The Performance of Big Data Workloads in Cloud Datacenters

Alexandru Uta, Alexandru Custura, Harry Obaseki

a.uta@vu.nl

Vrije Universiteit Amsterdam

Massivizing Computer Systems

Massivizing Computer Systems

Education for Everyone (Online)

Business Services

Cloud Computing

Big Science

Grid Computing

Online Gaming

Daily Life

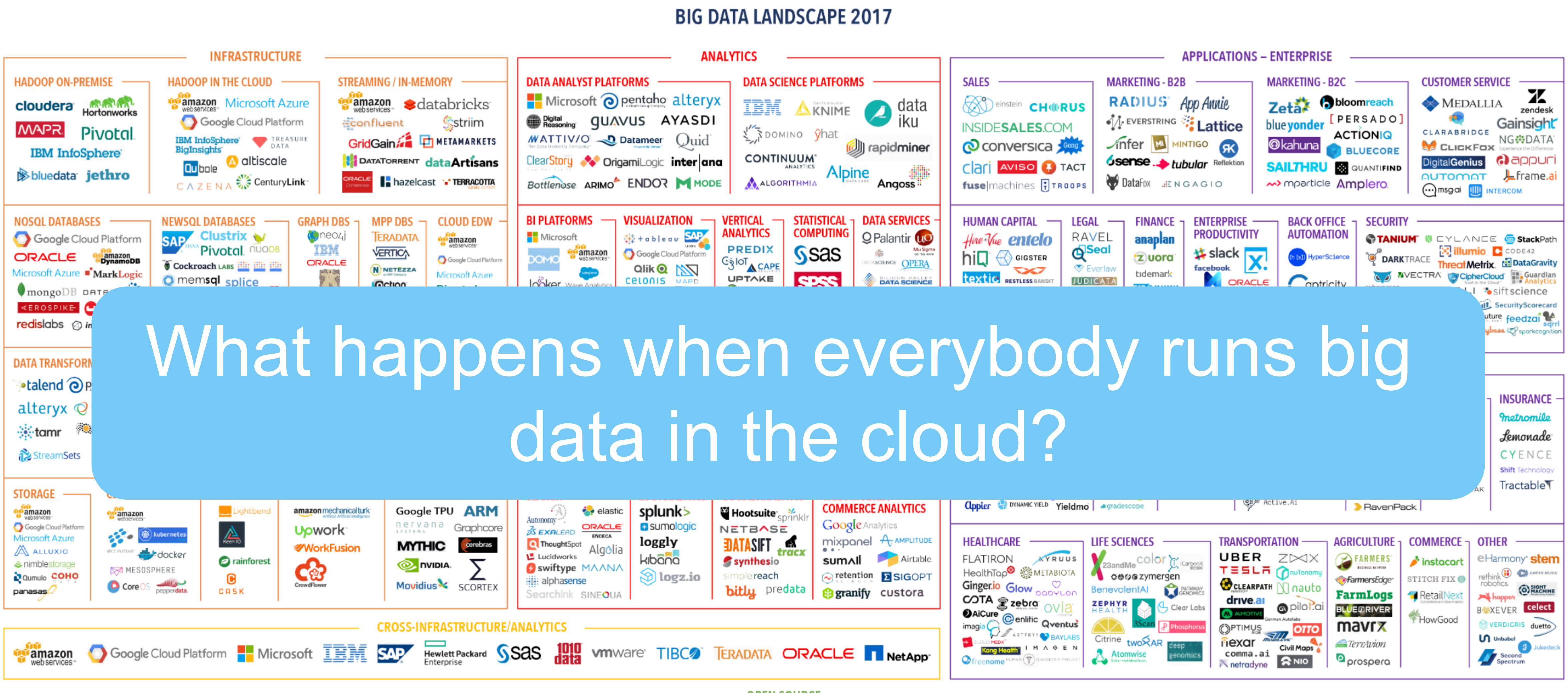
Big Data

Datacenters

Grid Computing
What is all about Grid ?
1) Sharing, Selecting, aggregation of resources with a policy universally agreed.
2) Distributive supercomputing for a better future
Super Computers
Cluster
Virtual Organizations
User, Scientists, Researchers
CTAAAGATGATCTTTAGTCCCGGTTCGAA
TCTTTAGTCCCGGTTGATAACACCAACC
GTAATACCAACCGGGACTAAAGATCCCG
GGGACTAAAGTCCCACCCCTATATATATG
TTCAAAATTTCTTCAAAAAAGAGGGGAG
GTGATTACATACAAATCGGAGGTGCCTA
TTTGTCATACTACATTTGCACCTATGTTTT
GTAAGTTGATGAGAGAGAAAATGTGTGT
CGACATAT
30.3 million
107 minutes per visitor
NORTH AMERICA
45.6 million
97 minutes per visitor
EUROPE
6.2 million
45 minutes per visitor
MIDDLE-EAST / AFRICA
14.9 million
67 minutes per visitor
LATIN AMERICA
47.9 million
47 minutes per visitor
ASIA PACIFIC
AVERAGE DAILY ONLINE GAMERS WORLDWIDE
Source: comScore MMX, Worldwide, April 2013, Age 15+
comScore Data Gem
My other computer is a data center
Google
webmonkey
ABN·AMRO
BIG DATA

Convenient to use big data + cloud

Wide variety of frameworks running together

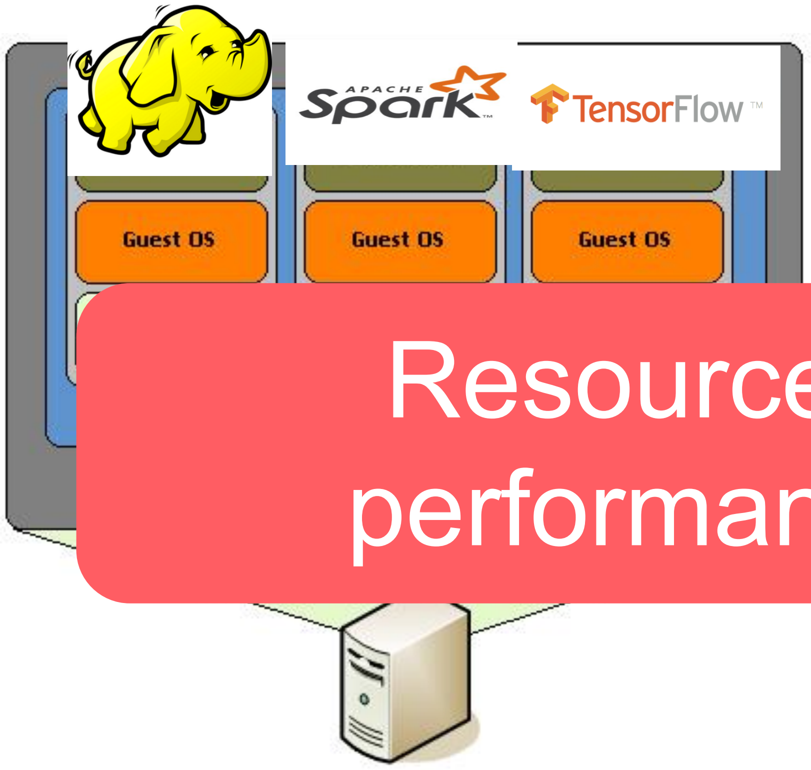


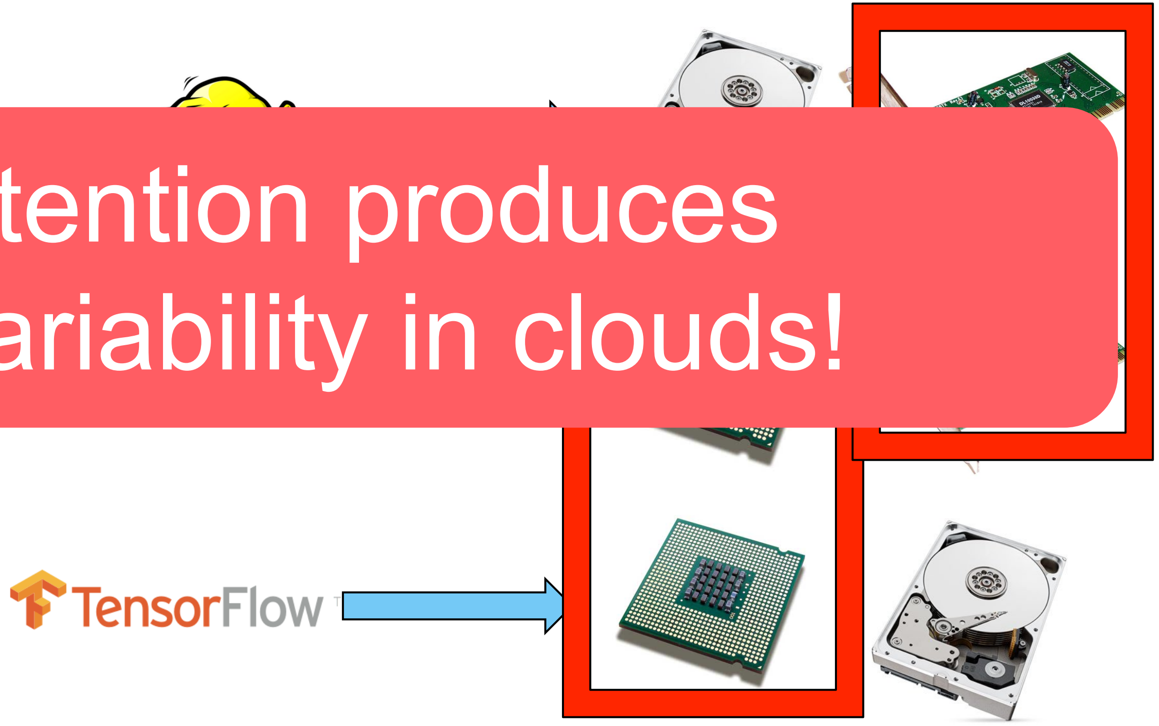
What happens when everybody runs big data in the cloud?

Image courtesy of mattturck.com

Co-location induces (resource) performance variability

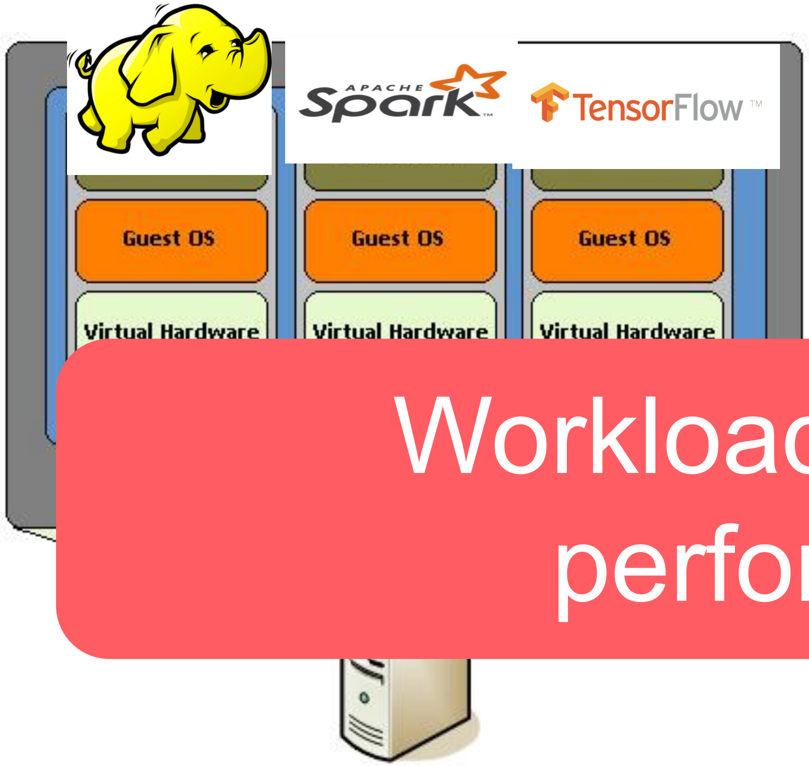
How does resource interference affect performance?



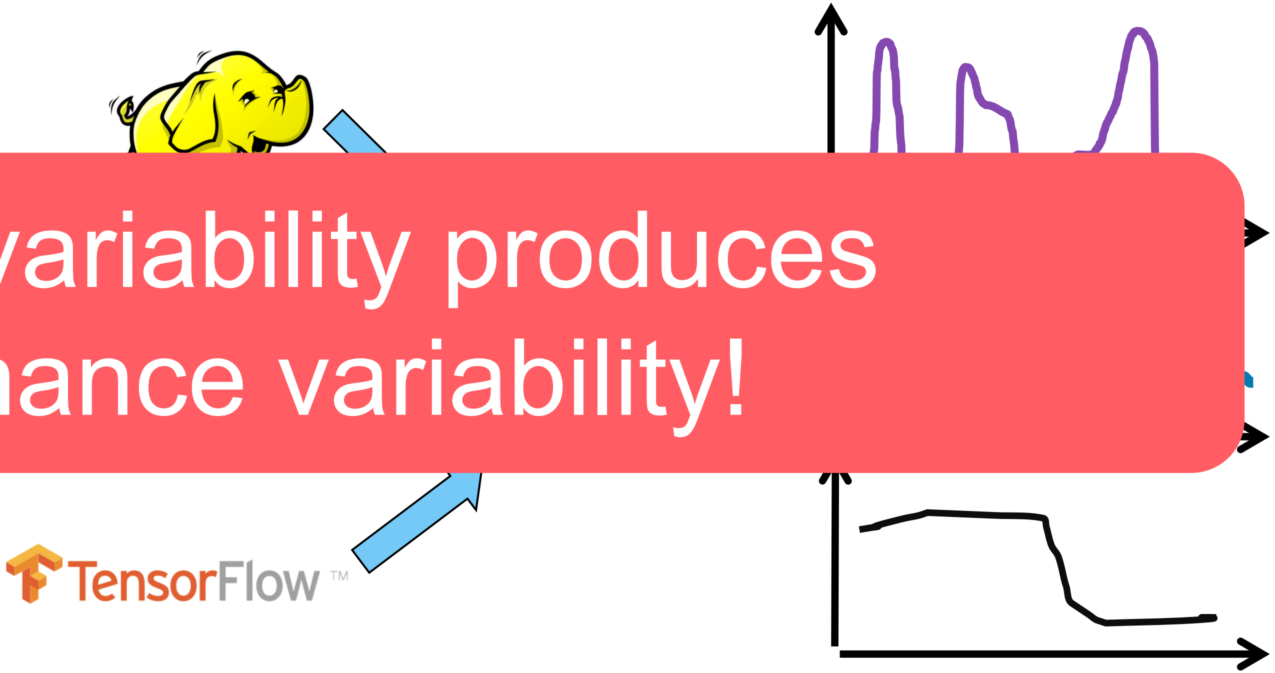


Resource contention produces performance variability in clouds!

Co-location induces (resource) performance variability



How does workload variability affect performance?

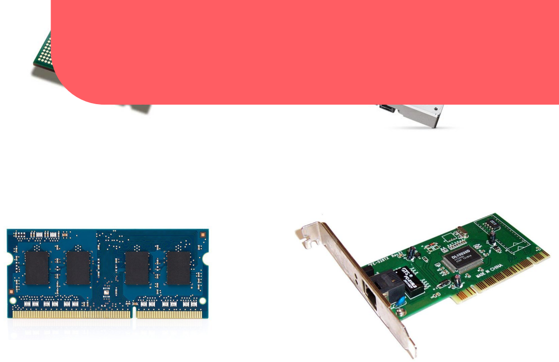


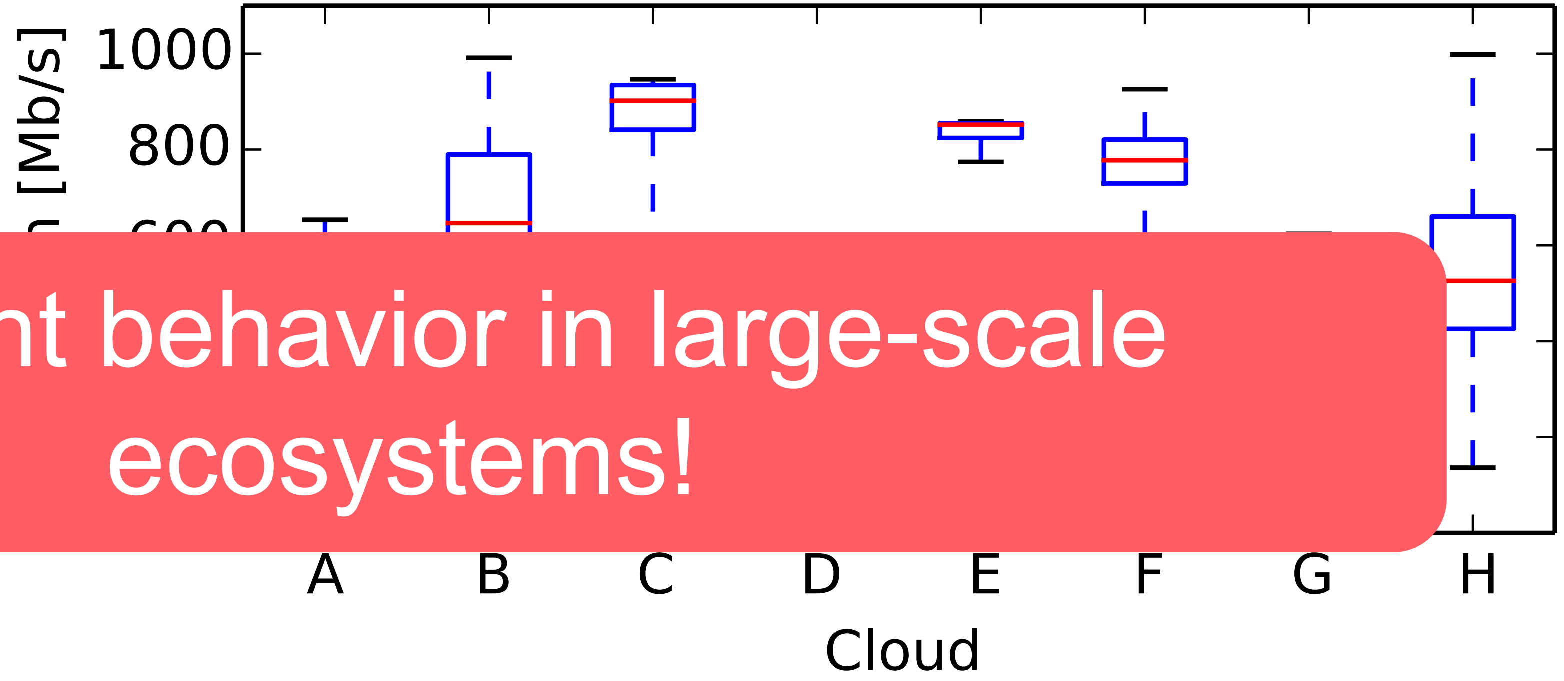
Workload variability produces performance variability!

Cloud (resource) performance is highly variable!

- Due to:
  - Co-location
  - Virtualization
  - Workload variability
  - Network congestion
- Affec

Emergent behavior in large-scale ecosystems!





Ballani et al., SIGCOMM 2011

Iosup et al., CCGrid 2011

Convenient to use big data + cloud, but…

Variability entails:

- Poor performance predictions
- Poor scheduling decisions

- Over-provisioning
- Extra costs

How to study performance variability?
How to control the variability?

How to study performance variability?

Traditional performance analysis:

- (1) Trace analysis
- (2) Benchmarking
- (3) Performance modeling

Current models, benchmarks do not consider resource variability!

- No study on resource performance variability and big data
- Variability **within** clouds and **between** clouds (performance portability issues)

A Framework for Studying Performance Variability

1

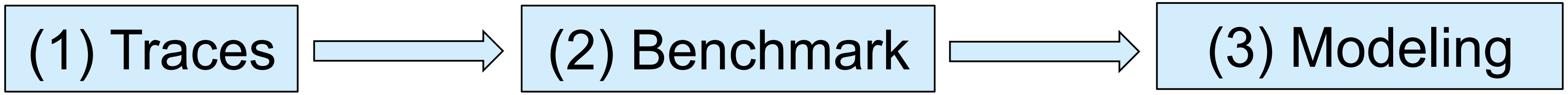
- Fallback to empirical evaluation based on previous observations

2

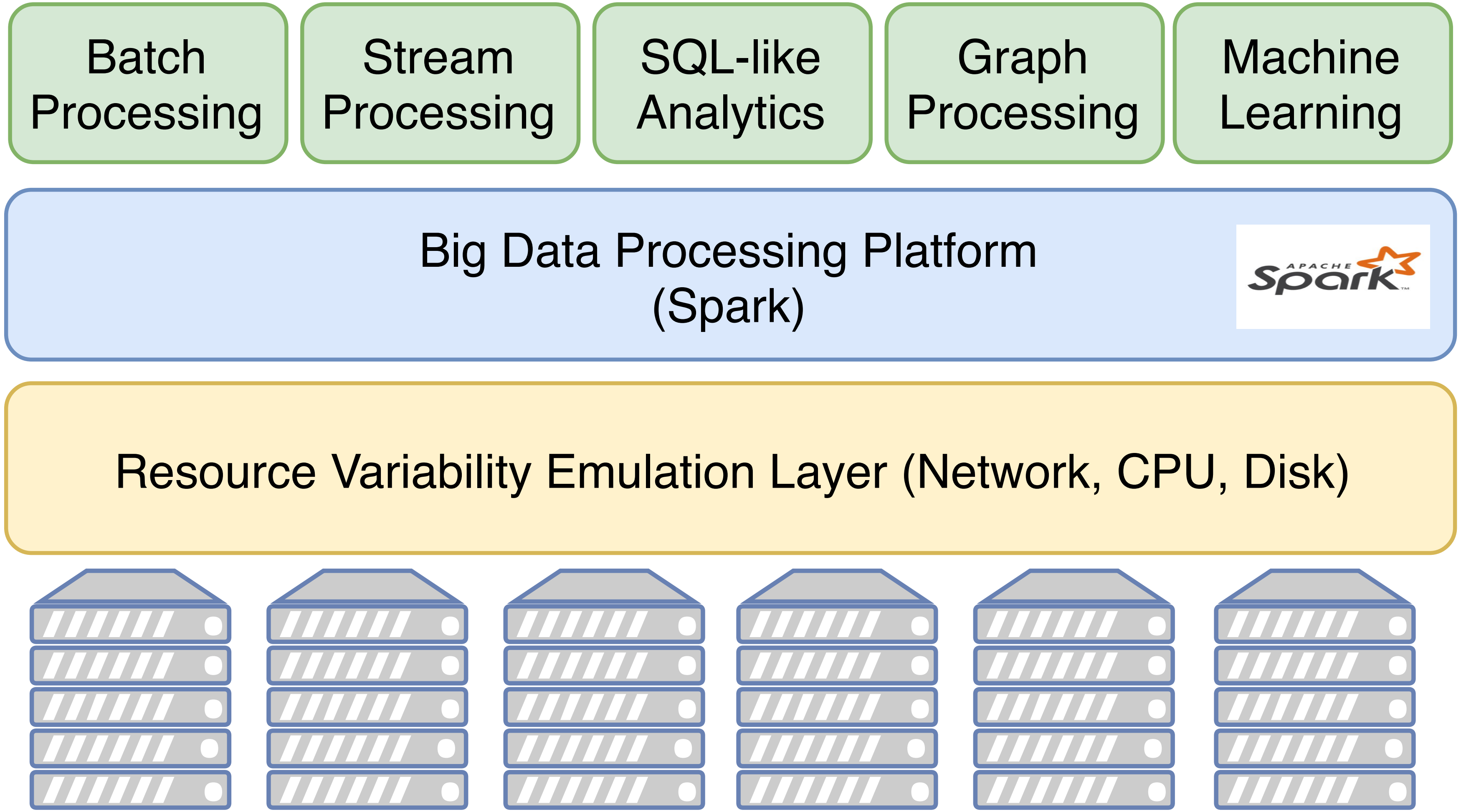
- Controlled environment that emulates real-world variability scenarios
- Multiple classes of big data applications

3

- Statistical analysis and performance modeling to understand correlations



Benchmarking Performance Variability



Batch Processing

Stream Processing

SQL-like Analytics

Graph Processing

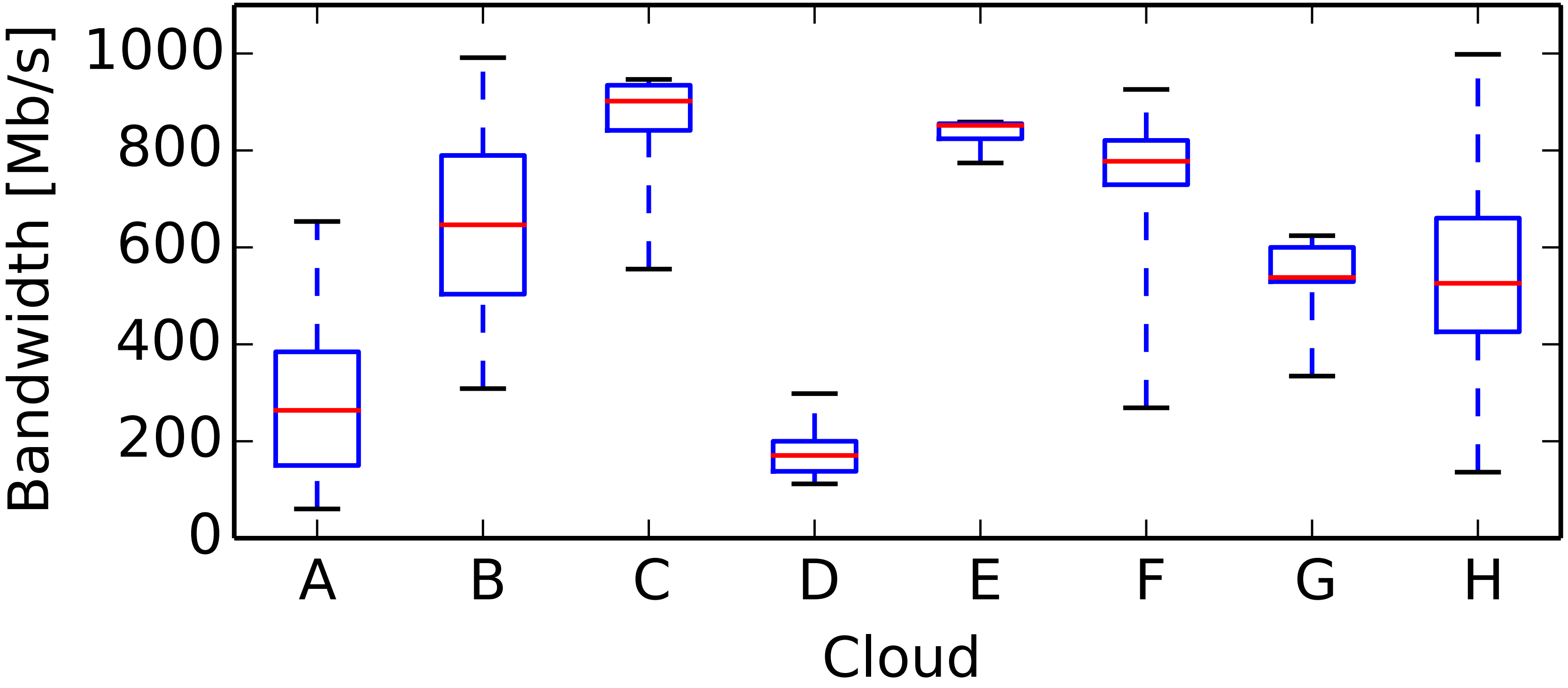
Machine Learning

Big Data Processing Platform (Spark)

Resource Variability Emulation Layer (Network, CPU, Disk)

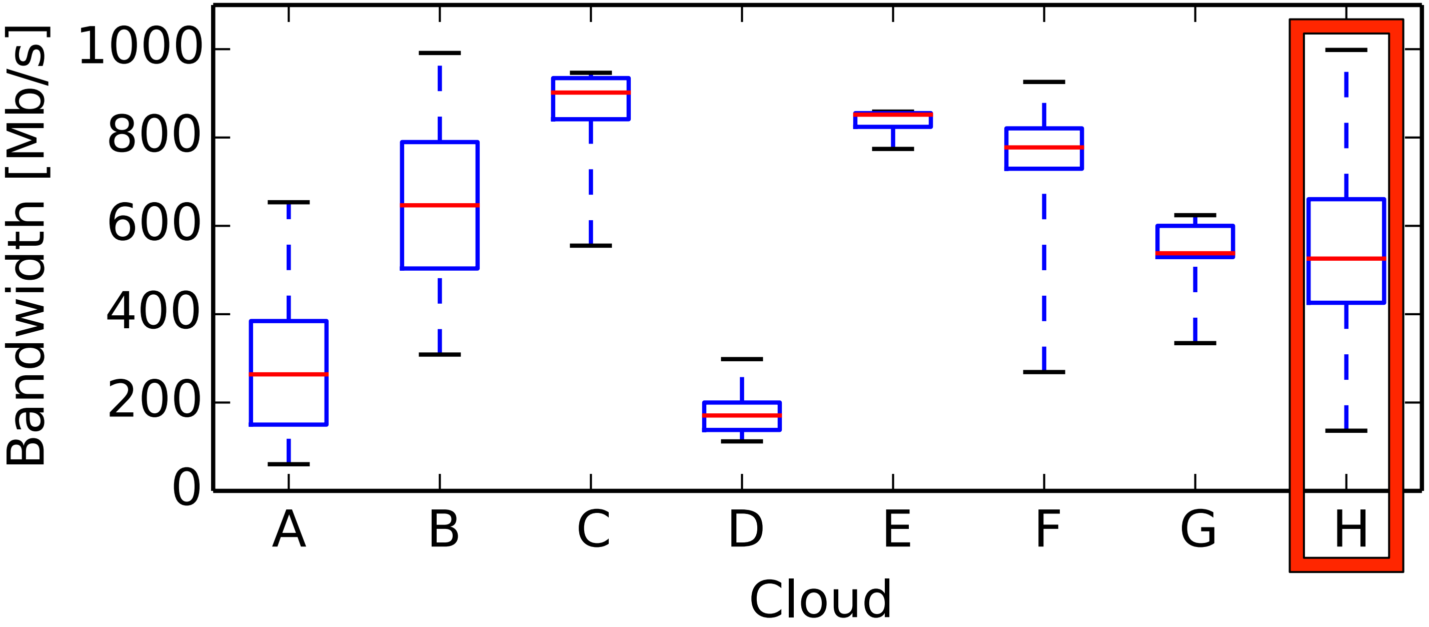
Quantifying network variability impact on Big Data

- Systematic study using A-H cloud bandwidth distributions
- Run a series of big data applications



Cloud network bandwidth emulation

- For each distribution:

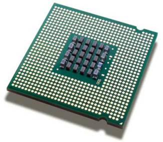
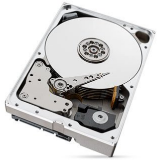
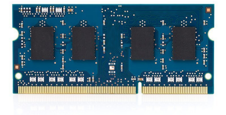
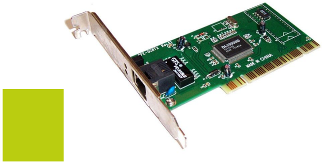


Vary bandwidth

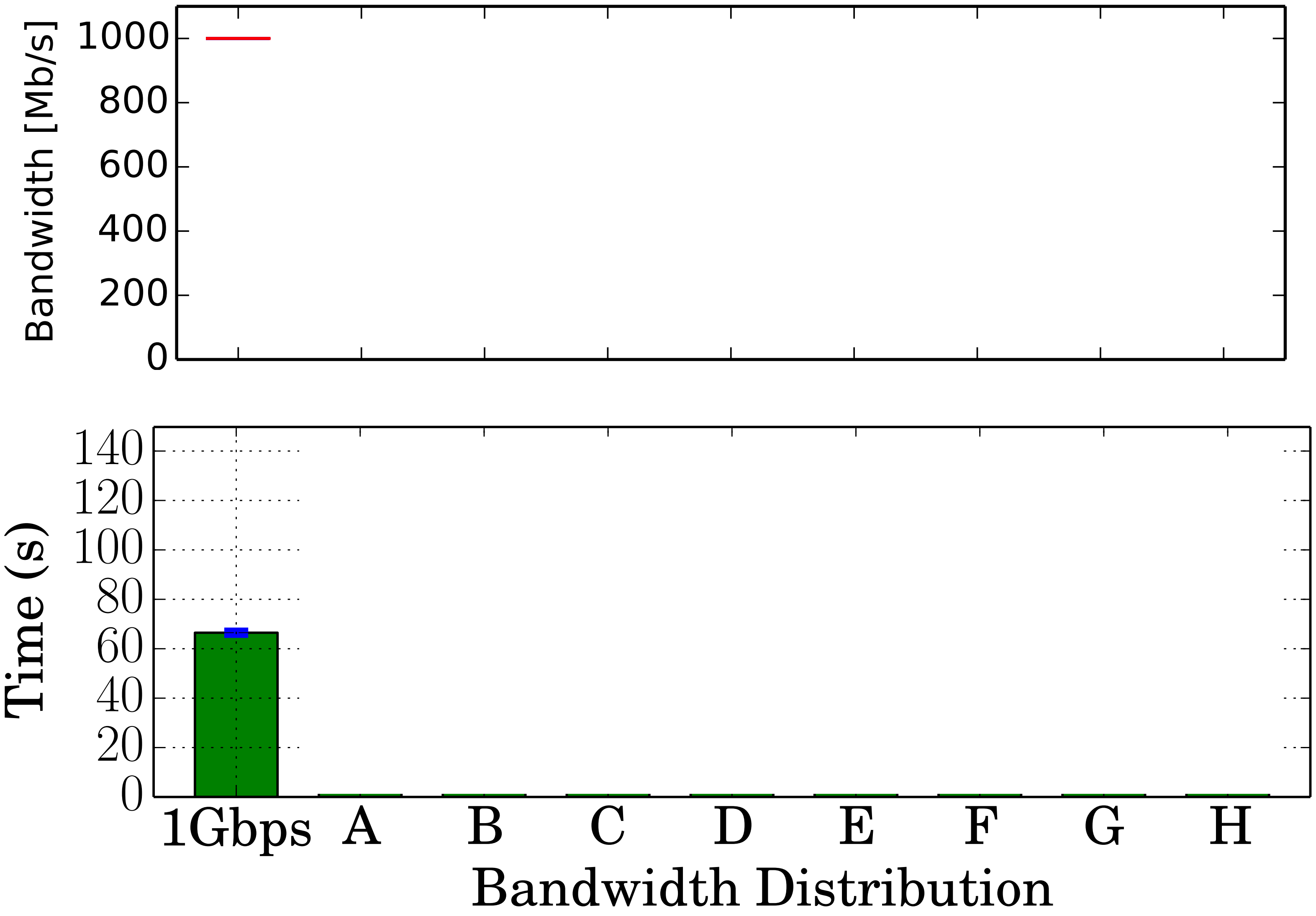
Cluster

Big Data Workloads

- HiBench suite, MapReduce-style apps
- 6 real-world applications from various domains
- Each app having different resource usage

Application				
Wordcount	++	--	0	0
Sort	--	++	0	++
Terasort	++	0	++	++
Naïve Bayes	0	0	++	--
K-means	++	--	0	--
PageRank	0	--	0	--

Variable network = Variable Runtime (Terasort)



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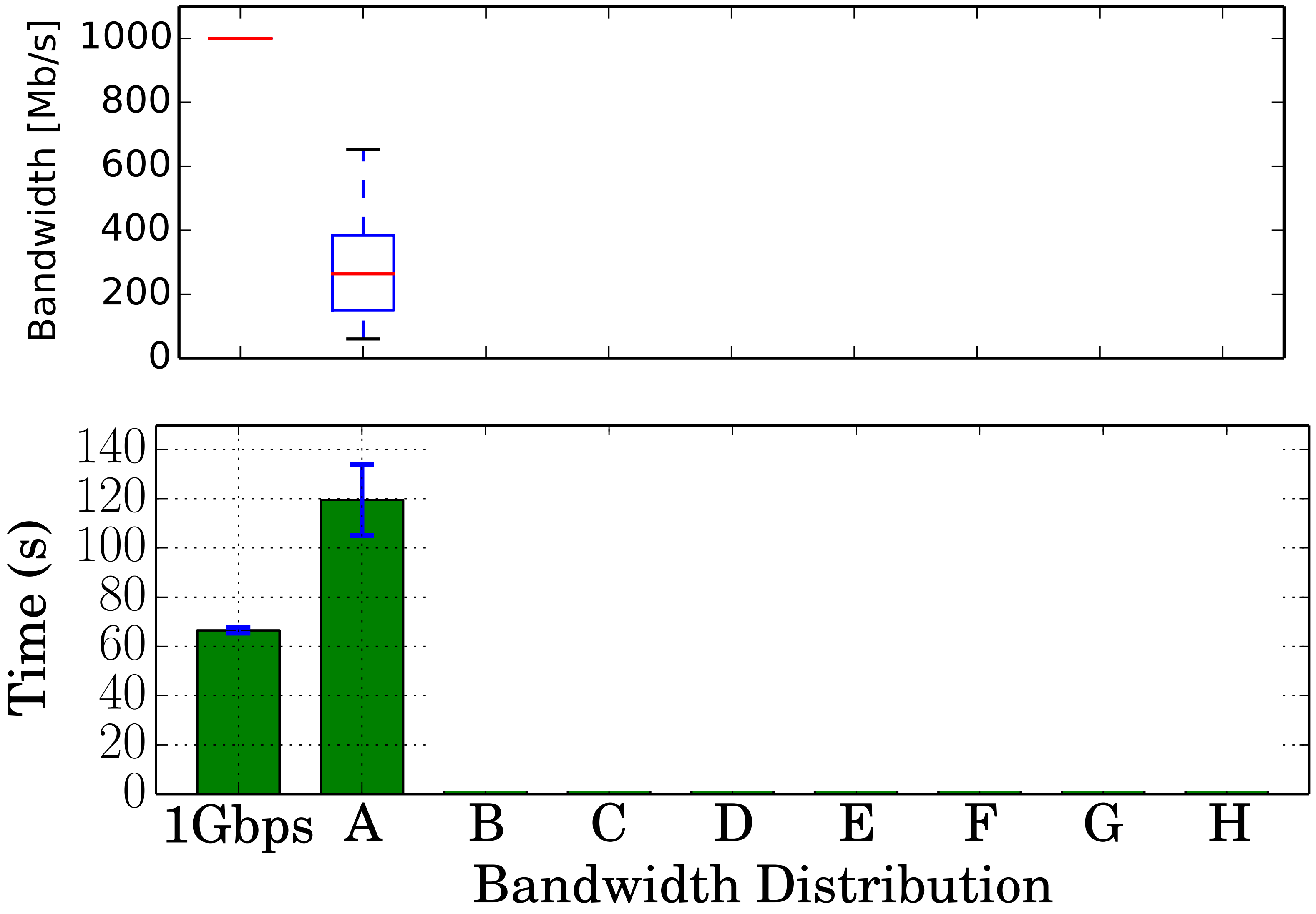

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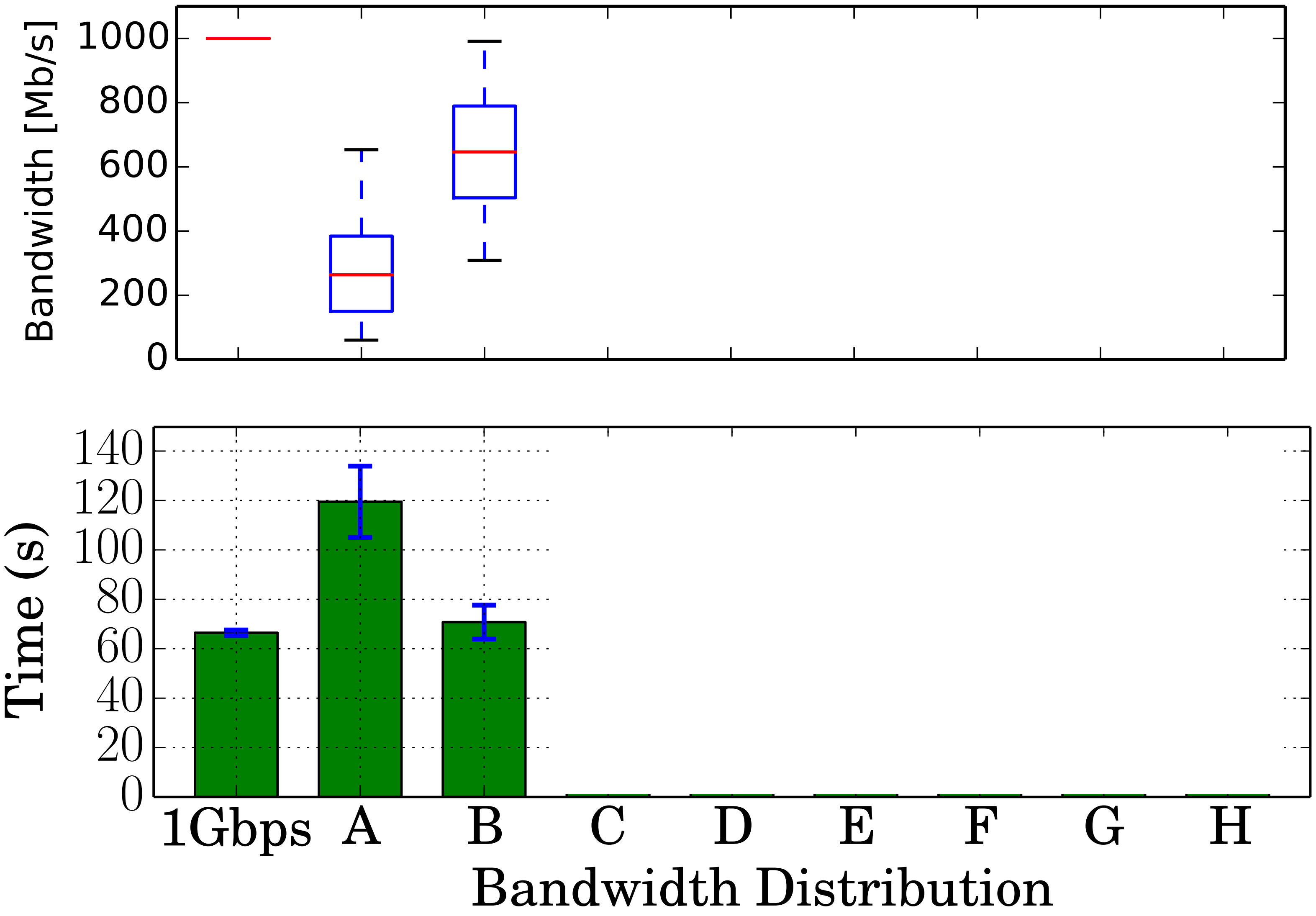
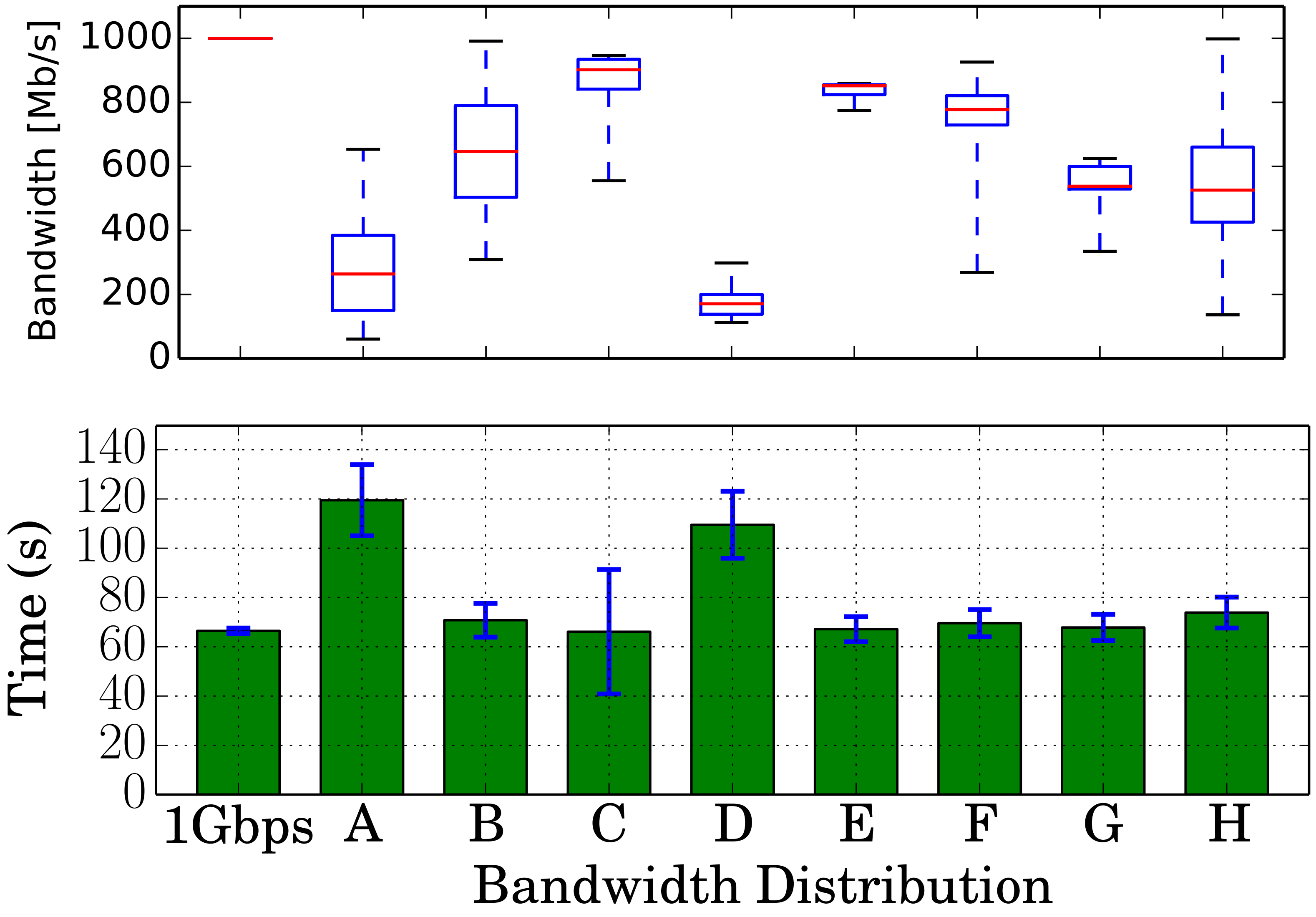
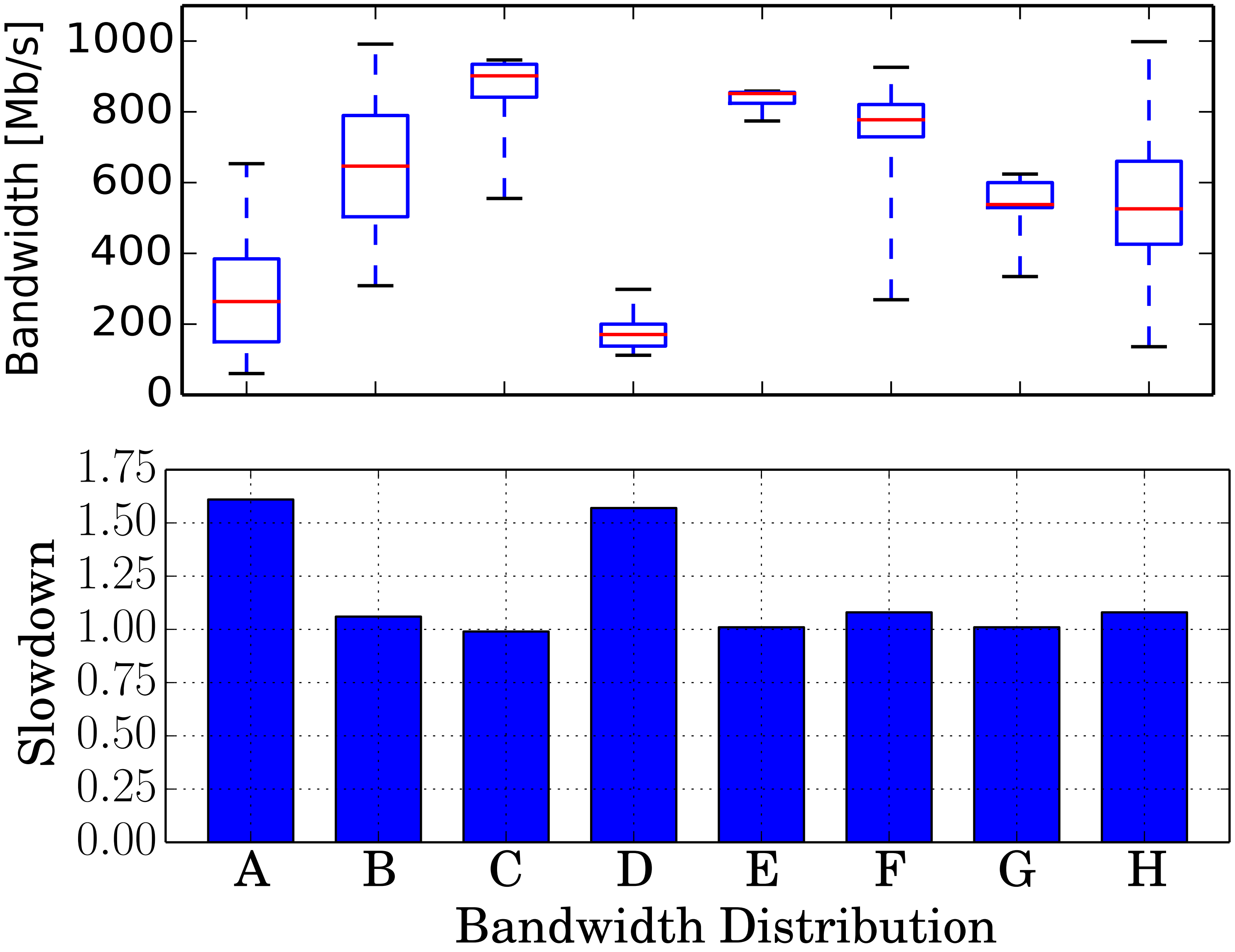


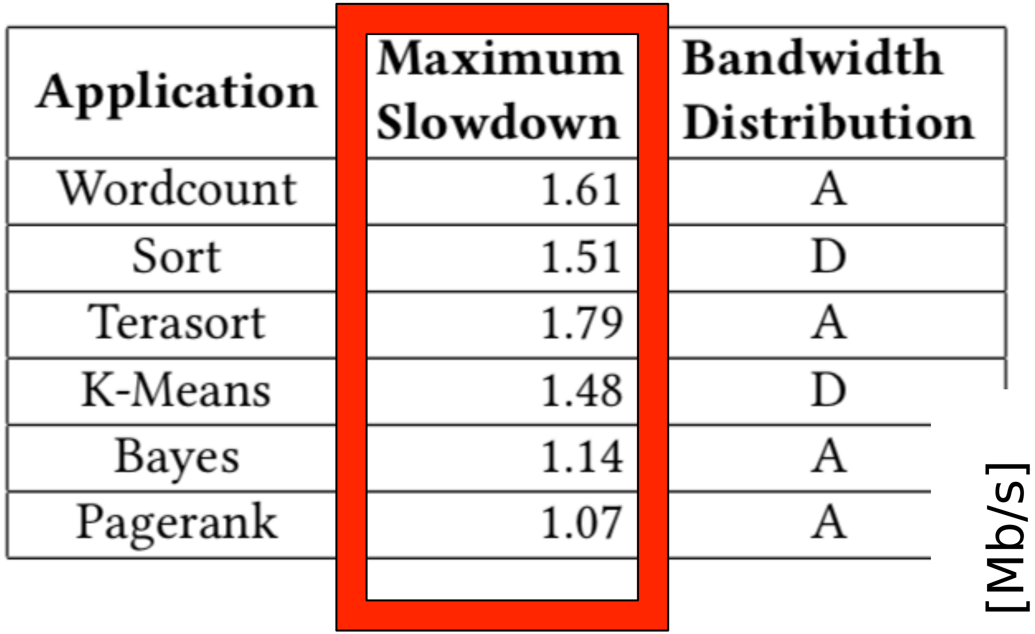
Variable network = Variable Runtime (Terasort)



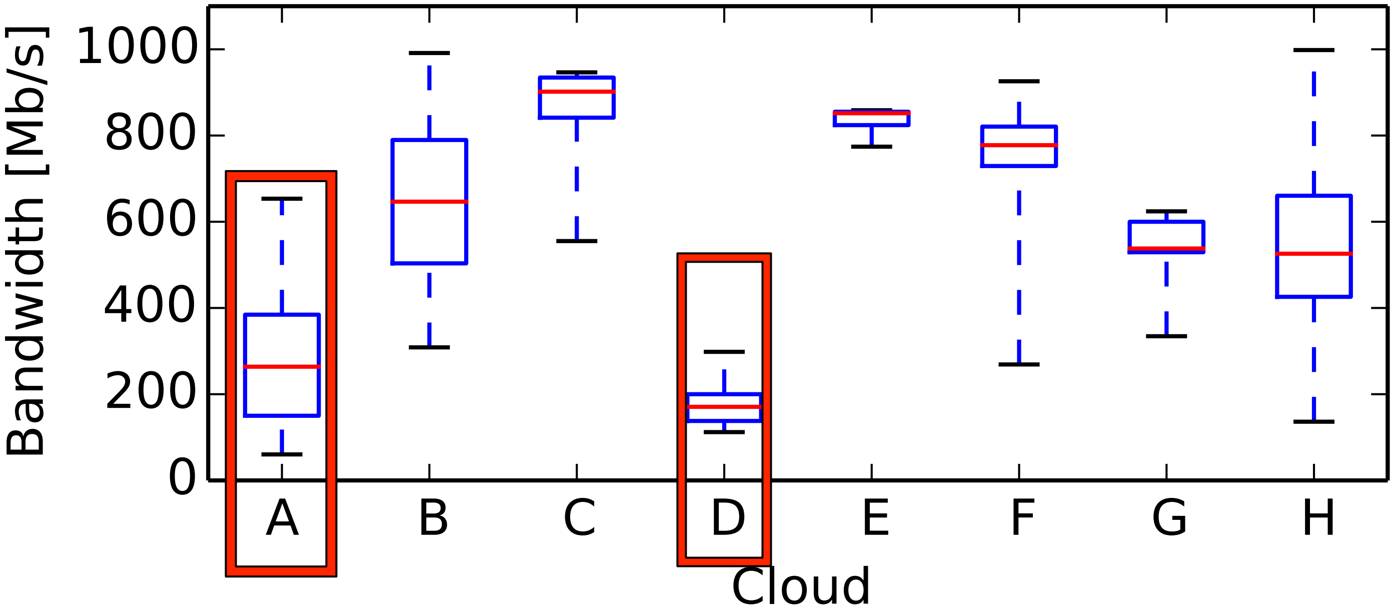
Surprisingly, non-network-intensive Wordcount slowed down



Most apps are slowed down on real clouds



Application	Maximum Slowdown	Bandwidth Distribution
Wordcount	1.61	A
Sort	1.51	D
Terasort	1.79	A
K-Means	1.48	D
Bayes	1.14	A
Pagerank	1.07	A



Take-home message

- Network variability leads to high slowdown for big data in the cloud
- Network variability also affects performance portability
- Surprisingly, also apps not network-bound applications slow down

Future work:

- In-depth statistical analysis
- Performance modeling tools
- Control through better scheduling

Alexandru Uta
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