Grid Enabled JaSkel Skeletons with GMarte

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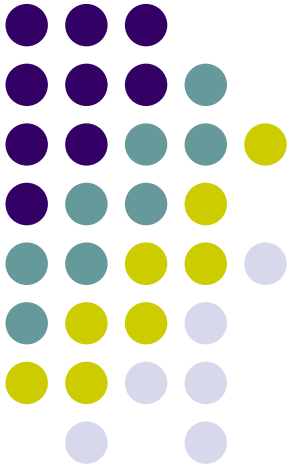

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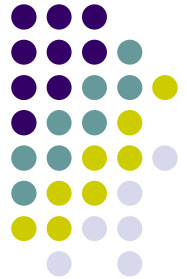


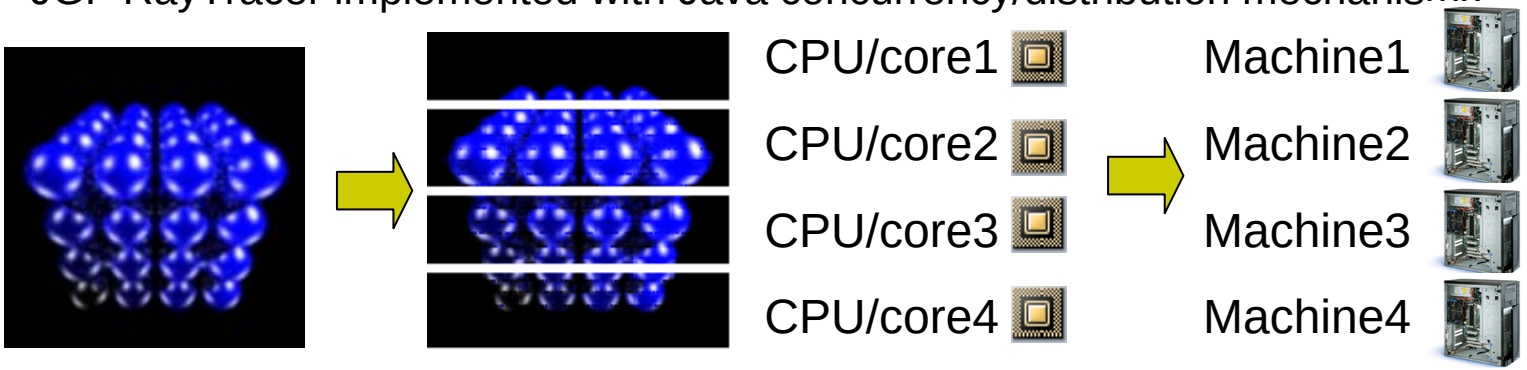
Presentation Outline

- Motivation for a Skeleton Framework
- JaSkel Overview
- GMarte Overview
- Performance Results
- Conclusions and Future work

Motivation for a Skeleton Framework

Traditional application development

- JGF RayTracer implemented with Java concurrency/distribution mechanisms



Sequential

```
RayTracer rt = new RayTracer();
Image result = rt.render(0,500);
```

Multicore/SMP

```
RayTracer rt[]=new RayTracer[4];

for(i=0; i<4; i++)
    rt[i] = new RayTracer();

for(int i=0; i<4; i++)
    new Thread()  {
        void run() {
            res[i] = rt[i].render(/*sub-interval*/);
        }
    }.start();

for(int i=0; i<4; i++)    result =  …
```

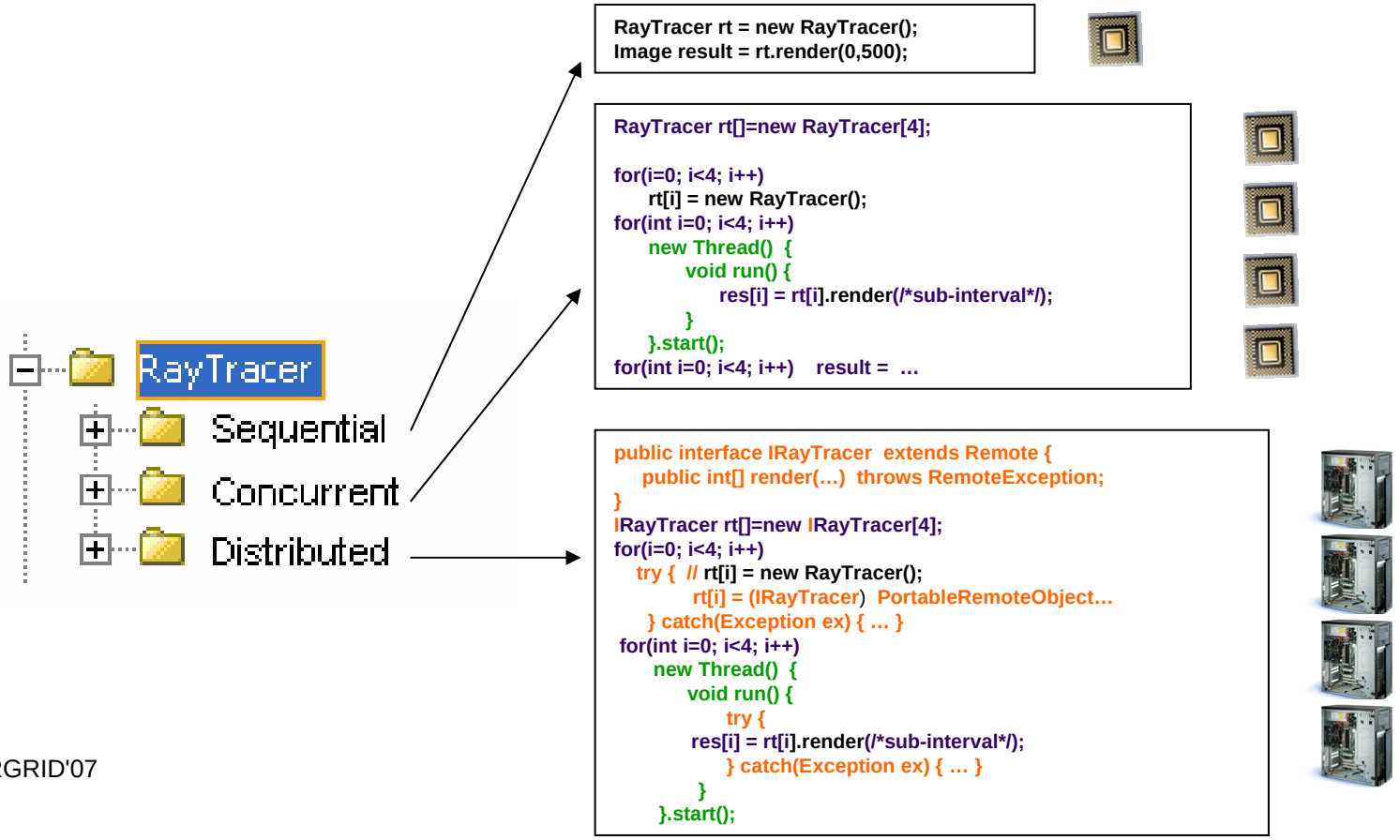
MPP/Cluster/Grid

```
public interface IRayTracer  extends Remote {
    public int[] render(…)  throws RemoteException;
}
IRayTracer rt[]=new IRayTracer[4];

for(i=0; i<4; i++)
   try {  // rt[i] = new RayTracer();
          rt[i] = (IRayTracer)  PortableRemoteObject…
    } catch(Exception ex) { … }

for(int i=0; i<4; i++)
     new Thread()  {
         void run() {
             try {
                 res[i] = rt[i].render(/*sub-interval*/);
             } catch(Exception ex) { … }
```

Motivation for a Skeleton Framework

Traditional application development

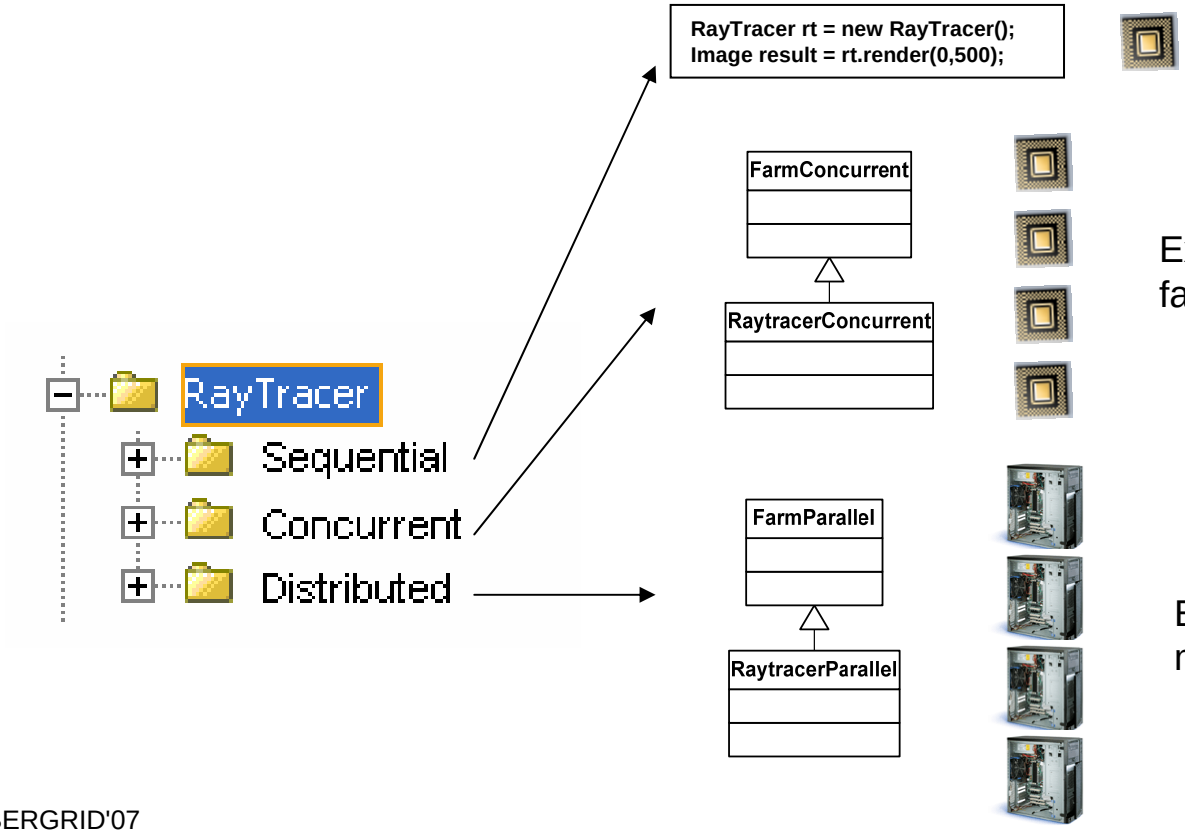
- (Non structured) support to application development



Motivation for a Skeleton Framework

Skeleton-based application development

- Modular (and structured) support to application development



Extend built-in shared-memory farm skeleton

Extend built-in distributed-memory farm skeleton

JaSkel Overview

Java-based skeleton framework

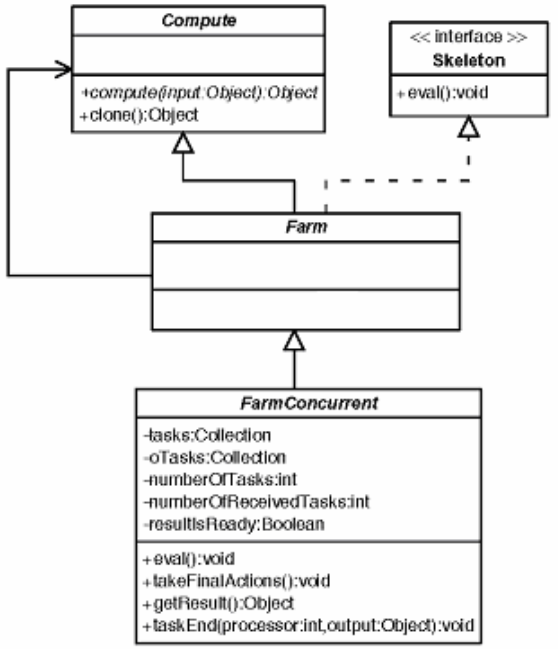
- Provides farm, pipeline and heart-beat skeletons
- Skeletons can be composed (e.g., farm+pipeline)
- Includes sequential skeletons for debugging purposes

Inheritance based framework

- Applications are developed by extending JaSkel skeletons
- Built-in skeletons can be refined by inheritance
- Built-in skeletons are organised into class hierarchies

Distributed execution is an orthogonal feature

- External tools adapt skeletons for distributed execution
- Improves control over skeleton distributed execution (useful for multi-level skeletons)
- Supports multiple distribution middleware

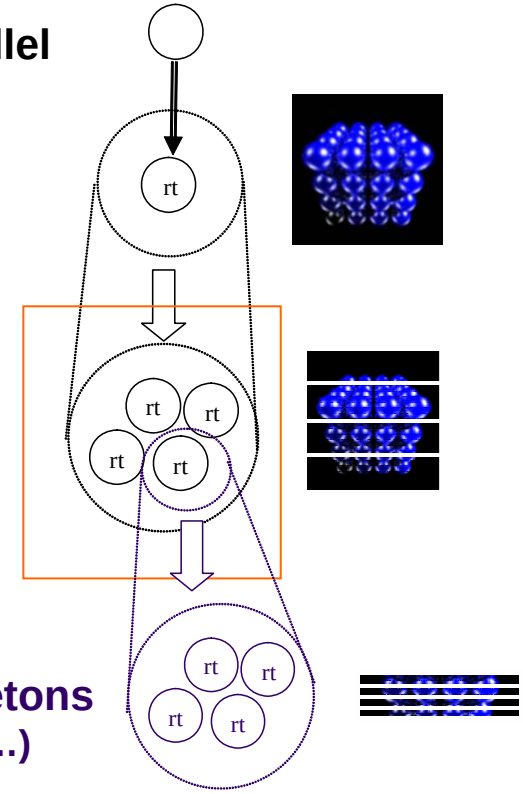


JaSkel Overview

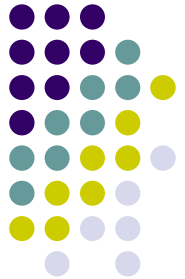
Structured approach to build complex parallel applications

Applying distribution to specific skeletons
(MPI, RMI, GMarte, …)

Composition of farm skeletons
(Farm+Farm, Pipeline+Farm, …)

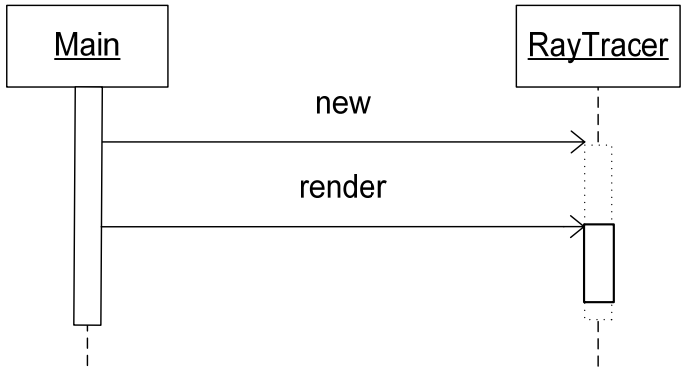


JaSkel Code Example



RayTracer: renders an image of 64 spheres

- Core Functionality

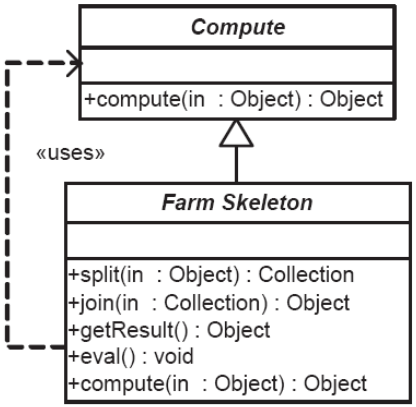



```
public class RayTracer {

    // renders an image
    public int[] render(Interval in) { … }
}


void public static void main(String[] arg) {

    RayTracer rt = new RayTracer();
    Interval in = new Interval(0,500);
    Image result = rt.render(in);
}
```

JaSkel Code Example (cont.)

Example: RayTracer – Farm Parallelisation

```
public class RayTracer extends Compute  {

    public int[] render(Interval in) { … }

    public Object compute(Object input) {
        return this.render((Interval) input);
    }
}

public class Farmer extends FarmConcurrent {
    public Farmer(Computer worker, Object inputTask) {
        super(worker, inputTask);
    }
    public Collection split(Object initialTask) {
        return(/* split interval */);
    }
    public Object join(Collection partialResults) {
        return(/* join partial results */);
    }
}
```

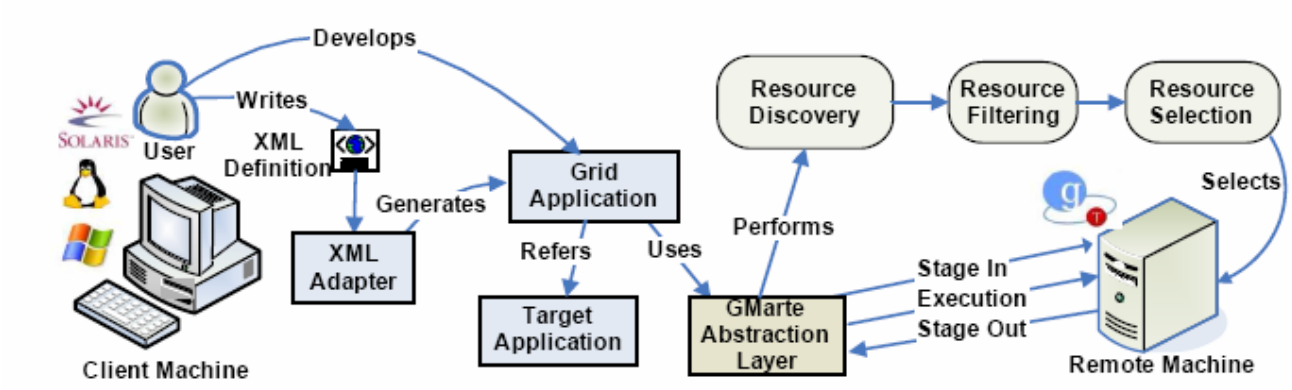



```
void public static void main(String[] arg) {

   RayTracer rt = new RayTracer();
   Interval in = new Interval(0,500);

   Farmer g = new Farmer(rt,in);              // farmer
   g.eval();                          // starts the farming process
   Image result = (Image) g.getResult();   // get results
}
```

GMarte Overview

Java library to interact with computational Grids

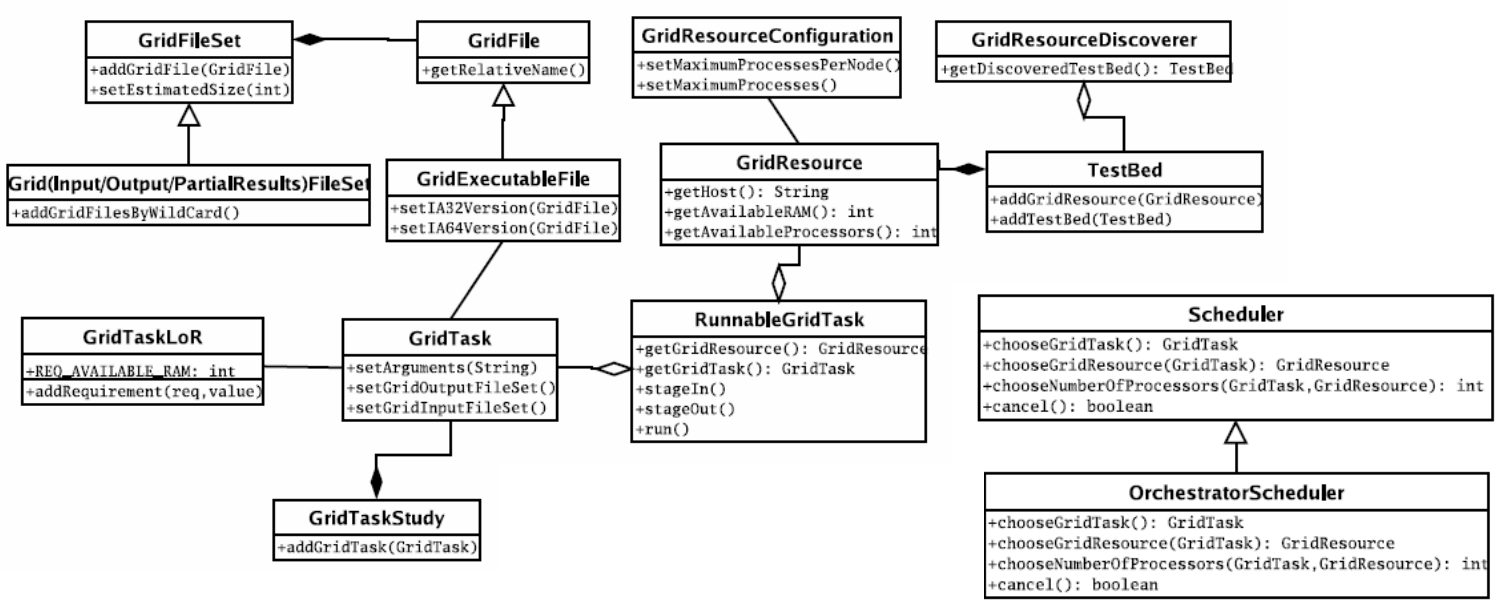
- Exposes an high level object-oriented API
- Simplifies the process of remote task execution by hiding grid-specific issues
  - **Resource discovery and selection**
  - **Grid meta-schedule**
  - **File stage-in and stage-out**



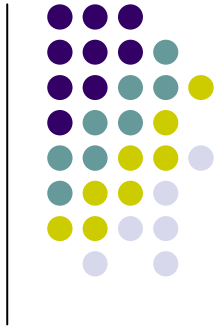
GMarte Overview

API overview

- GridTask, GridTaskStudy – tasks to execute on computational Grid
- GridResource, GridTestBed – Grid resources to use
- Scheduler – Meta-scheduler functionality



GMarte Code Example



1. **Specify task to execute**

```
GridTask gt = new GridTask("My Java Task");
gt.setGridExecutableFile(new JavaGridExecutableFile());
gt.setArguments("-jar myapp.jar schema.xsd");

GridInputFileSet gifs = new GridInputFileSet();
gifs.addGridFile("/home/user/schema.xsd");
gt.setGridInputFileSet(gifs);

GridOutputFileSet gofs = new GridOutputFileSet();
gofs.addWildCard("*.txt");
gt.setGridOutputFileSet(gofs);

GridTaskStudy gts = new GridTaskStudy();
gts.addGridTask(gt);
```

2. **Specify resource to use (optional)**

```
GridResource gr = new GridResource("amachine.lab.com");
TestBed tb = new TestBed();
tb.addGridResource(gr);
```

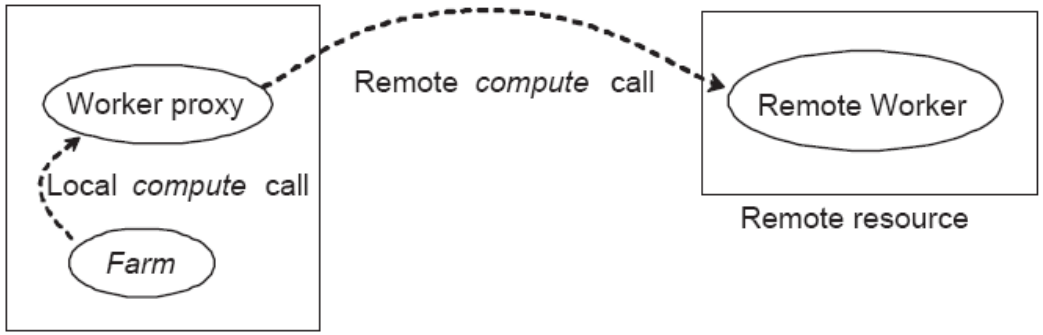
3. **Call GMarte scheduler**

```
Scheduler scheduler = new OrchestratorScheduler(tb, gts);
scheduler.start();
scheduler.waitUntilFinished();
```

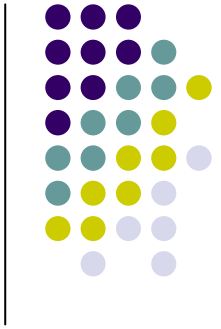
JaSkel-GMarte binding

Enables JaSkel applications to run on computational Grids

- Based on a code generator that rewrites skeleton implementations
  - **Client Skeleton (*Compute* instances) are replaced by proxies**
  - ***Compute* instances become stand-alone applications**
  - **Communication between client and server performed by files**



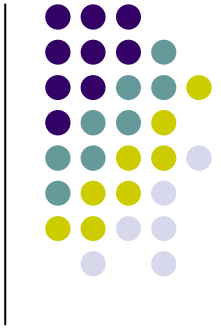
JaSkel-GMarte binding



- Client side code (worker proxy)
  - **Replaces *compute* method implementation**
    1. Writes method arguments to a file
    2. Creates a new GMarte *GridTask*
    3. Calls GMarte *scheduler* to execute task on remote resource
    4. Reads results from staged-out file
  - **GMarte tasks**
    1. select a remote resource
    2. stage-in the input files
    3. request the remote execution of the skeleton code
    4. stage-out the results.

```
public class RayTracer extends Compute { // worker proxy
    public Object compute(Object obj) {
            ... // generate RPC request (plain text file)
          GridTask gt = new GridTask("JaSkel worker);
          GridInputFileSet gifs = new GridInputFileSet();
          gifs.addGridFile("jaskel.jar"); // remote skeleton jar file
          gifs.addGridFile(/* RPC request file name */);
          gt.setGridInputFileSet(gifs);
          GridOutputFileSet gofs = new GridOutputFileSet();
          gofs.addGridFile(/* result file name */);
          gt.setGridOutputFileSet(gofs);
          ... // request task execution to GMarte
          ... // wait & read result from staged-out file
       return(/*result*/);
    }
}
```

JaSkel-GMarte binding



- Server side code (remote worker)
  - **Generates a new *main***
    1. creates a *Compute* instance
    2. reads *compute* arguments to a file
    3. calls *compute* method
    4. Write results to a file

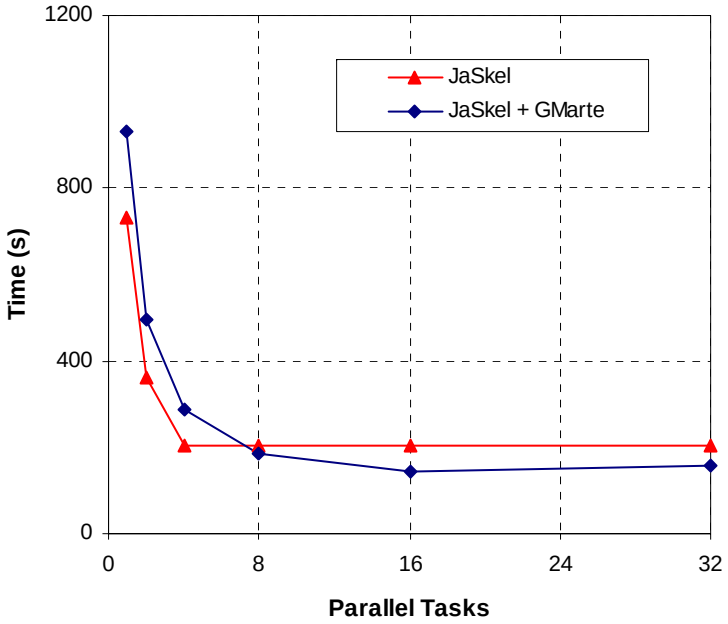
```
public static void main(String args[]) {
   RemoteRayTracer myWorker = new RemoteRayTracer();
   Object myData = ... // read data from file staged in by GMarte
   Object result = myWorker.render(myData);
   ... // save result into output file to be staged out by GMarte
}
```

  - **Generated code does not depend on GMarte**

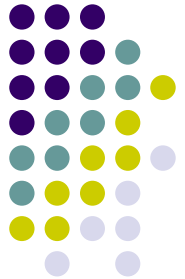
Performance Evaluation

JGF RayTracer (4000x4000 Image)

- 4-CPU Xeon 5130 vs computational Grid (two clusters)



Grid Enabled JaSkel Skeletons with GMarte



Conclusions

- Integrated framework address execution on multi-core, clusters and Grids
- Goals achieved:
  - **JaSkel framework supports a new distribution middleware (GMarte)**
  - **GMarte binding strongly reduces the amount of generated code and is loosely dependent of Grid related issues**

Future Work

- Tighter integration of JaSkel and GMarte meta-scheduling
  - **Support for multi-level skeletons**
- Evaluation on Grid environments with large scale applications