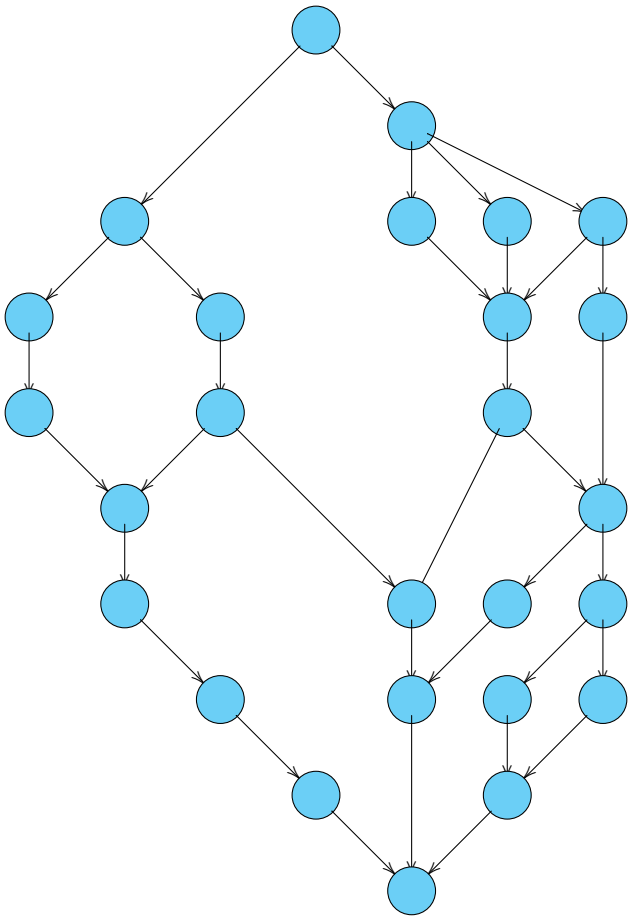
Consider the following dag representing a multithreaded computation, where each circle denotes a serially executing strand that takes unit time to execute:



Please provide a numerical answer to the following questions.

- What is the work of this computation?
- What is the span of this computation?
- What is the parallelism of this computation?

Solution:
Work = count the number of nodes. 26
Span = count the length of the longest path. 10
Parallelism = Work / Span = 2.6

Five students have implemented recursive Fibonacci programs, where the base case of each program returns 1 if the program input is `n = 0` or `n = 1`. For `n > 1`, the various students calculate Fibonacci using the code snippets for the recursive cases shown below:

a:
```
x = fib(n - 1);
y = fib(n - 2);
```

b:
```
x = cilk_spawn fib(n - 1);
y = cilk_spawn fib(n - 2);
cilk_sync;
```

c:
```
x = fib(n - 1);
y = cilk_spawn fib(n - 2);
cilk_sync;
```

d:
```
y = cilk_spawn fib(n - 2);
x = fib(n - 1);
cilk_sync;
```

e:
```
x = cilk_spawn fib(n - 1);
y = fib(n - 2);
cilk_sync;
```

Assume that the overhead of spawning a function is about 10 times the cost of an ordinary function call. Rank these codes in order of the performance you would expect for large n. (e.g., fastest $>$ second fastest $> \cdots >$ slowest):

Solution:

d ~ e > b > a > c

(c) still does everything in serial but has the added overhead of a spawn

(a) is serial

(b) does it in parallel but has the unneeded overhead of two spawns

(d) and (e) introduce the same number of spawns.

6.172 Performance Engineering of Software Systems

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