Comparing Scale-up and Scale-out...

... an Empirical Study... ?

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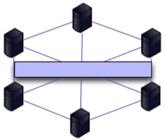
March 18, 2013

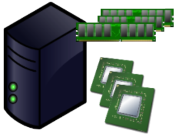
Scaling

Q: *What do we do when there is too much data?*

A: Scale the system

- out
  - ++ nodes to the system
  - → modify applications
- up
  - ++ resources to a single node
  - → modify the system





Q: *Which is better?*

Current Trend

1. push towards scale-out (past)

2. difficulty of scale-out (present)

3. push towards scale-up (future?)

Current Trend

1. push towards scale-out (past)
   - hardware
     - non-linear scaling
   - cost
     - 1 expensive node vs. many commodity servers
   - interoperability
     - OSs not designed for ++ resources
     - Barrelfish, FOS, Corey, Cerberus [15, 19, 1, 16]
     - Linux scalability, LANL study [2, 3]

Result: MapReduce, Dryad [6, 9]

Current Trend

1. push towards scale-out (past)
   - hardware
   - cost
   - interoperability

2. difficulty of scale-out (present)
   - workload specific architectures
     - Pregel, Spark, S4 [10, 21, 12]
   - application optimization
     - concurrent programming
     - parallel databases
     - resource management
   - complexity, unpredictability
     - NFS death spirals
     - faulty network interfaces
     - 100% CPU utilization on the gateway
     - namode/t-trackers/tmp won't format/start/reset

Maintaining a cluster is not fun

11	Adam Crume	12.04	SSD, bad ram chip	edid (nomodeset)
12	Joe Buck	12.04	SSD (ssd looks flakey,cannot do an fdisk)	edid (nomodeset)
13	Joe Buck	12.04	SSD	edid (nomodeset)
14	Joe Buck	12.04	SSD	edid (nomodeset)
15	Adam Crume	12.04		can't boot from cd-rom (use usb?)
16	Joe Buck	12.04	SSD	edid (nomodeset)
17	Joe Buck	12.04	SSD	edid (nomodeset)
18	Noah	12.04	SSD	edid (nomodeset)
19	Joe Buck	12.04	SSD	edid (nomodeset)
20		12.04	SSD issues with 2 hard drives	edid (nomodeset)
21	Joe Buck	12.04	SSD	edid (nomodeset)
22	Joe Buck	12.04	SSD: looks okay, keep an eye on it	edid (nomodeset)
23	Joe Buck	12.04	SSD	edid (nomodeset)
24	Noah	12.04	SSD	edid (nomodeset)
25	Joe Buck	12.04	SSD	edid (nomodeset)
26	Joe Buck	12.04	SSD this looks okay. Keep an eye on it	edid (nomodeset)
27	Noah	12.04	SSD	edid (nomodeset)
28	Noah	12.04	SSD	edid (nomodeset)
29	Noah	12.04	SSD	edid (nomodeset)
30	Noah	12.04	SSD	edid (nomodeset)
31	Noah	12.04		edid (nomodeset)
32	Noah	12.04		
33	**down**		RAM was pulled to fix another host. Replaced RAM is in Joe's desk (at least 1 bad chip in the bunch)	
34	Joe Buck	12.04		
35	Joe Buck	12.04		edid (nomodeset)
36	No BIOS or POST			edid (nomodeset)
37	Joe Buck	12.04		edid (nomodeset)
38	Joe Buck	12.04		edid (nomodeset)
39	Noah	12.04		edid (nomodeset)
40	Joe Buck	12.04		
41	Noah	12.04		
42				
43			keep an eye on this node. Is not booting. Not sure why.	
44	Noah	12.04		
45	Michael Sevilla		issdm SSH key not set	
46	Noah	12.04	keep an eye on this node	
47	Joe Buck	12.04	keep an eye on this node	

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Current Trend

1. push towards scale-out (past)
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3. push towards scale-up (future?)
   - simplicity
   - automization
   - evolve

Proposal: new scale-up vs. scale-out study

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Why? Because previous studies use:

1. narrow methodologies
   - distr. sys: # of nodes [15, 1, 16, 19, 13, 20, 17, 18, 2]
   - distr. sys: workload types [5, 21, 10]
   - single node: threads/cores [14, 7, 8, 9, 4]
2. out-dated systems
   - (8 $\times$ dual-core, 32GB RAM) vs. (14 nodes) [11]

Figure: The POWER5 p5 575 SMP server.

Proposal: new scale-up vs. scale-out study

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→ missing bottlenecks

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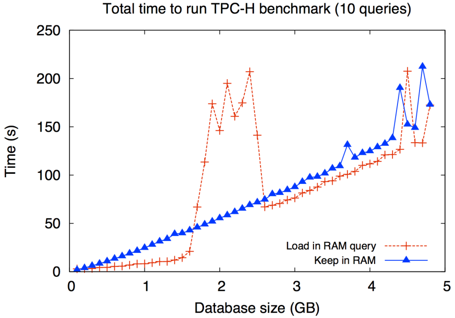
- **Key Observation**: big data uses a lot of data



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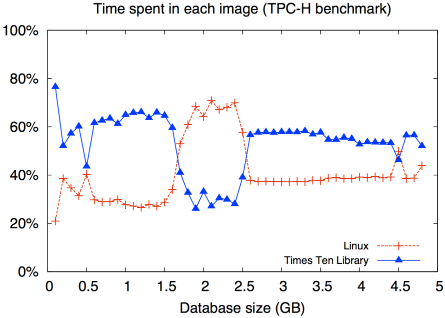

Proposal: new scale-up vs. scale-out study

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- **Hypothesis**: there will be new bottlenecks/slowdowns

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- Methodology: vary machine configs + data

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Long-term goal: construct performance grid

	M_1	M_2	M_3	$\dots$	M_n
A_1	p_{11}	p_{12}	p_{13}	$\dots$	
A_2	p_{21}	p_{22}	p_{23}		
$A_1{}'$	$p_{11}{}'$	$p_{12}{}'$	$p_{13}{}'$		
$A_2{}'$	$p_{21}{}'$	$p_{22}{}'$	$p_{23}{}'$		
$\vdots$	$\vdots$				
A_m					

This will help us:

1. create a cost function
2. identify the differences between scaling out and up

Methodology: vary machine configs + data

Short-term goal: small experiment comparing scale-out/up

```
foreach application
    while(!stressed)
        execute()
        measure_performance()
        ++data
```

Problem: how do we select applications?

- representative and feasible

Methodology: vary machine configs + data

Short-term goal: small experiment comparing scale-out/up

```
foreach application
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Problem: how do we port applications?

- functionality or methodology?
- fair and feasible

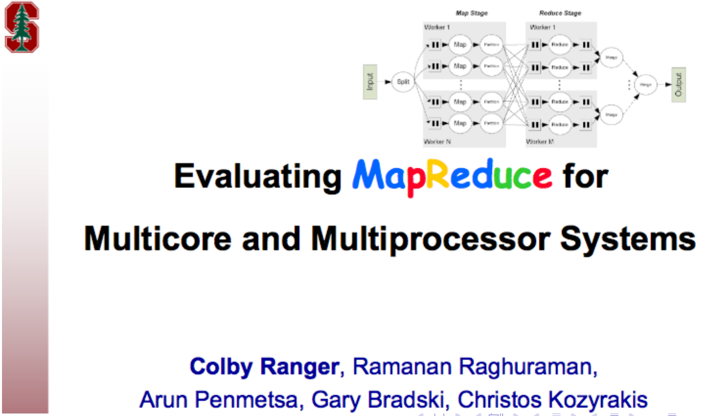
Implementation

Select apps.: existing distr. sys. benchmark (HiBench) [8]

- word count, sort, Terasort, PageRank, Nutch

Port apps.: Phoenix API/runtime

- MapReduce → multi-{core, processor}



Phoenix vs. MapReduce

	MapReduce	Phoenix
work distr.	master node worker nodes	parent process threads $\in$ core
communication	network i-keys $\in$ HDFS	shared-memory i-keys $\in$ L1 cache
fault tolerance	heartbeat remote re-exec.	timeout local re-exec.
combiner	$\in$ node after map	$\in$ thread after map

This makes our comparison:

- ✓ fair
- ✓ feasible
- ✓ representative

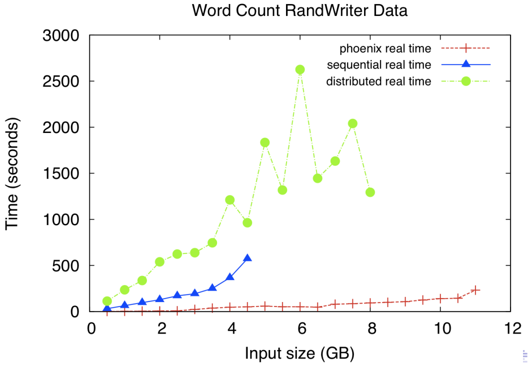
Porting progress

scale-out Hadoop (3 nodes)	scale-up ≡ methodology	scale-up ≡ functionality
✓ WordCount.java	✓ wc.cpp	✓ wc-seq.cpp
✓ Sort.java	✓ sort.cpp	✓ sort-seq.cpp.
✓ TeraSort.java	✗ tsort.cpp	✗ tsort-seq.cpp
✓ Hama	✗ pg_rank.cpp	✗ pg_rank-seq.cpp
✓ SolrIndex.java	✓ index.cpp	✓ index-seq.cpp

Initial Results: word count

	Data	Time	Error → Event	
`wc.cpp`	11.5 GB	232.82 secs	cpu throttled → `int_idle()`	+10%
`wc-seq.cpp`	4.5 GB	572.75 secs	bad allocation → `scan_swap()`	+8%

- scale-out vs. scale-up



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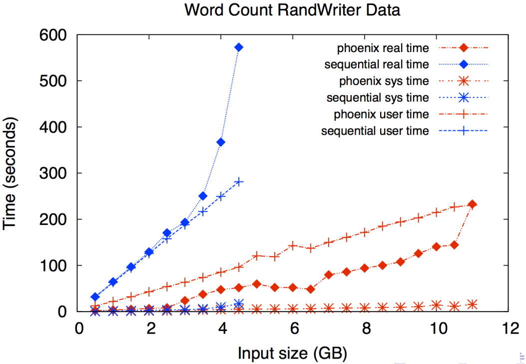
- scale-up timing breakdown



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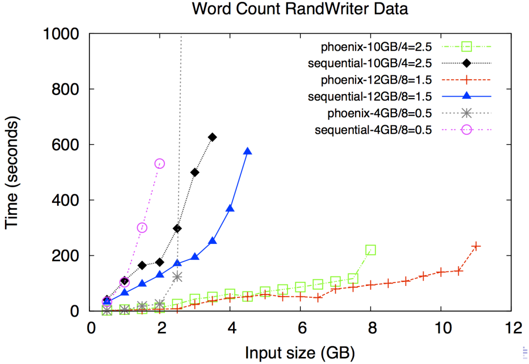
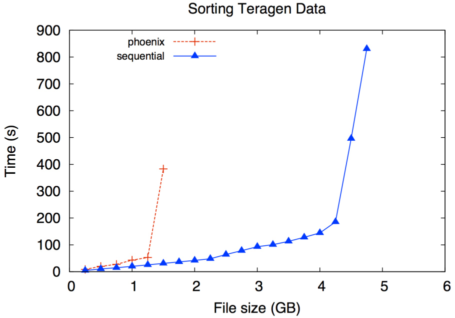
- scale-up $\frac{\text{mem}}{\text{core}}$ ratio breakdown



Initial Results: sort

	Data	Time	Error → Event	
`sort.cpp`	1.5	208.11	OOM; kill →	(+?%)
`sort-seq.cpp`	4.75	830.46	OOM; kill → `scan_swap()`	(+20%)



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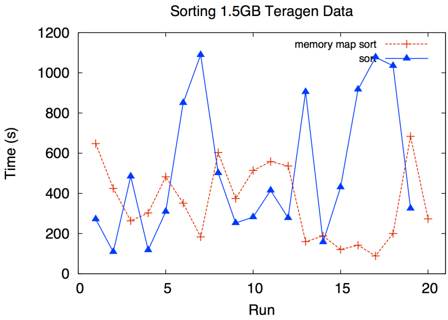

Conclusion

Lays the groundwork for scale-up vs. out study

- choose applications
- port applications
- methodology

The plan:

Spring Quarter

- port applications
- profile/take measurements
- write Masters Thesis

Summer

- intern @ TidalScale
- hands-on experience

Fall Quarter

- document summer expereince
- write paper?

Experience with Phoenix

```
class WordsMR : public MapReduceSort<...>{
    void map(data_type s, map_container out){
        wc_word word = { s.data+start };
        emit_intermediate(out, word, 1);
    }
    ...
    int split(wc_string& out){
        out.data = data + splitter_pos;
        out.len = end - splitter_pos;
    }
    ...
    bool sort(keyval a, keyval b){
        return a.val < b.val || ...;
    }
}
...
mapReduce.run()
```

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