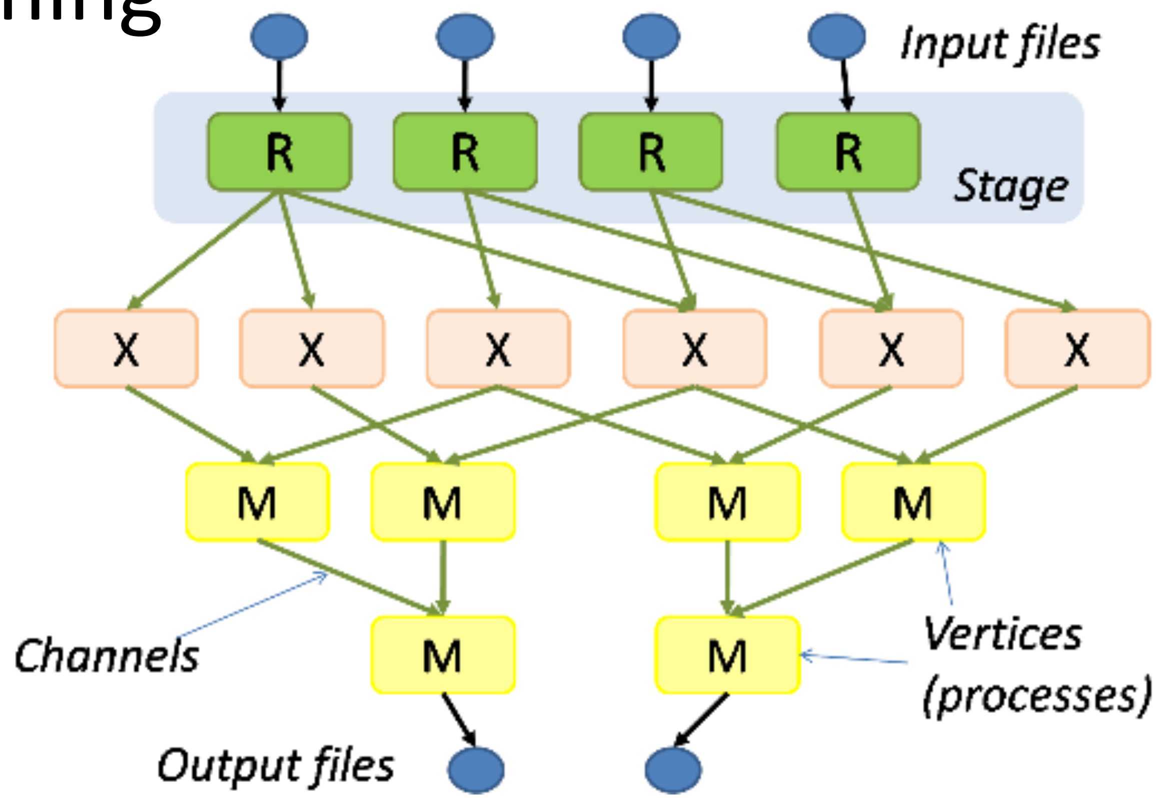
Banyan

A Framework for Distributing Tree-Structured Problems

Chris, David, Michelle

Context

- From class: MapReduce and Dryad
- Simple interfaces for distributed programming



But what about …

```
fun divide_conquer (problem) {
  subproblems = divide(problem)
  subanswers =
   map divide_conquer subproblems
  combine subanswers
}
```

- It’s recursive!

Our contribution: Banyan

- Framework for distributing **tree-structured** recursive programs
- Begins computation on one processor; ships subproblems as they arise
- Uses Fly tuplespace for memoization
- Theorem prover case study

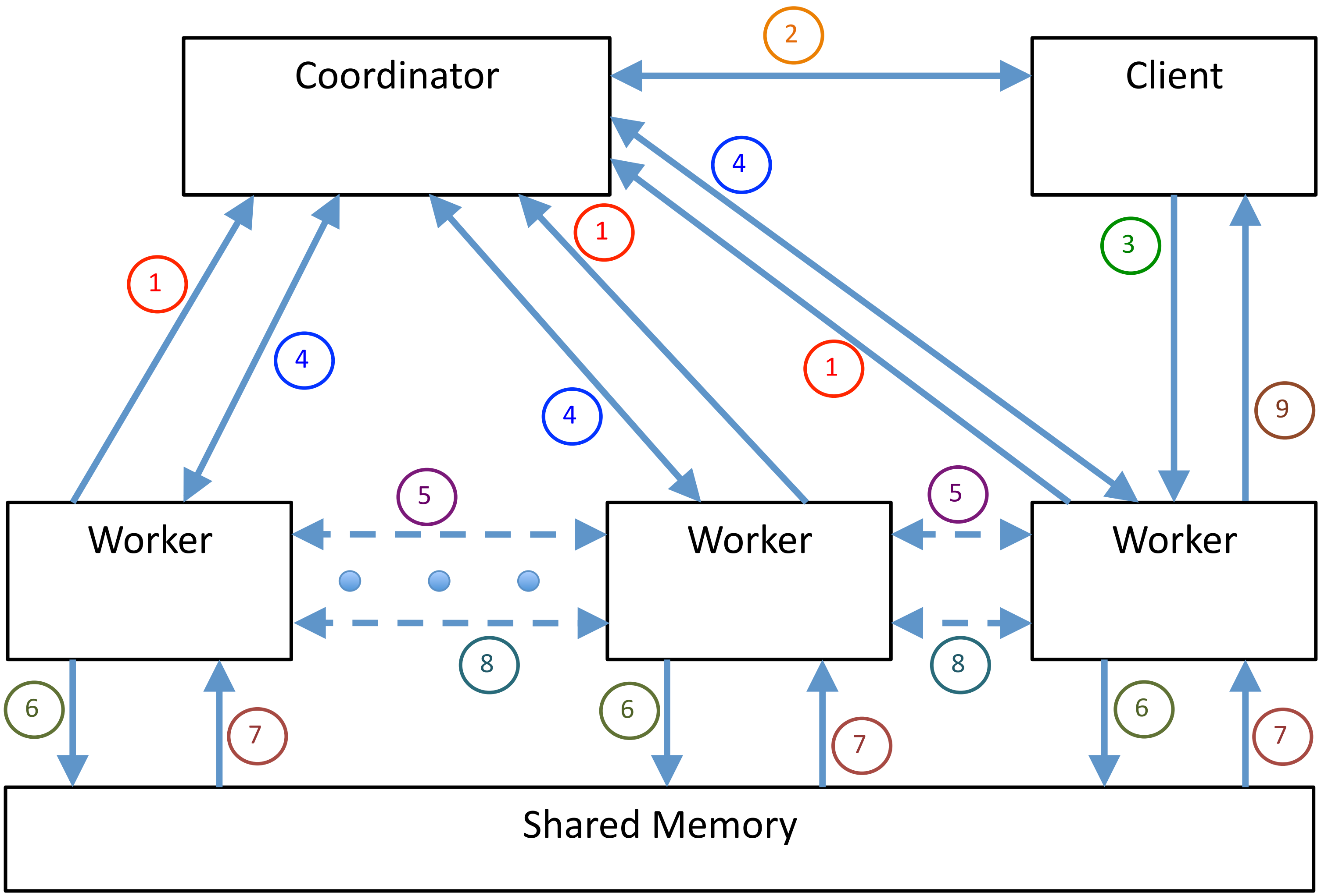
Outline

- Programmer interface
- Implementation
- Case study: theorem prover
- Results
- Future work and conclusion

Programmer interface

- Implement two primary functions:
  - **workHere**, to generate subproblems
  - **childReturned**, to combine answers
- Also
  - Generic message handler
  - Cooperative scheduling functions
  - Subproblem identifier for shared memory indexing

Architecture overview



Scheduling nodes

- Node priority expressed in **tickets**
- Job starts with fixed tickets; parents donate to children
- Active local nodes scheduled round-robin
- Subtrees shipped when local tickets exceed target
- Coordinator keeps workers balanced

Shared memory

- Fly tuple-space
  - Read, write, take
  - Read, take match on keyed **template**
- We use it to avoid duplicating work
  - Store node results
  - Check store on child create
  - Programmer supplies indexing scheme

Case study: Differential dynamic logic

- Interacting discrete and continuous components
- Hard parts:
  - Invariant generation
  - Quantifier elimination

DL as a Banyan Application

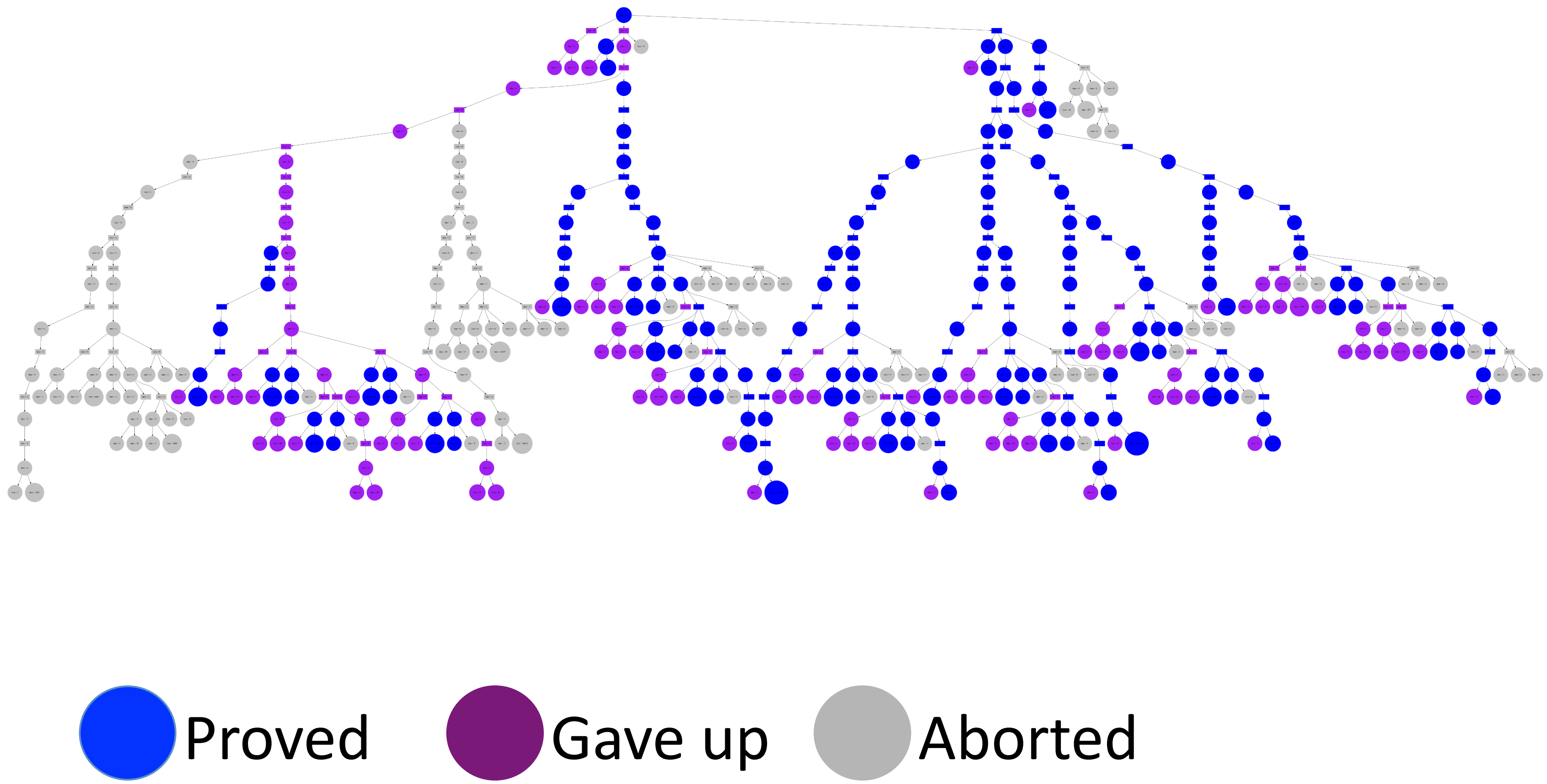
- Three concrete objects extending TreeNode
- Code snippet from AndNode:

```
def childReturned(child: Int, v: ReturnType): Unit =
 v match {
   case Proved(rl) =>
    numOpenChildren -= 1
    if(numOpenChildren <= 0) returnNode(Proved(rule))

   case GaveUp() =>
      returnNode(GaveUp())
 }
```

- It works!

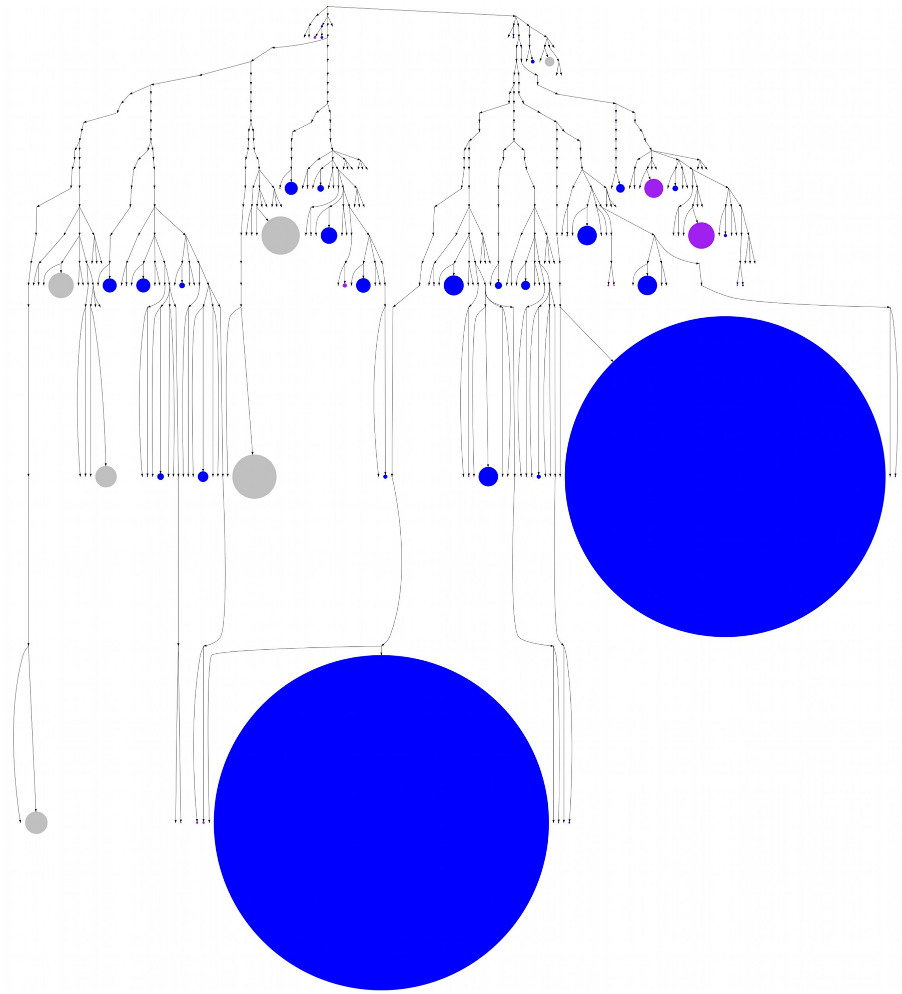
Water tank example



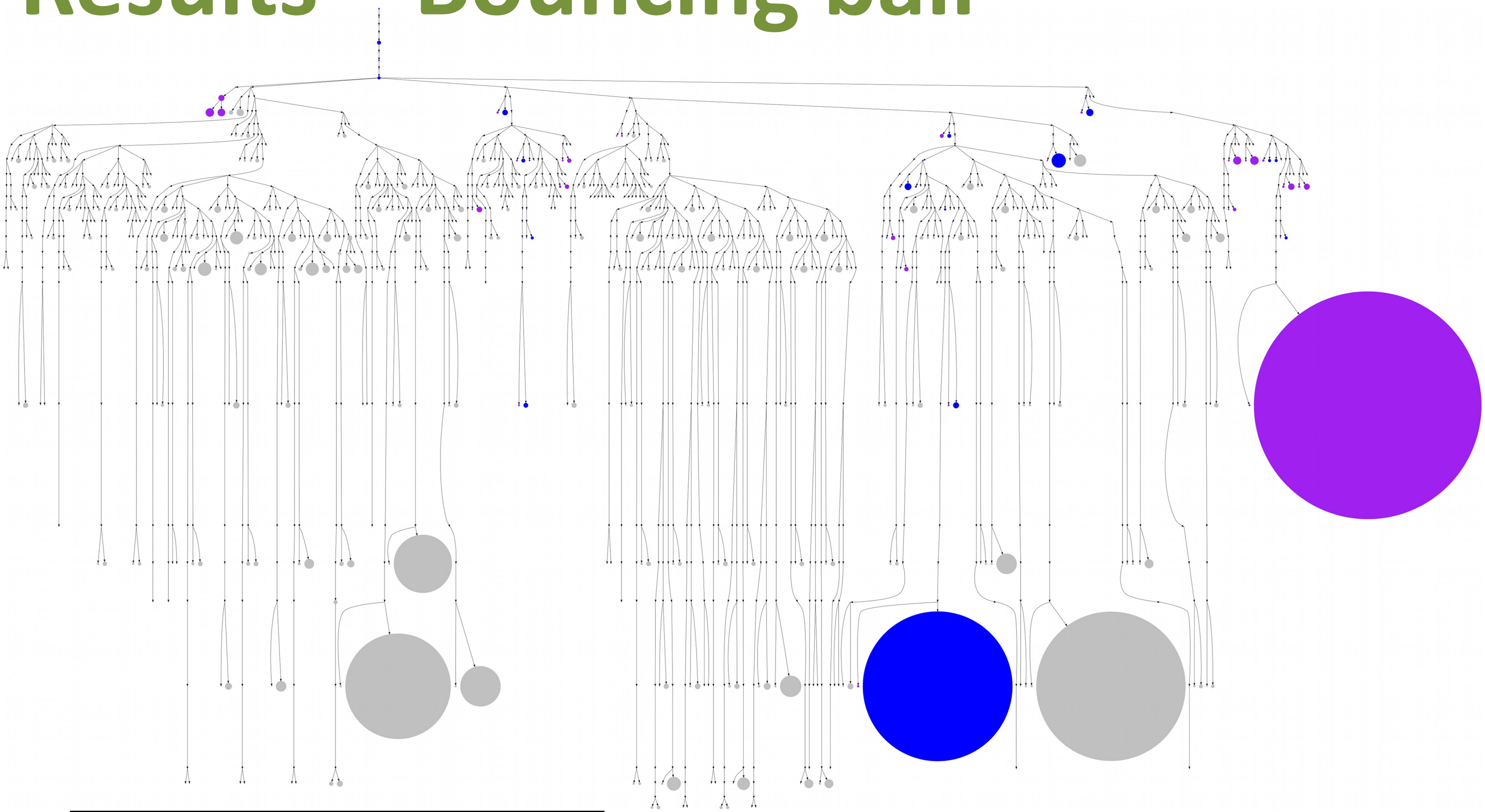
Results – Water tank

Workers	Time (s)
1	2978
4	1213

2.4x speedup



Results – Bouncing ball



Workers	T1 (s)	T2 (s)
1	209	147
4	50	62

3.2x speedup (avg)

Future work

- Optimize node distribution
- Pause/resume
- Dynamically add jobs, workers
- Fault tolerance
- Improve shared memory
  - Inexact matching
  - Multi-host flyspace
- Compare to simpler models

Conclusion

- We made a framework to facilitate distribution of tree-structured problems
- You can play with it:
  www.cs.cmu.edu/~renshaw/banyan