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Towards a better Parallelism

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Java Your Next (Cloud)

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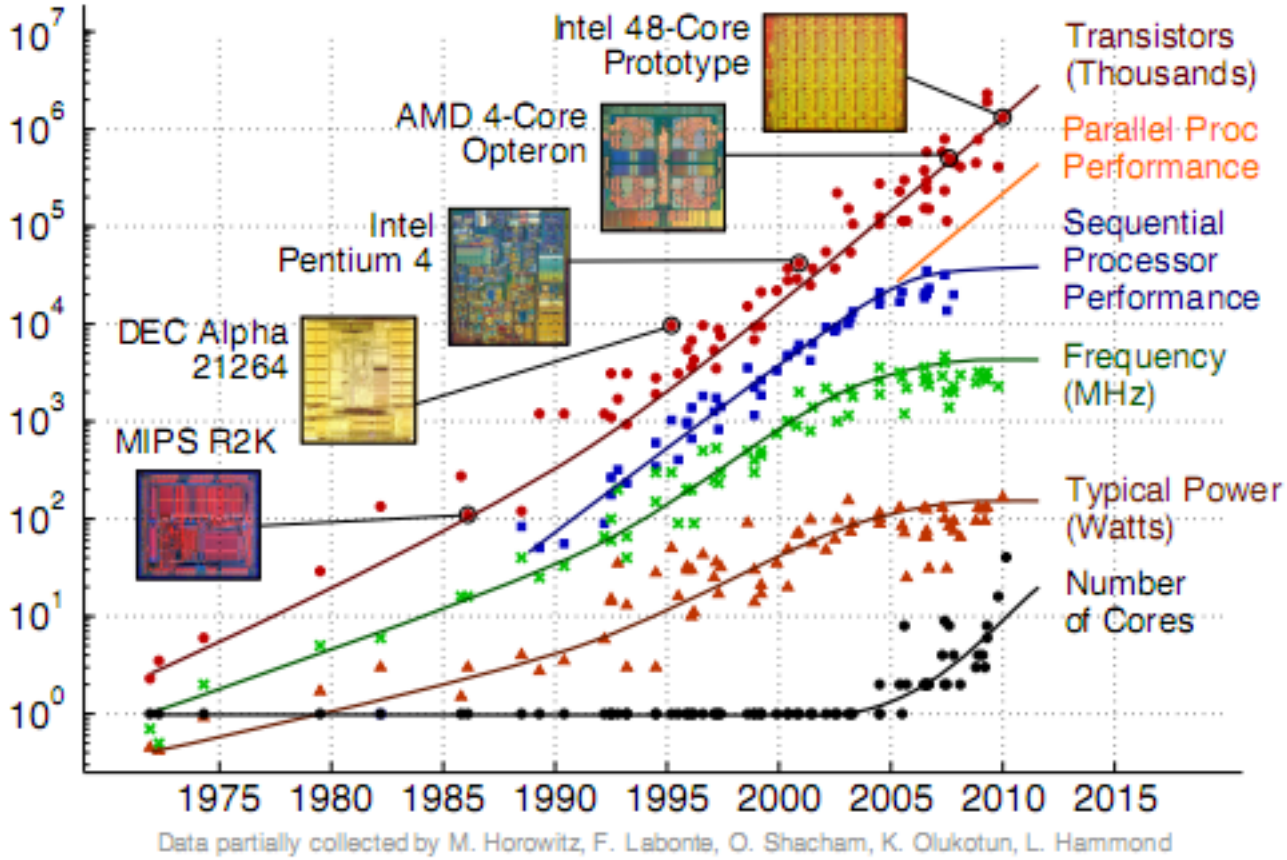
Agenda of the day …

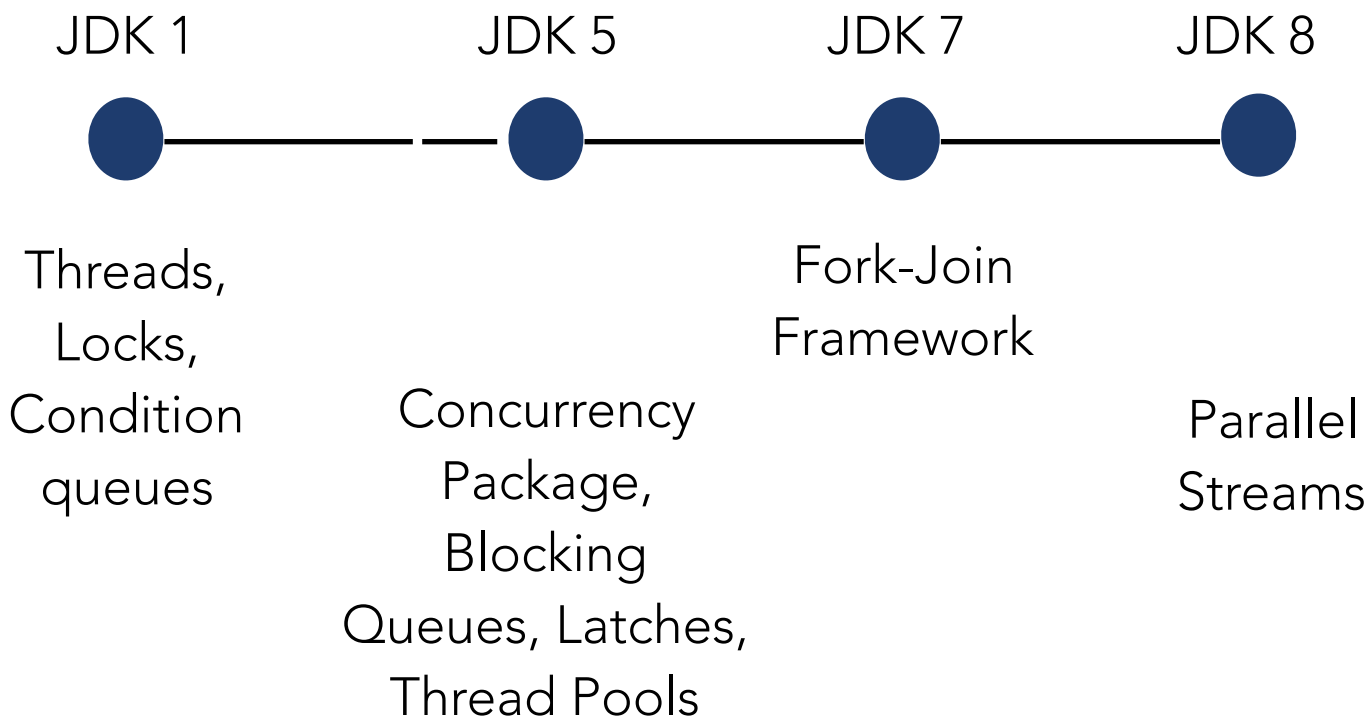
1. Future of Hardware
2. Software followed Hardware
3. Productive Parallelism
4. Performance Consideration
5. A glimpse of Parallel Streams
6. Where we are heading

Where future is trending …



Prepared by C. Batten - School of Electrical and Computer Engineering - Cornell University - 2005 - retrieved Dec 12 2012 - http://www.csl.cornell.edu/courses/ece5950/handouts/ece5950-overview.pdf

Software followed Hardware



What is Parallelism …

- Breaking the tasks into sub-tasks and get results faster.
- Faster and only faster (with more resources)
- Golden rule
  - Analyze -> Implement -> Test -> Repeat
- If results are not better (?), drop the idea.

Reference: Internet Movie Firearms Database (http://www.imfdb.org/wiki/Matrix,_The)

Any overhead ?

- Parallel computation always involves “more” task than its alternative sequential computation.
- Always a slow startup.

DECOMPOSE THE PROBLEM INTO TASK

LAUNCH TASK, MANAGE TASK, WAIT FOR COMPLETION

COMBINE RESULTS

+

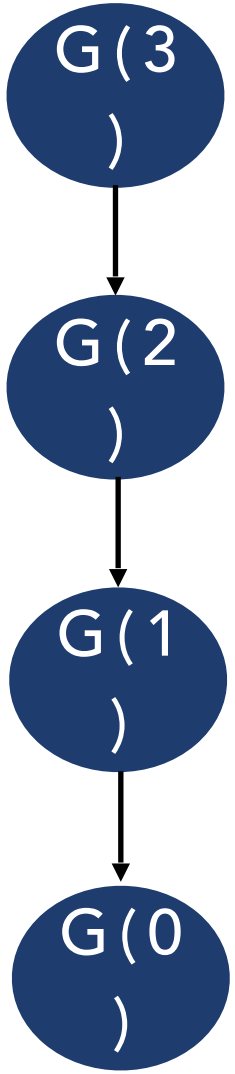
SOLVE THE PROBLEM

Data Flow Dependency

- Consider a problem and look at the data flow dependency.
- If it's a real iterative problem - Bad idea to think of parallelism.

$$G(N) = F(G(N-1)), \text{ IF } N > 0$$

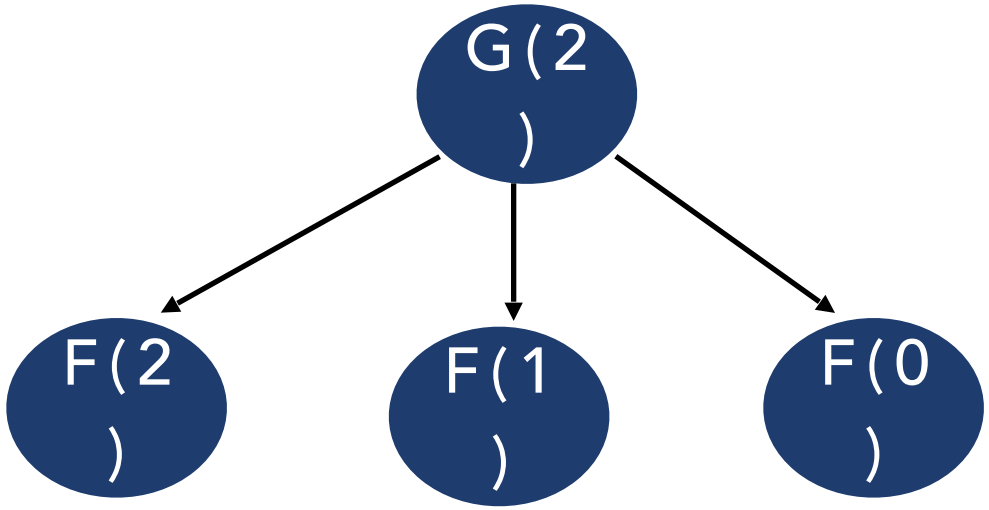
$$G(0) = F(0)$$

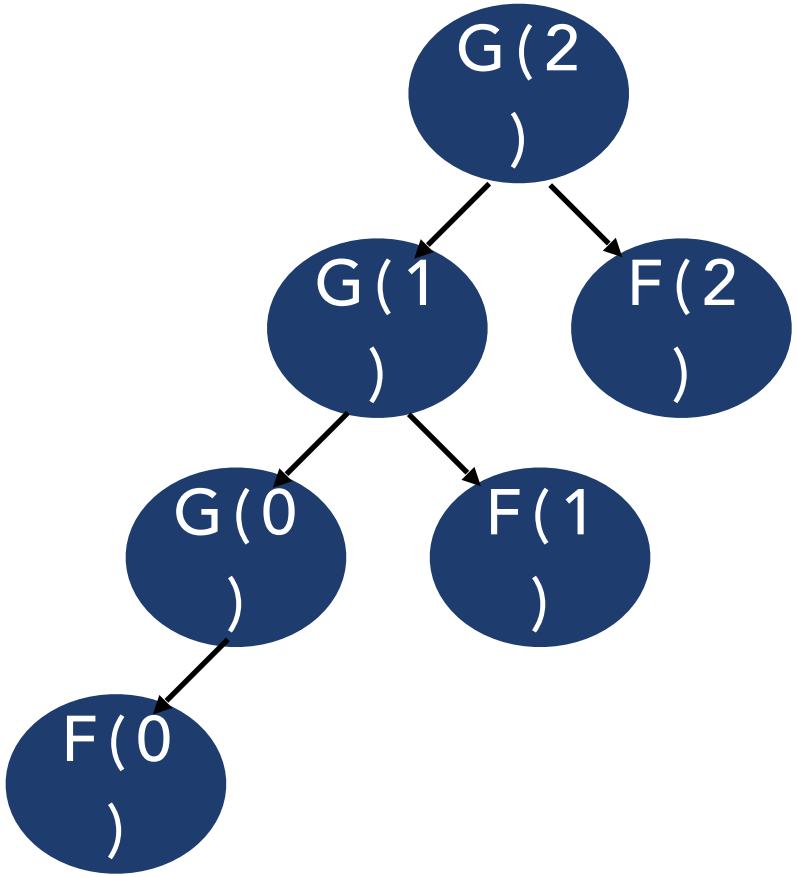


Parallelism can be exploited

$$G(N) = F(N) + G(N-1), \text{ IF } N>0$$

$$G(0) = F(0)$$





Let’s reach out to the parallel computation

```
int sum (int[] arr) {
    int sum = 0;
    for (int i : arr)
        sum = sum + i;
    return sum;
}
```

Sequential approach. Accumulator Pattern.

```
int sum (int[] arr) {
    int sum = 0;
    INT MID = arr.length/2;
    CONCURRENT {
        { for (int i=0; i< MID; i++)
            sum = sum + arr[i];  }
        { for (int i=MID;i<arr.length; i++)
            sum = sum + arr[i]; }
    }
    return sum;
}
```

//need to atomic

//need to atomic

Cont…

- The last solution is bad. Because we are spending time to safe-guard the data.
- Right approach (in the order) :-
  - Don’t share
  - Don’t mutate
  - Coordinate access

Cont…

```
int sum (int[] arr) {
    int LEFT = 0, RIGHT = 0;
    int MID = arr.length/2;
    CONCURRENT {
        { for (int i=0; i< MID; i++)
            ATOMIC { LEFT = LEFT + arr[i]; } }
        { FOR (int i=MID;i<arr.length; i++)
            ATOMIC { RIGHT = RIGHT + arr[i]; } }
    }
    return LEFT + RIGHT;
}
```

Fairly a good solution

Generic solution is required.

Leverage all the cores, split till sequential gives the better result.

Pseudo-Code for generic solution

```
// PSEUDOCODE
Result solve(Problem problem) {
    if (problem.size < SEQUENTIAL_THRESHOLD)
        return solveSequentially(problem);
    else {
        Result left, right;
        INVOKE-IN-PARALLEL {
            left = solve(extractLeftHalf(problem));
            right = solve(extractRightHalf(problem));
        }
        return combine(left, right);
    }
}
```

Introduction to Fork-Join Framework

- JDK7 introduced Fork And Join Framework.
- Works on Divide and Conquer
- Implements work-stealing algorithm.

```
if (my portion of the work is small enough)
        do the work directly

else
        split my work into two pieces
        invoke the two pieces and wait for the results
```

Introduction of ParallelStreams in Java8

- Build on top of FnJ Framework.
- FnJ was not so easy to use.
- You just have to say “.parallel()”

```
Arrays
    .stream(a)
    .parallel()
    .filter(s -> s > 5000000)
    .sum();
```

Magical, but unfortunately not…

Parallel Stream consideration

Performance Considerations

- Splitting of Source
  - source should be splittable
  - cost of computation for split
  - evenness, predictability of split
- Some source are awesome to split and some are not.
- Arrays (Good), LinkedList (Not good), Tree (so-so)
- Not only splitting, combining result should be considered.

Minimum Data to get benefit (Run Size: 500K)

THREAD/ THRESHOLD	500K	50K	5K	500	50
2 thread	1.0	1.07	1.02	0.82	0.2
4 thread	0.88	3.02	3.2	2.22	0.43
8 thread	1.0	5.29	5.73	4.53	2.03
32 thread	0.98	10.46	17.21	15.34	6.49

The NQ model

- Simple model for parallel performance
  - N: No of elements
  - Q: amount of work per item
  - N X Q > 10,000 -> chance for parallelism
  - Important for say “minimum data”

Locality Issues

- Locality is dangerous.
- CPU should be busy in good work
  - Cache misses are not good.
- Streams.of(int[].sum()) vs Streams.of(Interger[].sum())

Speed Up	N=1K	N=10K	N=1M
int	1x	6.2x	7.9x
Integer	-4.9x	1.5x	3.5x

Order insensitive operations

- Least parallel friendly.
- Always remember the bottle-neck principles.

```
OptionalLong m = Arrays.stream(a).parallel()  // killer
        .filter(s -> s > 5000000)
        .filter(x -> x == 5465759)
        .findFirst();
```

Must visit reference

- Java Concurrency in Practice (Book) - Brian Goetz
- Concurrency to Parallelism
- Introduction to Streams Library
- Java Fork-Join Framework - Doug Lea