Canopy

A Controlled Emulation Environment for Network System Experimentation

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Why Debugging Networked Systems is Hard

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- Tolerance to Varying Conditions
  - Want to be able to see how various conditions affect the system

Debugger Wish List

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- Rollback to any time
- Replay with only specified changes
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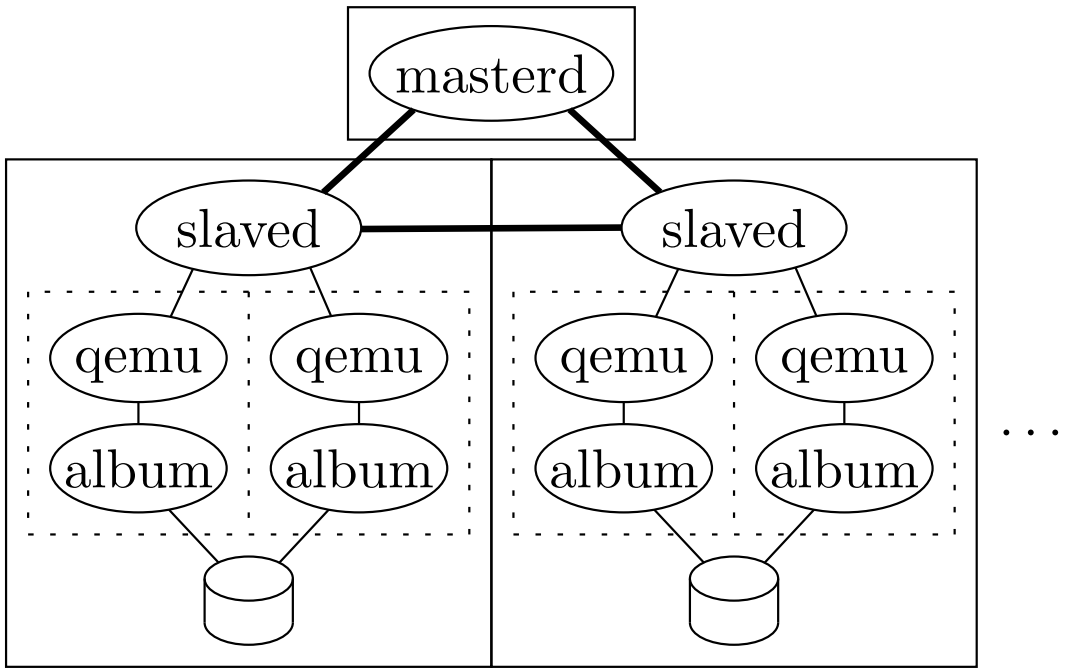
  - Master/slave system w/ barrier sync

Definitions and Overview



Barrier Synchronization

- Every packet arrives at its physical node before its virtual node needs it
- Barriers every 10 msec

Snapshotting and Restoring

- Incremental snapshot of every virtual node at every n barriers
- Rely on deterministic replay in order to restore to times without snapshots

Achieving Deterministic Replay

- Control over hardware that OS uses to gather entropy
- Control over virtual time
  - Also allows for control of relative CPU speeds

Demonstrations

- Ping
- HTTP download with packet loss

Conclusions

- Debugging networked systems is hard
- Canopy makes debugging networked systems easier using:
  - Centralized control
  - Global rollback
  - Deterministic replay with only specified changes
- Canopy scales approximately linearly with hardware

Future Work

- Quantify Performance Impact of using Canopy as a Debugging Environment
- More Sophisticated Network Model
- Improved User Interface