DryadLINQ

by Yuan Yu et al., OSDI'08

Ilias Giechaskiel

Cambridge University, R212
ig305@cam.ac.uk

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Conclusions

Takeaway Messages

- SQL cannot express iteration
  - Unsuitable for machine learning, graph processing, etc.
- MapReduce cannot express `Join`
  - Also, simplistic, so no automatic optimizations
- DryadLINQ fills the void:
  - Define declarative-imperative programming model using LINQ
  - Automatically and transparently optimize and distribute
  - Execute on top of Dryad infrastructure

Context: Language

LINQ [MBB06]

- Language-Integrated Query
- Design pattern of standard query operators
- SQL-like syntax + lambda expressions and anonymous types
- C#, F#, VB implementations
- Part of .NET development framework

Context: Platform

Dryad [IBY+07]

- "General-purpose distributed execution engine"
- Dataflow DAG graph (developer-provided)
  - Vertices: sequential programs
  - Edges: communication channels
  - Dynamic
- Dryad engine handles
  - Scheduling
  - Recovery
  - Data transfer

Dryad Graph

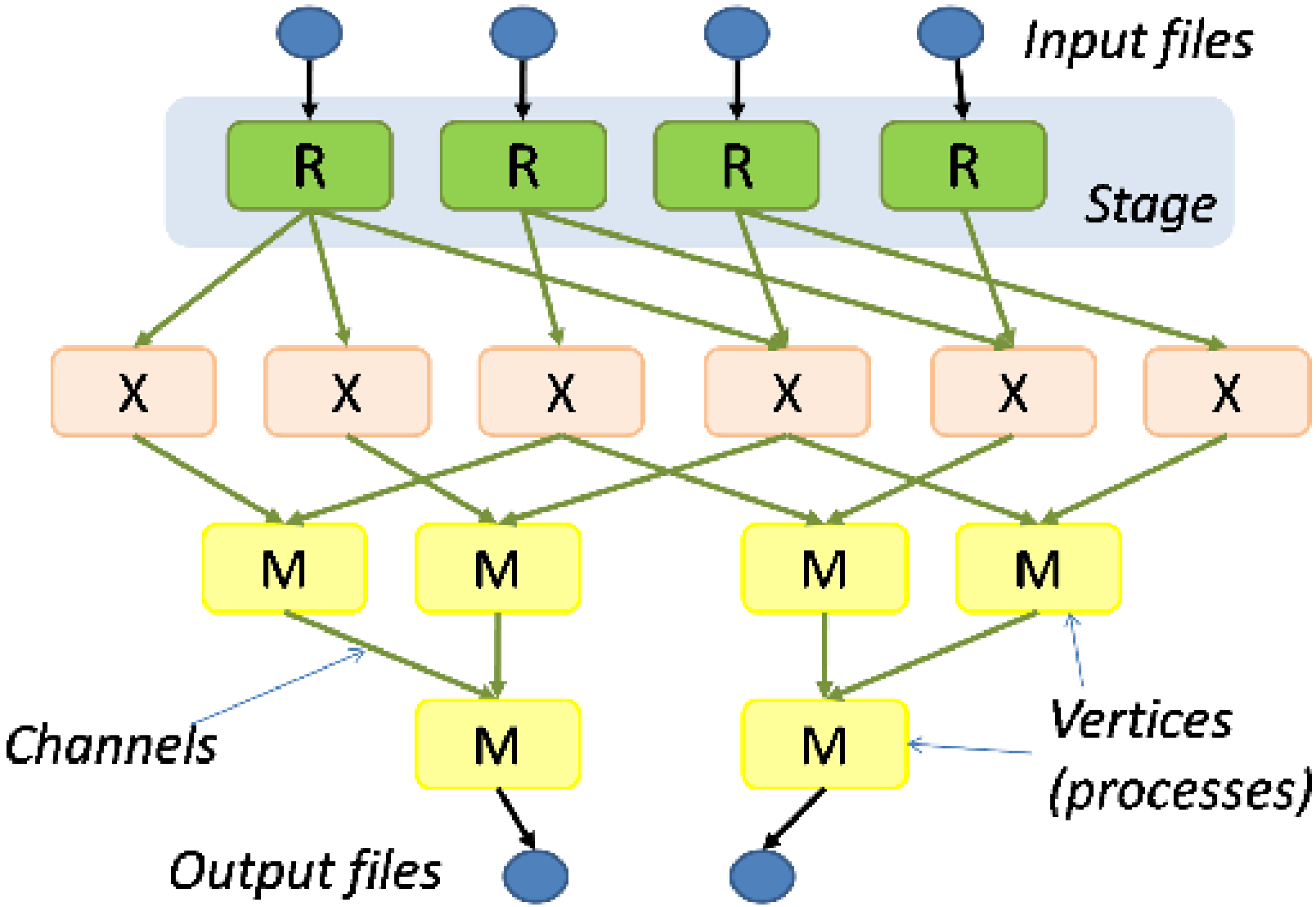


Figure: `https://research.microsoft.com/en-us/projects/dryad/`

Software Layers

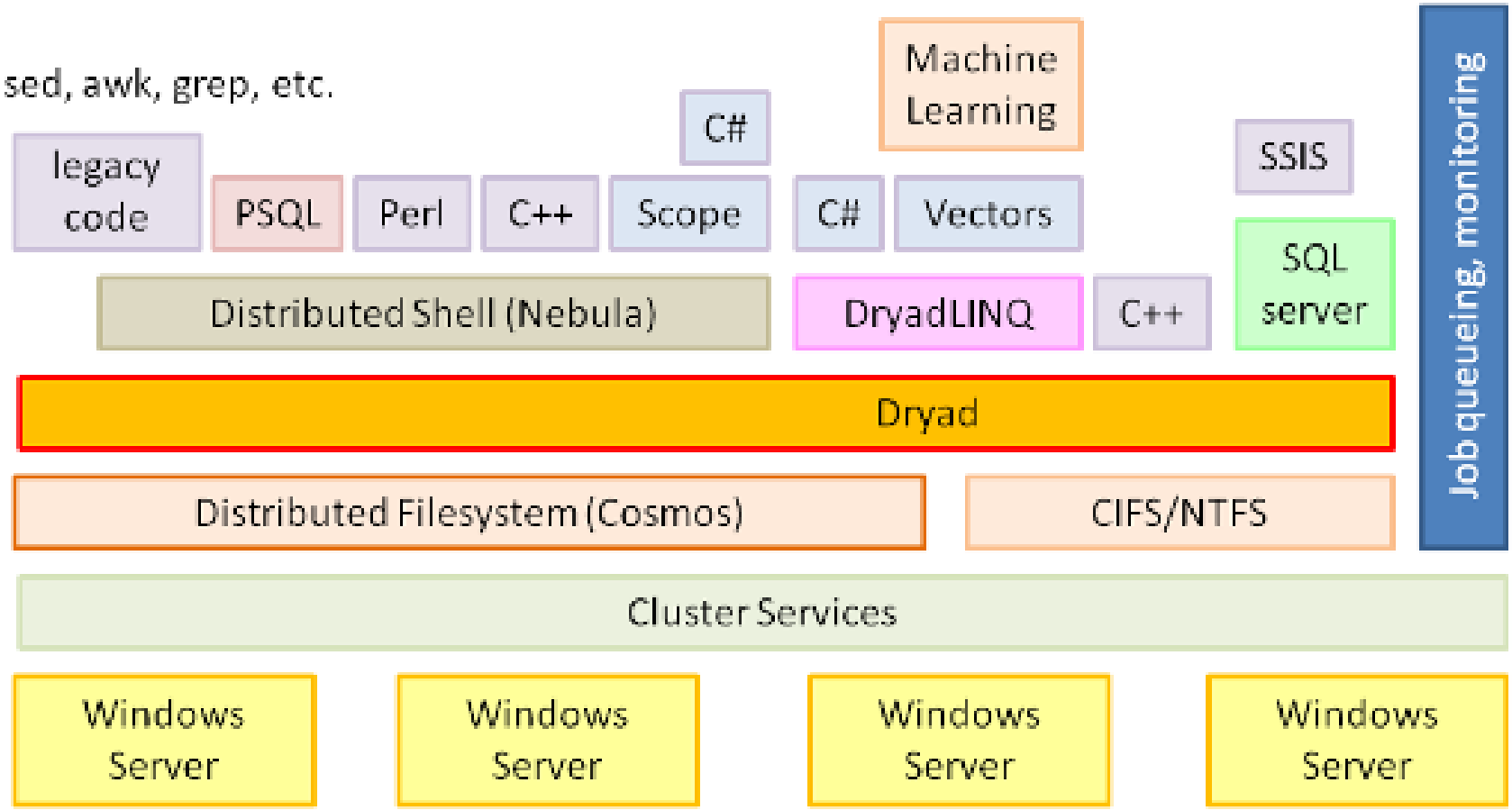


Figure: `https://research.microsoft.com/en-us/projects/dryad/`

DryadLINQ: Motivation

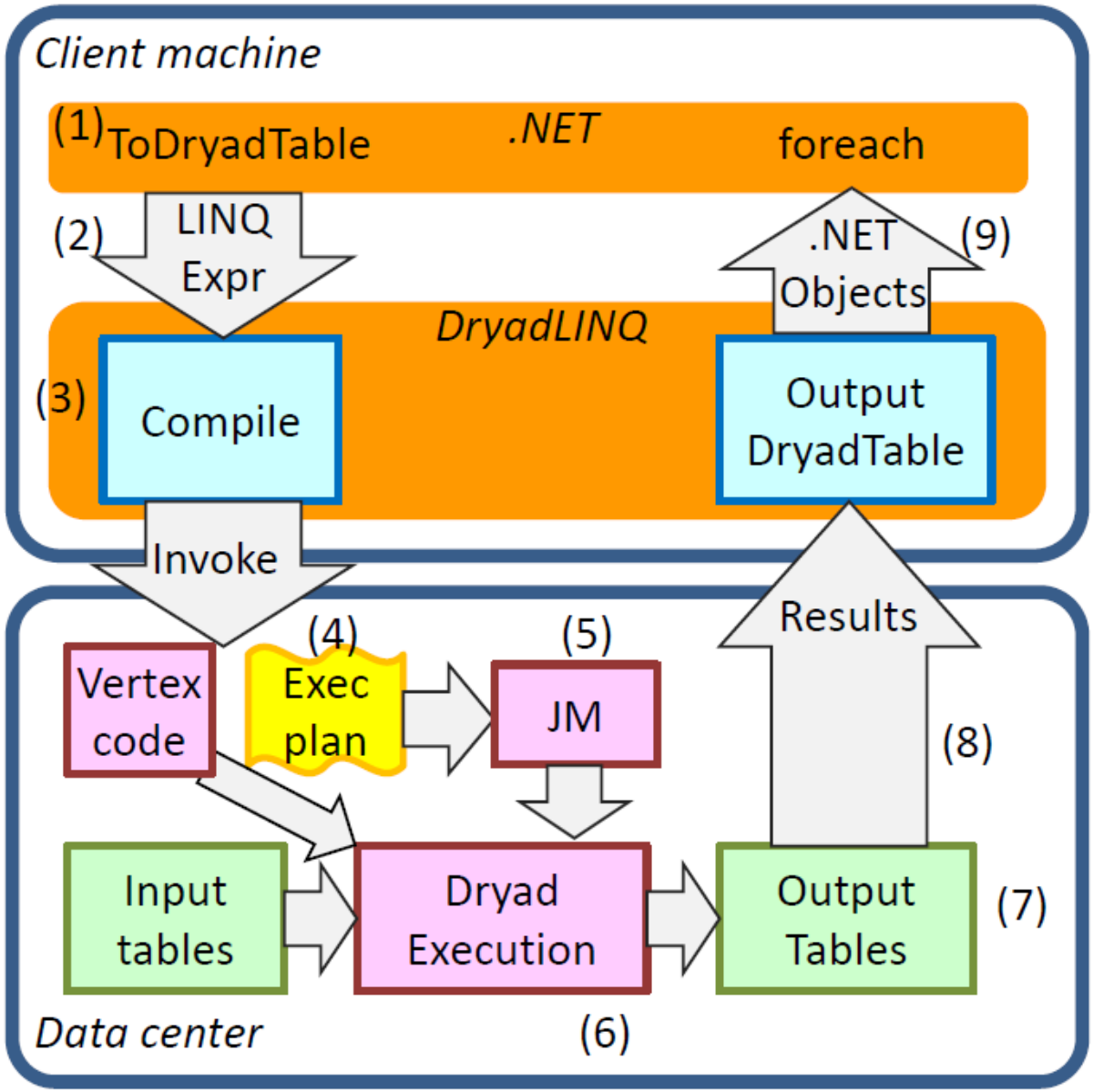
DBMS vs. MapReduce [PPR+09]

- Parallel DBMS
  - Robust, highly available
  - Faster and less code
  - Longer to tune and load data
  - Insufficient expressiveness
- MapReduce
  - Popular, simple
  - Less expressive and general

DryadLINQ

- Best of both worlds using LINQ on Dryad
- Hide Dryad complexity by automatic DAG construction
- Automatic scheduling and optimizations
- Transparent dynamic changes

DryadLINQ: Execution



DryadLINQ: Histogram Example [YIF+08a]

```
public static IQueryable<Pair>
    Histogram(IQueryable<string> input, int k)
{
IQueryable<string> words = input.SelectMany(x
    => x.Split(' '));
IQueryable<IGrouping<string, string>> groups =
    words.GroupBy(x => x);
IQueryable<Pair> counts = groups.Select(x =>
    new Pair(x.Key, x.Count()));
IQueryable<Pair> ordered =
    counts.OrderByDescending(x => x.count);
IQueryable<Pair> top = ordered.Take(k);
return top;
}
```

DryadLINQ: Histogram Example [YIF+08a]

```
"A line of words of wisdom"
        SelectMany(x => x.Split(' '));
["A","line","of","words","of","wisdom"]
        GroupBy(x => x);
[["A"],["line"],["of","of"],["words"],["wisdom"]]
        Select(x => new Pair(x.Key, x.Count()));
[{"A",1}, {"line",1}, {"of",2}, {"words",1},
   {"wisdom",1}]
        OrderByDescending(x => x.count);
[{"of",2}, {"A",1}, {"line",1}, {"words", 1},
   {"wisdom",1}]
        Take(3);
[{"of", 2}, {"A", 1}, {"line", 1}]
```

DryadLINQ: Optimizations

Static

- Conditional graph rewriting rules
- Pipelining
- Removing redundancy
- Eager aggregation
- I/O reduction

Dynamic

- During Dryad job execution
- Hooks in Dryad API
- Bases decisions on runtime topology

DryadLINQ: Experimental Evaluation

Hardware Configuration

- 240 computers
  - Two 2.6GHz dual-core AMD CPUs
  - 16GB RAM
  - Four 750GB SATA drives
- Connected through Linksys 48-port GBit Ethernet switches

Benchmarks

- Terasort
- SkyServer
- PageRank
- Large-Scale Machine Learning

DryadLINQ: Experimental Evaluation

Conclusions

- TeraSort
  - Constant average performance on local switches
  - Asymptotic behavior for more than one switch
- SkyServer
  - DryadLINQ fewer LOC than Dryad, but:
  - 1.3 times slower!
- PageRank
  - Optimized implementation 18x faster than naive version
- ML
  - Algorithms 50x faster than single computer

Evaluation

Criticisms

- Debugging
  - No-side-effect rule neither checked nor enforced
  - Easy to re-execute vertex, but what vertex?
  - Performance debugging harder
  - Job visualization [JYB11]
- Programming
  - Complex statements need annotations
  - LINQ syntax
- Performance
  - Lack of comparison with different systems
  - Lack of incremental processing
  - Early prototype

DryadLINQ: Today

Current State

- Spawned DryadInc for incremental computations [PBYI09]
- Dryad has been abandoned in favor of Hadoop
  `msdn.microsoft.com/en-us/library/hh378101.aspx`
- Naiad was started to address incremental shortcomings
  `research.microsoft.com/en-us/projects/naiad/`
  - Dataflow and graph ideas remain
  - New model developed

Conclusions

Key Insights

- Benefit from both DBMS and MapReduce
  - Hybrid programming style in known environment
- Combine static heuristics and runtime optimizations
- Give the illusion of single thread
  - Make distribution transparent to programmer

Key Questions

- How can you debug distributed applications?
- How does DryadLINQ compare to other platforms?
  - Performance and program implementation
- How can you optimize for incremental computations?
- Why was Dryad abandoned?
- Your questions?

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