ThoughtWorks® Deutschland

Parallel Programming with Java 7

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Some theory
New kids on the block
A lot of practice
Wrap up

Some theory	13:30 – 14:00
New kids on the block	14:00 – 14:30
All hands on deck	14:30 – 16:30
Wrap up	16:30 – 17:00

Part 1
Some theory

Why parallel programming?

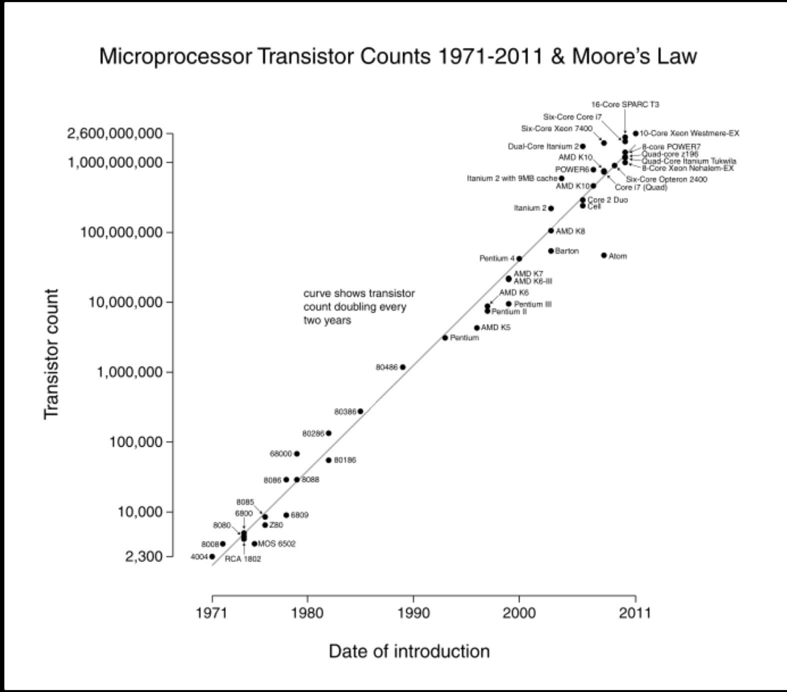
Grand challenge problems

- Modelling DNA structures
- Weather forecasting

Parallel programming splits problems into parts

- Parts are solved in parallel by multiple processors

No more free lunch



* Source: http://de.wikipedia.org/wiki/Mooresches_Gesetz

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Partitioning & divide-and-conquer

Data partitioning is applied to data (aka domain decomposition)

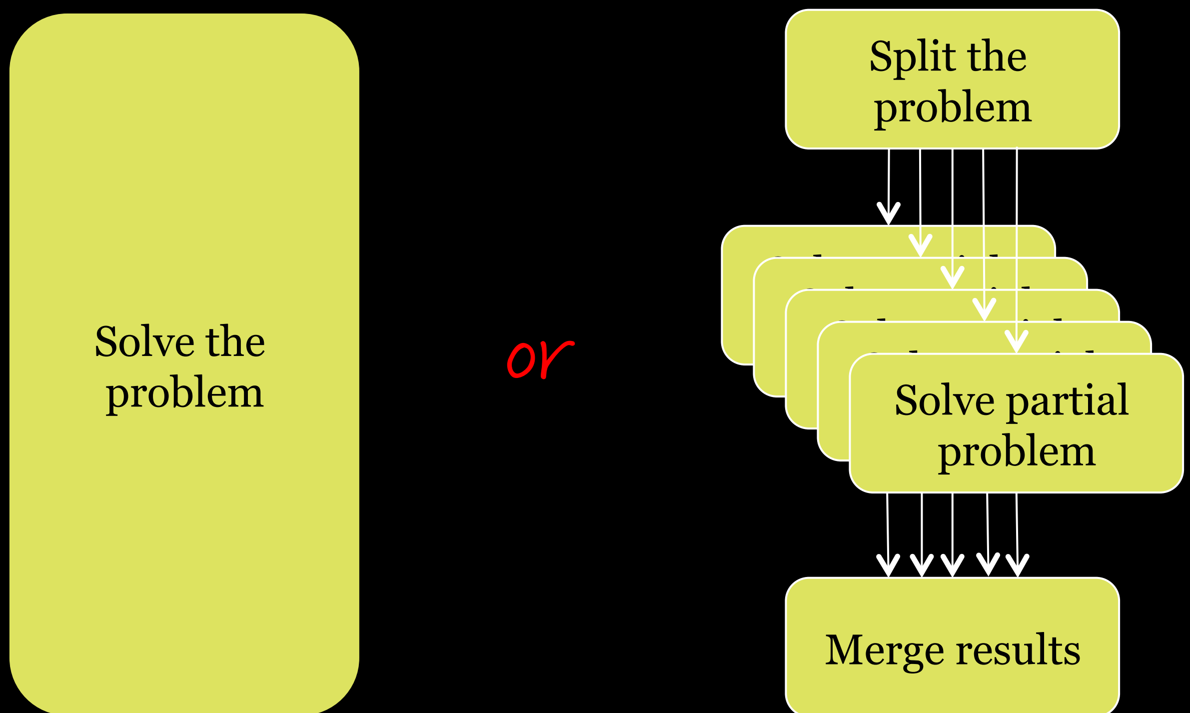
Functional decomposition concurrently executes independent functions

- Less common than data partitioning

Divide-and-conquer divides a problem into similar sub-problems

- Sub-problems have the same form as the original problem
- Can be repeated recursively

Which way is faster?



Amdahl's law (1/3)

S = speedup factor S = function(n,f) where

- n = number of processors/cores
- f = fraction of the computation that cannot be parallelised

Amdahl's law (2/3)

S = speedup factor = function(n,f) where

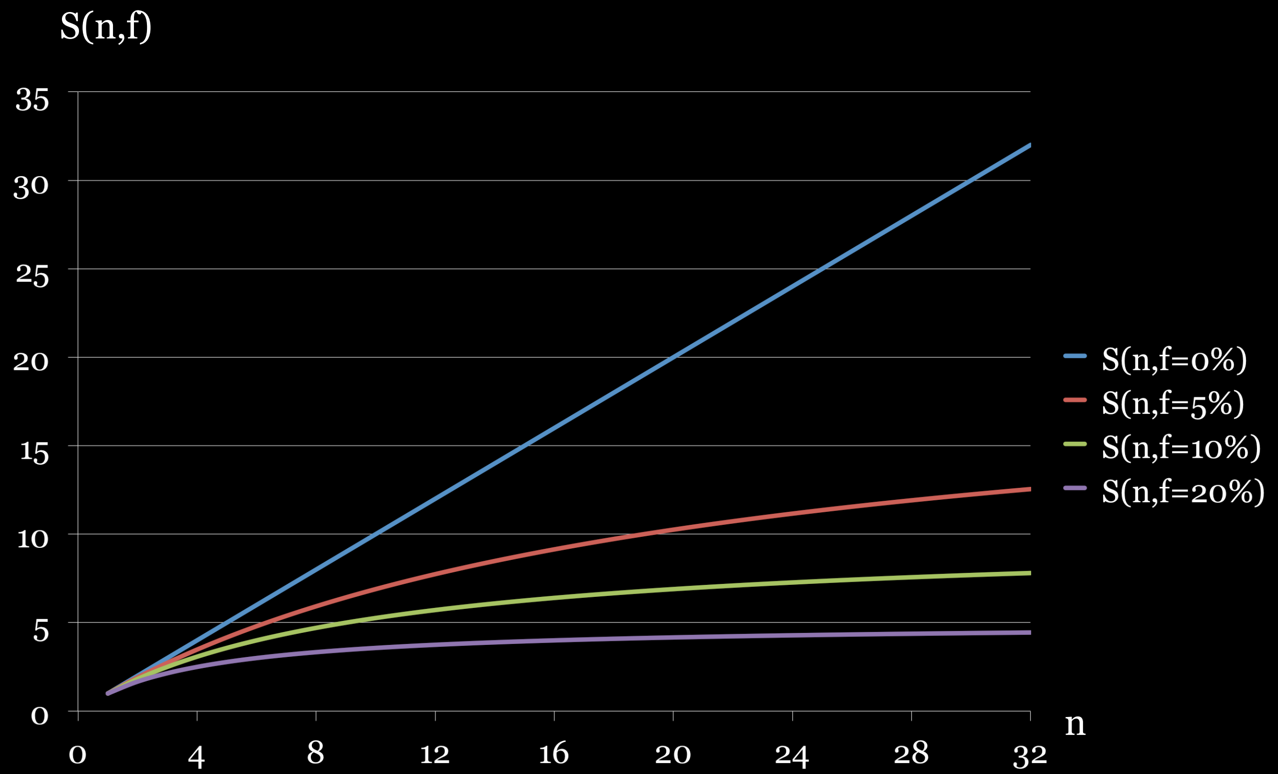
n = number of processors/cores

f = fraction of the computation that cannot be parallelised

$$S(n) = \frac{\textit{single processor execution time}}{\textit{n processor execution time}} = \frac{n}{1 + (n-1)f}$$

$$\lim_{n \to \infty} S(n) = \frac{1}{f}$$

Amdahl's law (3/3)



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How to benefit from multiple CPUs/cores in Java

Implicitly – magic done under the hood by the JVM

Explicitly – using Java 7's fork/join framework

This session focuses on the fork/join framework

Testing fork/join

Assert that…

… the core computation works as expected

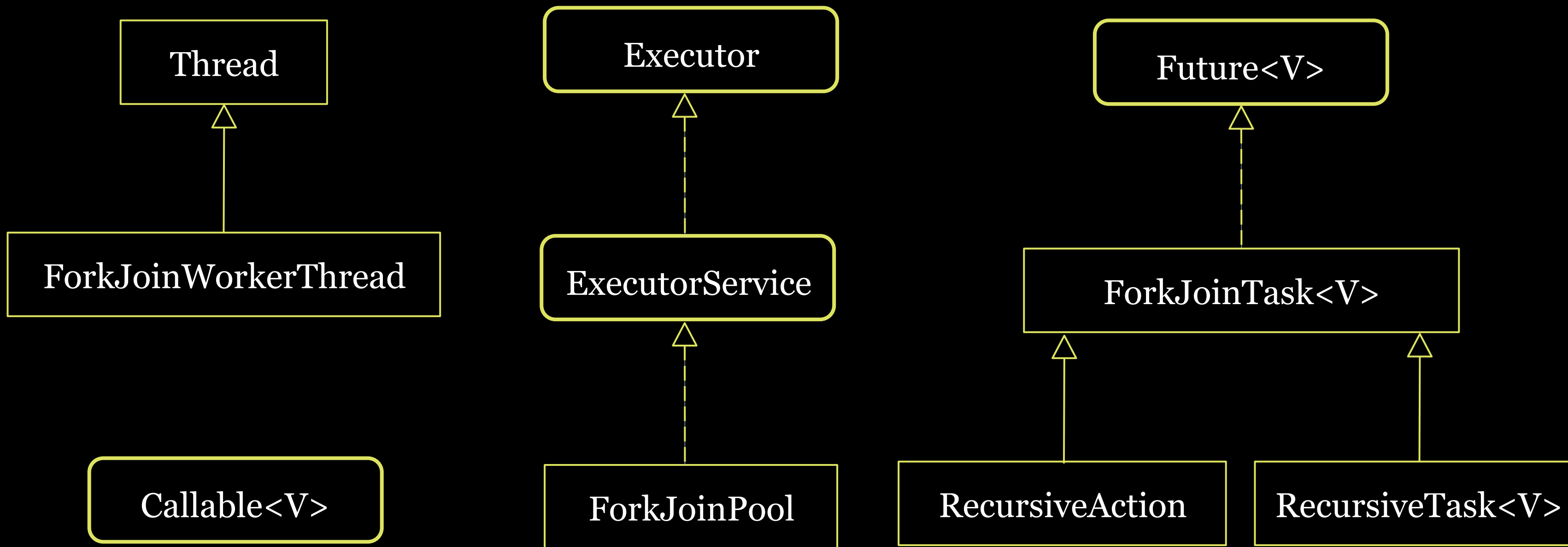
… the complete task works as expected

… splitting the task does not corrupt input data

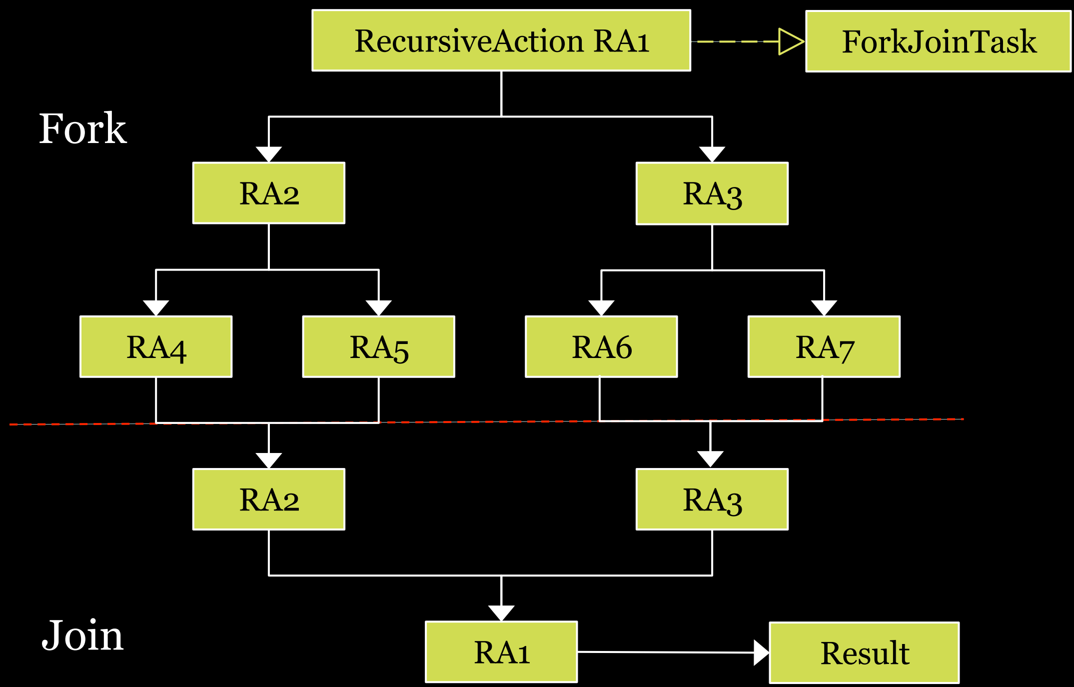
… merging results behaves as expected

Part 2
New kids on the block

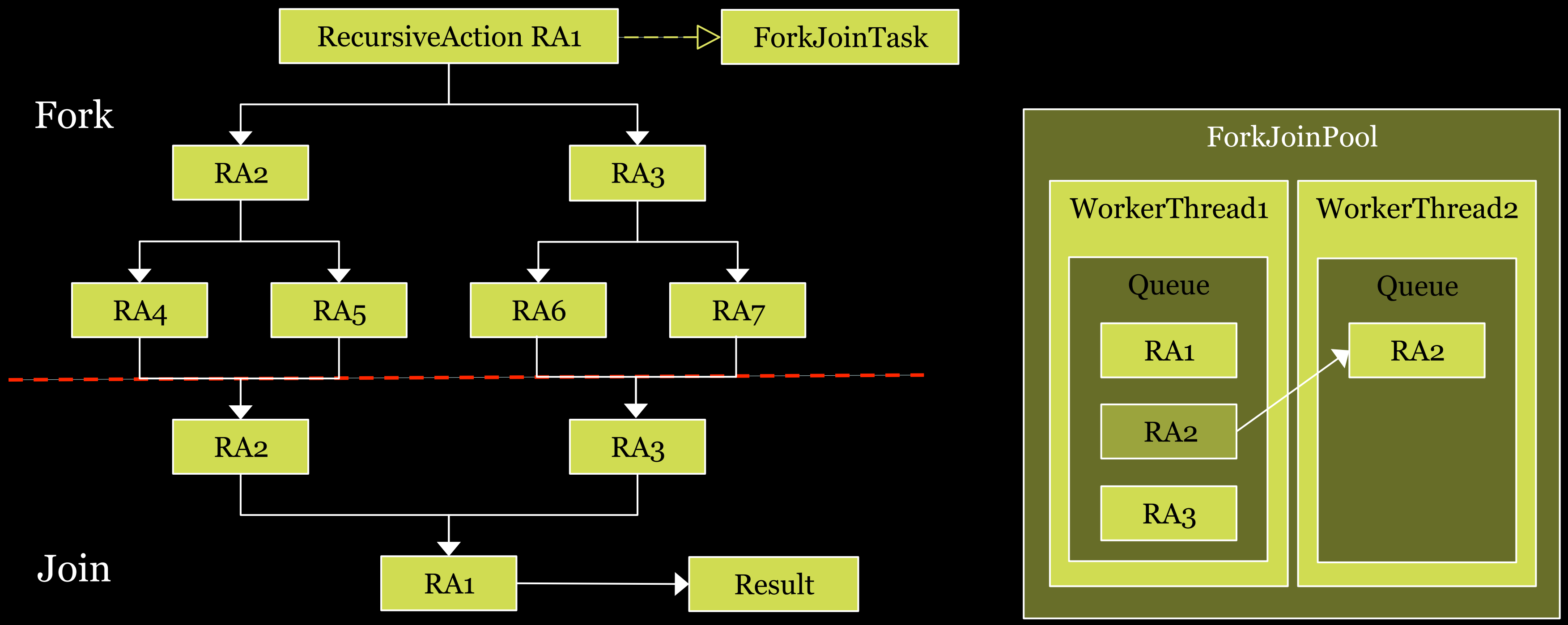
New classes on the block



Anatomy of the fork/join interaction (1/2)



Anatomy of the fork/join interaction (2/2)



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Part 3
All hands on deck

How to implement a ForkJoinTask generally

```
if (my portion of the work is small enough)
  do the work directly
else
  split my work into two pieces and fork them
  merge/join the results
```

A guided example: Calculating checksums

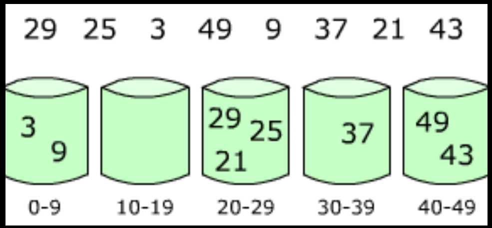
Setting up your environment

- Sources and slides are on the stick
- Follow the instructions in the README file

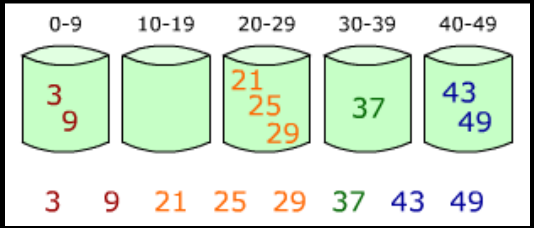
Exercise 1: Bucket sort

- Implement a sequential and a parallel version of bucket sort

- Put elements into buckets that represent ranges



- Sort and concatenate buckets



- Source: http://en.wikipedia.org/wiki/Bucket_sort

Exercise 1: Bucket sort as pseudo code

* ```
  function bucketSort(array, n) is
     buckets ← new array of n empty lists

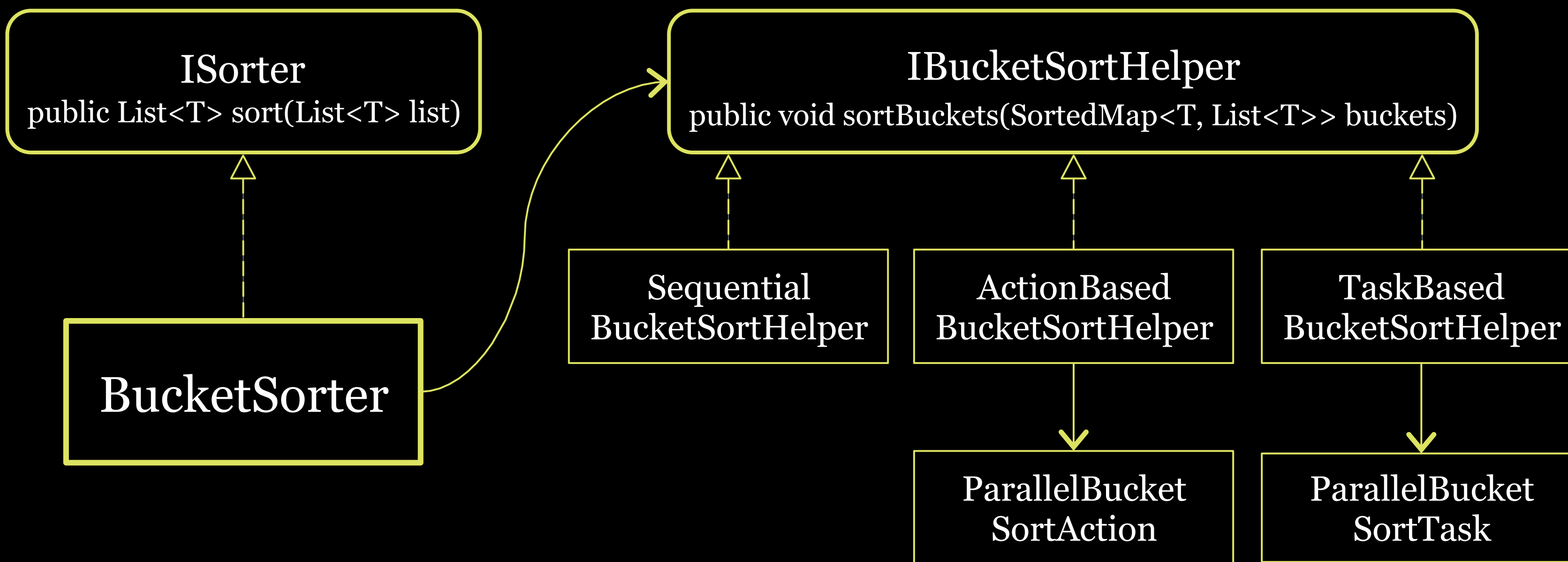
     for i = 0 to (length(array)-1) do
        insert array[i] into buckets[whichBucket(array[i])]

     for i = 0 to n - 1 do
        nextSort(buckets[i])

     return the concatenation of buckets[0], ..., buckets[n-1]
  ```

* Source: http://en.wikipedia.org/wiki/Bucket_sort
  ```

Exercise 1: One way to realise bucket sort

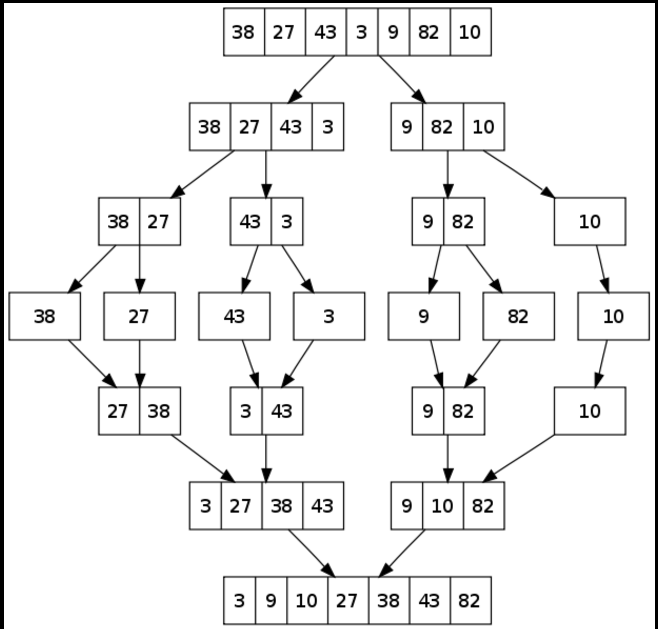


Exercise 2: Tuning the parallel bucket sort

- Buckets of equal width work well when the list to sort is evenly populated
- When the distribution of elements is skewed, the parallel bucket sort may degrade (why?)
- Run your parallel bucket sort with different kinds of lists (i.e. evenly populated ones and skewed ones)
- Improve the performance of your parallel bucket sort if required

Exercise 3: Merge sort

- Implement a sequential and a parallel version of merge sort
  - If the list is of length 0 or 1 the list is already sorted
  - Divide the unsorted list into two sublists of about half the size
  - Sort each sublist recursively by re-applying the merge sort
  - Merge the two sublists back into one sorted list



- Source: http://en.wikipedia.org/wiki/Merge_sort

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Exercise 3: Merge sort as pseudo code (1/2)

```
function merge_sort(m)
    if length(m) ≤ 1
        return m
    var list left, right, result
    var integer middle = length(m) / 2
    for each x in m up to middle
         add x to left
    for each x in m after or equal middle
         add x to right

    left = merge_sort(left)
    right = merge_sort(right)
    result = merge(left, right)

    return result
```

 Source: http://en.wikipedia.org/wiki/Merge_sort

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Exercise 3: Merge sort as pseudo code (2/2)

```
function merge(left,right)
    var list result
    while length(left) > 0 or length(right) > 0
        if length(left) > 0 and length(right) > 0
            if first(left) ≤ first(right)
                append first(left) to result
                left = rest(left)
            else
                append first(right) to result
                right = rest(right)
        else if length(left) > 0
            append first(left) to result
            left = rest(left)
        else if length(right) > 0
            append first(right) to result
            right = rest(right)
    end while
    return result
```

 Source: http://en.wikipedia.org/wiki/Merge_sort

Exercise 4: Searching strings in text files

- Implement a parallel search for a string in a text file
- The search string can be assumed to contain no whitespace (i.e. no spaces or tabs)
- Have a look at the following class:

  `com.thoughtworks.fjw.search.SimpleStringSearchTest`

  - The class contains examples for string based searching and reading from a text file

Exercise 5: Searching strings revisited

- Revisit your solution for the previous exercise
- Drop the assumption so that search strings can contain whitespace
- Consider how dropping the assumption affects the way you partition the text to search

Part 4
Wrap up

Thanks to Fabian for co-authoring the workshop

B. Wilkinson & M. Allen: Parallel Programming,
Prentice Hall, New Jersey 1999

Thank you

How can we help?

ThoughtWorks is a global custom software solutions consultancy trusted by many of the world's leading businesses with their most complex and critical systems.

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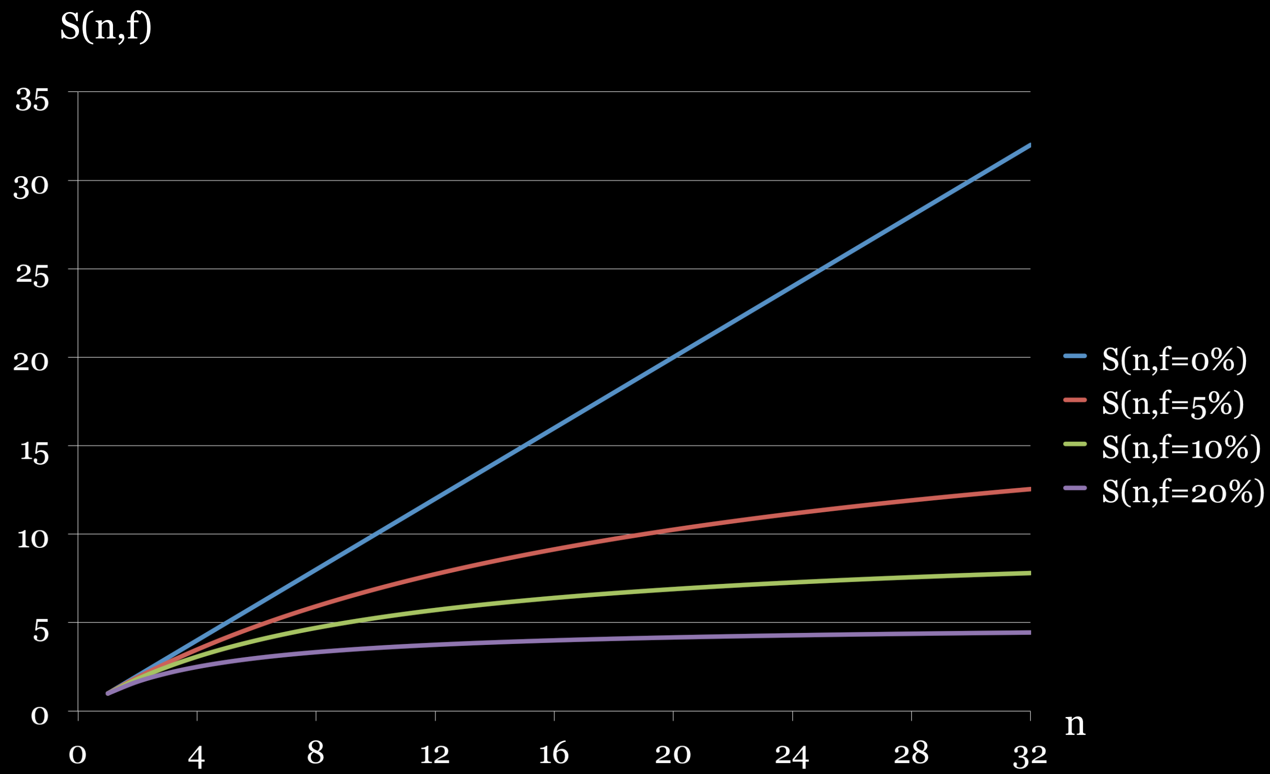
Backup slides

Amdahl's law (3/3)



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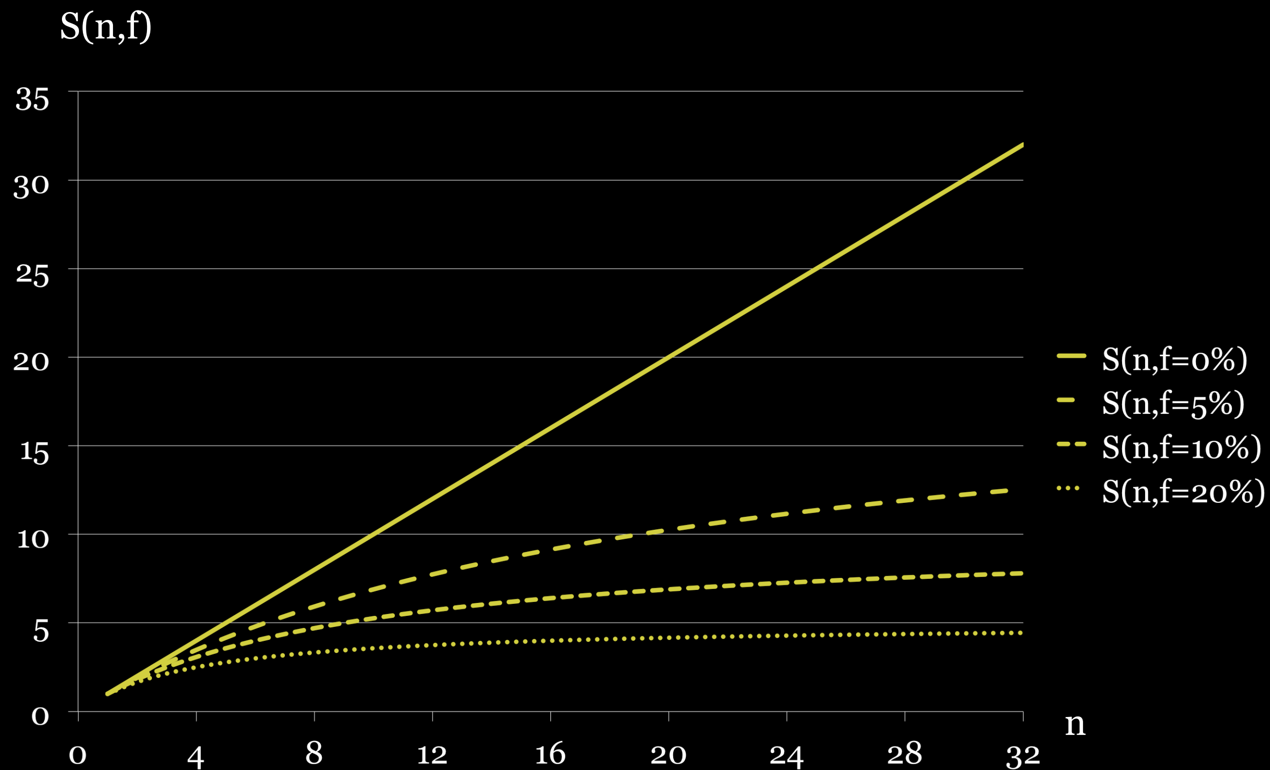
Amdahl's law (3/3)



Thread state diagram