IV Grid Plugtests: composing dedicated tools to run an application efficiently on Grid'5000

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Outline

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Grid challenges

Difficulties for exploiting grids

- Small groups of homogeneous resources (same cluster)
- Some network and CPU disparity among distinct clusters
- Possible traffic isolation in clusters (front node access)
- Resources can fail
- Security of the data
- Certification of the results

Main objective: maintain high performance computation

- Adapt work to processors heterogeneity
- Make use of interconnects hierarchy when possible
- Handle nicely nodes failures

Outline

1. Grid challenges
2. TakTuk, large scale remote executions deployment
   - Scalability
   - Adaptivity
3. Kaapi, large scale adaptive HPC engine
   - Static scheduling
   - Work-stealing scheduling
   - Fault tolerance
4. Conclusions

TakTuk, large scale remote executions deployment

Performs large scale remote executions deployment

- Handle platform topology constraints
- Platform independent
- Insensitive to failing resources

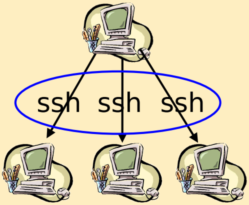
Provides support to applications

- Logical numbering and communication layer
- I/O redirection
- Files transfer
- Can execute distinct commands on distinct nodes

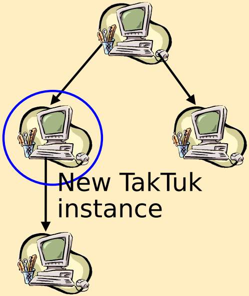
TakTuk scalability

Connects to individual nodes using some standard remote shell command (ssh, rsh, . . .)

Initiates connections in parallel



Propagates TakTuk itself to distribute work

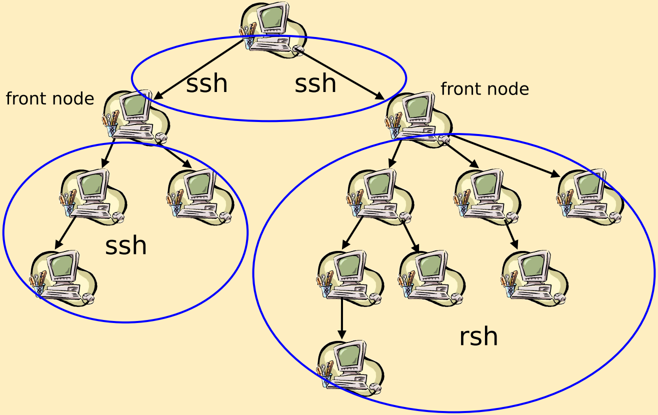


No installation required on remote nodes

TakTuk & topology

Deployment tree can be tailored to Grid topology

- Constrain first connections to front nodes



- Let the engine freely adapt within clusters

TakTuk adaptivity

Local parallelization

- Uses a sliding window of connection initiation processes
- Adapts the window size to local load (work in progress)

Work distribution

- Uses work-stealing to distribute connection tasks
- Sends more work to reactive nodes

Insensitivity to failing nodes

- Ignores unresponding nodes (customizable timeout)
- Removes lost connections from the tree

Outline

Kaapi: Athapascan API

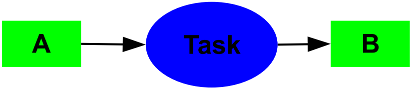
Data-flow graph

- Global address space
- Application is described as a dynamic data-flow graph
- Independent of the number of processors

Two C++ keywords

- `Shared<...>`: declares an object in the global memory
- `Fork<...>`: creates a new task that may be executed in concurrence with other tasks
- Access mode is given by the task: Read, Write, Exclusive, Concurrent write

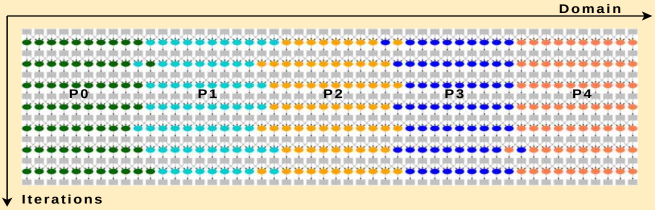
```
Shared<Matrix> A;
Shared<double> B;
Fork<Task>() (A,B);
```



Kaapi: Static scheduling (still experimental)

Well-fitted for iterative applications

- Partition the one-iteration graph (SCOTCH, METIS, DSC, ETF, . . .)
- Distribute each sub-graph on all the processes
- Repeat the sub-graphs to iterate

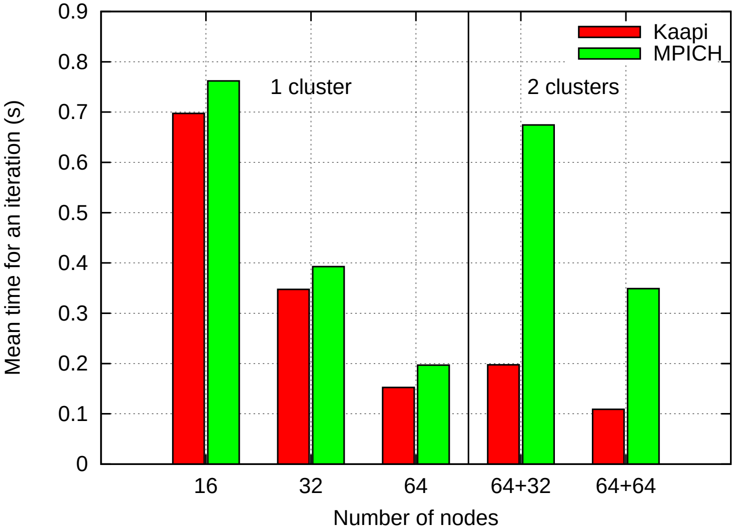


Applications

- ANR DISCO [S. Lanteri] Numerical application kernel
- Parallelization of Sofa (simulation of the dynamics of interacting objects)

Static scheduling: 3D-domain decomposition

Preliminary results, Kaapi vs MPICH:



Kaapi: Work-stealing scheduling

Well-fitted for series-parallel graphs (recursive applications)

An idle processor steals work to other processors

- Linear speedup if enough parallelism is available:
  $T_p = \frac{T_1}{p} + O(T_\infty)$
- Few steals: $O(p \times T_\infty)$
- Provable asymptotic optimality for some algorithms
- Works well with heterogeneous processors

Applications

- ANR CHOC [B. Lecun]: Combinatorial Problem
- ANR SAFESCALE [C. Cerin]: Certification of results
- Grid Plugtest: Solve N-Queens problem

2007 N-Queens Contest

During the GRID@WORK Event, Beijing, China

- Compute the maximal number of solutions to N-Queens
- 6 international teams from China, Poland, France
- Whole Grid'5000 (more than 3800 cores) available for the run

Kaapi/TakTuk Team (6 persons)

- TakTuk integration into ProActive (contest requirement)
- 1 day for parallelizing the application
- 4 days to optimize the sequential parts

Composition of dedicated tools

- ProActive where used to reserve nodes and access clusters
- TakTuk deployed Kaapi processes on all the nodes
- Kaapi processes computed all the solution of the N-Queens problem on Grid'5000 using work-stealing scheduling

N-Queens Contests results

2006 results: «Prix special du Jury» (not using ProActive)

- N-Queens N=22 computed in 8min 22s on 1458 cores
- N-Queens N=23 computed in 1h 13min on 1422 cores

Closest competitor: Vrije University (using Satin)

- N-Queens N=22 computed in 27min

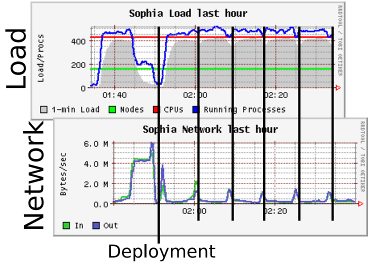
2007 results: First prize

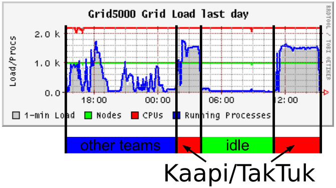
- single KAAPI/TakTuk application deployed on 3654 cores
- N-Queens N=22 computed in 3min 21s
- N-Queens N=23 computed in 35min 07s

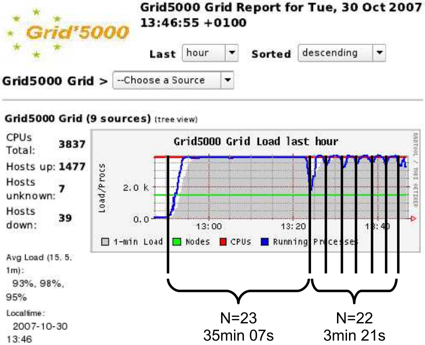
Closest competitors:

- ACT (China) deployed 3888 cores
- BUPT (China) computed N=22 in 24min 31s on 2925 cores
- Grid-TU (China) computed N=22 in 19min 36s on 1735 cores

Pictures of the runs







Fault tolerance

TIC: Theft-Induced Checkpointing

Specialized protocol for work-stealing

- Periodic checkpoints
- Forced checkpoints upon remote steal operation
- [Jafar & Krings & Gautier 2008]

CCK: Coordinated Checkpointing in Kaapi

Specialized protocol for static scheduling

- Coordinates processes to checkpoint
- Recomputes only the required subset of saved tasks to restart
- Provides adaptivity for static-scheduled application
- Implementation and evaluation in progress

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Scalability has been asserted

TakTuk:

- Fast and scalable application deployment
- Fault tolerant
- Provide a communication layer to contact all nodes

Kaapi:

- Use of TakTuk network to communicate with isolated nodes
- Scale up to thousands of heterogeneous cores
- Efficiency is preserved
- But fault tolerance is necessary due to a high failure rate

On-going works

- Static scheduling
- Two fault tolerance protocols : TIC and CCK
- Hierachical work stealing algorithm for hierarchical networks

Thanks for your attention ! Questions ?

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- Guillaume Huard (`guillaume.huard@imag.fr`)

- `http://kaapi.gforge.inria.fr`
- Thierry Gautier (`thierry.gautier@imag.fr`)
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