

CSCI-GA.3033-016  
**Virtual Machines: Concepts and Applications**  
**Homework Assignment 4**

Given the following assembly code (the same assembly you used in hw2 and hw3):

```
comp:
    push eax
    push ecx
    push ebp
    mov ebp, esp
    mov ebx, 1
    cmp eax, 1
    jle end
    mov ecx, eax
    dec eax
    call comp
    mul ebx, ecx
end:
    pop ebp
    pop ecx
    pop eax
    ret

start:
    mov eax, 0
loop: inc eax
      call comp
      cmp eax, 3
      jl loop
```

**1. Determine the static basic blocks**

**A**

```
comp: push eax
      push ecs
      push ebp
      mov ebp, esp
      mov ebx, 1
      cmp eax, 1
      jle end
```

**B**

```
mov ecx, eax
dec eax
call comp
```

**C**

```
mul ebx, ecx
```

**D**

```
end: pop ebp
      pop ecx
      pop eax
      ret
```

**E**

```
start: mov eax, 0
```

**F**

```
loop: inc eax
      call comp
```

**G**

```
cmp eax, 3
jl loop
```

## 2. Determine the dynamic basic blocks

**A**

```
start: mov eax, 0
loop:  inc eax
      call comp
```

**B**

```
comp: push eax
      push ecx
      push ebp
      mov ebp, esp
      mov ebx, 1
      cmp eax, 1
      jle end
```

**C**

```
end:  pop ebp
      pop ecx
      pop eax
      ret
```

**D**

```
cmp eax, 3
jl loop
```

E

```
loop: inc eax
      call comp
```

F

```
mov ecx, eax
dec eax
call comp
```

G

```
mul ebx, ecx
end: pop ebp
pop ecx
pop eax
ret
```

**3. Is the first instruction in each static basic block unique?**

Yes

**4. Is the first instruction in each dynamic basic block unique?**

Yes

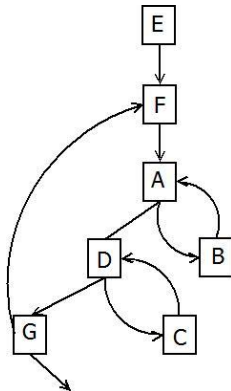
**5. Are all the instructions inside a static basic blocks unique (i.e. do not appear in any other static BB)?**

Yes

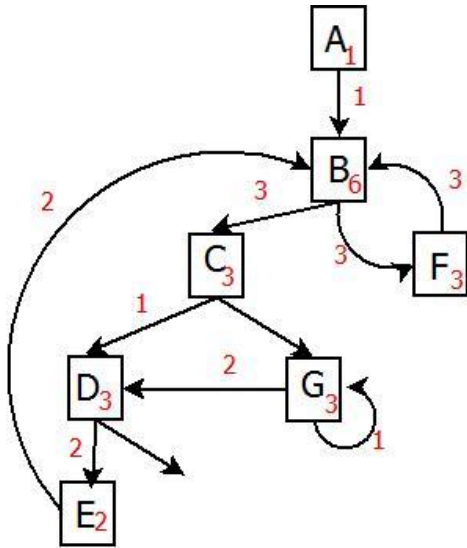
**6. Are all the instructions a dynamic basic block unique?**

No

**7. Draw the control flow graph using static basic blocks.**



**8. Draw control flow graph of dynamic basic blocks and annotate edges and nodes with frequency.**



Note from the above picture that edge frequency are enough to get blocks frequency too. The other way around is not possible

**9. Can we annotate the CFG in #7 with frequencies in the same way as we did in #8? If yes, what did we gain from using dynamic BB in translation then? If not, why not?**

Yes we can, if we execute the program and keep track of static BB executed.

However, translation is done at the dynamic BB level for several reasons:

- Dynamic BB depends on the dynamic flow of execution which the VM can keep track of. If we are to use static BB, we have to build those BB before execution and load it to the VM, which adds some extra overhead.
- Dynamic BBs tend to be larger than static BB. Hence, the resulted CFG will be a bit smaller, requiring smaller storage.
- The average larger size of dynamic BB gives more opportunities for optimizations.