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M.Sc. CS / AI & CS
Computer Systems
Complexity, Endianness and Intro to OS

Exercise #1: Consider the following fragment of Java code. Although this program does not really do anything, it is instructive to see how we can take actual code and analyze performance. Note: Do not worry about the undeclared variables.

```
int a = 5;
int b = 6;
int c = 10;

for (int i = 0; i < n; i++) {
   for (int j = 0; j < n; j++) {
      x = i * i;
      y = j * j;
      z = i * j;
   }
}

for (int k = 0; k < n; k++) {
   w = a * k + 45;
   v = b * b;
}

d = 33;
```

a) Formulate an expression to denote the overall execution time of this program considering that each Assignment Operation is treated as a unit of operation.

b) Identify the dominant term in this expression?

c) What is the Worst Case Complexity of this program in terms of Big O notation ?

Exercise #2:

What is the time complexity of following code segments?

a) Code Segment	**Time Complexity**

`int a = 0, b = 0;`
`for (i = 0; i < N; i++) {`
`  a = a + rand();`
`}`
 	
`for (j = 0; j < M; j++) {`
`  b = b + rand();`
`}`	

b) Code Segment	Time Complexity

`int a = 0;`
`for (i = 0; i < N; i++) {`
`  for (j = N; j > i; j--) {`
`  a = a + i + j;`
`  }`
`}`	

c) Code Segment	Time Complexity

`int i, j, k = 0;`
 	
`for (i = n / 2; i <= n; i++) {`
`  for (j = 2; j <= n; j = j * 2) {`
`  k = k + n / 2;`
`  }`
`}`	

d) Code Segment	Time Complexity

`int numberFound = 0`
`for i = 0..(n-1)/2`
`  for j = 0..(n-1)/2`
`  if BinarySearch(A[i,j])`
`  numberFound = numberFound + 1`	

Exercise #3: A program you have developed has a fixed startup time and a main algorithm which you know is $O(n^3)$. You have tested the program with 1 data item, and it takes 10 seconds to execute. With 100 data items it takes 15 seconds to run. Estimate how long (in seconds) this algorithm will take for 400 items?

Exercise #4: A sorting method with "Big-O" complexity O(n log n) spends exactly 1 millisecond to sort 1,000 data items. Assuming that time T(n) of sorting n items is directly proportional to n log n, that is, T(n) = c n log n, derive a formula for T (n), given the time T (N) for sorting N items, and estimate how long this method will sort 1,000,000 items.

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Exercise #5: Show how the following values would be stored in a byte-addressable machines with 32-bit words, using little endian and then big endian format. Assume that each value starts at address 1016. Draw a diagram of memory for each, placing the appropriate values in the correct (and labeled) memory locations.

- 0x456789A1
- 0x0000058A
- 0x14148888

Exercise #6: We have stressed the need for an operating system to make efficient use of the computing hardware. When is it appropriate for the operating system to forsake this principle and to “waste” resources? Why is such a system not really wasteful?

Exercise #7: How does the distinction between kernel mode and user mode function as a rudimentary form of protection (security) system?

Exercise #8: Which of the following instructions should be privileged?

a) Set value of timer.

b) Read the clock.

c) Clear memory.

d) Issue a trap instruction.

e) Turn off interrupts.

f) Modify entries in device-status table.

g) Switch from user to kernel mode.

h) Access I/O device.

The rest can be peroformed in user mode.