Virtual Machine Workloads: The Case for New Benchmarks for NAS

virtual

T2M

Vasily Tarasov,* Dean Hildebrand,×
Geoff Kuenning,^ Erez Zadok*

*Stony Brook University, ×IBM Research – Almaden, ^Harvey Mudd College

Overview



Storage Companies



FastStorage Inc.



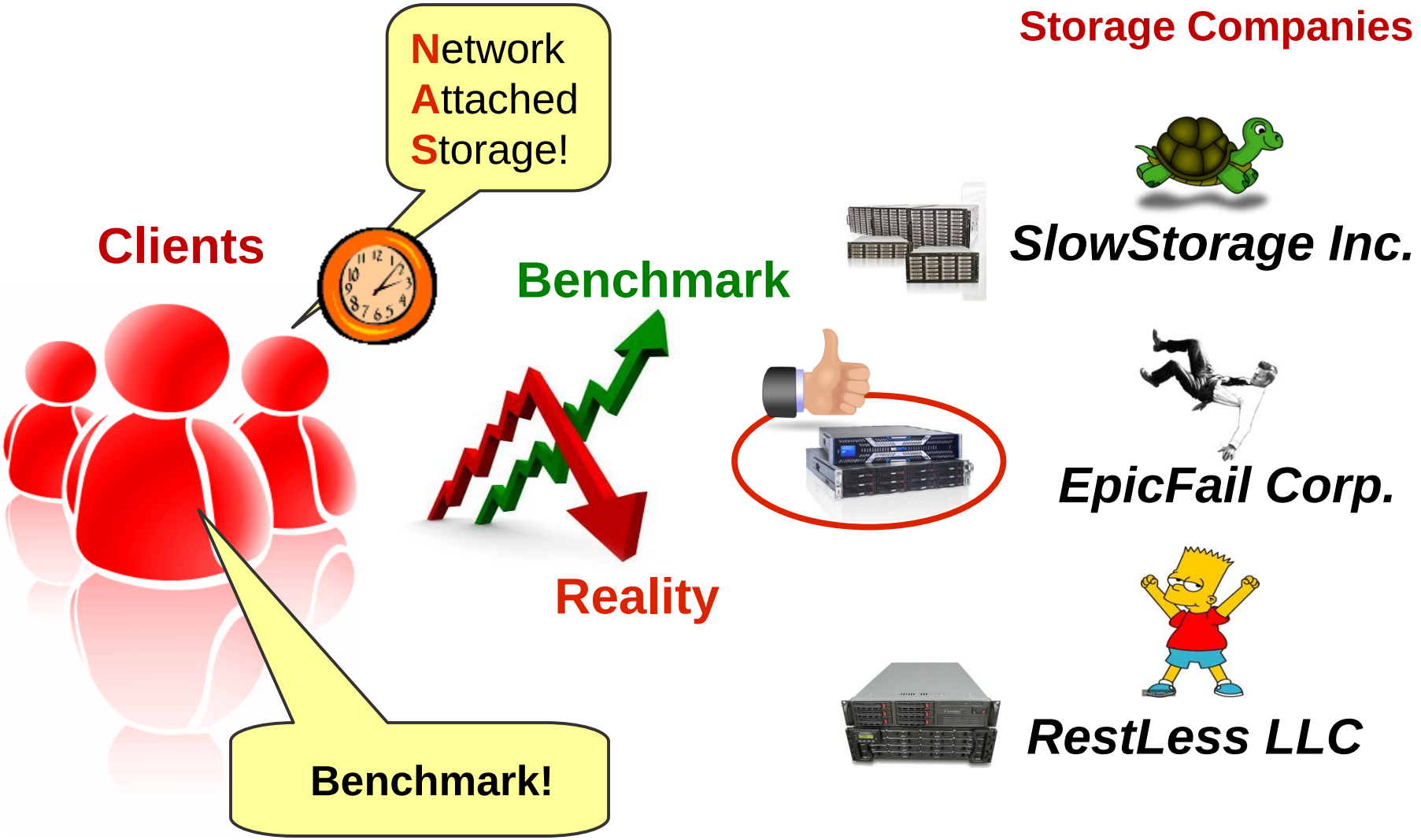
NeverFail Corp.



TroubleFree LLC

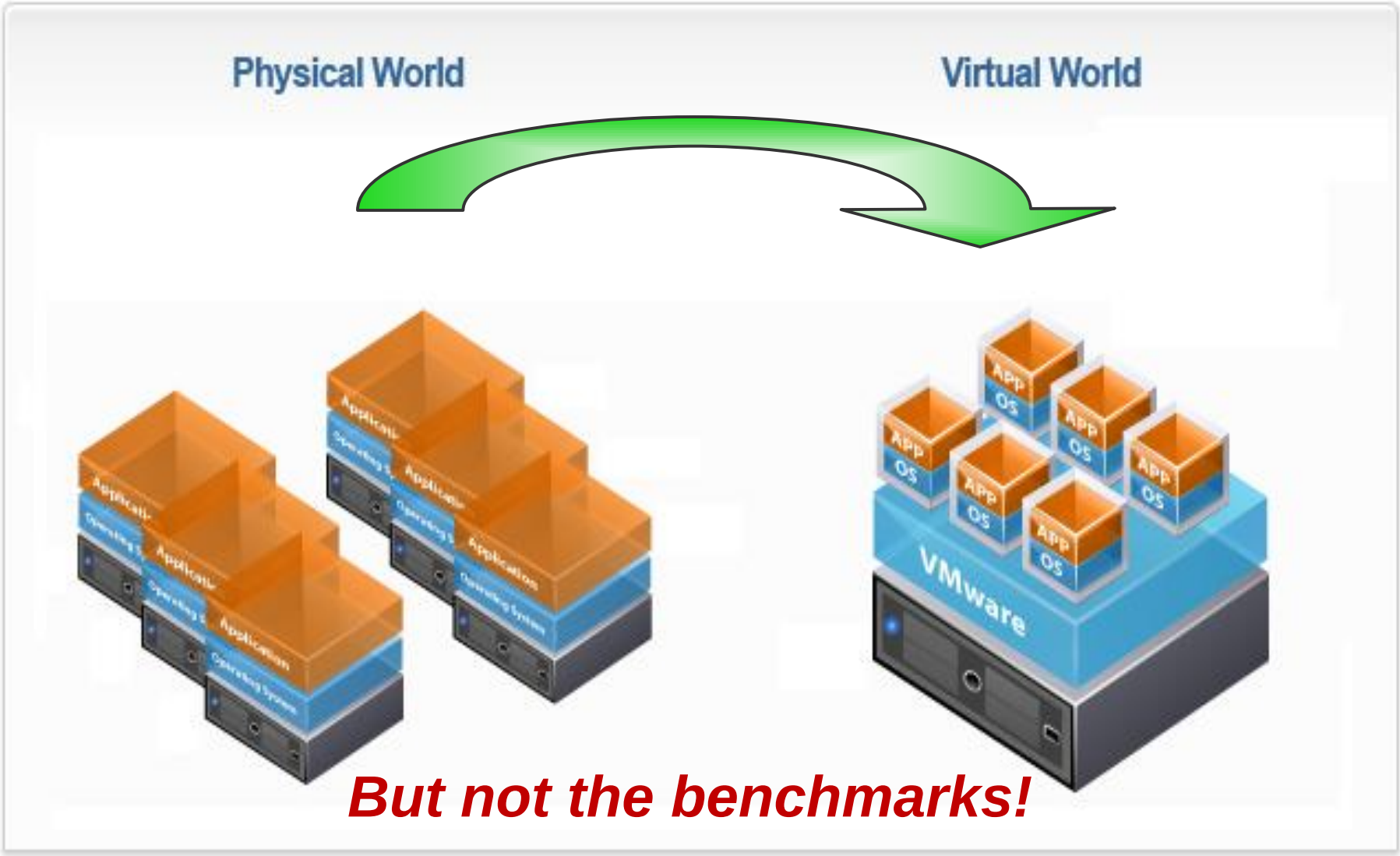
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Overview



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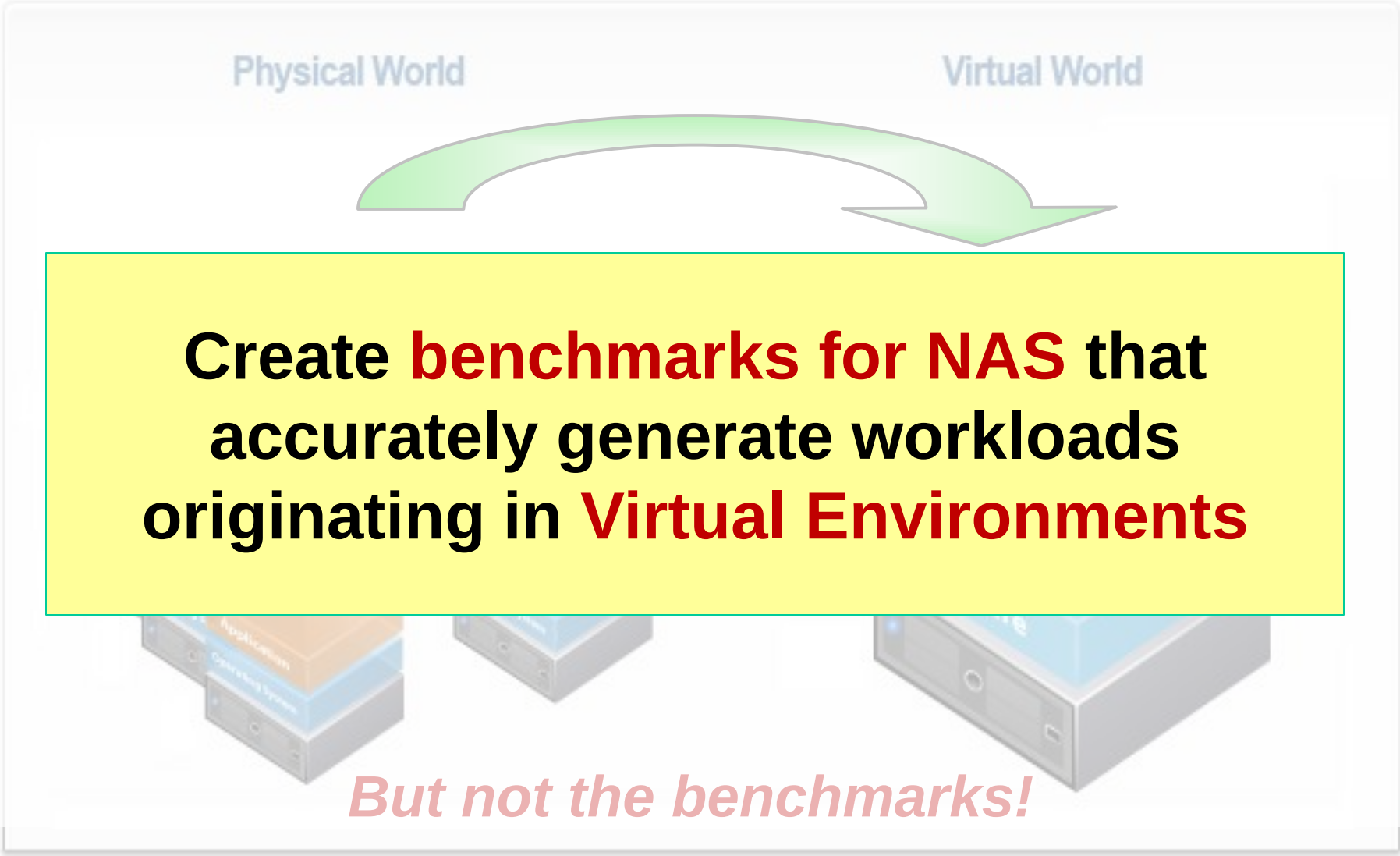
Overview



But not the benchmarks!

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Overview



Create benchmarks for NAS that accurately generate workloads originating in Virtual Environments

But not the benchmarks!

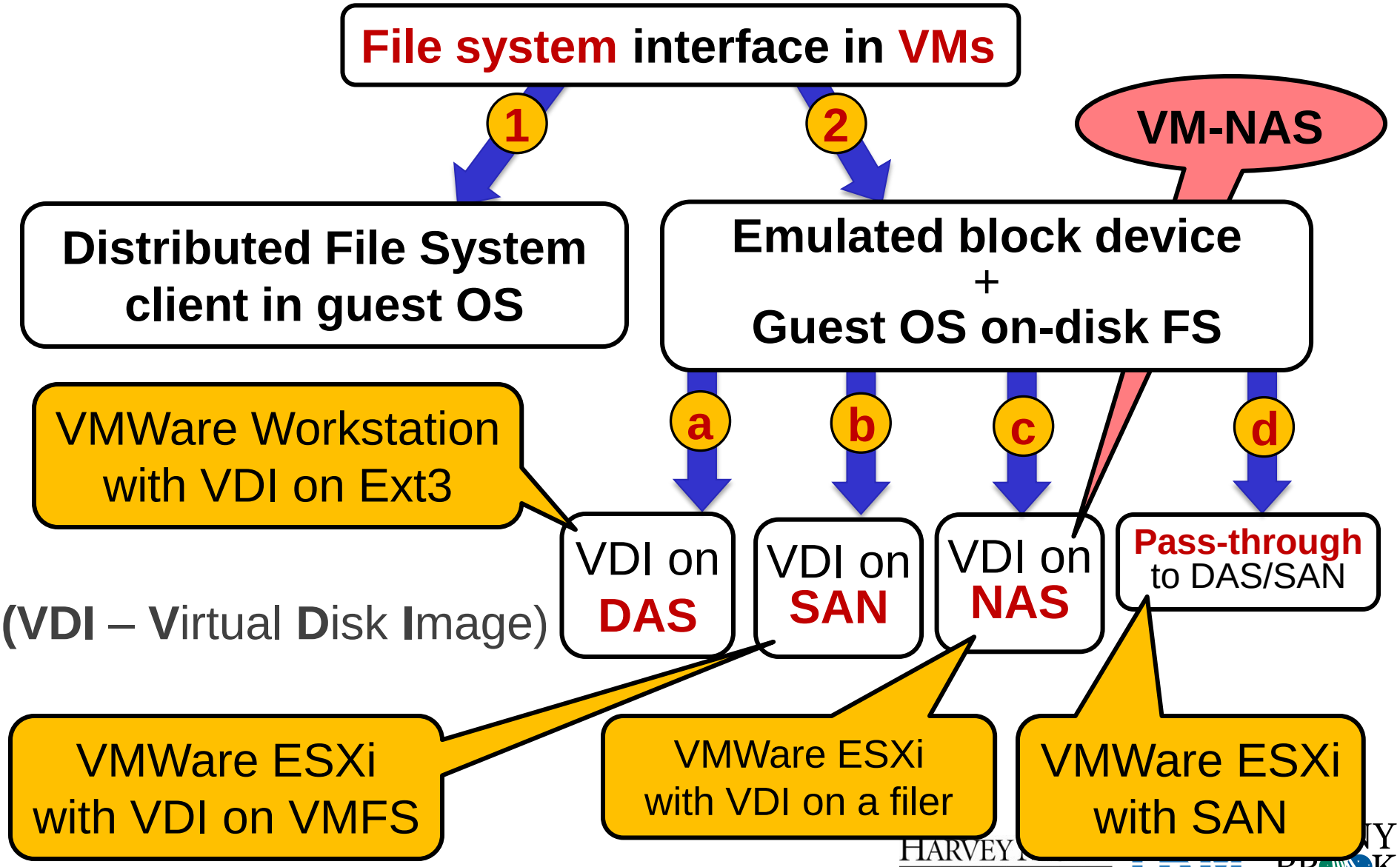
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Outline

1. **Background**
2. Experimental Setup
3. Workload Characterization
4. Benchmark Creation
5. Benchmark Accuracy
6. Conclusions and Future Work

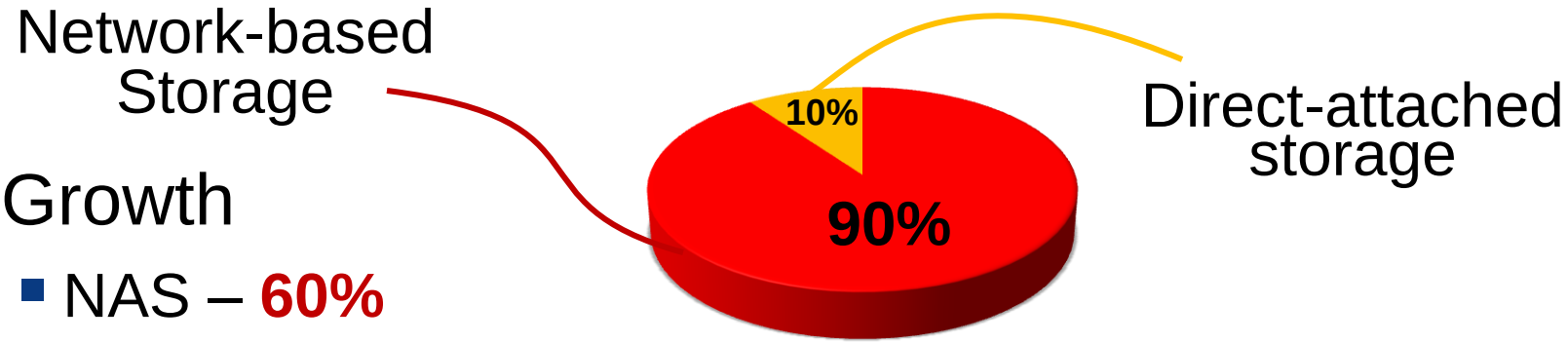
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Data Access Options for VMs



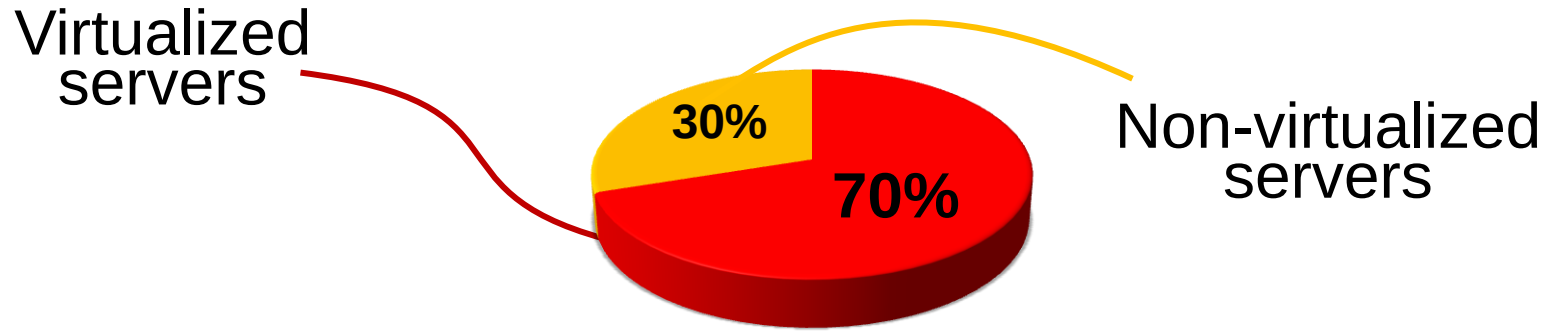
Trends

- **Shipped storage capacity** **[IDC 2010]** **(by 2014)**

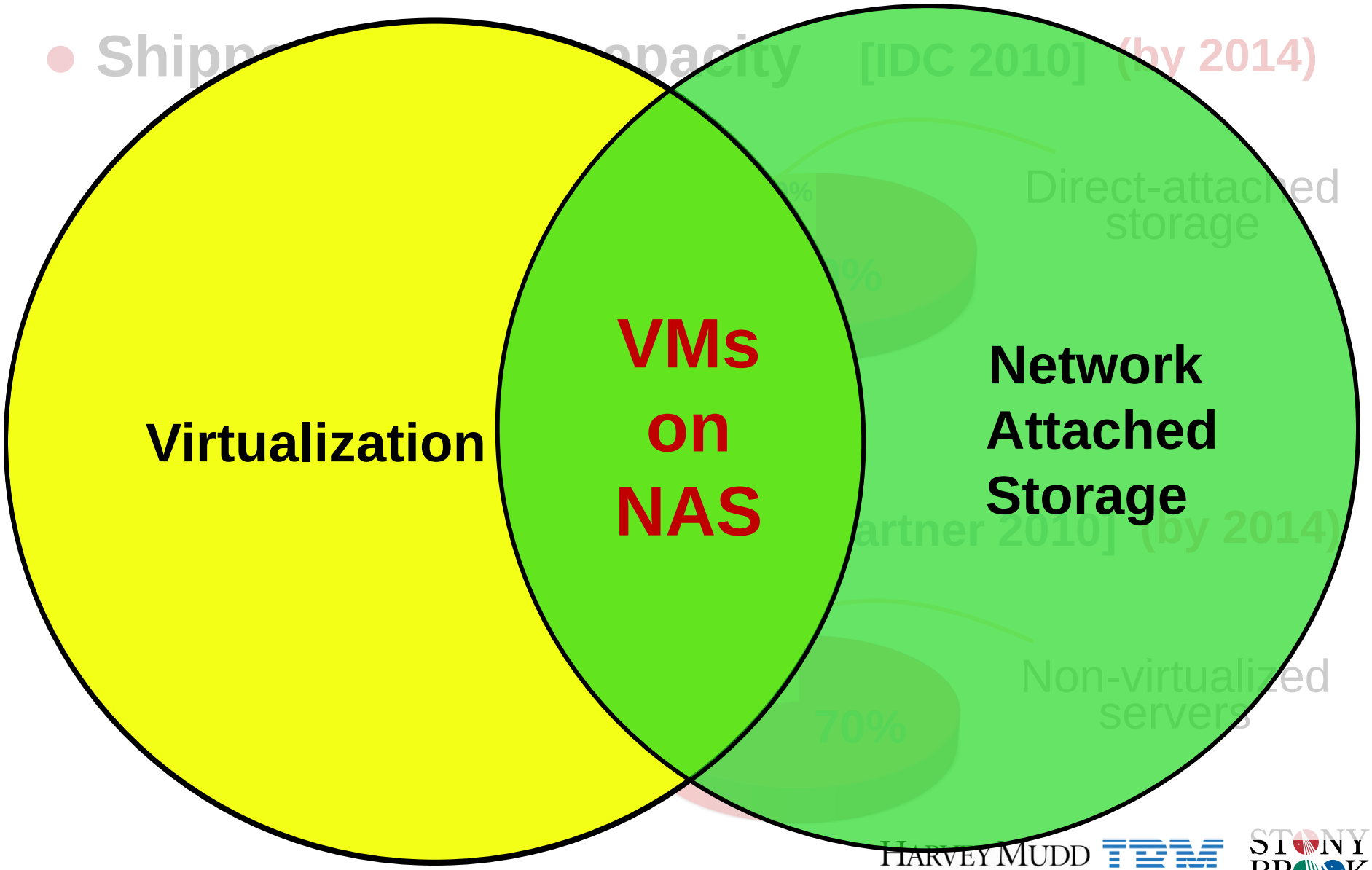


  - Growth
    - NAS – **60%**
    - SAN – 23%

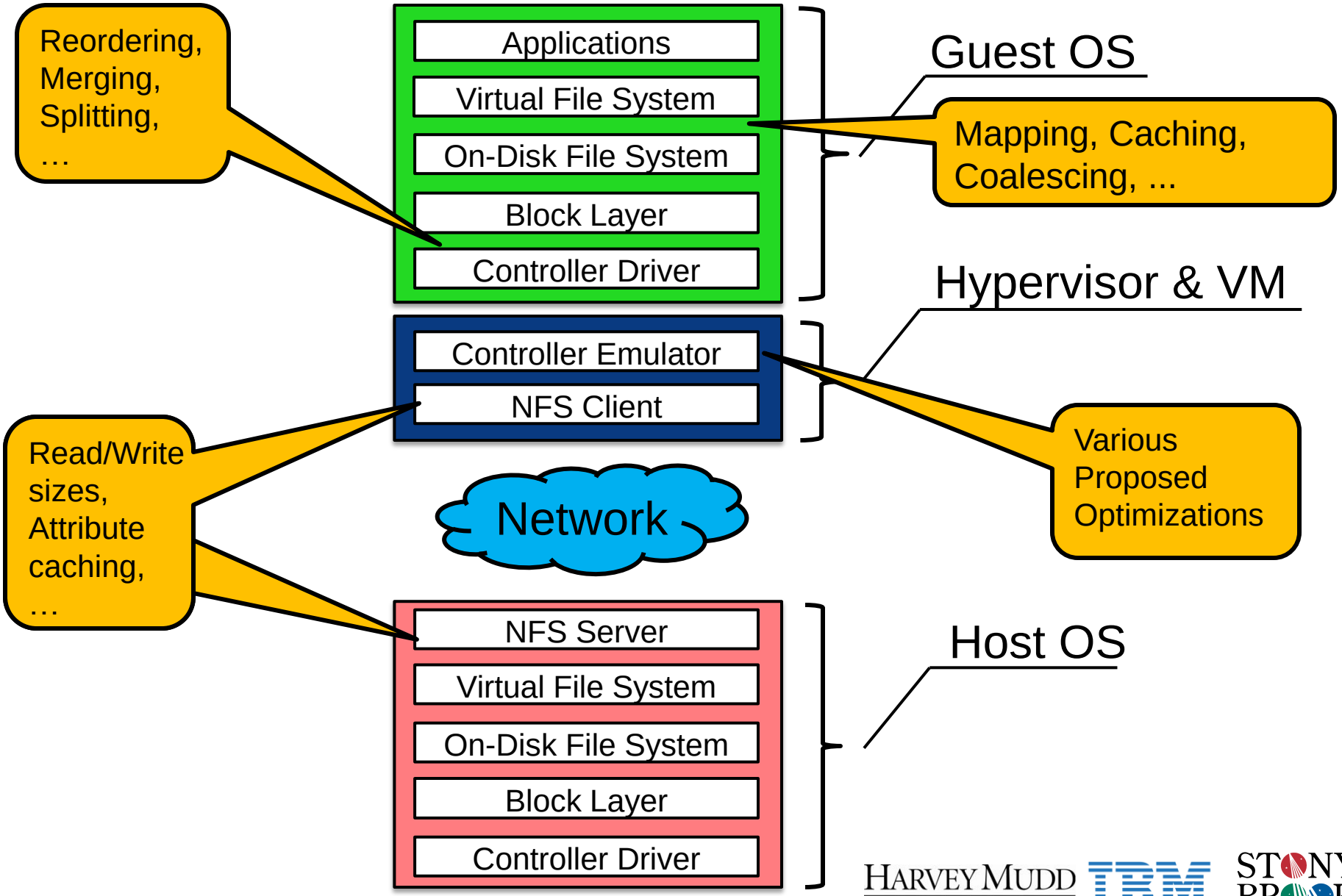
- **x86 server virtualization** **[Gartner 2010]** **(by 2014)**



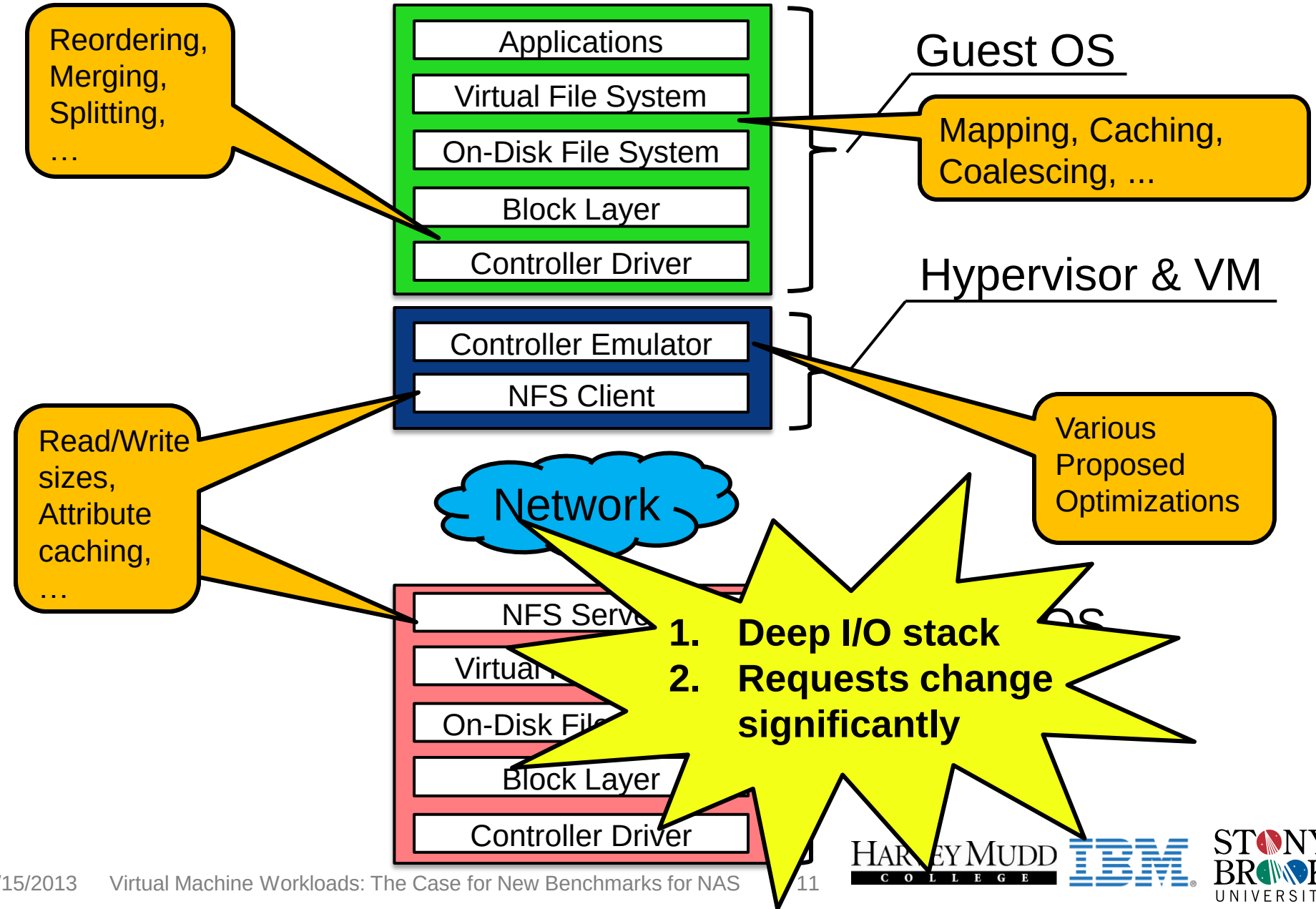
Trends



VM-NAS I/O Stack



VM-NAS I/O Stack

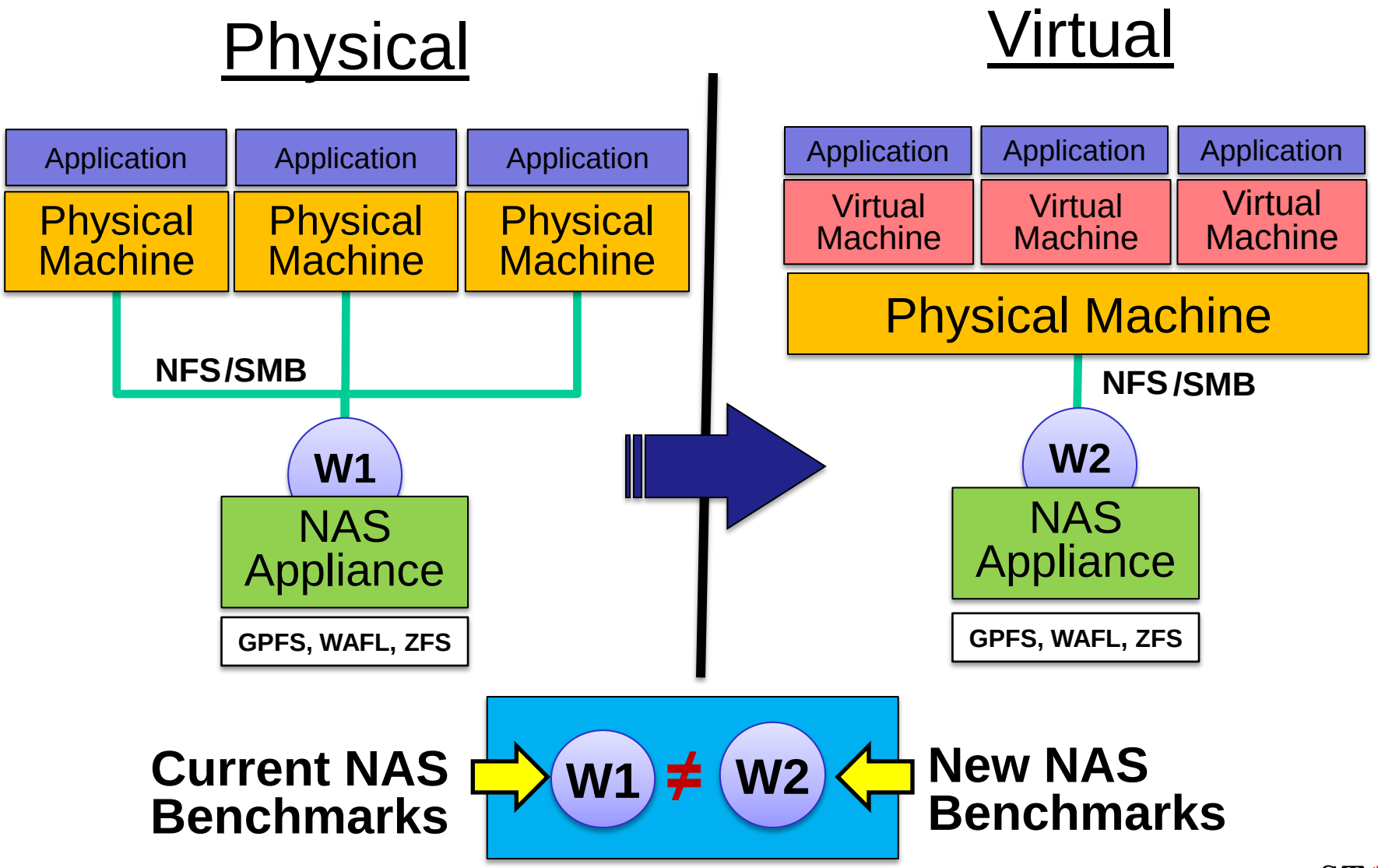


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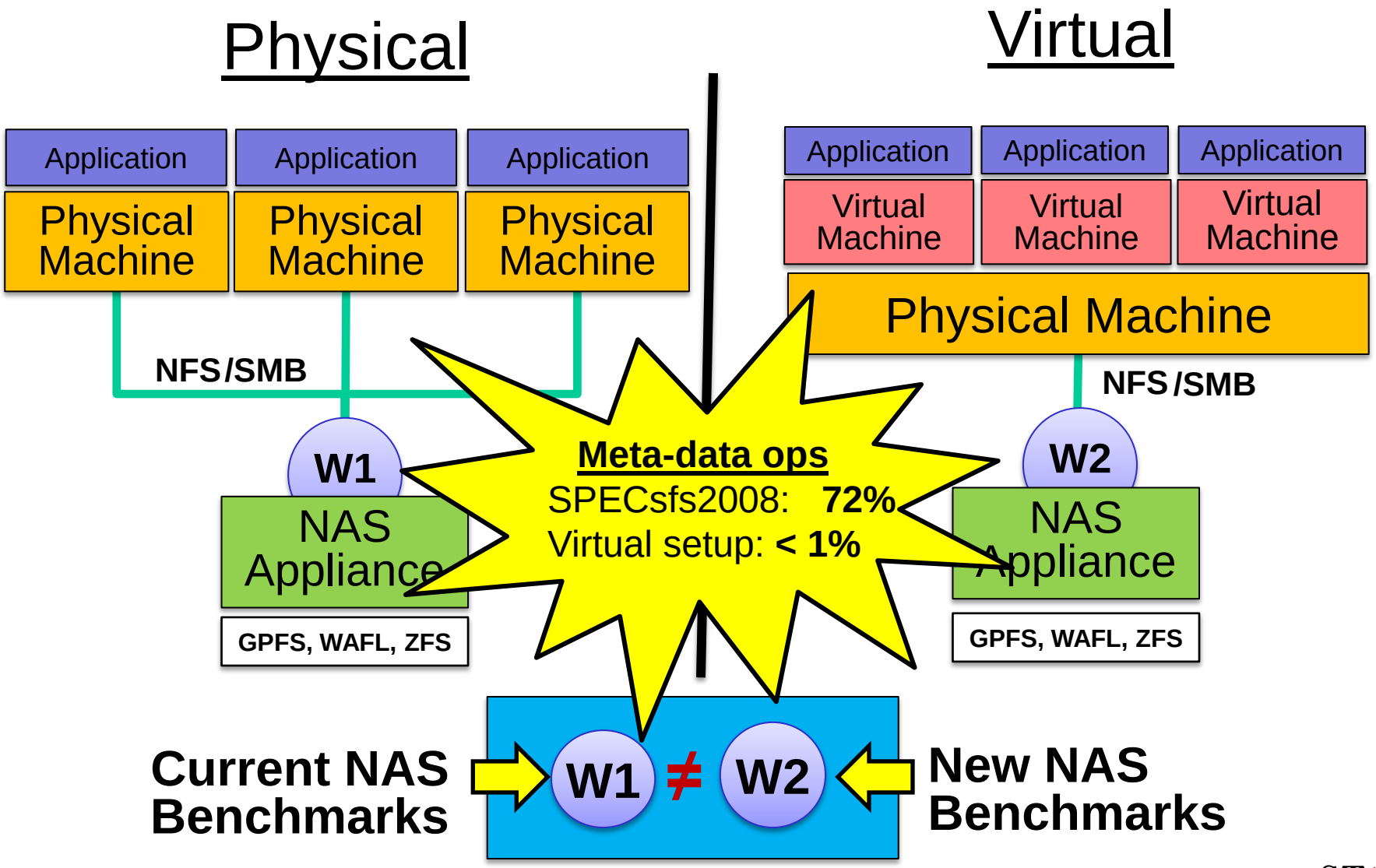
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Physical vs. Virtual



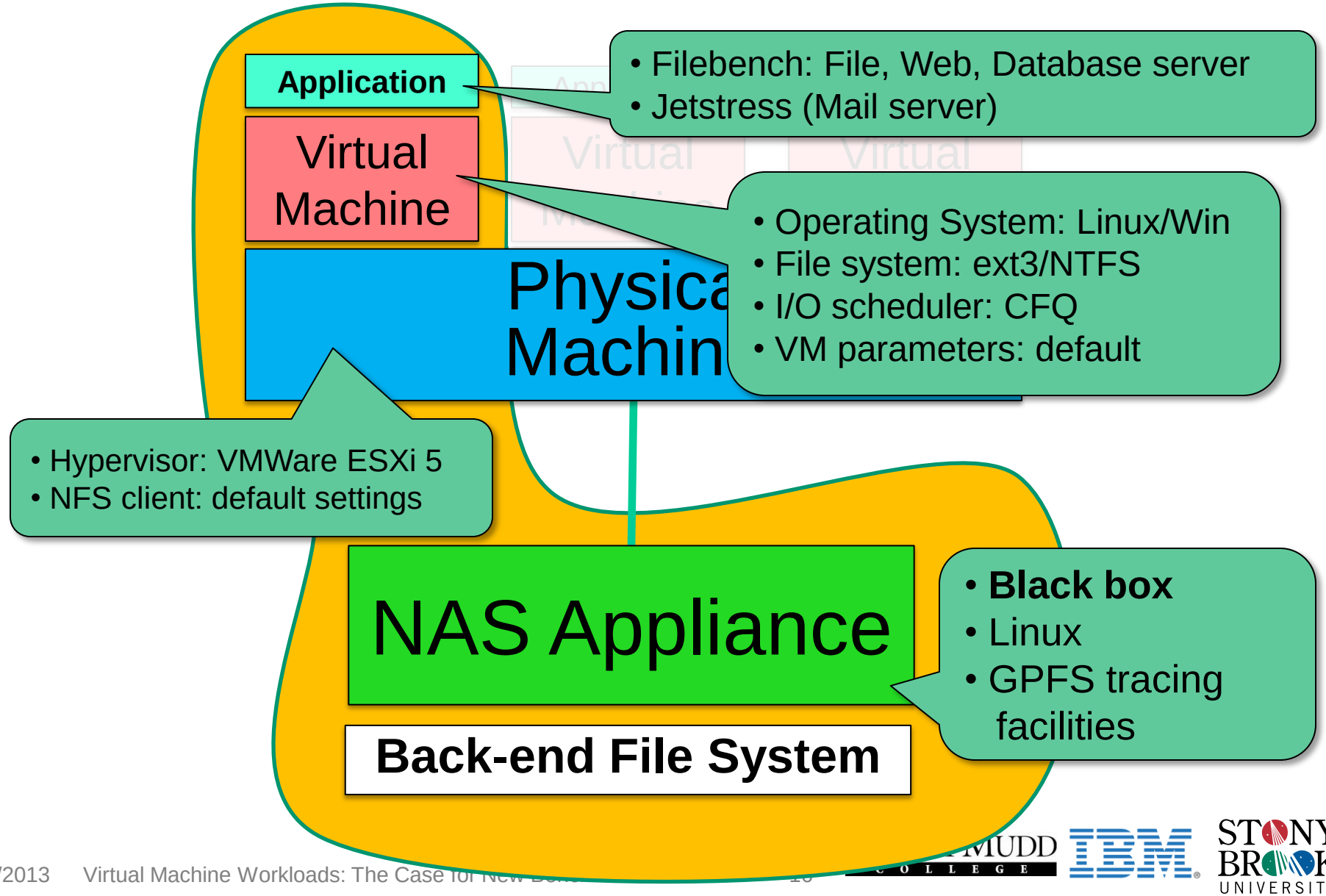
Physical vs. Virtual



How to Evaluate VM-NAS?

- **Run old benchmarks in VMs**
  - Cumbersome
    - Hypervisors, VMs , OSes, applications
  - Inflexible
    - Many combinations of different workloads
  - Expensive
    - Equipment to run hypervisors and VMs
- **Create new benchmarks**

Configuration



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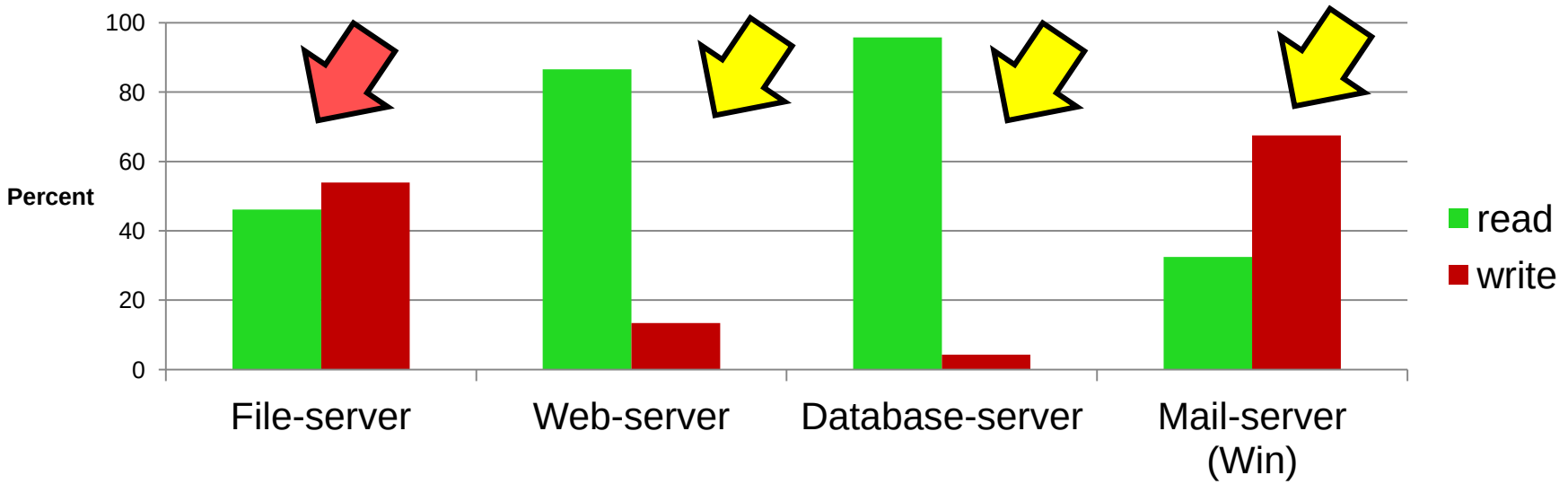
Observations

Workload Property	Physical NAS clients	Virtual NAS clients
File and directory count	Many files and directories	Few files per VM
Directory tree depth	Deep and non-uniform	Shallow and uniform
File size	Lean towards small files	Multi-gigabyte, but sparse
Meta-data operations	Many	Almost none
I/O synchronization	Async and sync	All writes are sync
In-file randomness	Workload-dependent	Increased randomness
Cross-file randomness	Workload-dependent	Predictable
I/O sizes	Workload-dependent	Increased and decreased
Read-modify-write	Infrequent	More frequent
Think time	Workload-dependent	Increased

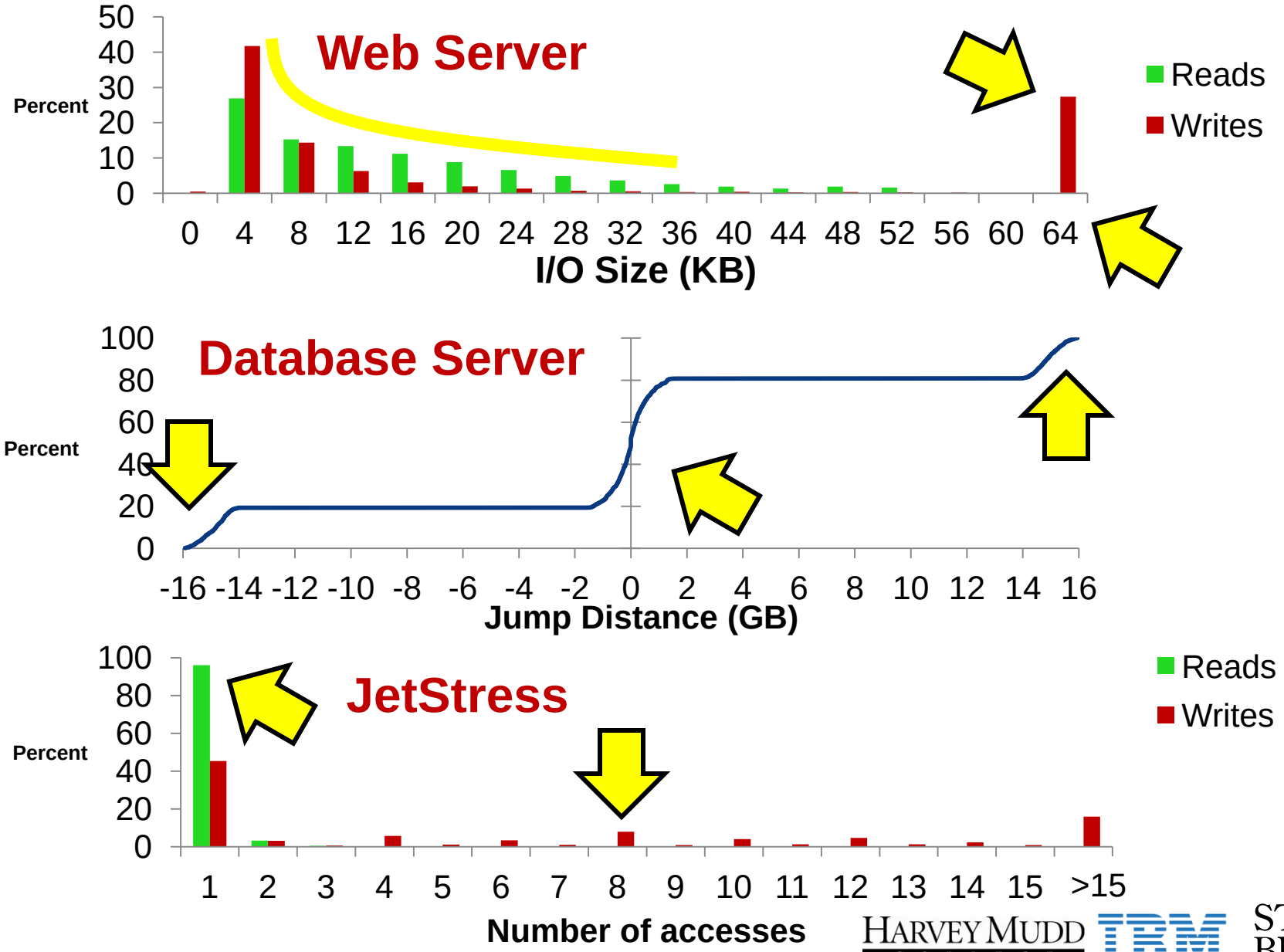
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Workload Features

- Read/write ratio
- I/O Size distribution
- Jump distance distribution
  - LBA distance between two consecutive requests
- Offset reuse



I/O Size, Jump Distance, Offset Popularity

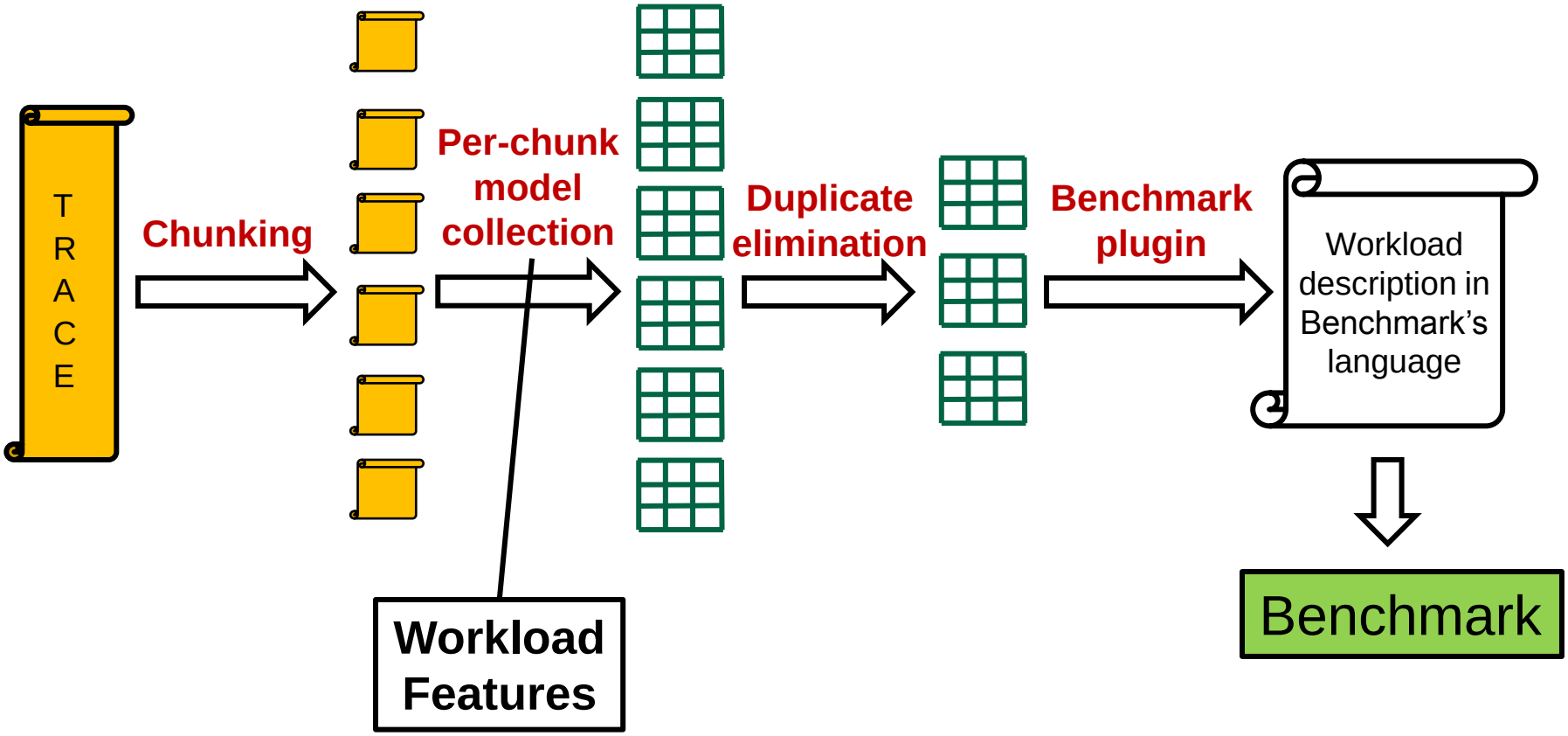


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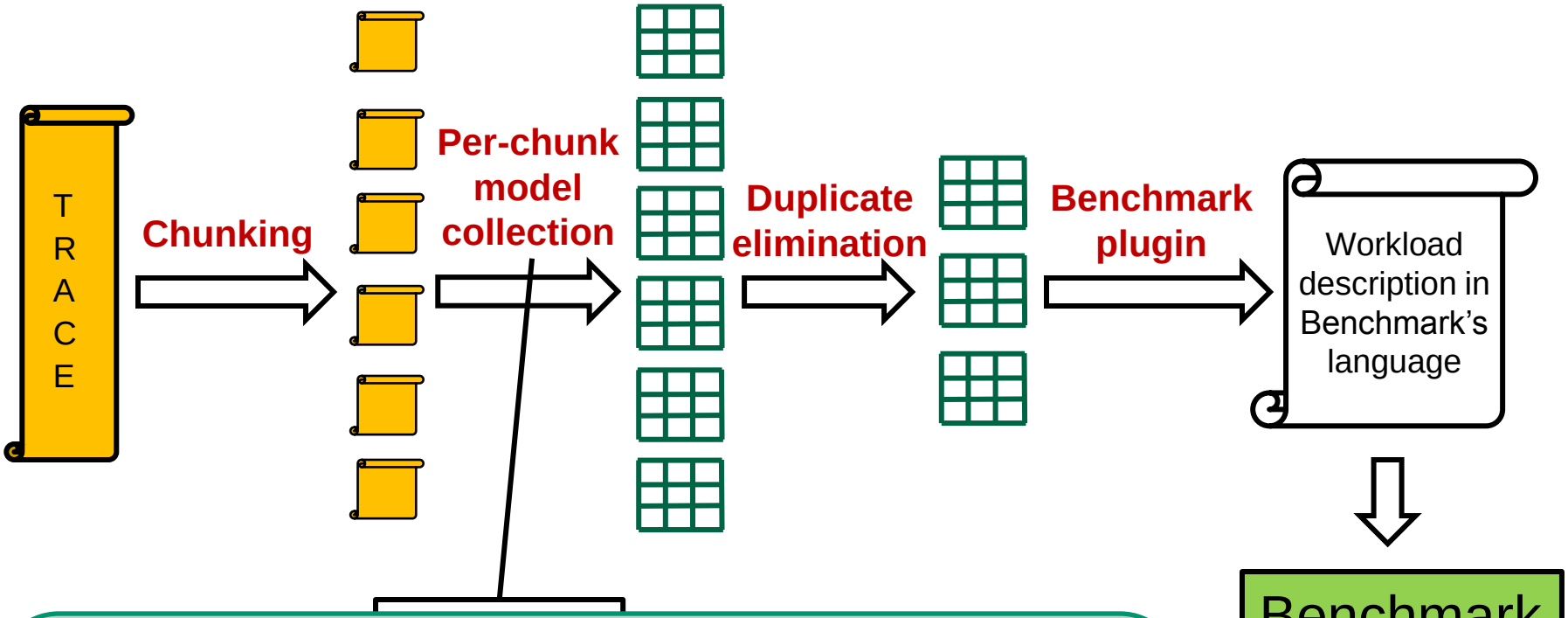
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T2M Converter



T2M Converter



1. Benchmarks generate stationary workloads – almost **no chunking**
2. Block level traces ➡ NFS traces
   But **block-on-file**.

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Multi-VM Declarations

- Define hypervisors and VM:

```
define hypervisor type=esx51 {

        define vm type=fileserver,instances=5 {
                …
        }

        define vm type=webserver,instances=2 {
                …
        }
}
```


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Outline

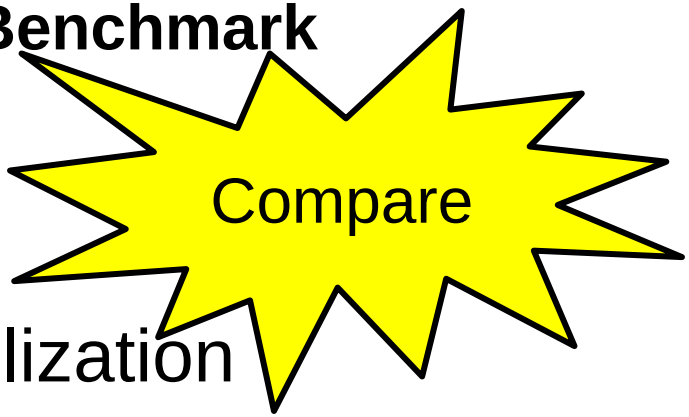
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Accuracy Metrics

1 **Non-virtualized Benchmark in VM**

2 **Virtualized Benchmark**

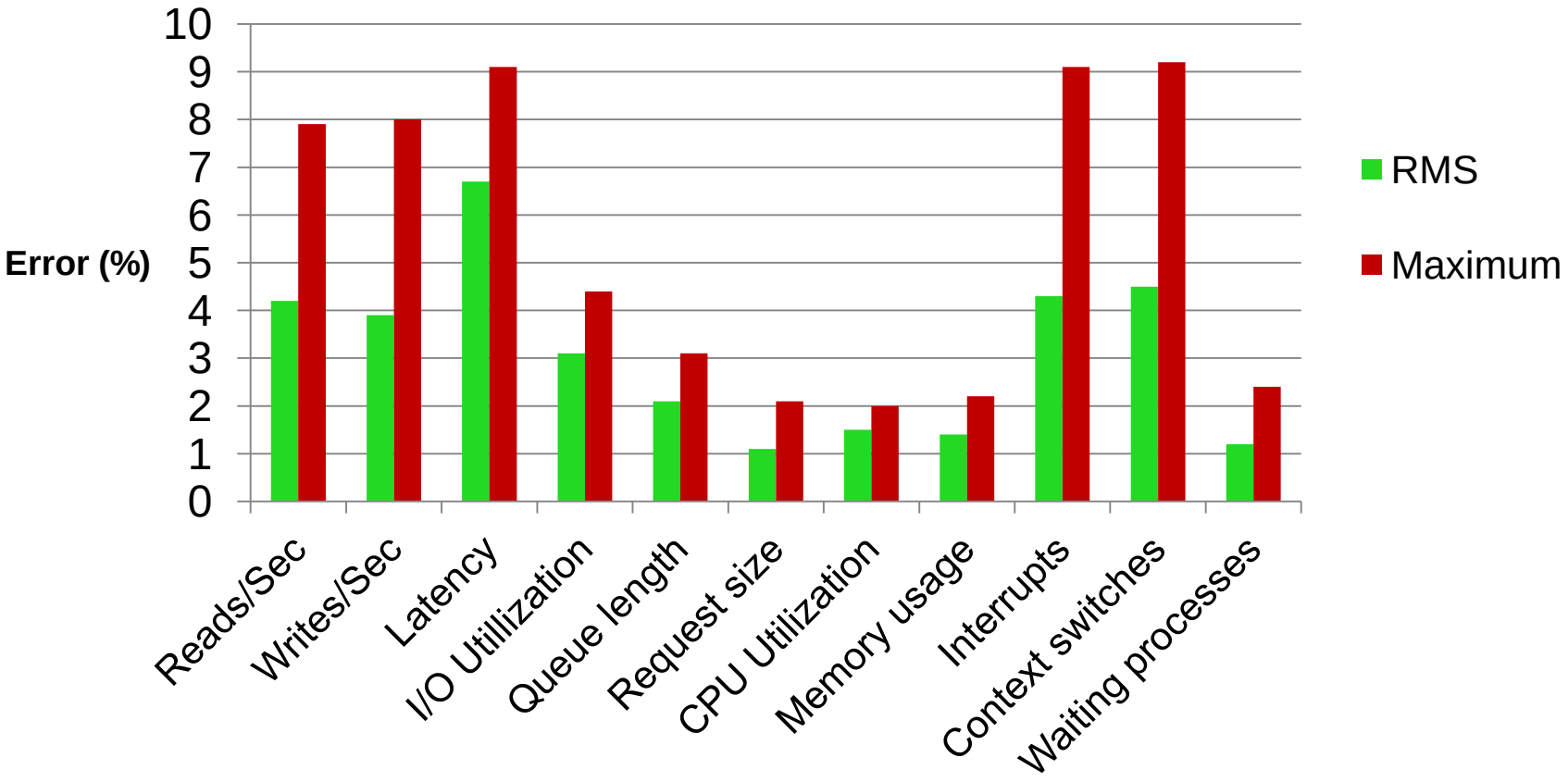


Monitored NAS parameters:

- Reads/Sec
- Writes/Sec
- Latency
- I/O Utilization
- Queue length
- Request size
- CPU Utilization
- Memory usage
- Interrupts
- Context switches
- Waiting processes

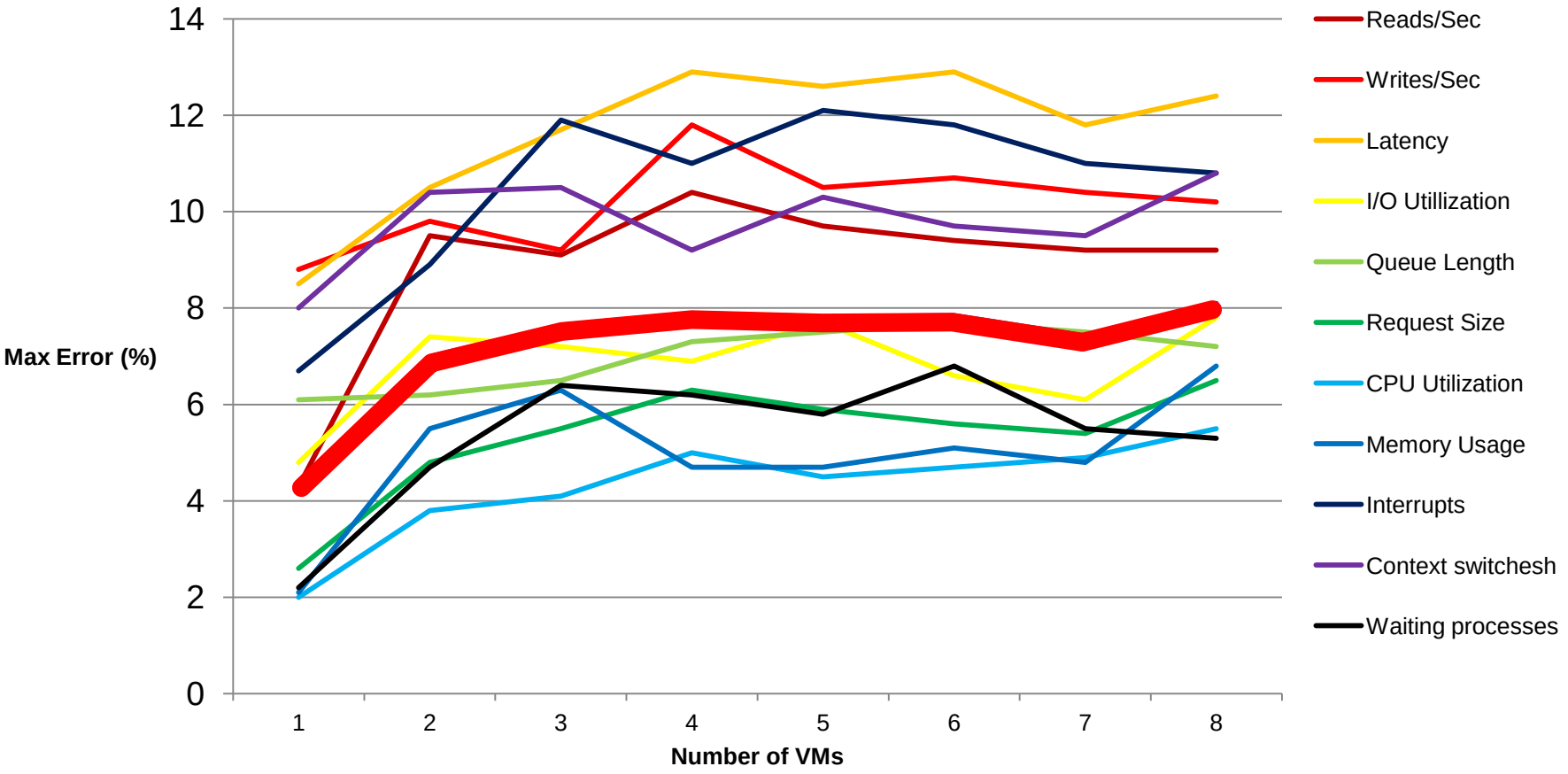
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Single VM Accuracy (Web-Server)



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Multi-VM Accuracy



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Conclusions

- Virtualization causes NAS workloads to change
- Current benchmarks are no longer representative
- Need for VM-oriented benchmarks
  - Trace-based analysis of VM-NAS workloads
  - Trace2Model for NFS traces
  - Created a set of VM-benchmarks
  - Accuracy within 10% on average

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Future Work

- Explore other configurations
  - The impact of VM-NAS parameters
  - VM workload classification
- VM-specific workloads
  - snapshotting, boot and update storms
- Emulate I/O request transformations
  - Multi-level trace analysis
  - Higher flexibility

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Vasily Tarasov,[✶] Dean Hildebrand,[×] Geoff Kuenning,[⅄] Erez Zadok[✶]

[✶]**Stony Brook University,** [×]**IBM Research – Almaden,** [⅄]**Harvey Mudd College**

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