Software Quality Assurance (WS20/21)
Problem Set 4

Problem 1: Measurement Theory

a) We have A a set of software modules. We introduce a new binary empirical relation ¤ between two software modules on the set A. Write the formal definitions of the measurement axioms that should be satisfied by ¤ to yield an ordinal scale?

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Axiom 1: Reflexivity	a ¤ a, ∀a ∈ A
Axiom 2: Transitivity	a ¤ b, b ¤ c → a ¤ c ∀a, b, c ∈ A
Axiom 3: Connectivity (Completeness)	a ¤ b or b ¤ a, ∀a, b ∈ A

b) In Measurement Chapter, slide number 17, the following relations has been defined:

1. •≥ more complex or equally complex
2. •> more complex
3. •≈ equally complex

Clarify which axioms does each of the previous relations satisfy and subsequently the binary relation they form?

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1. •≥ more complex or equally complex

Reflexivity	a •≥ a, ∀a ∈ A
Transitivity	a •≥ b, b •≥ c → a •≥ c ∀a, b, c ∈ A
Connectivity	a •≥ b or b •≥ a, ∀a, b ∈ A
Strict weak order	

2. •> more complex

Reflexivity *NOT SATISFIED*	a •> a, ∀a ∈ A
Transitivity	a •> b, b •> c → a •> c ∀a, b, c ∈ A
Connectivity	a •> b or b •> a, ∀a, b ∈ A
Anti-symmetry	a •> b ^ b •> a → a ≠ b
Strict total Order	

3. •≈ equally complex

Reflexivity	a •≈ a, ∀a ∈ A
Transitivity	a •≈ b, b •≈ c → a •≈ c ∀a, b, c ∈ A
Symmetry	a •≈ b ^ b •≈ a, ∀a, b ∈ A
Completeness *NOT SATISFIED*	a •> b or b •> a → a ≠ b
Equivalence relation	

Problem 2: Measurement Theory

On which scale types are the following measurement value groups valid and why? Please give the corresponding mapping and range for each group.

a) House number

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   Value range: ℕ, sometimes with additional letter (a,.....,z)
   Build rule: position (alternating, odd side, even side), construction time
   Scale: ordinal

b) Sea level of different sites

   -

   Value range: ℤ, ℚ
   Build rule: relative to zero-point height measurement
   Scale: interval

c) The amount of ducks on a lake

   -

   Value range: ℕ
   Build rule: counting
   Scale: absolute

d) Weights of Martians on their planet

   -

   Value range: ℚ
   Build rule: spring balance
   Scale: interval

Problem 3: Data flow oriented test

What is McCabe's cyclomatic number? Determine the cyclomatic number for the following code snippets:

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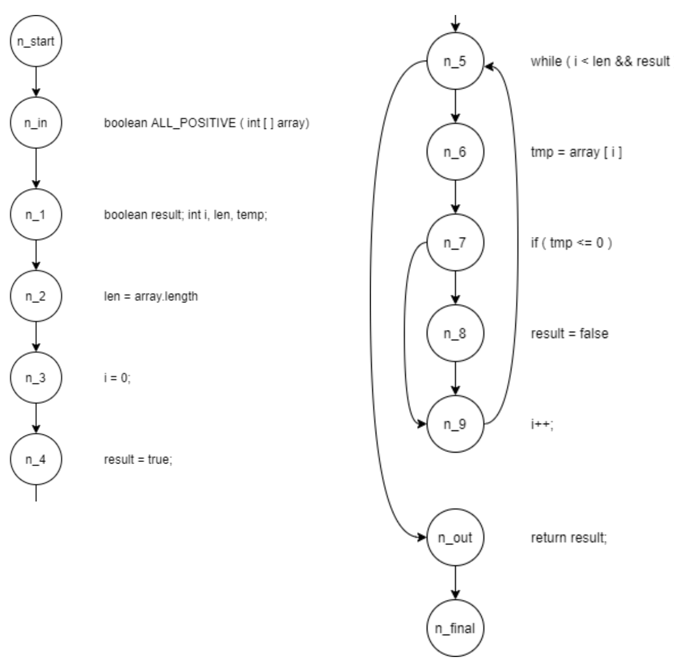
e – n + 2

a)

```
boolean ALL_POSITIVE(int[] array) {
  boolean result;
  int i,len,tmp;
  len = array.length;
  i=0;
  result=true;
  while (i<len&&result) {
    tmp=array[i];
    if (tmp<=0)
      result=false;
    i++;
  }
  return result;
}
```

Control flow:



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Edge, E = 16; Node, N = 15;
McCabe complexity = 16-15+2 = 3

** Event if we draw the control flow diagram differently, still we'll have same complexity.

b)

```
public static int sum(int n) {
  int sum = 0;
  int i;
  for (i = 1; i <= n; i++) {
    sum = sum + i;
  }
  return sum;
}
```

E = 9, N= 9
McCabe Complexity = 9-9+2 = 2

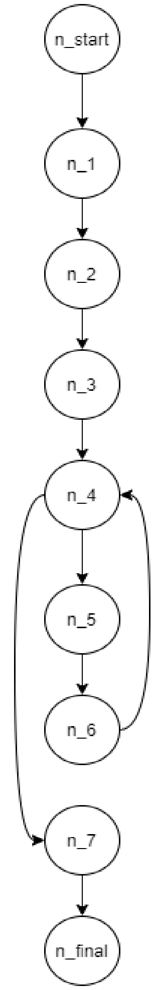

Figure 3.b

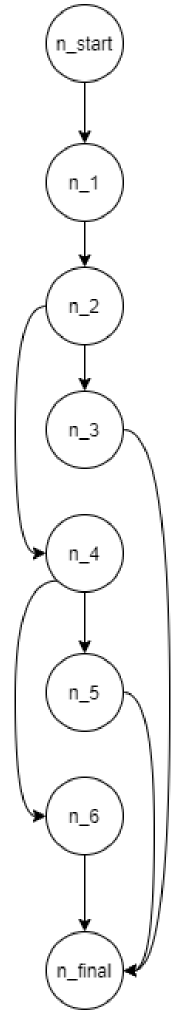

Figure 3.c

c)

```
public string printlnMCS() {
  if (Type == MCSType.security)
    return "MCS " + Number + " " + SecurityValue + "\n";
  else if (Type == MCSType.safety)
    return "MCS " + Number + " " + SafetyValue + "\n";
    else
      return "MCS "+Number+" ("+SafetyValue+", "+SecurityValue+")"+"\n";
}
```

E = 9, N= 8
McCabe Complexity = 9-8+2 = 3

Problem 4: Single Measurement

Given is a measure P, which equals the number of the atomic predicates in a software module. Atomic predicates in the sense of the measure P are only present in the decisions of a module. They have a Boolean value range and are not combined

Example: (x>5) is an atomic predicate; ((x=6) OR (y<z)) is not an atomic predicate, but is combined of two atomic predicates together

a) What is the measure type of P?

-

Product measure on the code level

b) Can the values of P be used as ordinal scale?

-

Yes, Modules can be ordered according to the count of atomic predicates.

c) Can the values of P be used as rational scale in terms of the textual chaining of two modules?

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Yes (chaining obtains relation for monotony, archimedic, associativity)

Problem 5: Single Measurement

A data-flow oriented measure M_d should describe the number of different data accesses to different variables. Counted are defs, c-uses and p-uses; however, each variable will be counted only once.

Example: If defs(x) occurs more than once, only one time will be counted. If c-uses(x) occurs once or more times, the measure value will just be increased by 1. The same rule holds for p-uses(x). Accesses to a different variable (e.g., y) will also be counted again.

$y := x + 1;$

$y := y^2;$

$z := y - 1;$

For the code section mentioned above, the value of M_d is 4.

a) How should the empirical relation be evaluated concerning the given *modifications* 1-3, in order to apply the measure M_d as an ordinal scale?

1. Add data access to new variable? +1 def, +1 c-use (Measure increases)
2. Add already available data access to available variable? Measure constant.
3. Add new data access type to available variable? +1 c-use (Measure increases)

We can apply M_d as an ordinal scale.

b) Can the measure M_d be used as a rational scale concerning the textual chaining of two modules? If so, why?

-

No, Measure could stay the same in case the same variables are used in both modules

c) Please give the monotony condition as a criterion for the rational scale. Explain the significance of the monotony condition in your own words.

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Adding the same quantities to two parts in the ordered relation, ordering stays unchanged.

d) Please prove that measures M, that are quotients $M\ (C) = \frac{M_a(C)}{M_b(C)'}$, generally do not fulfill the monotony condition in general (see the example of the textual chaining).

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Monotony: $x \geq y \leftrightarrow x \circ z \geq y \circ z \leftrightarrow z \circ x \geq z \circ y$, $\forall\, x, y, z \in A$

Example:

M (x) = 4/2 = 2; M (y) = 4000/3000 = 1.33; So $x \geq y$

M (z) = 100/100 = 1

M ($x \circ z$) = 104/102 = 1.02; M ($y \circ z$) = 4100/3100 = 1.32; So $y \circ z \geq x \circ z$

Which violates monotony.

Scales

Scale Type	Operations	Transformations	Example
Nominal	=, ≠	All unique	Gender, job, …
Ordinal	=, ≠, <, >	Strictly monotonic	Marks, 1,2,3,4,5,6
Interval	=, ≠, <, >, +, -	Liner, y = ax+b	Temp in ◦C
Rational	=, ≠, <, >, +, -, *, :	Liner, y = ax	Distance in m
Absolute	=, ≠, <, >, +, -, *, :	None	Quality