

**CSC 4504 : *Langages formels et applications***

**(Event-B)**

**J Paul Gibson, A207**

`paul.gibson@it-sudparis.eu`

<http://www-public.it-sudparis.eu/~gibson/Teaching/CSC4504/>

**Practical Exam 1**

<http://www-public.it-sudparis.eu/~gibson/Teaching/CSC4504/PracticalExam1.pdf>

## Exam Instructions

You are to work alone and there must be no communication with other students during the exam.

You have a maximum of 3 hours

You can use books/notes/web during the exam (but must not use the web/internet/email to share information)

You must submit your answers by email (before you leave the exam room), to:

[paul.gibson@it-sudparis.eu](mailto:paul.gibson@it-sudparis.eu)

**(Zip up all RODIN files and all .txt,.pdf, .doc, etc... files into a single file <yourname>.zip and add it as an attachment to the email.)**

There are 2 questions, each carry equal marks

## Question A: comprehension

Consider the following Event-B models:

context `array`, machine `m0` and machine `m1`

They can be downloaded from the web page:

<http://www-public.it-sudparis.eu/~gibson/Teaching/CSC4504/Downloads/FindSomething.zip>

- `m0` is an abstract specification of the requirements of the machine to be implemented
- `m1` is a refinement of `m0`

### QUESTION

1. What is the result being calculated by `m0`? **[3 marks]**
2. What algorithm is `m1` using to correctly implement this function? **[5 marks]**
3. Implement the algorithm in Java **[2 marks]**

# Question A: comprehension

## CONTEXT

array

## CONSTANTS

n  
a

## AXIOMS

axm1 :  $n \in \mathbb{N}1$   
axm2 :  $a \in 1..n \rightarrow \mathbb{Z}$

END

## MACHINE

m0

## SEES

array

## VARIABLES

find\_result

## INVARIANTS

inv1 :  $\text{find\_result} \in \mathbb{N}$

## EVENTS

INITIALISATION  $\triangleq$

STATUS

ordinary

BEGIN

act1 :  $\text{find\_result} \in \mathbb{N}$

END

find  $\triangleq$

STATUS

ordinary

ANY

j

WHERE

grd1 :  $j \in 1..n$

grd2 :  $\forall k \cdot k \in 1..n \Rightarrow a(k) \leq a(j)$

THEN

act1 :  $\text{find\_result} = j$

END

END

# Question A: comprehension

## MACHINE

m1

## REFINES

m0

## SEES

array

## VARIABLES

find\_result

low

high

## INVARIANTS

inv1 : low  $\in$  1..n

inv2 : high  $\in$  1..n

inv3 : low  $\leq$  high

inv4 :  $a(\text{low}) < a(\text{high}) \Rightarrow (\forall j. j \in 1..low-1 \Rightarrow a(j) \leq a(\text{high}))$

inv5 :  $a(\text{low}) < a(\text{high}) \Rightarrow (\forall j. j \in high+1..n \Rightarrow a(j) \leq a(\text{high}))$

inv6 :  $a(\text{high}) \leq a(\text{low}) \Rightarrow (\forall j. j \in 1..low-1 \Rightarrow a(j) \leq a(\text{low}))$

inv7 :  $a(\text{high}) \leq a(\text{low}) \Rightarrow (\forall j. j \in high+1..n \Rightarrow a(j) \leq a(\text{low}))$

# Question A: comprehension

## EVENTS

```
INITIALISATION ≐
STATUS
  ordinary
BEGIN
  act1 : find_result ∈ N
  act2 : low = 1
  act3 : high = n
END

find ≐
STATUS
  ordinary
REFINES
  find
WHEN
  grd1 : low = high
WITH
  j : j = low
THEN
  act1 : find_result = low
END
```

```
inc_low ≐
STATUS
  convergent
WHEN
  grd1 : low ≠ high
  grd2 : a(low) < a(high)
THEN
  act1 : low = low + 1
END

dec_high ≐
STATUS
  convergent
WHEN
  grd1 : low ≠ high
  grd2 : a(high) ≤ a(low)
THEN
  act1 : high = high - 1
END

VARIANT
  low .. high

END
```

## Question 2: specification

You are to model a machine that can find the range of an array of integers, where the range is defined as the difference between the maximum and minimum values.

For example  $\text{range}([2, 3, 2, 4, 1, 7, 3]) = 6$  since  $\text{max} = 7$  and  $\text{min} = 1$

### QUESTION

1. Specify the function `range` in a context `range_ctx` [3 marks]
2. Specify an abstract machine `range_mch0` which calculates the range [3 marks]
3. Specify `range_mch1` to be a refinement of `range_mch0`. (This machine must be deterministic). [4 marks]