

**SE 2AA4, CS 2ME3 (Introduction to Software
Development)**

Winter 2018

11 Generic MIS (Ghezzi Ch. 4)

Dr. Spencer Smith

Faculty of Engineering, McMaster University

January 30, 2018



11 Generic MIS (Ghezzi Ch. 4)

- Administrative details
- ssh with X11 forwarding
- Homework exercise on specification
- Uses for abstract objects
- Implementing objects with other objects as state variables
- Generic modules
- Generic stack abstract object
- Properties exhibited by a stack module
- Generic queue ADT
- Access routine idioms
 - ▶ Set idioms
 - ▶ Sequence idioms
 - ▶ Tuple idioms
- Exceptions
- Quality Criteria

Administrative Details

- Assignment 1
 - ▶ Partner files now in your repo
 - ▶ Part 2: January 31, 2018
 - ▶ If you know how, tag your assignment submissions
- Questions?

X Windows

- If you want to use a gui on mills, you can use X11 forwarding
- On a Mac or with Linux, you use `ssh -X` or `ssh -Y`
- `ssh -X mills.cas.mcmaster.ca` (or `-Y`)
- On a Mac you need XQuartz installed
- If you know the details for Windows, please post to Avenue

Homework Answer: Access Routine Semantics

totalArea():

- output

$out := ? \quad (i : \mathbb{N} | i \in [0..|s| - 1] : s[i].area())$

averageRadius():

- output

$out :=$

Homework Answer: Access Routine Semantics

totalArea():

- output

$$out := \sum_{(i : \mathbb{N} | i \in [0..|s| - 1])} s[i].area()$$

averageRadius():

- output

$$out :=$$

Homework Answer: Access Routine Semantics

totalArea():

- output

$$out := \sum_{(i : \mathbb{N} | i \in [0..|s| - 1])} s[i].area()$$

or?

averageRadius():

- output

$$out :=$$

Homework Answer: Access Routine Semantics

totalArea():

- output

$$out := \sum_{(i : \mathbb{N} | i \in [0..|s| - 1]) : s[i].area()}$$

or?

$$out := \sum_{(c : CircleT | c \in s : c.area())}$$

averageRadius():

- output

$$out := ?$$

Homework Answer: Access Routine Semantics

totalArea():

- output

$$out := \sum (i : \mathbb{N} | i \in [0..|s| - 1] : s[i].area())$$

or?

$$out := \sum (c : CircleT | c \in s : c.area())$$

averageRadius():

- output

$$out := \sum (c : CircleT | c \in s : c.radius()) / |s|$$

Uses for Abstract Objects

- Creating a single abstract object corresponds to the singleton design pattern
- Provides “global” variables
- Uses
 - ▶ Shared resource
 - ▶ Hoffman and Strooper example (assembler)
 - ▶ Look up table for global state (read only)
 - ▶ Logger (write only)
- Problematic for testing if high coupling and frequent state changes, since many test cases will depend on the state of the abstract object

Objects with Other Objects as State Variables

Potential prob with the naive implement of deque of CircleT?

```
@staticmethod
def pushBack(c):
    Deq.s = Deq.s + [c]
```

Consider

```
p1 = PointT(1.5, 2)
c1 = CircleT(p1, 5)
Deq.init()
Deq.pushBack(c1)
c1.r = 6 #circumventing information hiding
print(c1.rad())
print(Deq.back().rad())
```

Solutions to Potential Problem

- Interface prevents potential abuse
 - ▶ Provide no mutators in the interface, just a constructor and selectors
 - ▶ Assume information hiding will be respected
- A more robust implementation
 - ▶ The state variable stores copies of objects, not references
 - ▶ Use copy library in Python

```
import copy
...
    @staticmethod
    def pushBack(c):
        cnew = copy.deepcopy(c)
        Deq.s = Deq.s + [cnew]
```

New Problem for Robust Implementation

```
p1 = PointT(1.5, 2)
c1 = CircleT(p1, 5)
Deq.init()
Deq.pushBack(c1)
print(c1 == Deq.back())
```

Why is the behaviour not what we would naively expect?

What can we do about it?

New Problem for Robust Implementation

```
p1 = PointT(1.5, 2)
c1 = CircleT(p1, 5)
Deq.init()
Deq.pushBack(c1)
print(c1 == Deq.back())
```

Why is the behaviour not what we would naively expect?

What can we do about it?

Redefine Equality for CircleT

```
class CircleT:  
  
    def __init__(self, cin, rin):  
        self.c = cin  
        self.r = rin  
  
    def __eq__(self, cin):  
        return self.c == cin.cen() and  
               self.r == cin.rad()
```

What other classes will need `__eq__` redefined?

Examples of A2 from 2017

- Solution assuming information hiding in repo of previous assignment solutions ([here](#))
- Robust solution in the same folder as these lecture slides ([here](#))

Generic Modules

- What if we have a sequence of integers, instead of a sequence of point masses?
- What if we want a stack of integers, or characters, or pointT, or pointMassT?
- Do we need a new specification for each new abstract object?
- No, we can have a single abstract specification implementing a family of abstract objects that are distinguished only by a few variabilities
- Rather than duplicate nearly identical modules, we parameterize one **generic module** with respect to type(s)
- Advantages
 - ▶ Eliminate chance of inconsistencies between modules
 - ▶ Localize effects of possible modifications
 - ▶ Reuse

Generic Stack Module Syntax

Generic Module

Stack(T)

Exported Constants

MAX_SIZE = 100

Exported Access Programs

Routine name	In	Out	Exceptions
...

Stack Module Syntax

Exported Access Programs

Routine name	In	Out	Exceptions
s_init			
s_push	T		FULL
s_pop			EMPTY
s_top		T	EMPTY
s_depth		integer	

Semantics

State Variables

State Invariant

Assumptions

Semantics

State Variables

s : sequence of T

State Invariant

Assumptions

Semantics

State Variables

s : sequence of T

State Invariant

$$|s| \leq \text{MAX_SIZE}$$

Assumptions

Semantics

State Variables

s : sequence of T

State Invariant

$|s| \leq \text{MAX_SIZE}$

Assumptions

$s_init()$ is called before any other access routine

Access Routine Semantics

s_init():

- transition:
- exception:

s_push(x):

- transition:
- exception:

s_pop():

- transition:
- exception:

Access Routine Semantics

s_init():

- transition: $s := \langle \rangle$
- exception:

s_push(x):

- transition:
- exception:

s_pop():

- transition:
- exception:

Access Routine Semantics

s_init():

- transition: $s := \langle \rangle$
- exception: none

s_push(x):

- transition:
- exception:

s_pop():

- transition:
- exception:

Access Routine Semantics

s_init():

- transition: $s := \langle \rangle$
- exception: none

s_push(x):

- transition: $s := s || \langle x \rangle$
- exception:

s_pop():

- transition:
- exception:

Access Routine Semantics

s_init():

- transition: $s := \langle \rangle$
- exception: none

s_push(x):

- transition: $s := s || \langle x \rangle$
- exception: $exc := (|s| = MAX_SIZE \Rightarrow FULL)$

s_pop():

- transition:
- exception:

Access Routine Semantics

`s_init()`:

- transition: $s := \langle \rangle$
- exception: none

`s_push(x)`:

- transition: $s := s || \langle x \rangle$
- exception: $exc := (|s| = MAX_SIZE \Rightarrow FULL)$

`s_pop()`:

- transition: $s := s[0..|s| - 2]$
- exception:

Access Routine Semantics

s_init():

- transition: $s := \langle \rangle$
- exception: none

s_push(x):

- transition: $s := s || \langle x \rangle$
- exception: $exc := (|s| = MAX_SIZE \Rightarrow FULL)$

s_pop():

- transition: $s := s[0..|s| - 2]$
- exception: $exc := (|s| = 0 \Rightarrow EMPTY)$

Access Routine Semantics Continued

s_top():

- output:
- exception:

s_depth():

- output:
- exception:

Access Routine Semantics Continued

s_top():

- output: $out := s[|s| - 1]$
- exception:

s_depth():

- output:
- exception:

Access Routine Semantics Continued

`s_top()`:

- output: $out := s[|s| - 1]$
- exception: $exc := (|s| = 0 \Rightarrow \text{EMPTY})$

`s_depth()`:

- output:
- exception:

Access Routine Semantics Continued

`s_top()`:

- output: $out := s[|s| - 1]$
- exception: $exc := (|s| = 0 \Rightarrow \text{EMPTY})$

`s_depth()`:

- output: $out := |s|$
- exception:

Access Routine Semantics Continued

`s_top()`:

- output: $out := s[|s| - 1]$
- exception: $exc := (|s| = 0 \Rightarrow \text{EMPTY})$

`s_depth()`:

- output: $out := |s|$
- exception: `none`

Stack Module Properties

$\{true\}$
 $s_init()$
 $\{|s'| = 0\}$

$\{|s| < MAX_SIZE\}$
 $s_push(x)$
 $\{|s'| = |s| + 1 \wedge s'[|s'| - 1] = x \wedge s'[0..|s| - 1] = s[0..|s| - 1]\}$

$\{|s| < MAX_SIZE\}$
 $s_push(x)$
 $s_pop()$
 $\{s' = s\}$

Generic Queue Module ADT Syntax

Generic Template Module

QueueADT(T)

Exported Types

QueueT = ?

Exported Constants

MAX_SIZE = 100

Exported Access Programs

Routine name	In	Out	Exceptions
...

QueueADT Module Syntax

Exported Access Programs

Routine name	In	Out	Exceptions
new QueueT		QueueT	
add	T		queue_full
pop			queue_empty
front		T	queue_empty
isempty		boolean	

Semantics

State Variables

State Invariant

Assumptions

Semantics

State Variables

s : sequence of T

State Invariant

Assumptions

Semantics

State Variables

s : sequence of T

State Invariant

$$|s| \leq \text{MAX_SIZE}$$

Assumptions

Access Routine Semantics

new QueueT():

- transition:
- output:
- exception:

add(x):

- transition:
- exception:

pop():

- transition:
- exception:

Access Routine Semantics

new QueueT():

- transition: $s := \langle \rangle$
- output: $out := self$
- exception: none

add(x):

- transition:
- exception:

pop():

- transition:
- exception:

Access Routine Semantics

new QueueT():

- transition: $s := \langle \rangle$
- output: $out := self$
- exception: none

add(x):

- transition: $s := s || \langle x \rangle$
- exception: $exc := (|s| = MAX_SIZE \Rightarrow queue_full)$

pop():

- transition:
- exception:

Access Routine Semantics

new QueueT():

- transition: $s := \langle \rangle$
- output: $out := self$
- exception: none

add(x):

- transition: $s := s || \langle x \rangle$
- exception: $exc := (|s| = MAX_SIZE \Rightarrow queue_full)$

pop():

- transition: $s := s[1..|s| - 1]$
- exception: $exc := (|s| = 0 \Rightarrow queue_empty)$

Access Routine Semantics Continued

front():

- output:
- exception:

isempty():

- output:
- exception:

Access Routine Semantics Continued

front():

- output: $out := s[0]$
- exception: $exc := (|s| = 0 \Rightarrow \text{queue_empty})$

isempty():

- output:
- exception:

Access Routine Semantics Continued

front():

- output: $out := s[0]$
- exception: $exc := (|s| = 0 \Rightarrow \text{queue_empty})$

isempty():

- output: $out := |s| = 0$
- exception: none

Queue Module Properties

$\{true\}$

$q_init()$

$\{|s'| = 0 \wedge is_init\}$

$\{|s| < MAX_SIZE\}$

$add(x)$

$\{|s'| = |s| + 1 \wedge s'[0] = x \wedge s'[1..|s'| - 1] = s[0..|s| - 1]\}$