

# Parallel FP/OO Programming with Java

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# 内容简介

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- Java并发与并行历史
  - 函数式编程与面向对象编程
  - 结构化并发/并行
- 三大并行框架
  - 并行流（函数式框架）
  - Fork-join pool（面向对象的框架）
  - CompletableFuture（反应式异步框架）
- 反应式流
  - Flow, Akka-stream, Rxjava
- 项目案例研究
  - its, quiz, common-utils
  - concurrency-practice工程介绍

# 并发与并行

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- 并发：控制访问共享资源的正确性和效率。
- 并行：增加额外资源让答案产生更快。
  - 分治
  - 粗粒度的任务并行和细粒度数据并行
- 求1到1亿的总和。
  - 串行
  - 并发
  - 并行

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

```
int sumConcurrent(int[] array) {  
    int mid = array.length / 2;  
    int sum = 0;  
    CONCURRENT {  
        {  
            for (int i = 0; i < mid; i++)  
                ATOMIC { sum = sum + array[i]; }  
        }  
        {  
            for (int i = mid; i < array.length; i++)  
                ATOMIC { sum = sum + array[i]; }  
        }  
    }  
    return sum;  
}
```

```
int sumPartitioned(int[] array) {  
    int mid = array.length / 2;  
    int leftSum = 0, rightSum = 0;  
    CONCURRENT {  
        {  
            for (int i = 0; i < mid; i++)  
                leftSum = leftSum + array[i];  
        }  
        {  
            for (int i = mid; i < array.length; i++)  
                rightSum = rightSum + array[i];  
        }  
    }  
    return leftSum + rightSum;  
}
```

# Java并发与并行历史

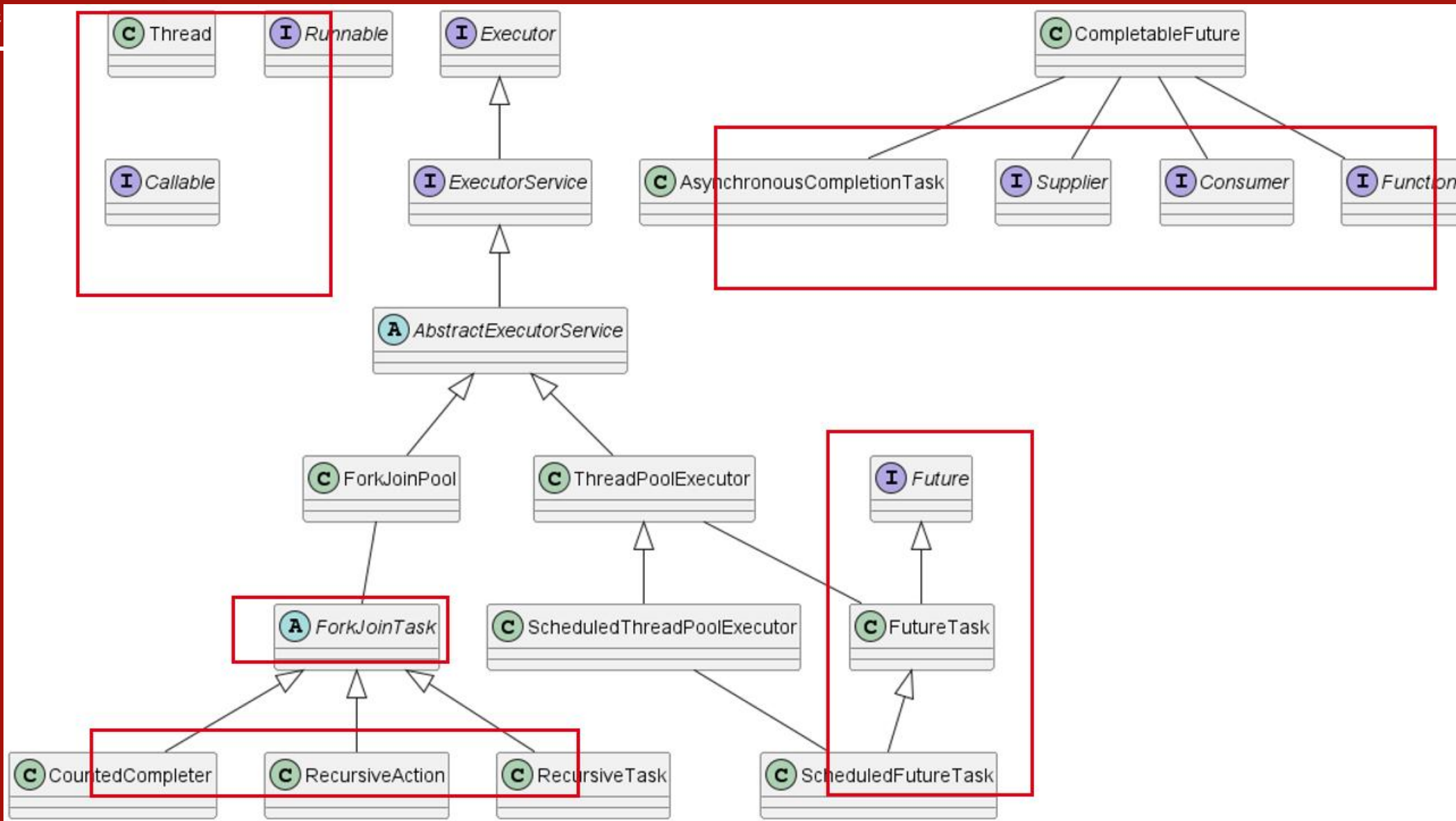
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- 历史演进: 1.1 → 5 → 7 → 8 → 9
  - 1.1: wait/notify/thread, synchronize
  - 5: juc: 并发集合, executor 框架, aqs
  - 7: fork-join
  - 8: stream, CompletableFuture
  - 9: flow
- 特点
  - 从任务并行到数据并行
  - 从OO到FP
  - 抽象层次越来越接近领域问题
- java.util.concurrent 并发包
  - 理解难度: 2 > 4 > 1 > 3
  - 使用难度: 1 > 4 > 3 > 2
  - Today: 结构化并行
- JEP 428: Structured Concurrency



# 任务以及任务执行，结构化并行

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# 并行流

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- 基础模型
  - 起始流(Source): Source和Spliterators
  - 转换(Transforming): Filtering, Mapping, Debugging, Sorting, Deduplicating, Truncating,
  - 终止流(End): Search, Collection, Reduction, Side-Effecting
- 处理大规模数据集
  - MapReduce, MapCollect

# 并行流

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- 使用场景
  - 源很好分割: intrange, longrange
  - 数据量很大
  - 无状态计算, 无共享变量计算
  - 计算密集型, 非IO密集型
  - 机器学习, 数据处理领域
- Doug Lea: When to use parallel streams
  - compute expensive/independent
  - efficiently spittable
- Effective Java3
  - item48: Use caution when making streams parallel

源	可分解性
ArrayList	极佳
LinkedList	差
IntStream.range	极佳
Stream.iterate	差
HashSet	好
TreeSet	好

# 并行流-代码演示

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- demo1 ParallelStreamBenchmark
- demo2 WordCounterSplitter



# Fork Join框架

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- ForkJoinPool

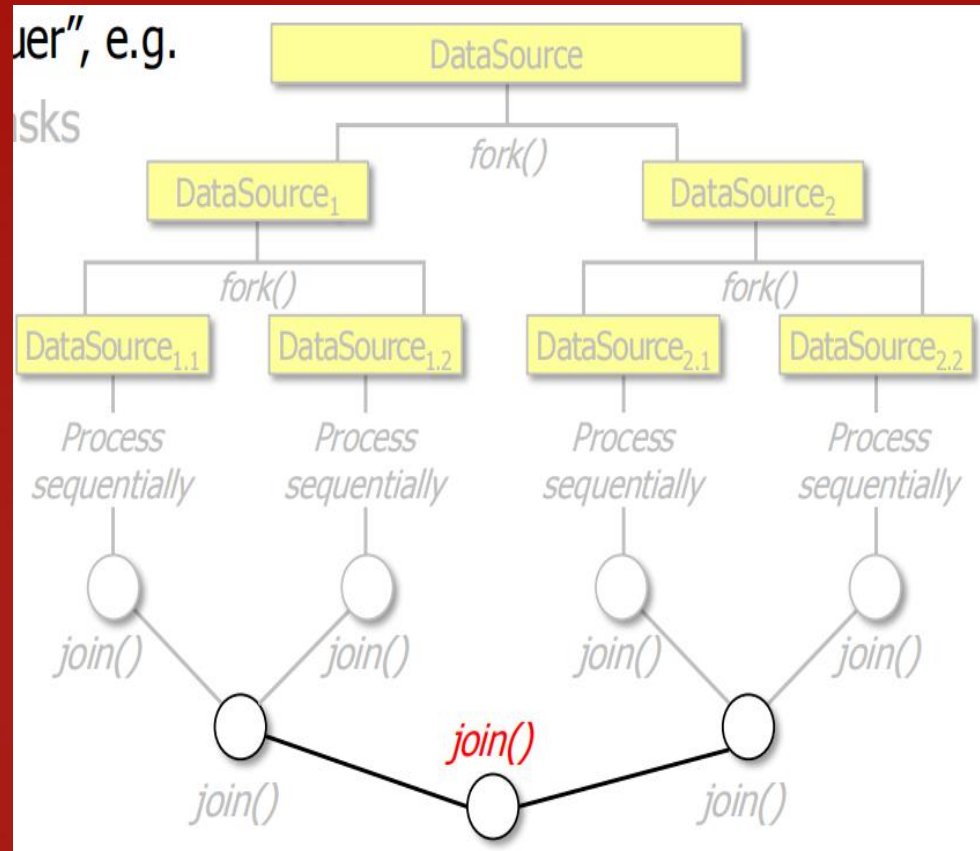
- deque
- work steal

- ForkJoinTask

- fork
- join
- invoke

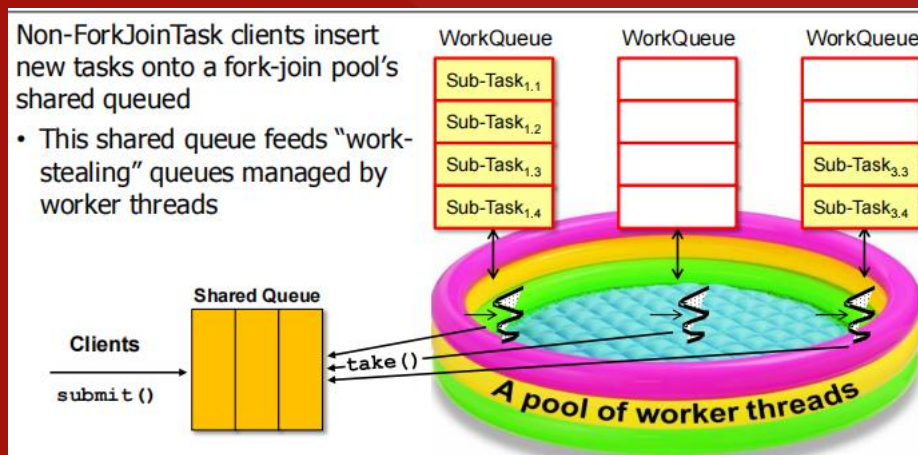
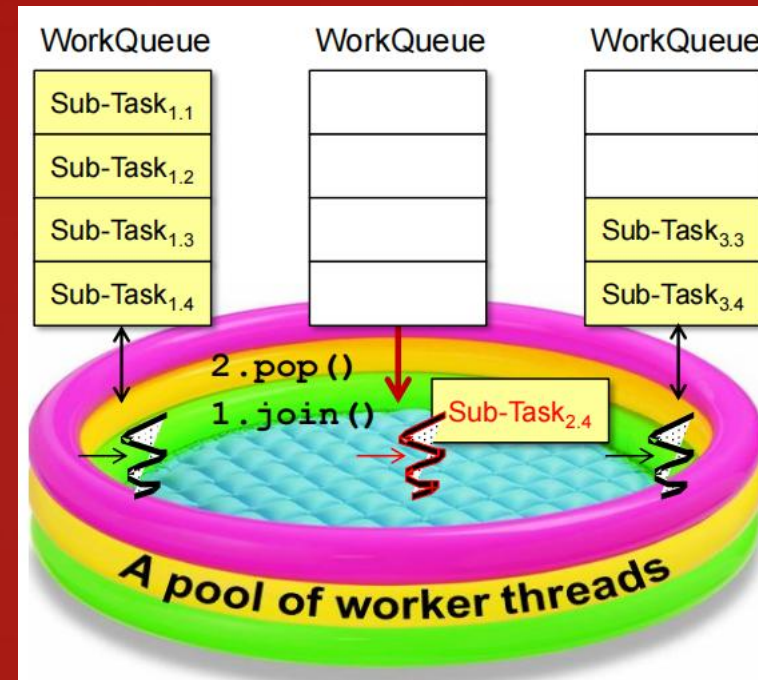
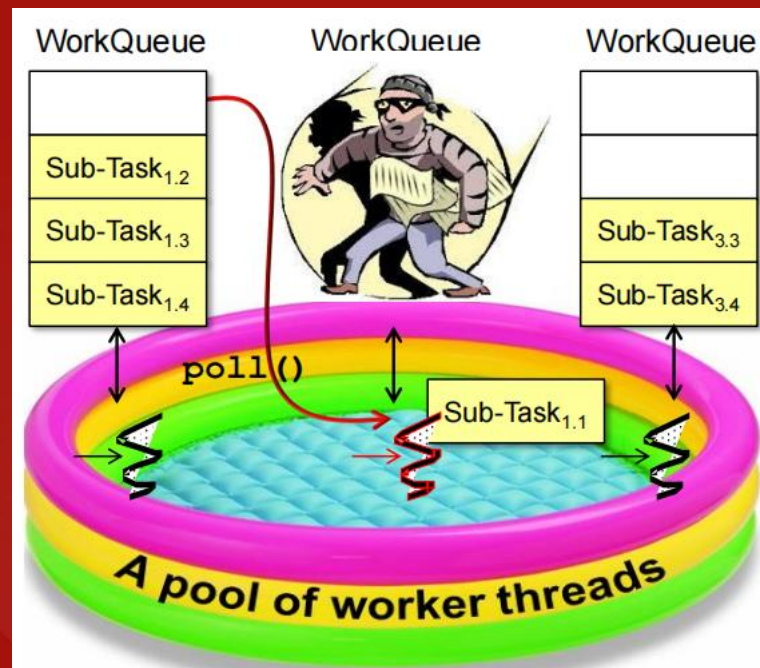
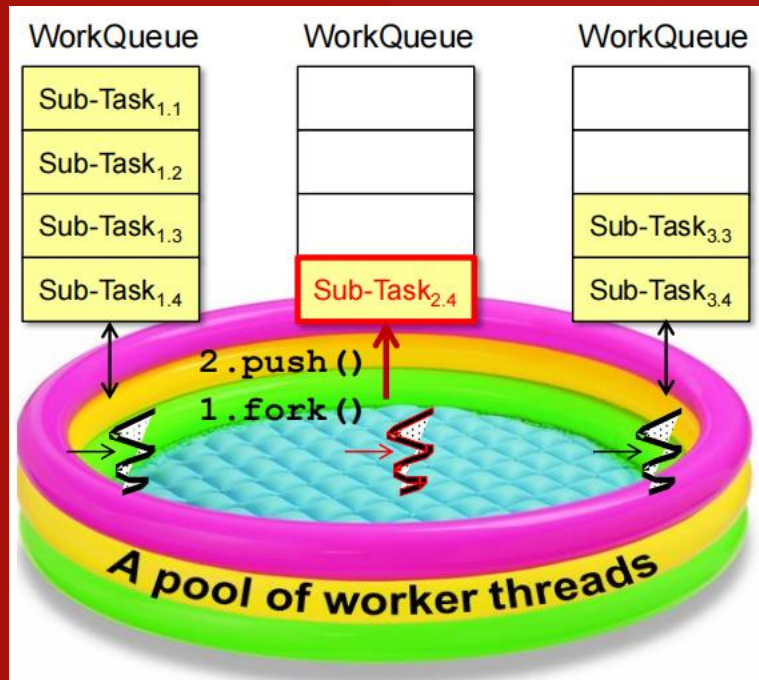
```
Result solve(Problem problem) {  
    if (problem is small)  
        directly solve problem  
    else {  
        split problem into independent parts  
        fork new subtasks to solve each part  
        join all subtasks  
        compose result from subresults  
    }  
}
```

- 使用场景：计算密集型，分治，任务递归可以划分为子任务，如k-means聚类，归并/快速排序，矩阵相乘/LU分解，高斯积分，求和等。



# Fork Join框架

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# Fork Join框架-代码演示

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- demo3 ForkJoinSumCalculator
- demo4 common.ForkJoinUtils
- demo5 common.BlockingTask

# CompletableFuture

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- 异步计算
  - 中断线程
  - Future
  - CompletableFuture
- 函数式异步计算阶段: CompletionStage
- 类似工具
  - ExecutorCompletionService (JDK1.5)
  - Guava: ListenableFuture (JDK1.6)
  - Cassandra Datastax Driver AsyncCqlSession

# CompletableFuture

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- 理解API

- 计算执行: `applyFunction`, `acceptConsumer`, `runRunnable`
- 触发计算: 单阶段 `thenXXX`, 两阶段 `combineXXX/eitherXXX`, 多阶段 `allOf/anyOf`
- 执行机制: `default`, `async`, 自定义 `Executor`
- 计算结果: `whenComplete`, `handle`, `join`
- 异常处理: `exceptionally`

- 使用场景

- IO密集型, 混合负载计算
- 异步任务关联, 依赖
- 包装IO API

# CompletableFuture-代码演示

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- demo6 旅行社订票 CompletableFutureDemo

# 案例学习

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- adaplearn-quiz的FutureCollector
- adaplearn-its的CompleteFuture组合
- common-utils

# concurrency-practice杂谈

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- 项目Github地址
- Java并发学习资料库，2020开始维护。
- 学习资料以及路径
  - 使用->知识完备->设计
  - 书籍
  - 课程
  - 论文
- 综合案例    SearchStreamGangTest





# 感谢各位的聆听

網易 NETEASE