Algorithms

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Today's Lecture

- Counting Instructions

Counting Instructions

- When analyzing algorithms, we will need to count the number of instructions that are executed.
- How many instructions are in the following algorithm?

```
int a;
a = 1;
System.out.println(a);
```

Answer

```
int a;
a = 1;
System.out.println(a);
```

Declaration (1 instruction)

Assignment (1 instruction)

Print (1 instruction)

3 instructions in Total

Instruction	Count	Frequency	Sub Total
int a;	1	1	1
a = 1	1	1	1
println	1	1	1
TOTAL			**3**

Counting Instructions

Counting Instructions

- When analyzing algorithms, we will need to count the number of instructions that are executed.
- How many instructions are in the following algorithm?

```
int a;
int b;
int sum;
a = 1;
b = 2;
sum = a + b;
System.out.println(sum);
```

Answer

7 instructions in Total

```
int a;
int b;
int sum;
a = 1;
b = 2;
sum = a + b;
System.out.println(sum);
```

Declaration (1 instruction)

Assignment (1 instruction)

Will count this as one even though there is an addition (1 instructions)

Print (1 instruction)

Here is more of a breakdown…

Counting Instructions

Instruction	Count	Frequency	Sub Total
int a;	1	1	1
int b;	1	1	1
int sum;	1	1	1
a = 1	1	1	1
b = 2	1	1	1
sum = a + b	1	1	1
println	1	1	1
TOTAL			**7**

Counting Instructions

Counting Instructions - if

- How many instructions are in the following algorithm?

```
int a;
int a = 5;

if (a< 0 || a>10)
{
   System.out.println("bad");
}
```

Hints: Each relational operation will count as one instruction. { and } do not count as instructions.

Counting Instructions - if

- How many instructions are in the following algorithm?

```
int a;
a = 5;

if (a< 0 || a>10)
{
   System.out.println("bad");
}
```

Declaration (1 instruction)

Assignment (1 instruction)

Two relational operations (2 instructions)

Print (1 instruction)

{ and } do not count as instructions

5 instructions in Total

Counting Instructions - if

Instruction	Count	Frequency	Sub Total
int a;	1	1	1
a = 5;	1	1	1
if (a< 0 || a>10)	2	1	2
{	0	0	0
System.out.println("bad");	1	1	1
}	0	0	0
TOTAL			**5**

- a<0 and a> 10 each count as a separate instructions.
- The { and } do not count as instructions.

Counting Instructions - for

- How many instructions are in the following algorithm?

```
int i;
int total = 0;
for (i=0; i<10; i++)
{
   total = total + 1;
}
```

Hint: The assignment, relation operation, and increment in the for loop should be counted individually (some of those may happen more than once).

Counting Instructions - for

- How many instructions are in the following algorithm?

```
int i;
int total = 0;

for (i=0; i<10; i++)
{
   total = total + 1;
}
```

Each declaration will count as 1

i < 10 runs 11 times (need an extra check to break out of the loop)

i++ runs 10 times

Loop body runs 10 times

{ and } do not count as instructions

Instruction	Count	Frequency	Sub Total
int i;	1	1	1
int total = 0;	1	1	1
for(i=0;	1	1	1
i < 10;	1	11	11
i++	1	10	10
{	0	0	0
total = total + 1;	1	10	10
}	0	0	0
TOTAL			**34**

- The for loop initialization happens only once (i=0).
- The for loop i<10 happens 11 times. It is 11 and not 10 because it runs the check for each time through the loop body (0-9 is 10 times) then runs an extra check when i=10 to break out of the loop.

Counting Instructions - for

Counting Instructions - allocation

- How many instructions are in the following algorithm?

```
int[] ar;
ar = new int[5];
```

Hint: Memory allocation will count as one instruction separate from the assignment.

Counting Instructions - allocation

- How many instructions are in the following algorithm?

```
int[] ar;
ar = new int[5];
```

Declaration (1 instruction)

Memory allocation and assignment happen here (2 instructions)

3 instructions in Total

Instruction	Count	Frequency	Sub Total
int[] ar;	1	1	1
ar = new int[5];	2	1	2
TOTAL			**3**

- Memory allocation and assignment are each one instruction.

Counting Instructions – allocation

Counting Instructions – array access

- How many instructions are in the following algorithm?

```
int[] ar;
ar = new int[5];
ar[0] = 3;
```

Hint: Accessing an array element counts as one instruction separate from the assignment.

Counting Instructions – array access

- How many instructions are in the following algorithm?

```
int[] ar;
ar = new int[5];
ar[0] = 3;
```

Declaration (1 instruction)

Memory allocation and assignment happen here (2 instructions)

Array access and assignment happen here (2 instructions)

5 instructions in Total

Instruction	Count	Frequency	Sub Total
int[] ar;	1	1	1
ar = new int[5];	2	1	2
ar[0] = 3;	2	1	2
TOTAL			**5**

- Memory allocation and assignment are each one instruction.
- Array access and assignment are each one instruction.

Counting Instructions – array access

Counting Instructions

- How many instructions are in the following algorithm?

```
int i;
int[] ar;
int total = 0;
ar = new int[3];
ar[0] = 10;
ar[1] = 20;
ar[2] = 30;

for (i=0; i<3; i++)
{
   total = total + ar[i];
}
```

Counting Instructions

- How many instructions are in the following algorithm?

```
int i;
int[] ar;
int total = 0;
ar = new int[3];
ar[0] = 10;
ar[1] = 20;
ar[2] = 30;

for (i=0; i<3; i++)
{
   total = total + ar[i];
}
```

Declaration (1 instruction)

Memory allocation and assignment happen here (2 instructions)

Array access and assignment happen here (2 instructions)

Array access and assignment happen here (2 instructions). Loop body runs 3 times.

25 instructions in Total

Instruction	Count	Frequency	Sub Total
int i;	1	1	1
int[] ar;	1	1	1
int total = 0;	1	1	1
ar = new int[3];	2	1	2
ar[0] = 10;	2	1	2
ar[1] = 20;	2	1	2
ar[2] = 30;	2	1	2
for(i=0;	1	1	1
i < 3;	1	4	4
i++	1	3	3
{	0	0	0
total = total + ar[i];	2	3	6
}	0	0	0
TOTAL			**25**

Counting Instructions

Summary of Instructions to Count

- Each instruction in the table counts as 1.

Instruction Type	Example
Declaration	int i;
Assignment	i = 10;
Array Access	a[1]
Memory Allocation (call to new)	new Employee()
Comparison (<, ==, etc…)	i < x
Method Call	System.out.println(x);
While Loop Header with Test	while (x < 10)
Increment	i++;

- { } do not count as instructions.
- If more than one of the above are in the same statement, you must count each. For example:

```
ar = new int[3]; // Assignment and memory alloc (count = 2)
ar[0] = 10; // Array access and assignment (count=2)
System.out.println(ar[0]); // Method call and Array access (count=2)
```

- **End of Slides**

End of Slides