Dependency-Aware Parallel Tasks

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Programming Model

Motivation

- Fine-grained parallelism is required for performance
- Need simpler abstractions
- Abstractions must support expressiveness

Programming Model

- The program is divided up into tasks
- Tasks are annotated with which data they need
- Dependencies are deduced from these annotations

Tasks depend on data,
not on other tasks

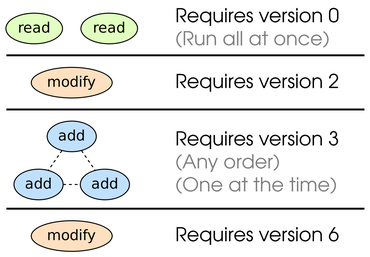
Data Versions

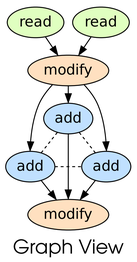
- Versions of task parameters specify dependencies
- More expressive than a DAG
- A task requires a certain version to run

Example

8 tasks accessing the same handle x:

read x, read x, modify x, add x, add x, add x, modify x





Graph View

Distributed Memory Implementation

- All shared data is distributed over the nodes
- Remote data is requested by *listeners*
- When the requested versions become ready, data is sent to all requesting nodes
- Communication is non-blocking
- Viewed as state machine to handle async events

Experiment: Dependencies

Experiment: Cholesky factorization, as an example of non-trivial dependencies.

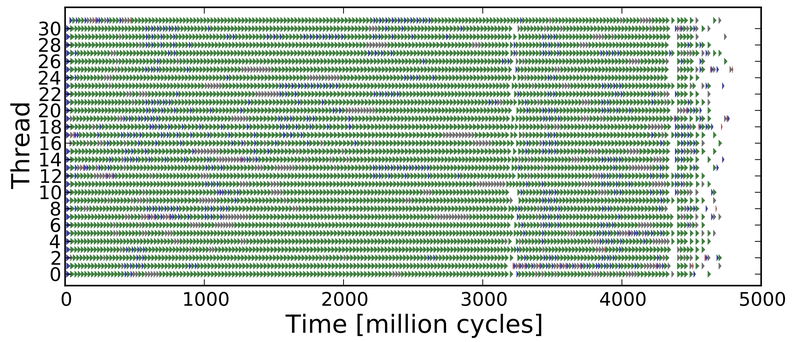


Figure 1: Execution trace of a Cholesky factorization of 32×32 blocks, executed on 32 cores. Each triangle represents a task working on blocks of 256×256 elements. Each task is a call to Intel's Math Kernel Library (MKL).

Speedup: 28.2x on 32 cores, compared to a single MKL call. MKL also has parallel Cholesky, but only achieved 21.1x. MKL might not be optimized for the AMD Bulldozer system this experiment was run on.

Experiment: Scalability

Experiment: Find what task granularity is required for scaling. We avoid effects from shared resources by executing tasks that only delay for a specific time.

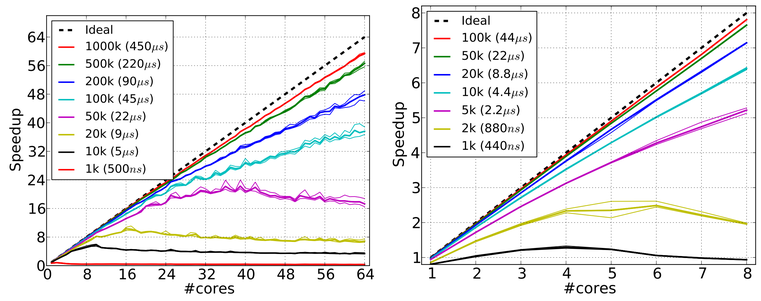


Figure 2: Scaling for different task granularities on (Left) 4 × 16 core AMD and (Right) 2 × 4 core Intel.

On 64 cores; tasks need to take ~500,000 cycles.
On 8 cores; tasks need to take ~20,000 cycles.

Experiment: Distributed Memory

Experiment: Assembly of a matrix, to be used in a partial differential equations solver.

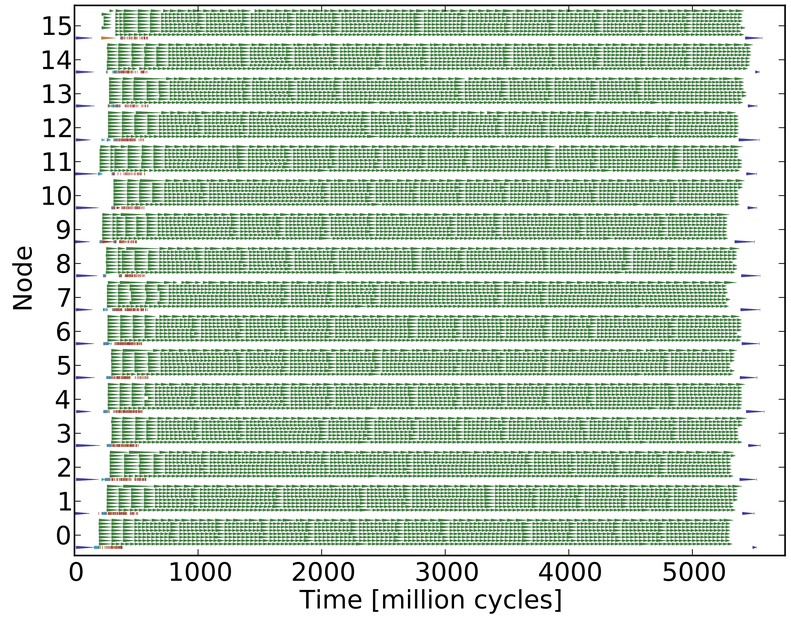


Figure 3: Execution trace from running on 16 nodes with 8 cores each. The matrix is divided into 16,384 blocks of 512×512 elements. Each task writes one block.

Task color meaning			
Green:	Calculation	Blue:	MPI barrier
Cyan:	Create tasks	Red:	MPI receive
Grey:	Other	Orange:	MPI initiate start

Speedup: 97.7x on 128 cores (over best serial speed)

Conclusions

Tasks give easy access to performance

Acknowledgements

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