always normalized: numerator and denominator have 1 as their only common divisor.
3. Write Python code for the class `Rational`.
4. Describe how the design of our library manager would change if files would be used for the catalog and people.
   Which functions would change?