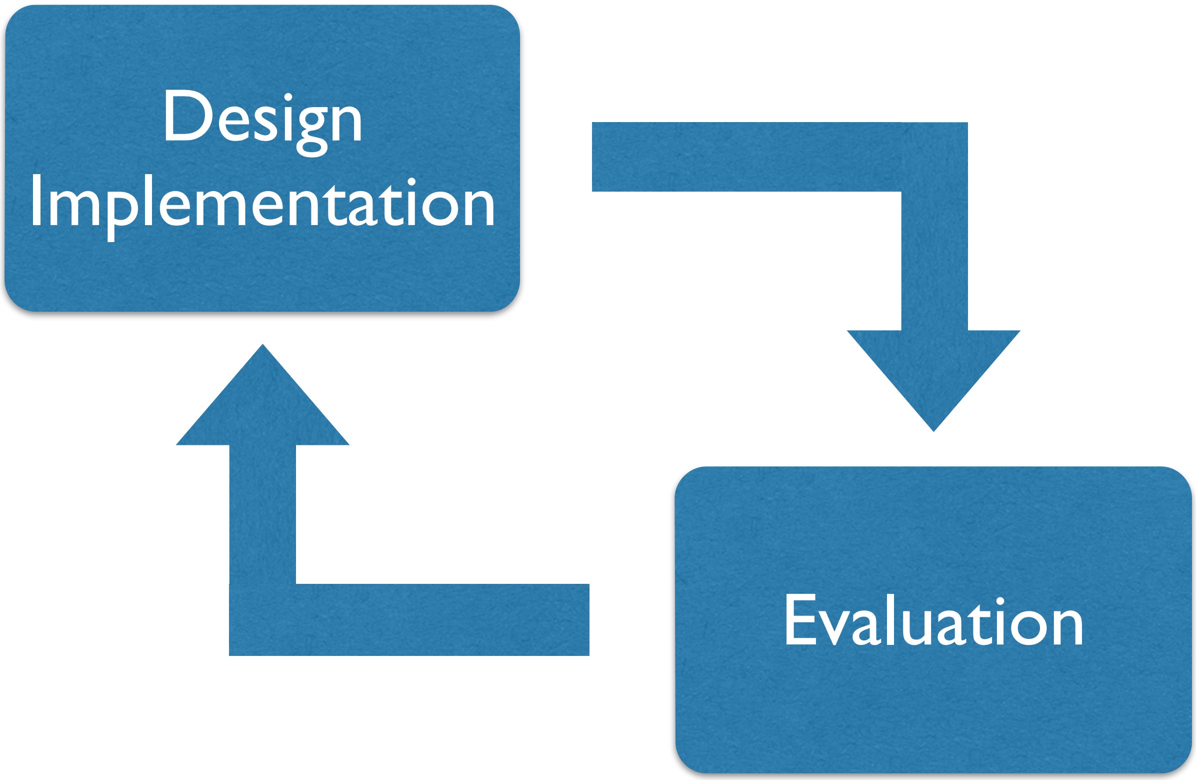
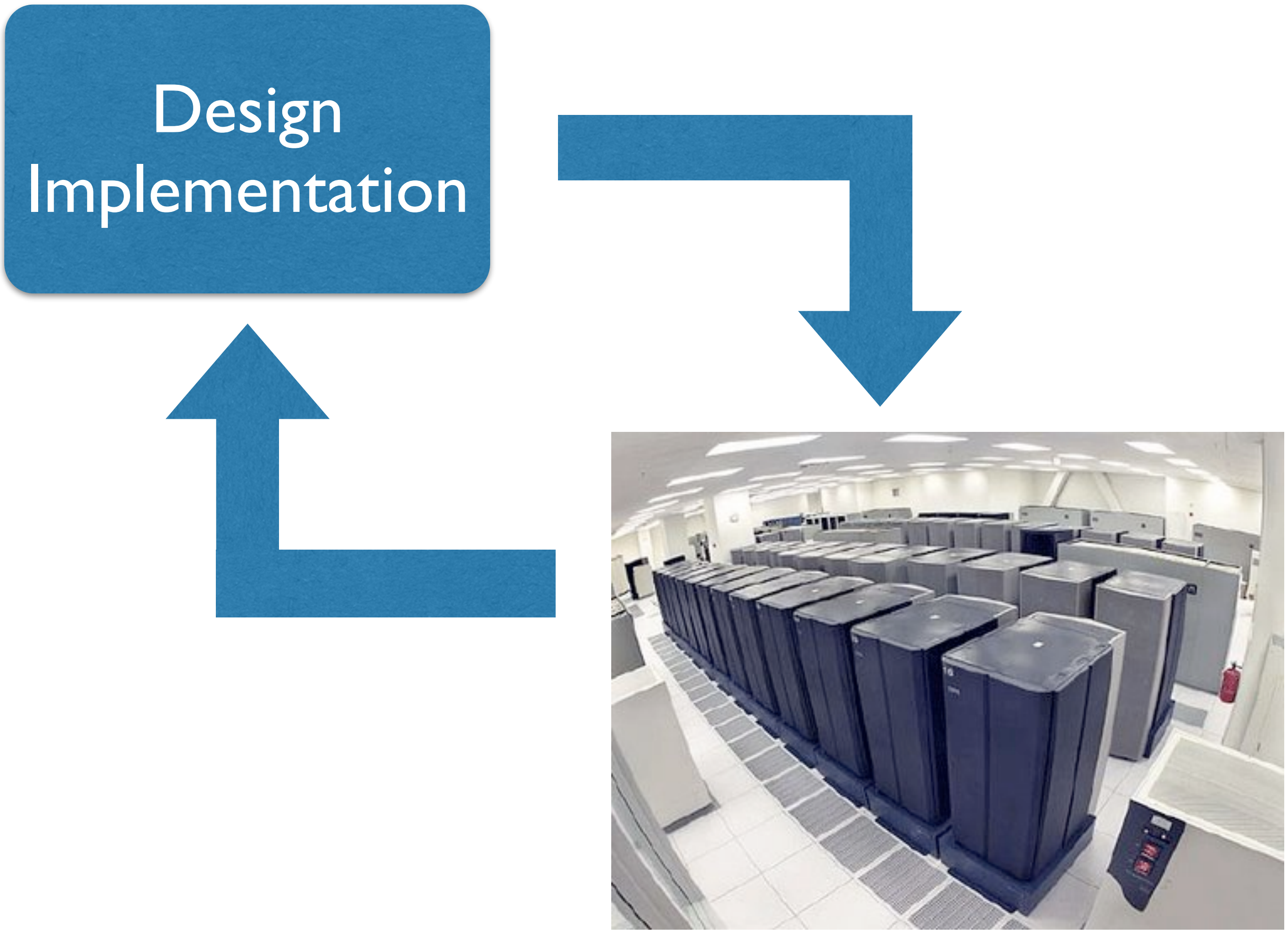
# Exalt: Empowering Researchers to Evaluate Large-Scale Storage Systems

Yang Wang, Manos Kapritsos, Lara Schmidt,
Lorenzo Alvisi, and Mike Dahlin
The University of Texas at Austin

# We need to evaluate our prototypes



# We need to evaluate our prototypes



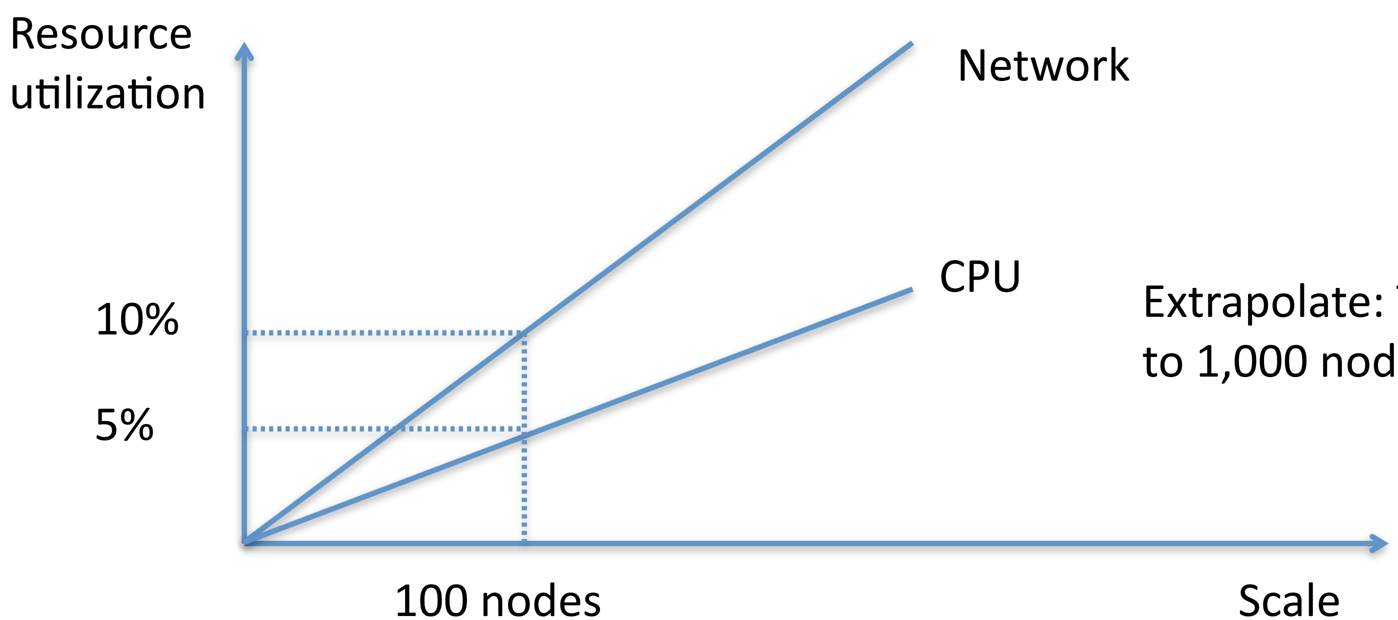

Industrial deployment:
tens of PBs
thousands of nodes

Researchers:
hundreds of TBs
hundreds of nodes

- Salus (Wang et al. NSDI 13): 108 servers
- Eiger (Lloyd et al. NSDI 13): 256 servers
- Spanner (Corbett et al. OSDI 12): Hundreds of servers

# Extrapolation?

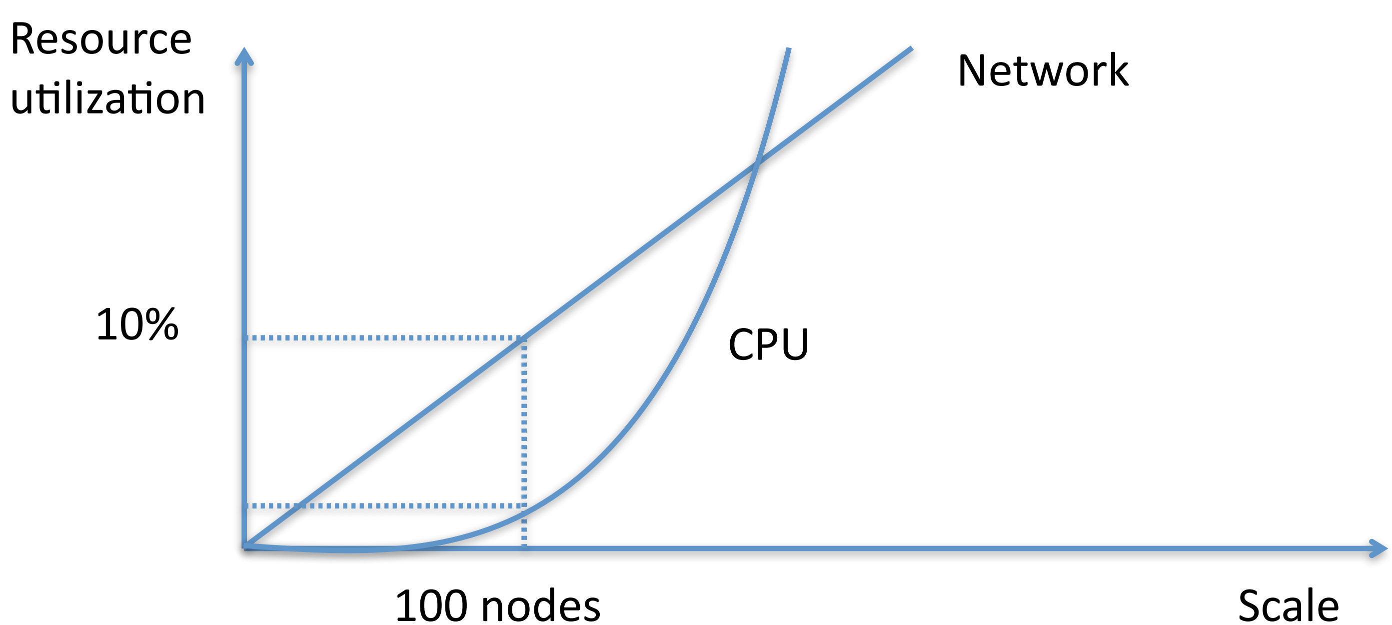
- Measure with a small cluster
- Predict the behavior at full scale
- Assumption:
  - Resource consumption grows linearly with scale



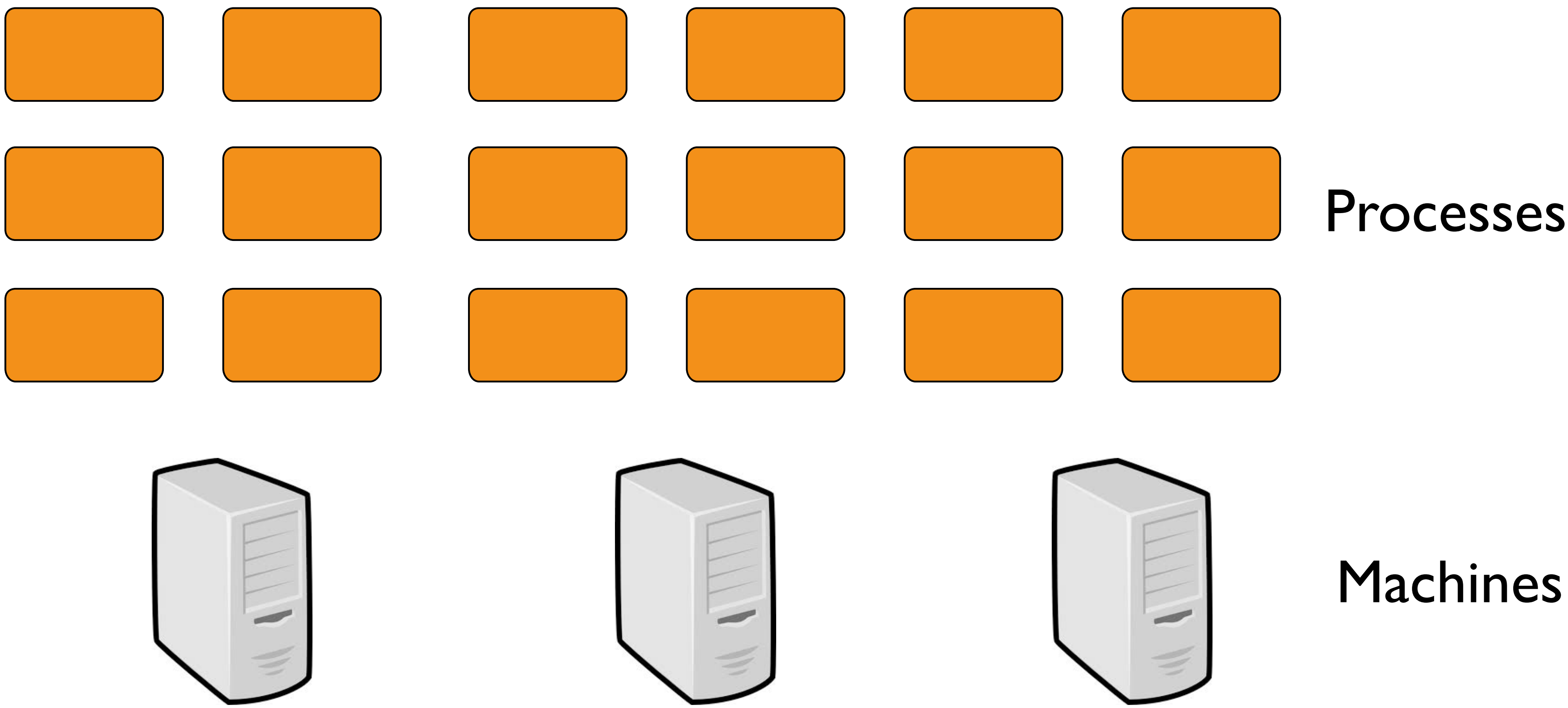

Extrapolate: The system can scale to 1,000 nodes.

# Extrapolation?

- Measure with a small cluster
- Predict the behavior at full scale
- Assumption: May not hold
  - ~~Resource consumption grows linearly with scale~~

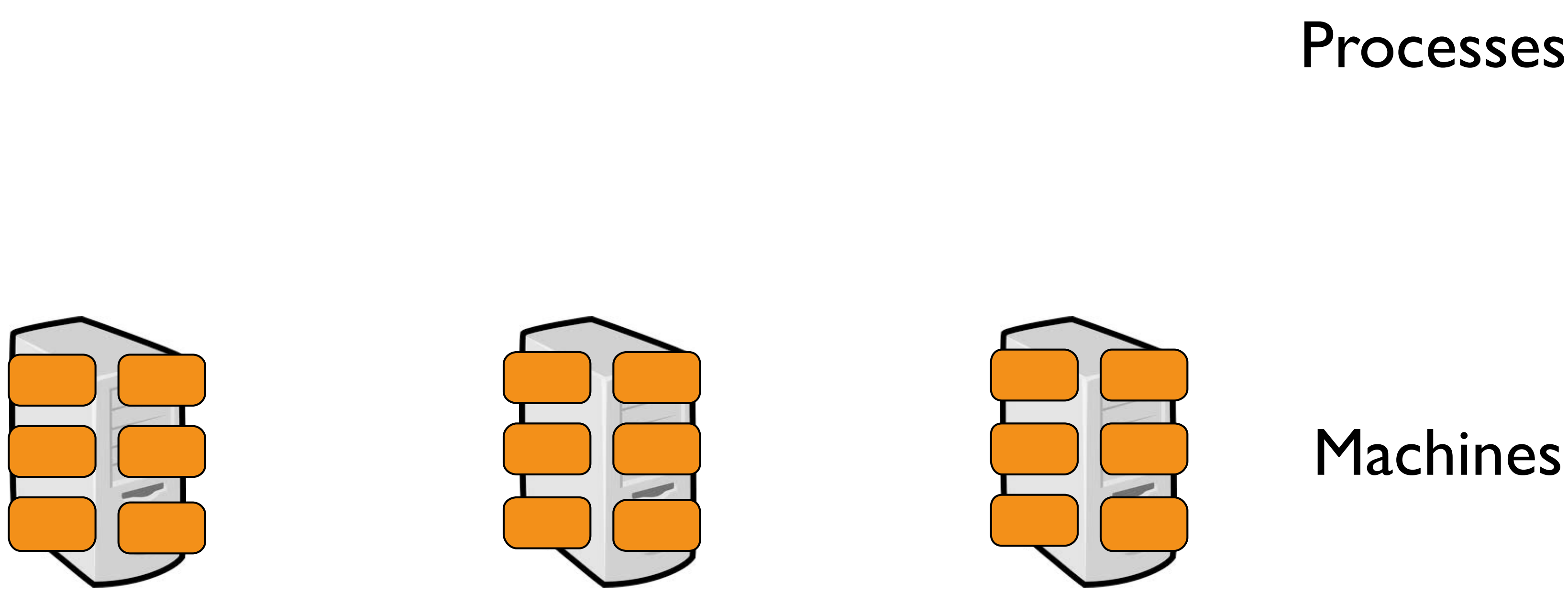


# Can we run prototypes at full scale?



# Can we run prototypes at full scale?

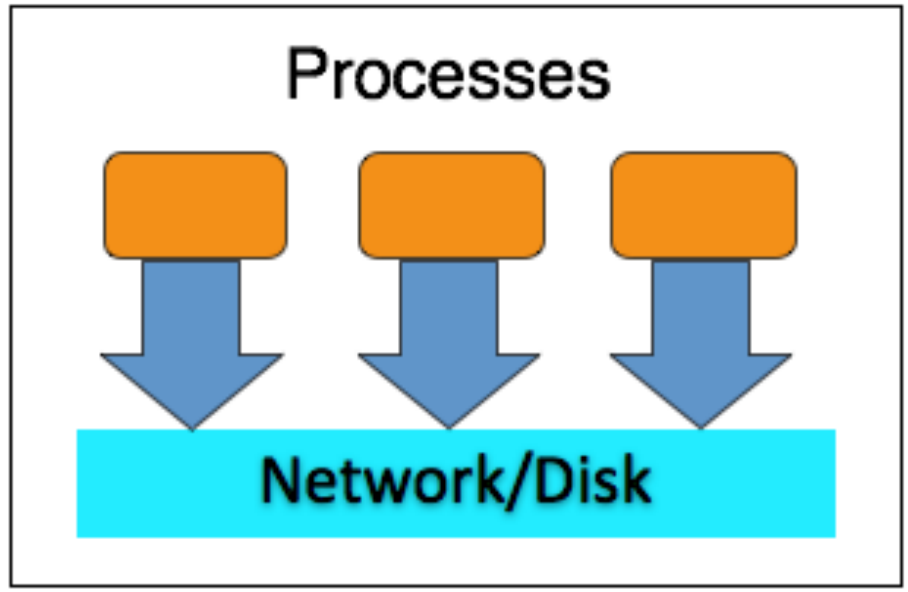
- Colocate multiple processes on one node

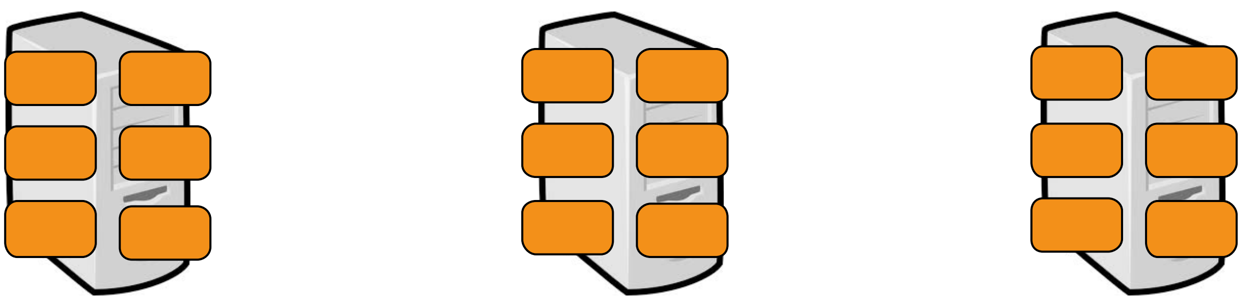


# Can we run prototypes at full scale?

- Colocate multiple processes on one node

**Problem:**
**Limited I/O resource**



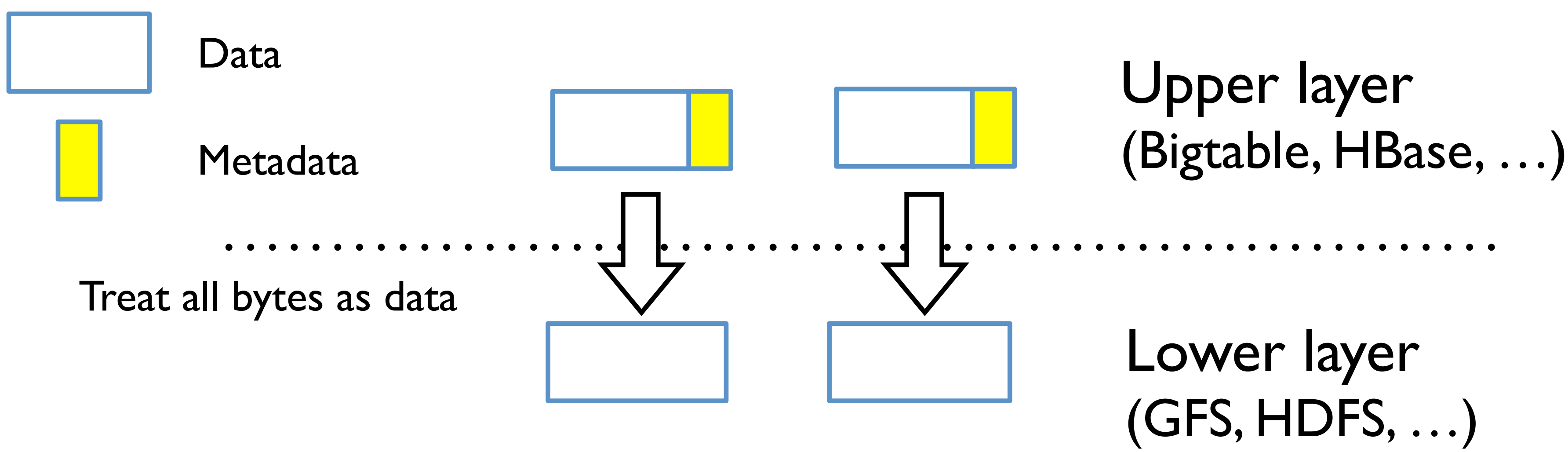
Machines

# Data content doesn't affect system behavior

- Clients can write/read synthetic data
- Abstract away data on I/O devices
- Reduce resource requirement of each process

# How to abstract away data?

- Discard data? (David, Agrawal et al. FAST 2011)
  - Doesn't work with large-scale storage systems



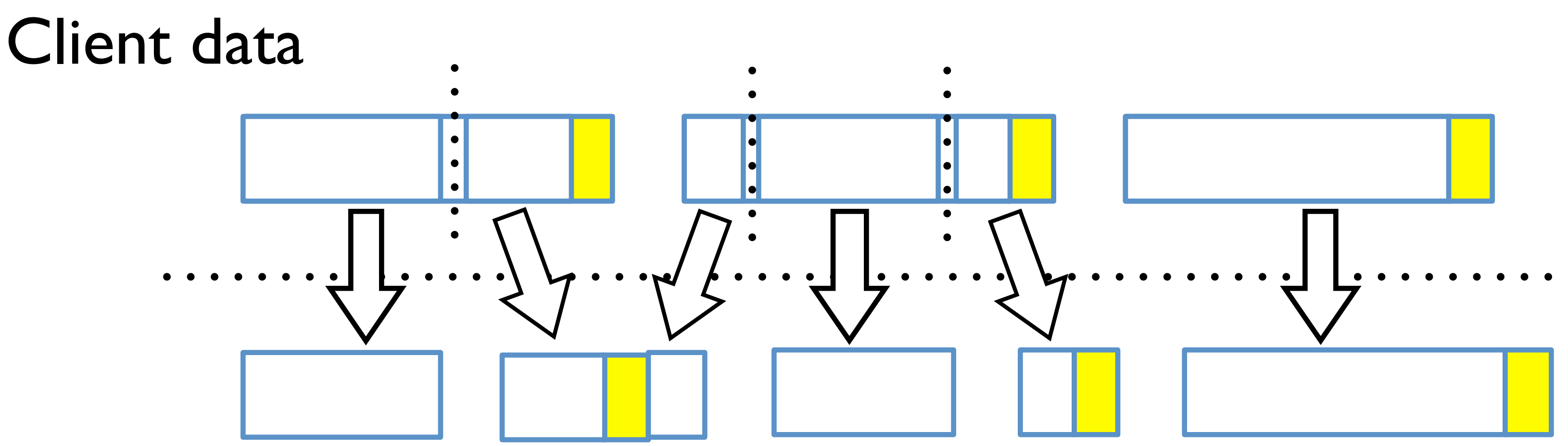

- Our approach: Compress data

# Requirements of compression

- CPU efficient
  - General-purpose algorithms (e.g. Gzip) are CPU heavy
- High compression ratio
- Lossless compression
- Be able to work with mixed data and metadata

# Challenge: Data mixed with metadata

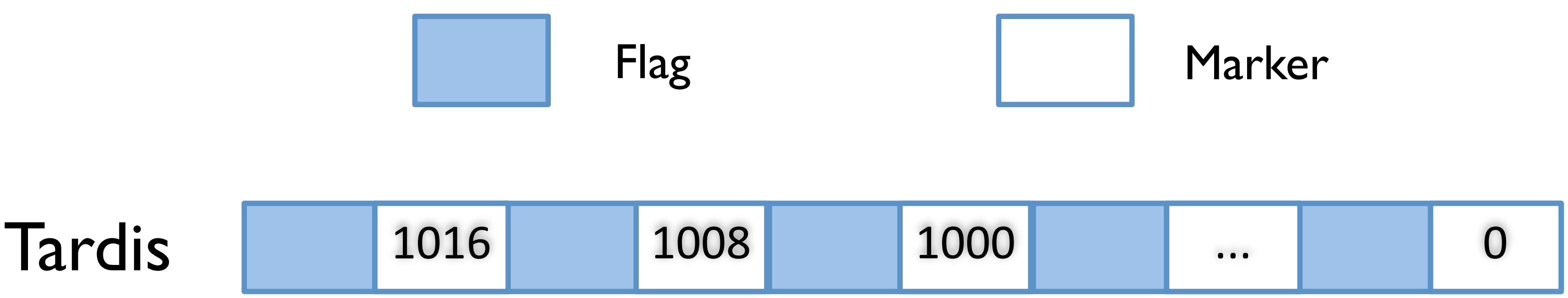
- System may add metadata
- System may split data (possibly nondeteministically)




**Key: Locate metadata inside data**

# Solution: Tardis data pattern

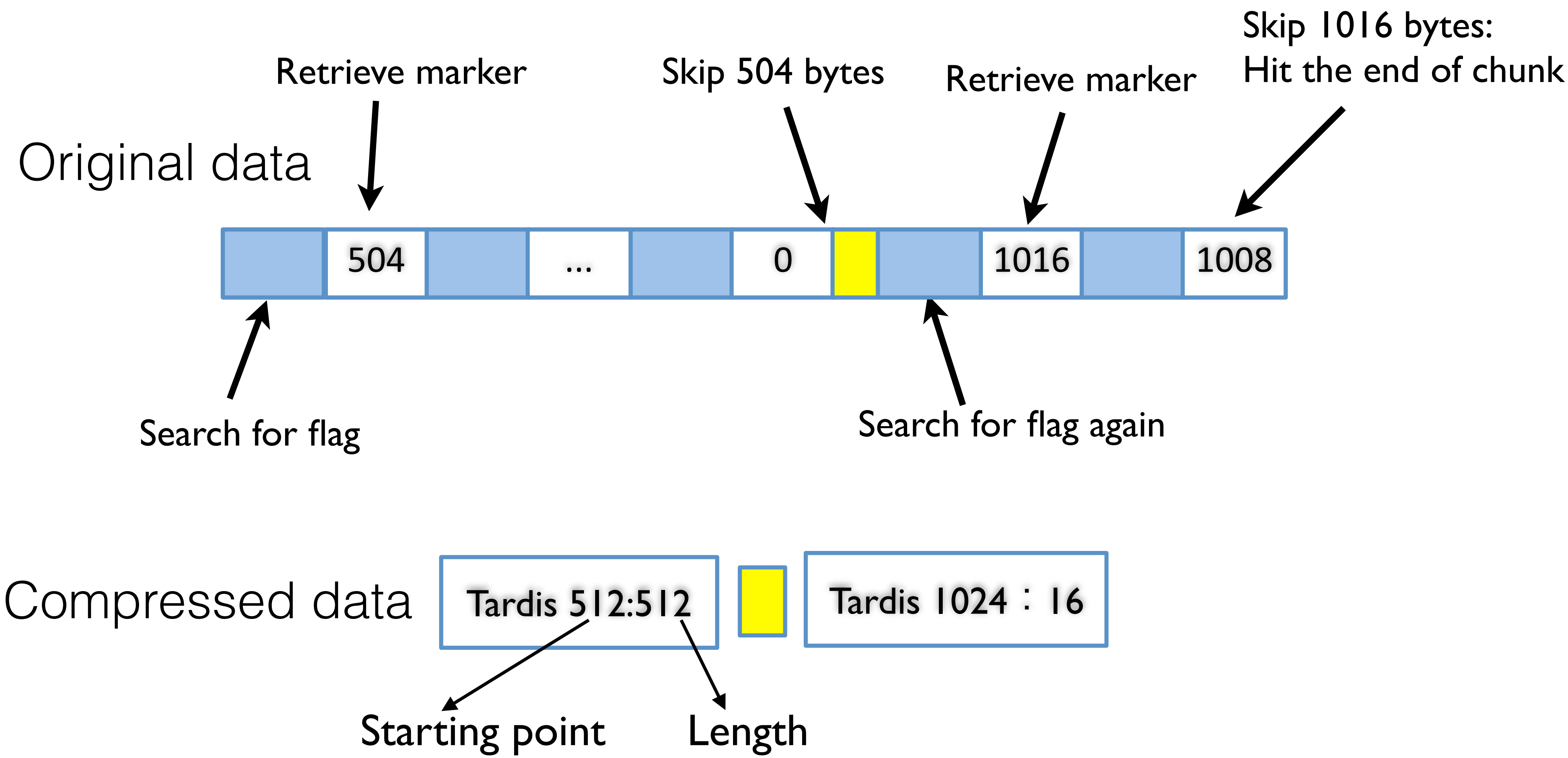
- Make data distinguishable from metadata
  - **Flag**: sequence of bytes that does not appear in metadata
- Efficiently locate metadata: Follow sorted pattern
  - **Marker**: number of remaining bytes to the end




1KB data chunk and 4-byte flags and markers

# Tardis compression

33,000 times faster than gzip



# How to find an appropriate flag?

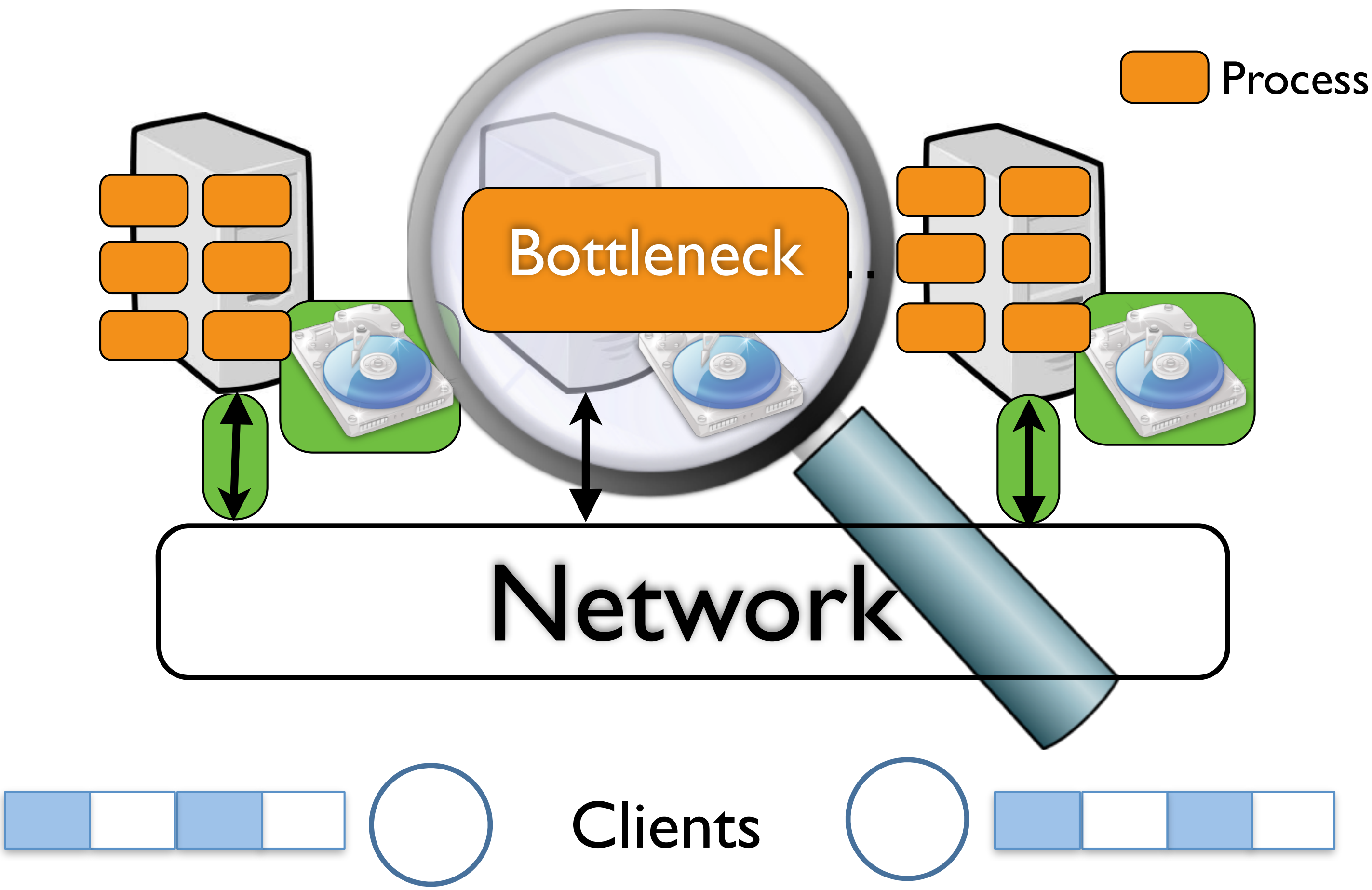
- Scan all metadata: Expensive

- Observation: Tardis is only used for testing

- A randomly chosen 8-byte flag works
  - HDFS
  - HBase

# Testing with Tardis

- Run potential bottleneck nodes in real mode.
- Run most nodes in emulated mode.



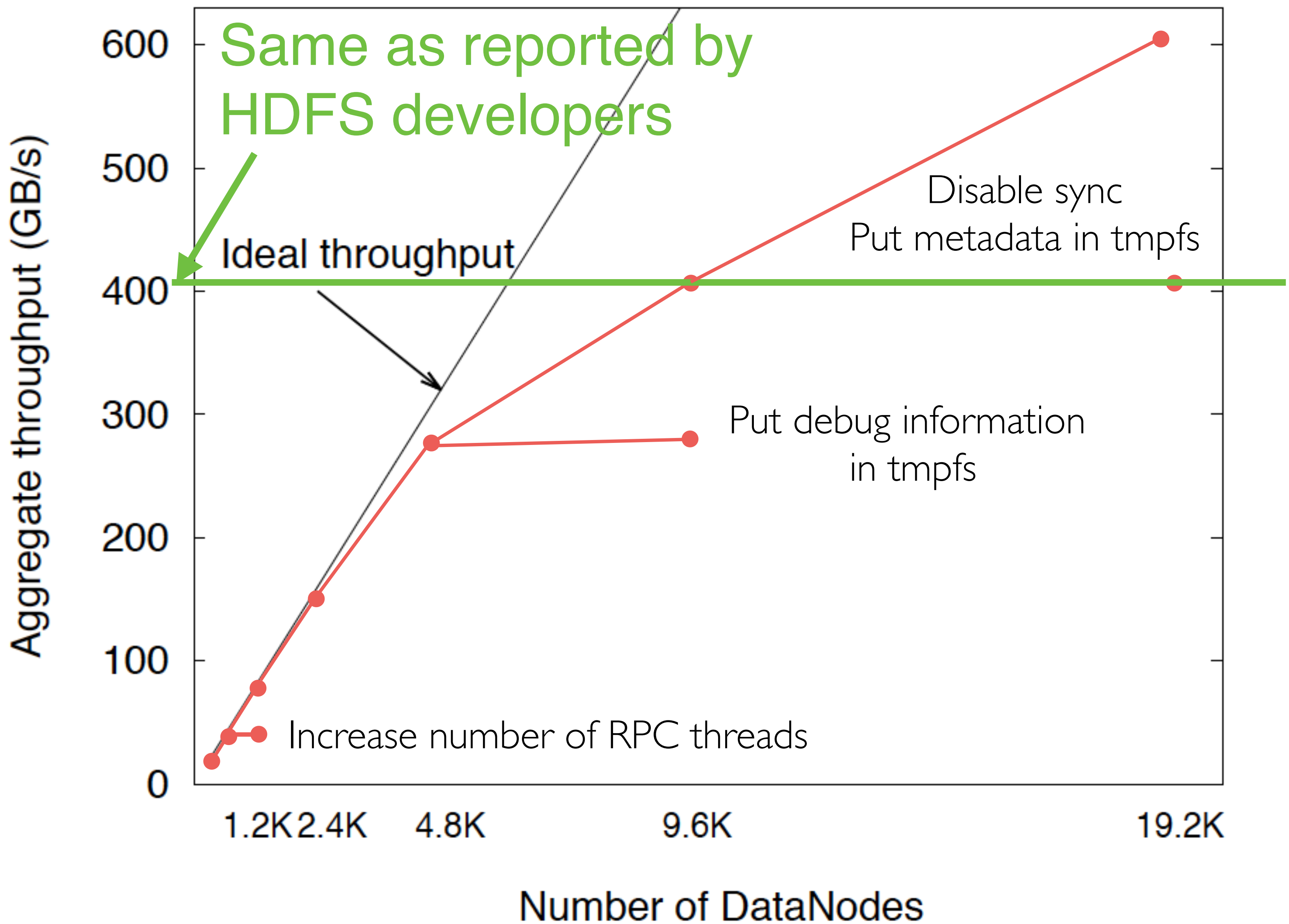
# Implementation

- Emulated devices: disk, network, and memory
- Disk and network: Transparent emulation
  - Byte code instrumentation (BCI)
  - Usage: java -Xbootclasspath exalt.jar <original app>
- Memory: Require code modification
  - None for HDFS; 71 LOC for HBase

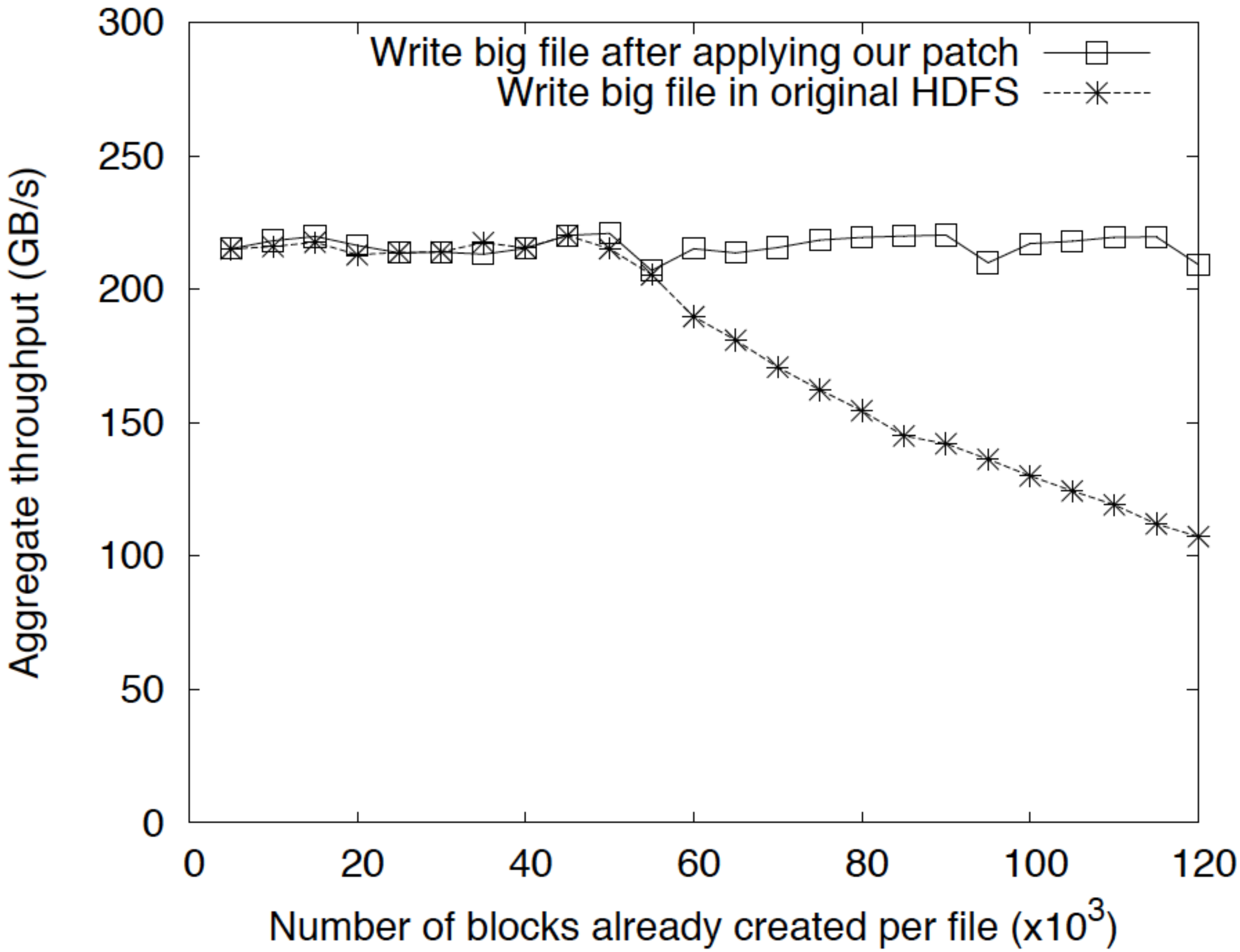
# Case studies

- Apply our emulator to HDFS and HBase
  - Measure their scalability
  - When we find a problem, analyze its root cause, and fix it
- Testbed:
  - Texas Advanced Computing Center (TACC)

# Scalability of HDFS



# One problem of HDFS: Big files




HDFS performance degradation as file grows large.

# Applying Exalt more broadly

- CPU intensive systems?
  - DieCast (Gupta et al. NSDI 2008)
- Data sensitive applications/benchmarks?
  - Record (on a large testbed) and replay (on a small one)
- The target system modifies data?
  - Ad-hoc solutions for de-duplication, encryption, etc

# Conclusion

Industry

Researchers

https://code.google.com/p/exalt/