Maximizing Speedup through Self-Tuning of Processor Allocation

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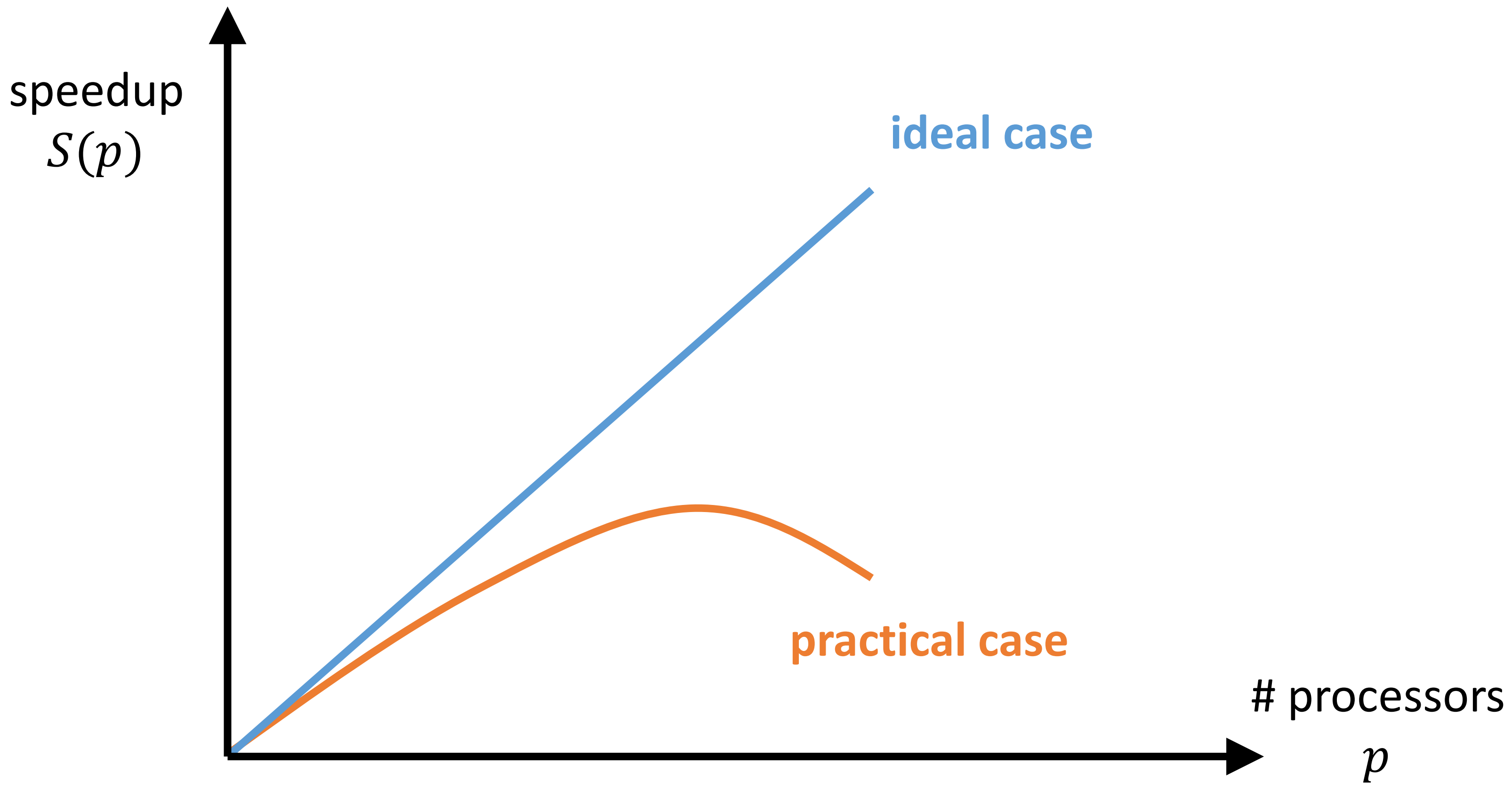
Contents

- **Motivation**
- Experimental Environments
- Self-Tuning Algorithm
- Multi-Phase Self-Tuning Algorithm
- Conclusion

Motivation



Motivation

- Speedup $S(p)$ is not **linear** with respect to processor number p
  - “many parallel applications achieve maximum speedup at some intermediate allocation”

- Dynamic measurements are needed
  - it varies over tasks (also time)
  - “No static allocation may be optimal for the entire execution lifetime of a job”

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Experimental Environments

- Machine
    - **KSR-2 COMA** shared memory multiprocessor
- Parallelization
    - **KSR KAP** preprocessor
    - **KSR PRESTO** runtime system and **CThreads**
- Monitoring
    - H/W monitoring unit – *the event monitor*
- Benchmarks
    - iteration { parallel region { do jobs } }

Runtime Measurement

- **Core metric**: Efficiency $E(p)$ and Speedup $S(p)$

$$E(p) = 1 - \underbrace{\frac{WT(p) - UT(p)}{WT(p)}}_{\text{System overhead}} - \underbrace{\frac{IT(P)}{WT(p)}}_{\text{Idleness}} - \underbrace{\frac{PST(p)}{WT(p)}}_{\substack{\text{Communication} \\ \text{(= Processor stall)}}}$$

$$S(p) = p \times E(p)$$

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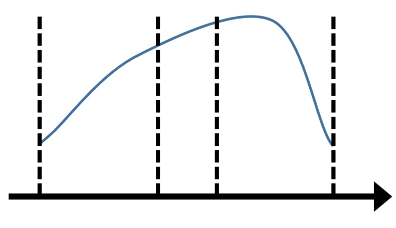
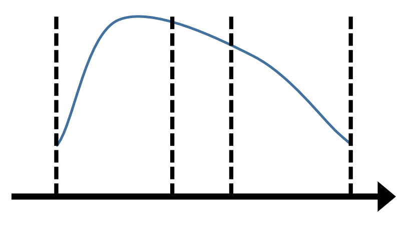
Self-Tuning Algorithm

- A basic self-tuning algorithm using **MGS**

- (Target) $S(p) : [1, P] \to R$
  - First, narrow the range as below
  - $[1, P]$
  - $[S(P), P]$ practically, $(1 < S(P) < P)$
  - Then apply **MGS** manner optimization to the interval



(case 1)



(case 2)

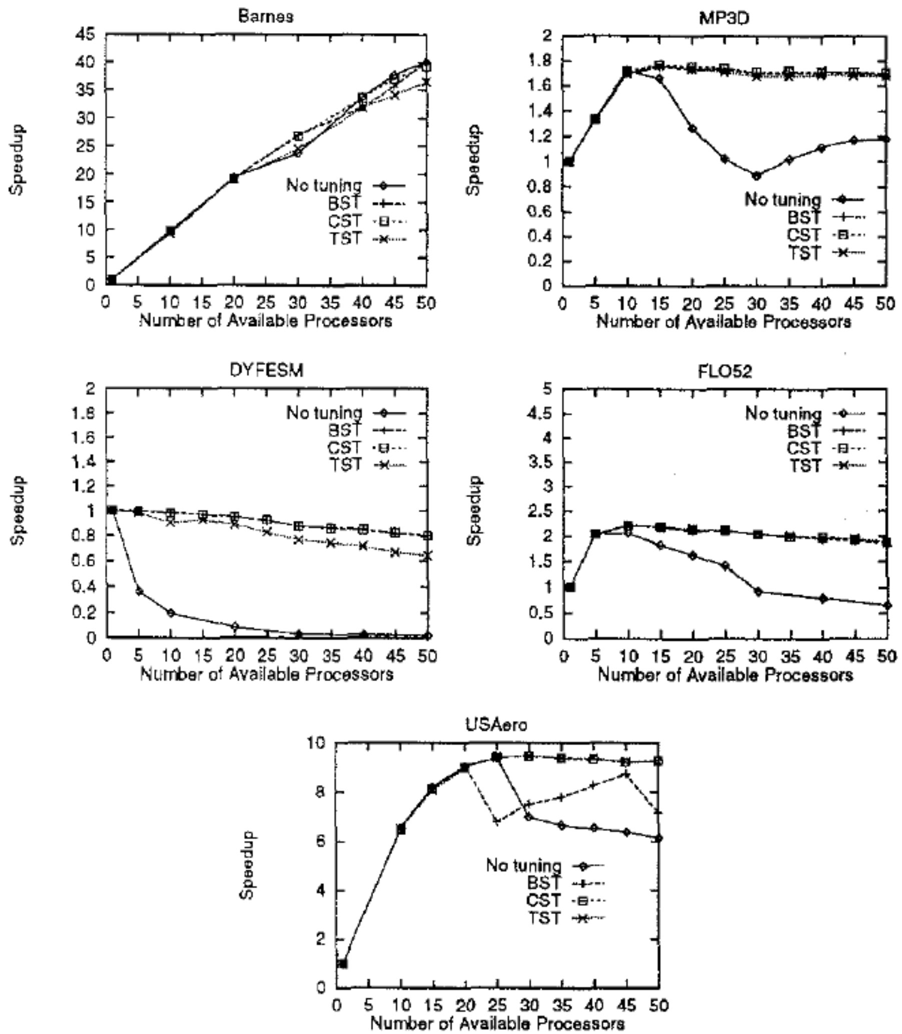
Self-Tuning Algorithm

- But, speedup is also a function of time!

- A change-driven self-tuning algorithm
  - it reinitiate speedup when **significant change** in efficiency occurred

- A time-driven self-tuning algorithm
  - it reinitiate speedup **periodically** and when significant change occurred

Self-Tuning – Performance



No tuning
Basic self-tuning
Change-driven self-tuning
Time-driven self-tuning

Contents

Multi-Phase Self-Tuning Algorithm

```
loop {
        parallel { // phase 1
                do job 1
        }
        parallel { // phase 2
                do job 2
        }
}
```

Multi-Phase Self-Tuning Algorithm

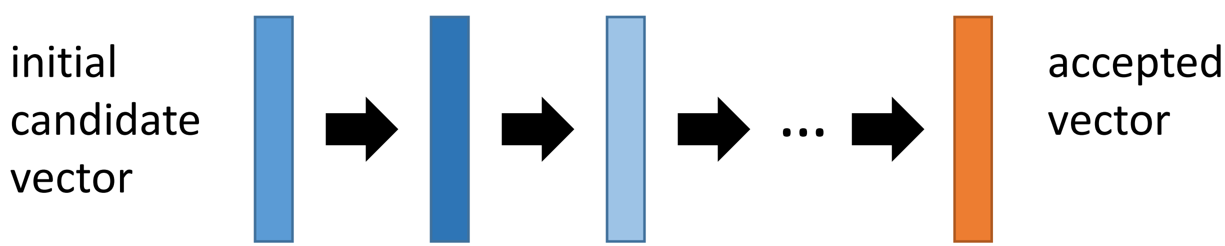
- Speedup $S(p)$ of each phase may be maximized in different processor number p

- Extension of the optimization problem
  - For each iteration, there are N many phases
  - Find a processor allocation vector $(p_1, p_2, \dots, p_N)$ which maximizes total speedup $S = \sum S_{phase}(p_{phase})$

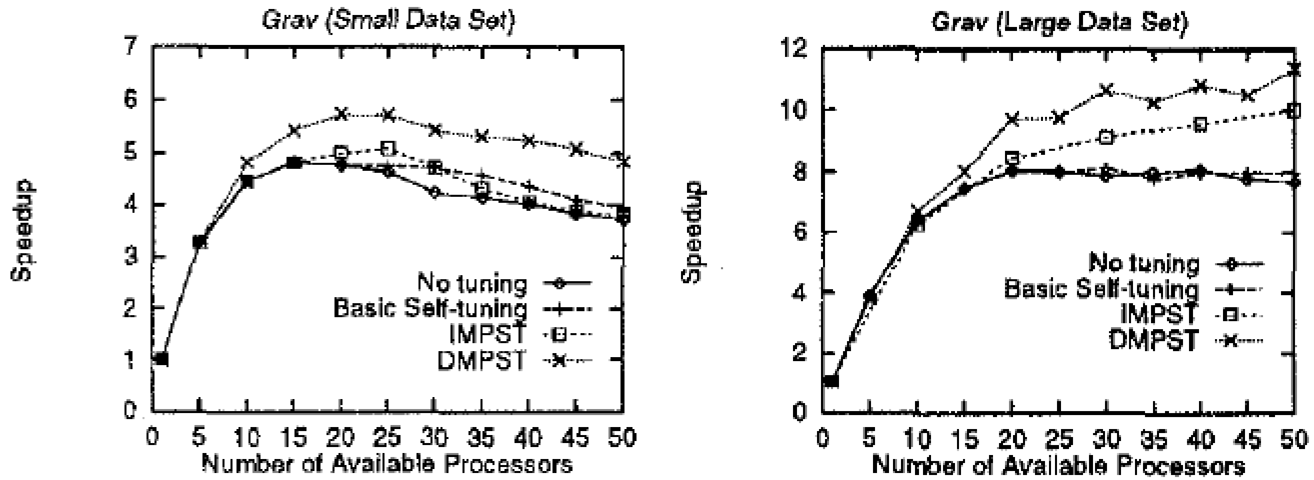
Multi-Phase Self-Tuning Algorithm

- Independent multi-phase self-tuning algorithm
  - apply the basic self-tuning alg. to each phase independently
  - but, phases are dependent each other

- Inter-dependent multi-phase self-tuning algorithm
  - randomized approach



Multi-Phase Self-Tuning – Performance



No tuning
Basic self-tuning
Independent multi-phase self-tuning
Inter-dependent multi-phase self-tuning

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Conclusion

- “proposed a technique to automatically regulate the number of processors used in the execution if a parallel program so as to maximize its speedup”

- “simple search procedures, guided by the runtime measurements, can automatically select appropriate numbers of processors”

- “self-tuning is especially promising for compiler-parallelized applications”