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The Ibis Project:

Simplifying Grid Programming & Deployment

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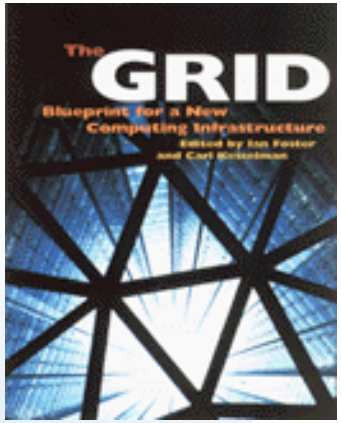

The 'Promise of the Grid'

Efficient and transparent (i.e. easy-to-use) wall-socket computing over a distributed set of resources [Sunderam ICCS'2004, based on Foster/Kesselman]

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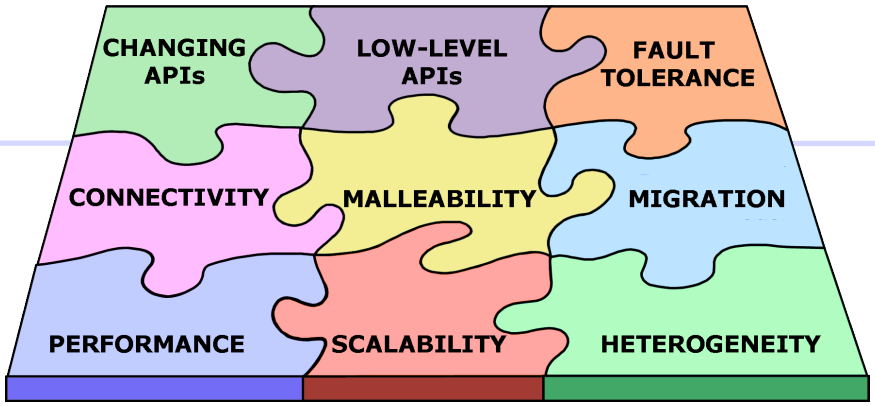
Reality: 'Problems of the Grid'

- Performance & scalability
- Heterogeneous
- Low-level & changing programming interfaces
- Connectivity issues
- Fault tolerance
- Malleability

User



Wide-Area Grid Systems

- writing & deploying grid applications is hard

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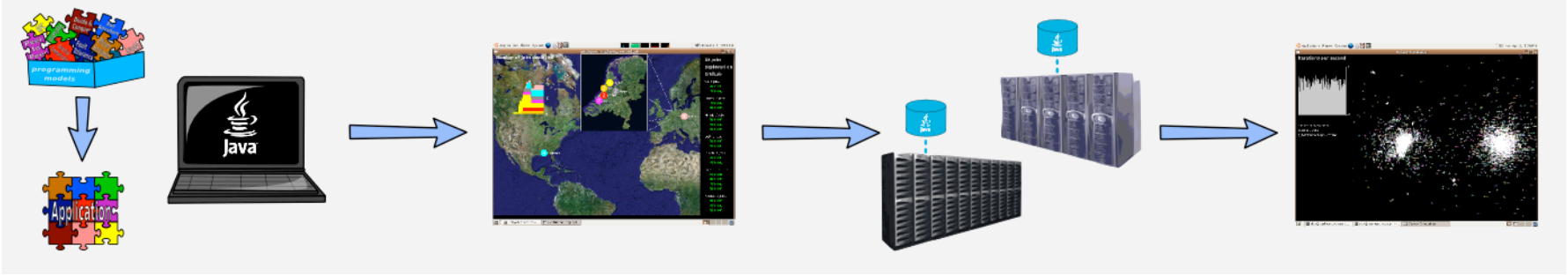
The Ibis Project

- Goal:
  - drastically simplify grid programming/ deployment
  - ``Grids as promised''



Approach

- Minimal assumptions about execution environment
  - Virtual Machines (Java) deal with heterogeneity
- Use middleware-independent APIs
- Different programming abstractions
- Designed for dynamic/unhelpful grid environments
- Modular and flexible: can replace Ibis components by different implementations

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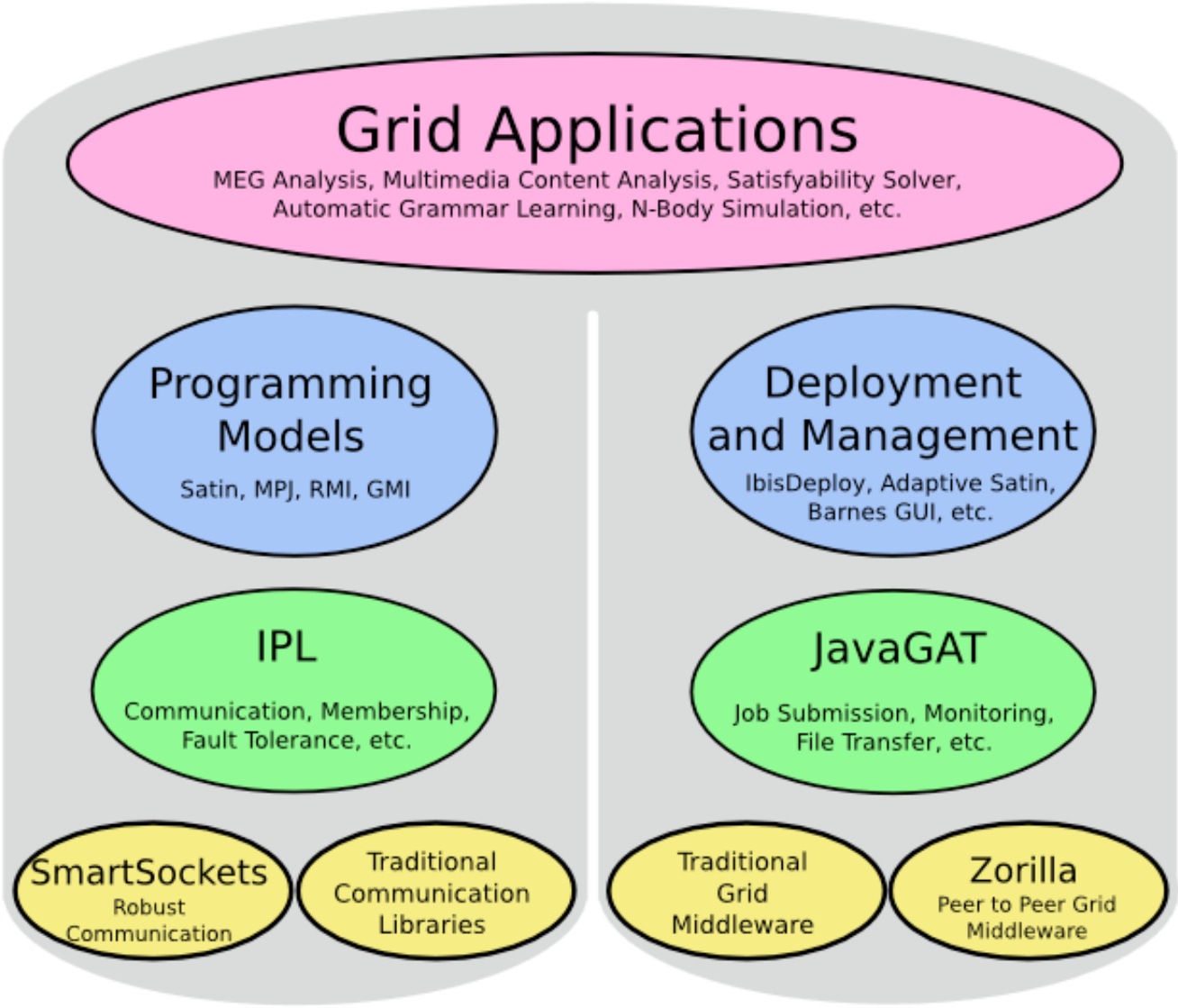
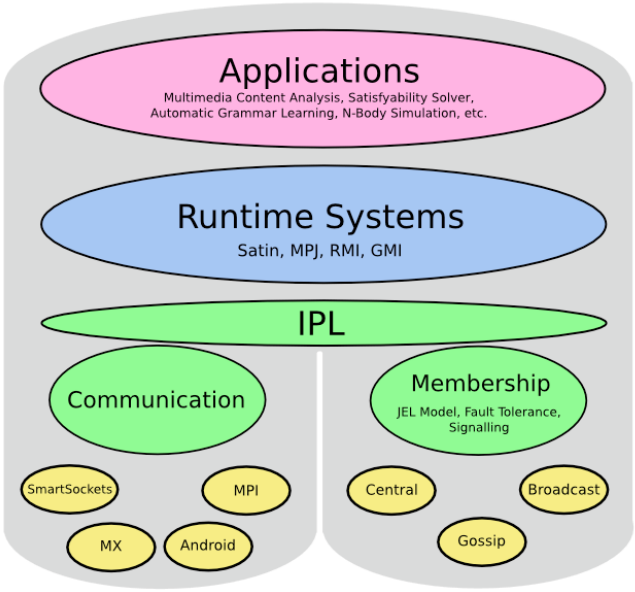
Global picture



Grid programming



- Programming models:
  - Message passing (RMI, MPJ)
  - Divide-and-conquer (Satin)
  - Stream processing (Maestro)
- IPL (Ibis Portability Layer)
  - Java-centric “run-anywhere” library
  - Can handle fault tolerance, malleability
- SmartSockets
  - Solve connectivity problems automatically (firewalls, NAT, addressing problems)

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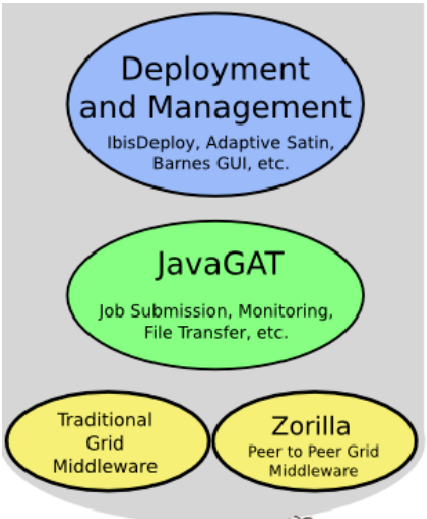
Grid deployment

- JavaGAT: Java Grid Application Toolkit
  - Make applications independent of underlying grid
  - Used for file copying, resource discovery, job submission & monitoring, user authentication
  - API is currently standardized (SAGA)
- Zorilla P2P system
  - Job management, gossiping, clustering, flood scheduling



Ibis applications

- e-Science (VL-e)
  - Brain MEG-imaging
  - Mass spectroscopy

- Multimedia content analysis
- Video processing
- Many HPC applications
  - SAT-solver, N-body, grammar learning, ….

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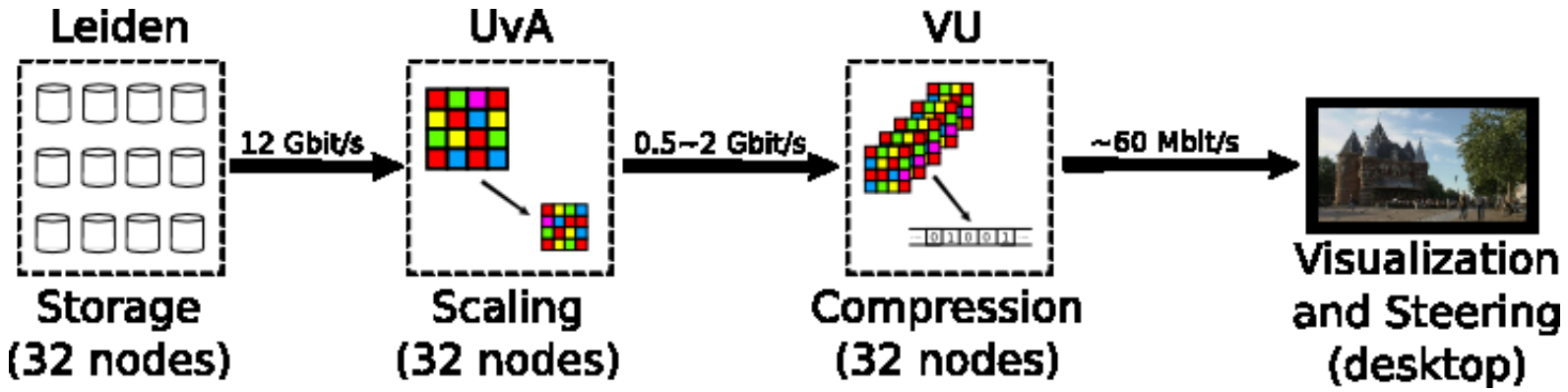
vl·e virtual laboratory for e·science

European users

- D-Grid: Workflow engine for astronomy
- U. Erlangen: grid file system
- INRIA: ProActive on Ibis RMI
- U. Patras: Jylab scientific computing
- UPC Barcelona: Grid Superscalar
- HITACHI: Peta-scale data management

High Resolution Video Processing

- Realtime processing of CineGrid movie data
  - 3840x2160 (4xHD) @ 30 fps = 1424 MB/sec
- Multi-cluster processing pipeline
  - Using DAS-3, StarPlane and Ibis



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Summary

- Goal: Simplify grid programming/deployment
- Key ideas in Ibis
  - Virtual machines (JVM) deal with heterogeneity
  - High-level programming abstractions (Satin)
  - Handle fault-tolerance, malleability, connectivity problems automatically (Satin, SmartSockets)
  - Middleware-independent APIs (JavaGAT)
  - Modular

Image processing

- Frank Seinstra's research
- Previous: Horus: parallel implementation of low-level image processing operations (UvA, Arnold Smeulder's group)
- New: Jorus: Horus in Java and on Ibis

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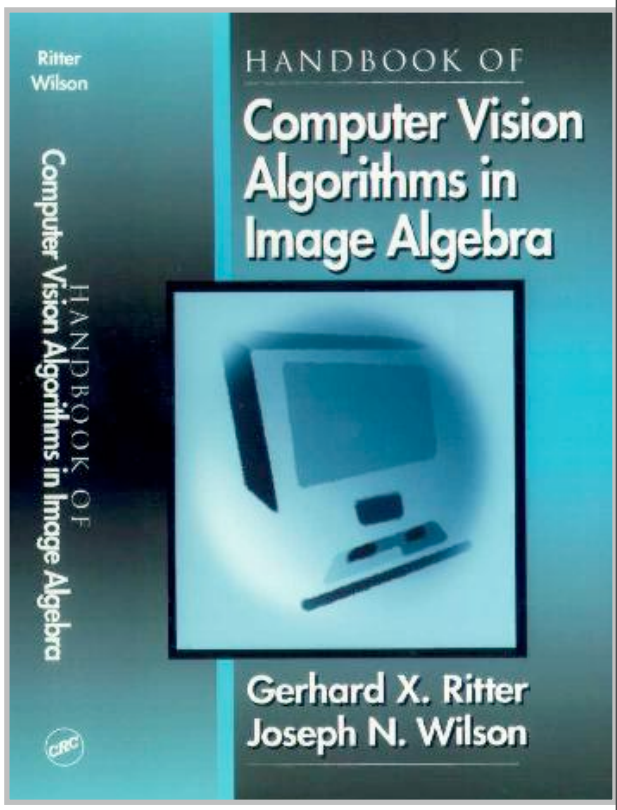
Low Level Image Processing `Patterns' (1)

- Unary pixel Operations
  - absolute value
- Binary pixel Operations
  - addition
- N-ary Pixel Operations:
  Template, Kernel, Filter,
  Neighborhood operations
  - Gauss filter



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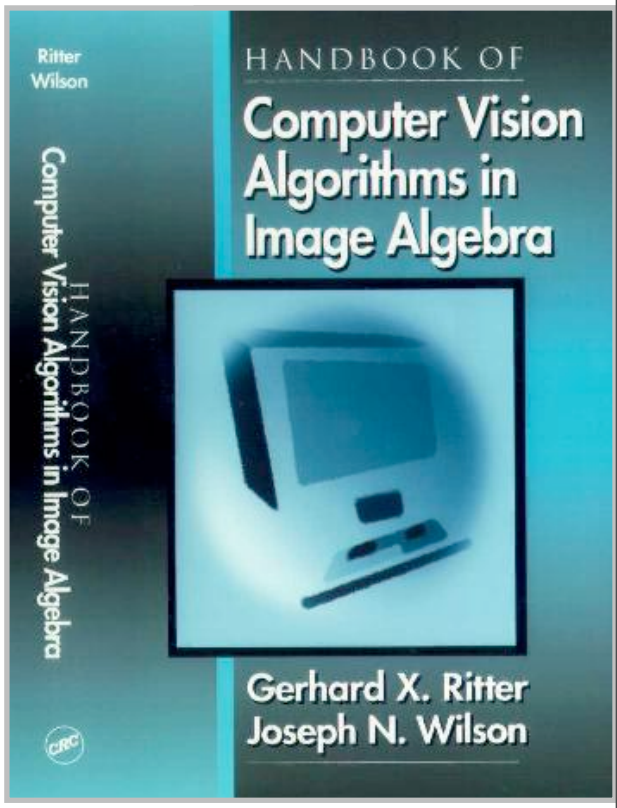
Low Level Image Processing `Patterns' (2)

- Reduction Operation
  - sum of pixel values
- N-Reduction Operation
  - histogram
- Geometric Transformation
  - rotation



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Example Application: Template Matching

```
for all images {
    inputIm = readFile ( … );
    unaryPixOpI ( sqrdInIm,  inputIm,  “set” );
    binaryPixOpI ( sqrdInIm,  inputIm,  “mul” );
    for all symbol images {
        symbol = readFile ( … );
        weight = readFile ( … );
        unaryPixOpI (filtIm1, sqrdInIm, “set”);
        unaryPixOpI (filtIm2, inputIm, “set”);
        genNeighborhoodOp (filtIm1, borderMirror, weight, “mul”, “sum”);
        binaryPixOpI (symbol,  weight,  “mul” );
        genNeighborhoodOp (filtIm2, borderMirror, symbol, ”mul”, “sum”);
        binaryPixOpI (filtIm1, filtIm2, “sub”);
        binaryPixOpI (maxIm, filtIm1, “max”);
    }
    writeFile ( …, maxIm, … );
}
```

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Implementation

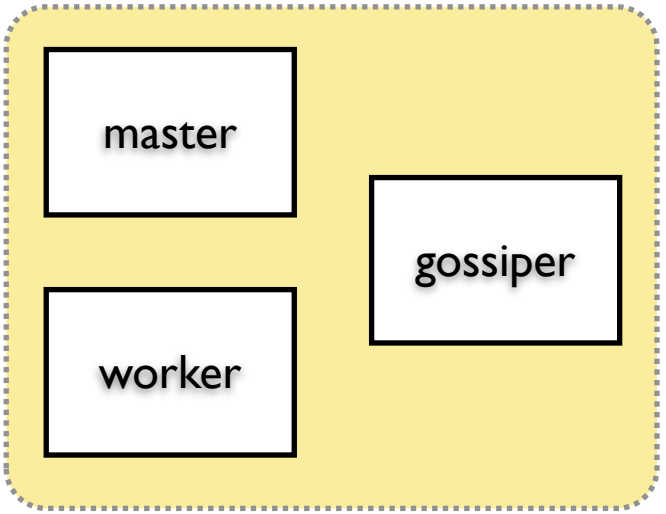
- Load distribution by Horus
- Optimizer to generate the best sequence of operations
- All parallelism is hidden from the user: still the same Horus code
- But different Horus code can have better or worse parallelism

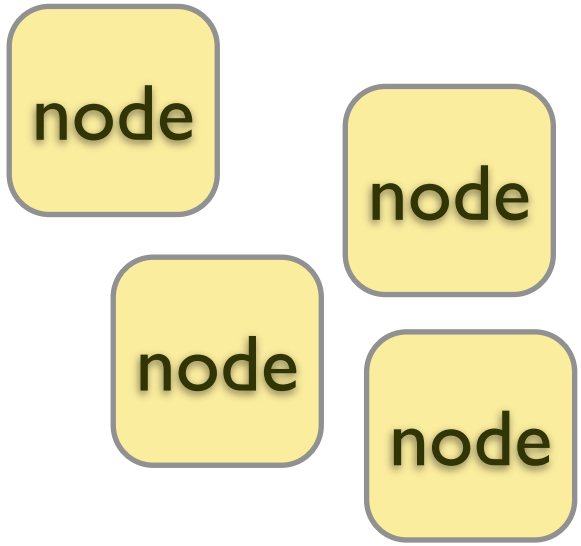
Maestro

- Programming model for stream processing
- Self-organizing: no central coordination
- Learning (but requires repeatable performance in the processing steps)
- Inherently very robust

Maestro nodes

- Master selects fastest worker for each task, based on past performance and total completion time for job type
- Worker reports back to master, and submits next job in the flow to local master
- Gossiper helps ensure recent performance info for all nodes





Example application

Convert video frames:

```
convertJob = jobs.createJob(
  "benchmark",
  new GenerateFrameTask(),
  new ScaleUpFrameTask( 2, slowScale, allowScale ),
  new SharpenFrameTask( slowSharpen, allowSharpen ),
  new CompressFrameTask(),
  new SaveFrameTask( dir )
);
```

Results

Run image processing on 40 nodes: 20000 frames

- All nodes the same (homogeneous)
- 20 nodes no sharpening, 20 no scaling
- 20 nodes 4 times slower sharpen, 20 slow scale

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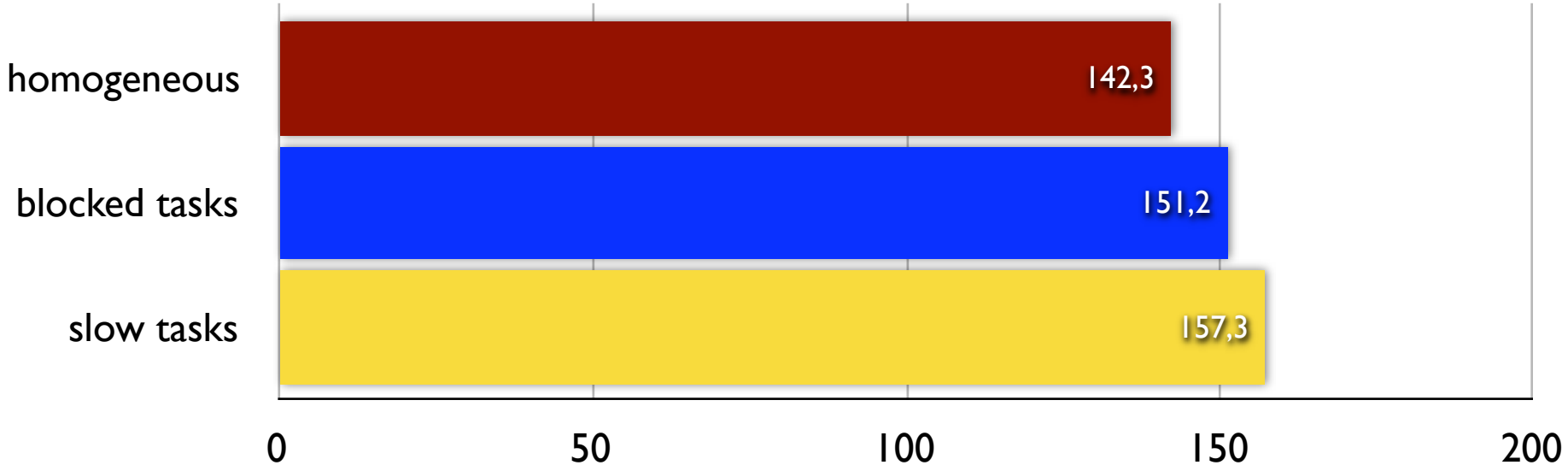

Summary

- Our group is very interested in astronomy applications
- We can offer:
  - Robust grid computing
  - Efficient parallel image processing
  - Stream computing
- Typical research question: can XXX be done on grid systems?