Configuring Debugging as Search: Finding the Needle in the Haystack

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Some slides borrowed from Aditya Y.S.V

Whats the big picture?

- Can we automate some of the diagnostic tasks of the system administrator ?
- This paper – Partial automation of diagnosis!

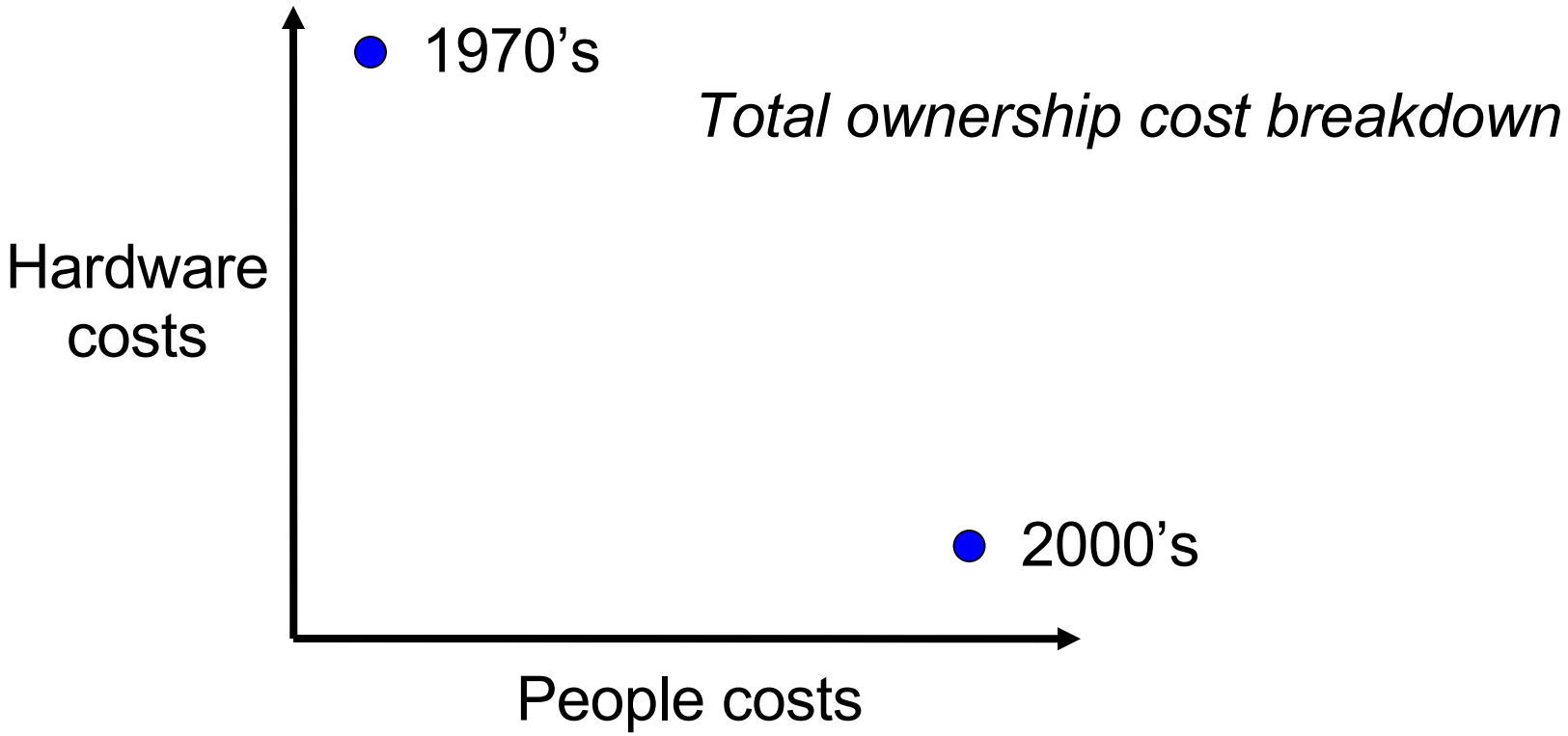
Configuration Debugging

- Configuration changes can cause system failure
  - Dynamic library upgrades
  - Installing an incompatible library
  - Windows Registry Modifications
  - Security policy change
- *What caused the failure?*

Configuration Debugging

- This work addresses the problem of diagnosing configuration errors that cause a system to function incorrectly.
- The basic idea is to search for the time when the system transitioned to a failed state.
- The paper presents a tool **CHRONUS** which automates this.

Motivation

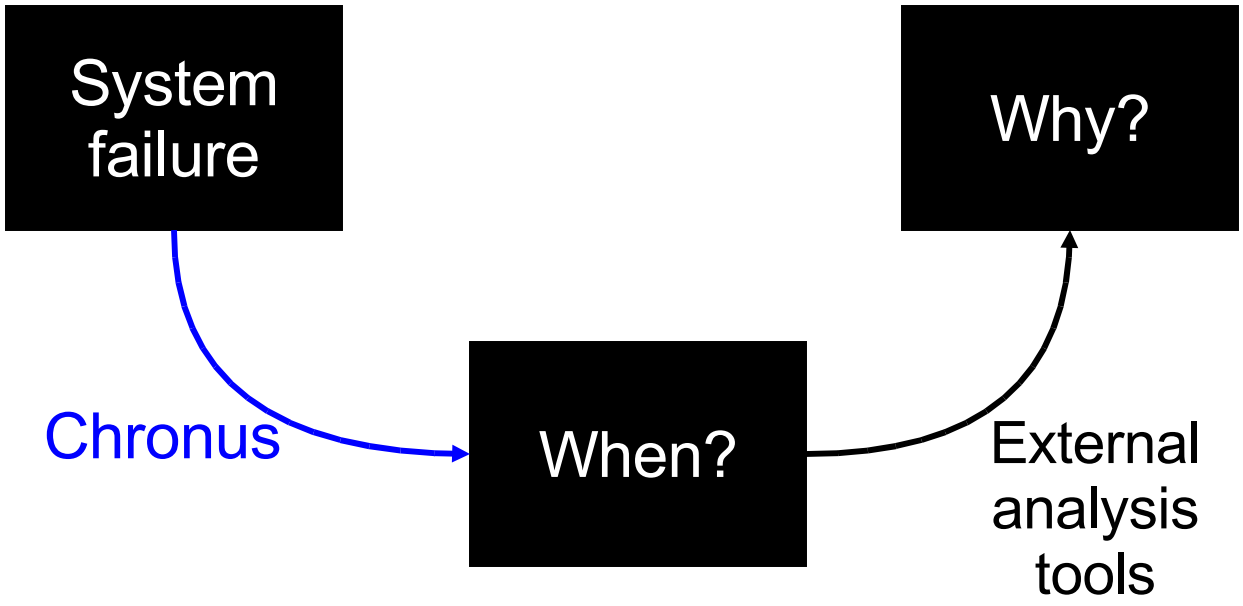


- System experts are expensive!

Existing Approaches

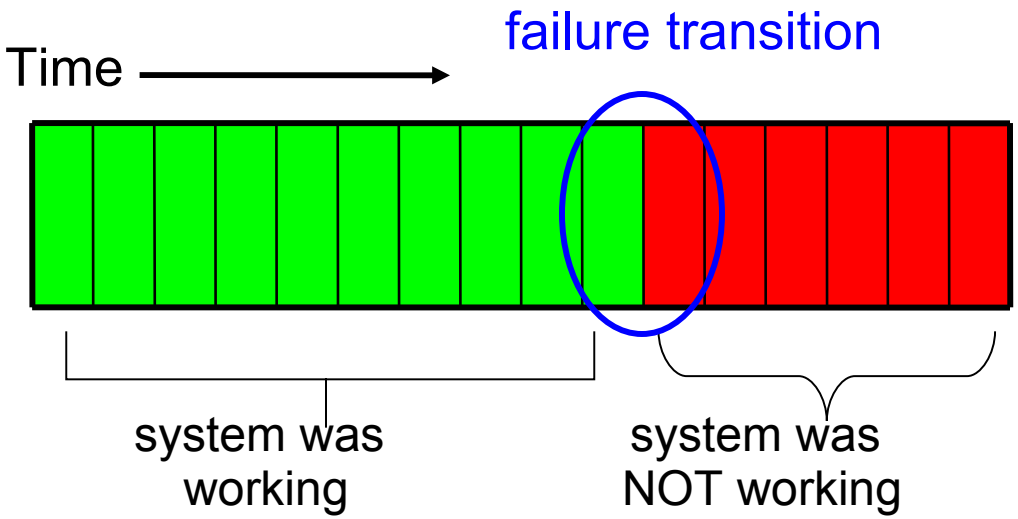
- Prevention: Complex systems, Difficult to anticipate side-effects of change
- Recovery: Windows XP restore. The problem with this is that it is a transition in itself and so it isn't always safe.
- Expert Systems: "Static Database" of known error configurations. Correction from this can be automated.
  - Complex systems -> complex rule database

The Basic Approach



System Overview

- Chronus reveals **when** a system failed



- Chronus pro-actively **logs system states**

System Overview

Design components	Design choices
Time Travel	Time travel disks, virtual machines
Testing	Software probes, copy-on-write disks
Search	Binary search

Time Travel

- Persistent vs. Transient state captures
- Chronus :- Only persistent storage.
  - Lacks Completeness
  - Less Overhead
- Some configuration changes need system restarts.

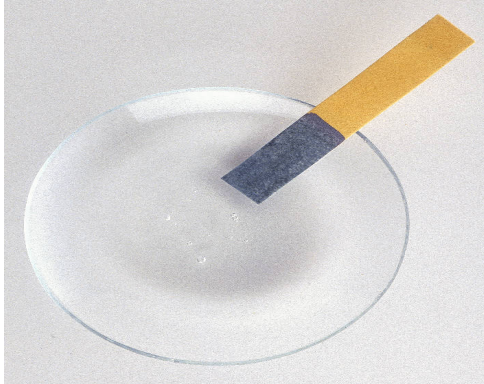
Virtual Machines

- The various states are checked by doing a virtual reboot of the system.
- Virtual reboot is faster than physical reboot
- Good way for terminating failed tests.

Disadvantages of VM

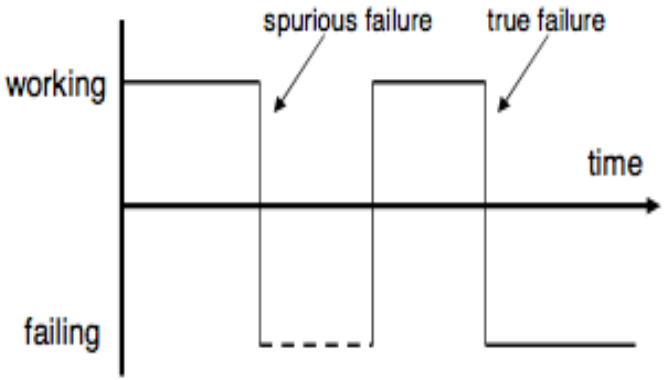
- Performance Overhead
- May not be able to expose the latest devices and device drivers
- Cannot diagnose errors within the virtualization layer itself such as updates to physical device driver.

Testing



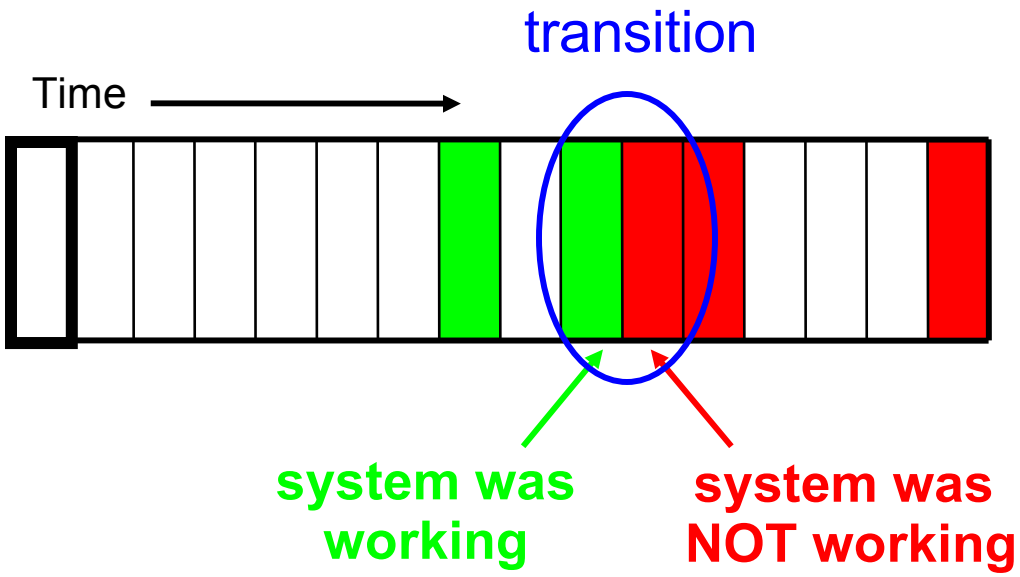
- Automated diagnosis uses a user supplied "*software probe*"
- Written on the fly
- It has a manual method of software probe if all you remember is a series of GUI actions

Search

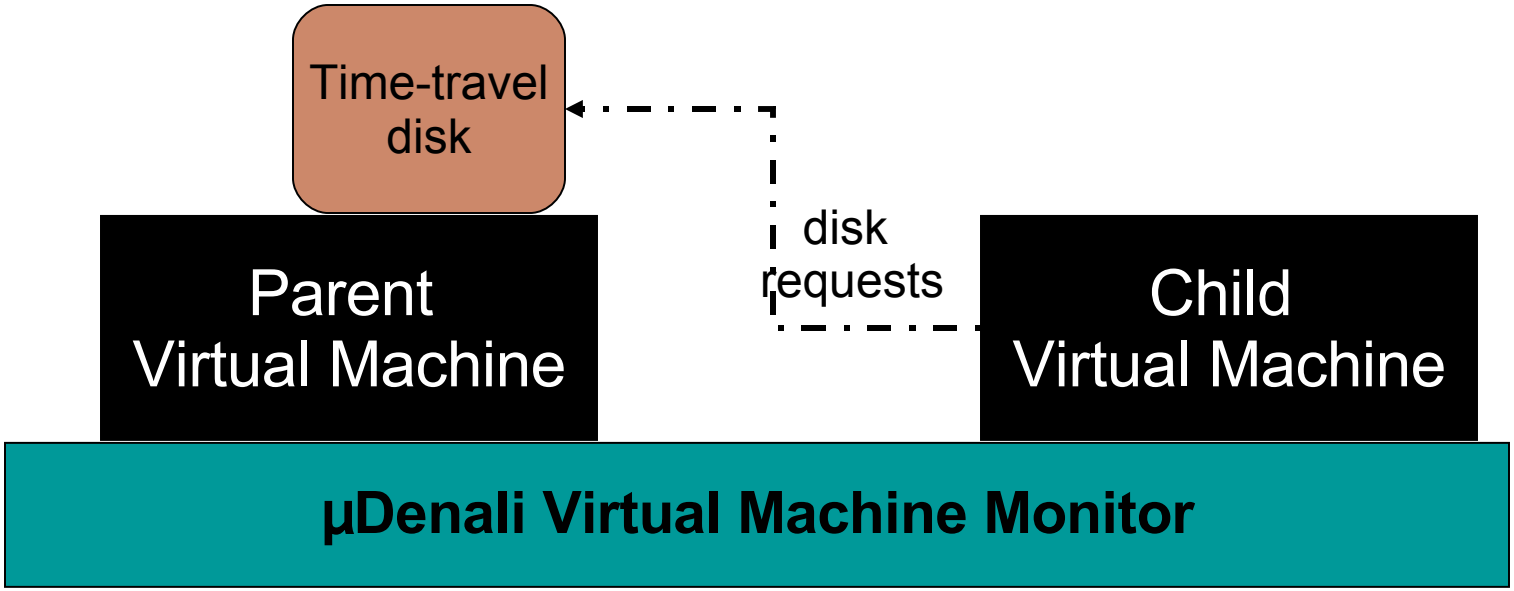


- Binary search
- Spurious Errors
  - Implicate a past upgrade
- Strategy to overcome spurious errors.
  - Run Chronus several times.
  - Different time ranges for each search

Binary Search



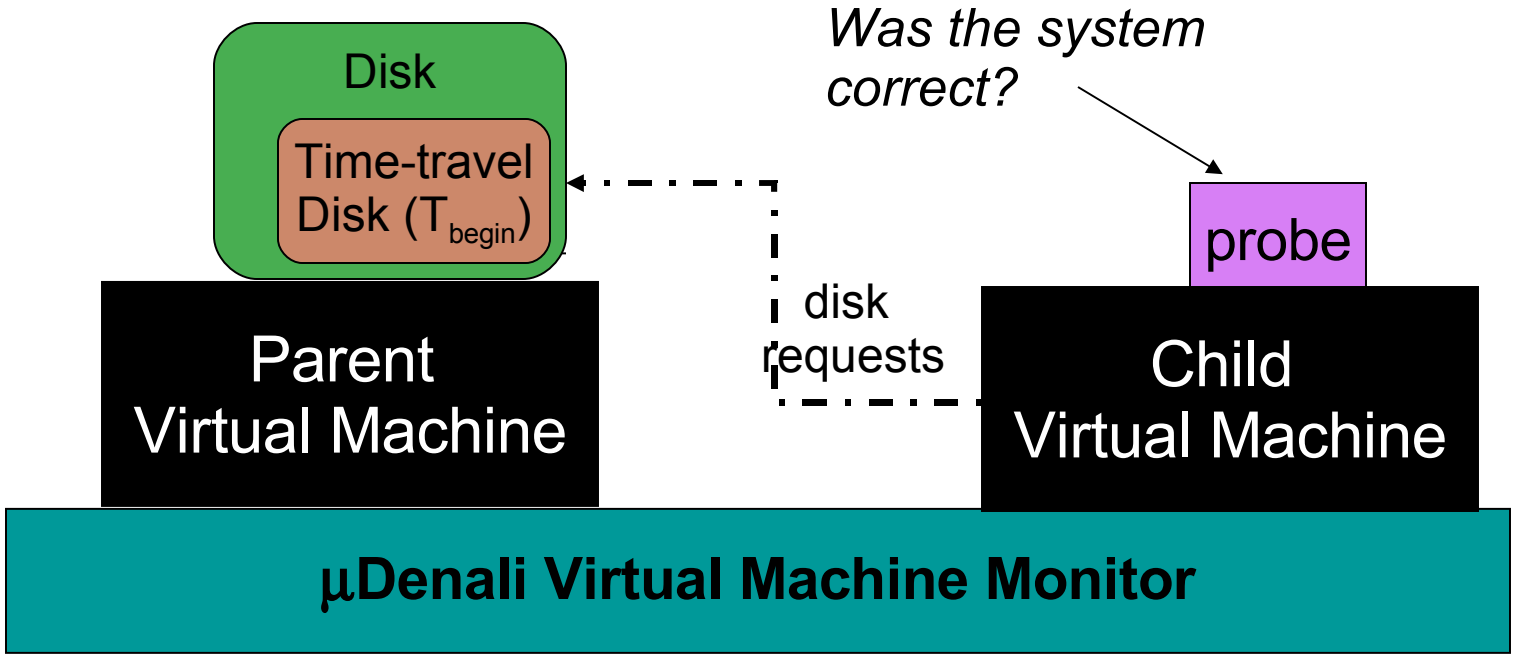
Phase #1: Normal operation



- Child VM runs normal user programs
- Parent VM records disk writes to a time-travel disk
  - Each block write represents an instant in time

Phase #2: Debug Mode

User command: `search` T_{begin} T_{end}



Testing

- Internal and external probes
- Pre-processing - wrap TTDisk with a Copy-on-write disk
- Execute the probe on boot
- Halt the child VM
- Mount the COW disk and do post processing

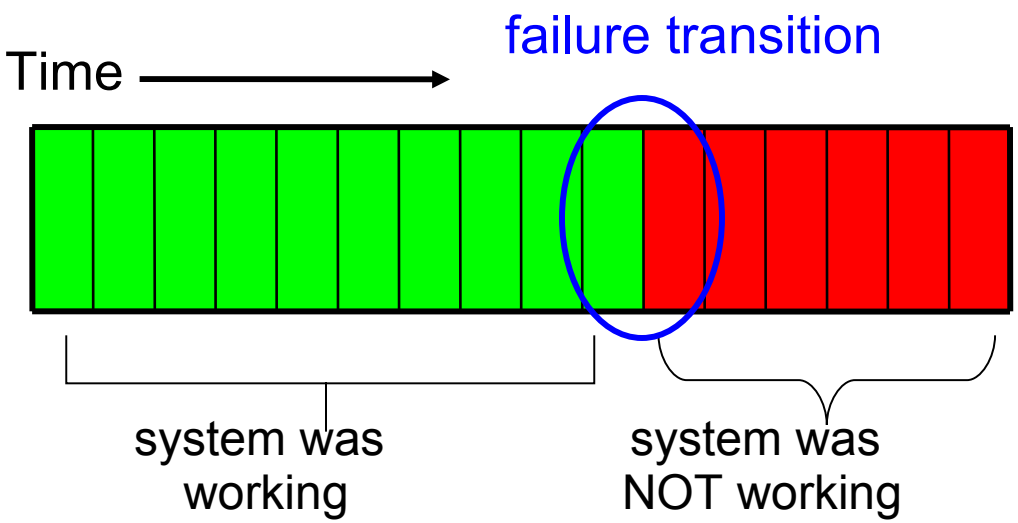
Implementation

- Command-line interface
- *Search* (TTDisk, Range log indices, probe)
- *Attach*- Mounts child system before and after state change
- *diff* - What precise change caused the failure?

Debugging experience - sshd

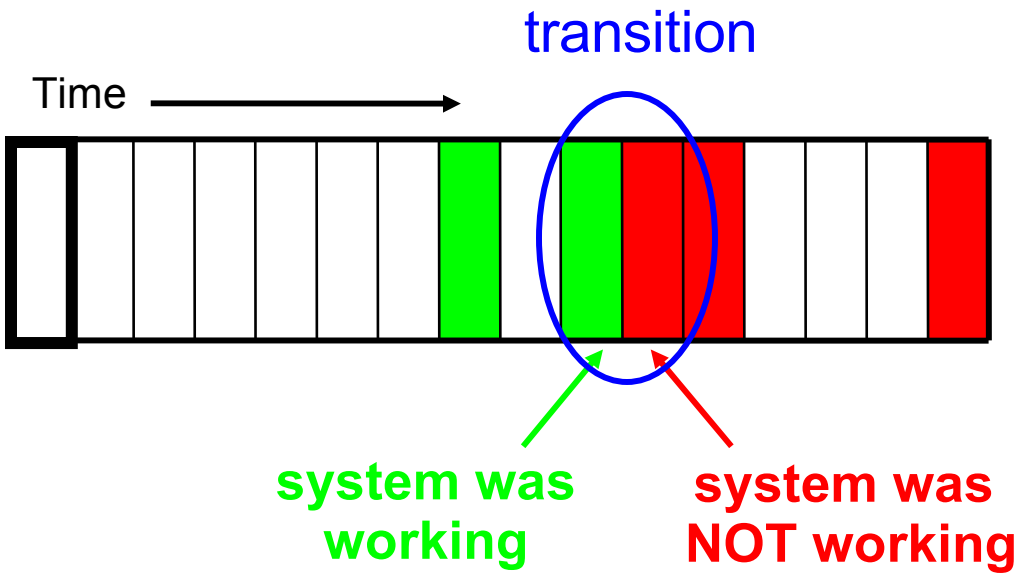
- Fault-injection: Random configuration errors
- sshd doesn't respond to remote login requests
- Probe: login via ssh and execute the UNIX date command

Binary search




```
>>> search netbsd andrew.time
0000: SSHD UP   5267: SSHD DOWN  2633: SSHD UP
3950: SSHD UP   4608: SSHD UP    4937: SSHD DOWN
4772: SSHD UP   4854: SSHD UP    4895: SSHD UP
4916: SSHD UP   4926: SSHD DOWN  4921: SSHD DOWN
4918: SSHD UP   4919: SSHD UP    4920: SSHD DOWN
```

Debugging experience: sshd

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Debugging Experience- sshd

- >>> attach andrew.time 4919 4920
- >>> diff -r /child1 /child2
  - Binary file /etc/ssh/ssh_host_key differs

Case Study: Mozilla Web Browser

- Mozilla Web Browser on the NetBSD OS
- Does Chronus apply to all errors?
  - No, 15 out of 24
  - 7-> scripts, 8 -> manual control (GUI)
- Methodology: install several extensions
- Symptom: Mozilla freezes on startup
  - Fails to respond to user input

Debugging the Mozilla Hang

- Step 1: write a probe that tests the behavior:

```
#!/bin/sh
mozilla &
sleep 5
mozilla -remote ping()
echo 'SUCCESS' > /TTOUTPUT
```

blocks if Mozilla hangs

Mozilla Hang ……..

Step 2: invoke search over a time range:

```
% search -begin 169354 -end 180025

169354: SUCCESS  180025: FAILURE 174689: FAILURE
172021: SUCCESS  173355: SUCCESS 174022: FAILURE
173688: FAILURE  173521: SUCCESS 173604: FAILURE
173562: FAILURE  173541: SUCCESS  173551: SUCCESS
173556: FAILURE  173553: FAILURE  173552: SUCCESS
```

Mozilla Hang …….

- Step 3: compute the change:

```
% attach time-travel-disk 173552 173553
% diff -r /before /after
```

```
file /.mozilla/default/zc1irw5u.slt/chrome/chrome.rdf differs:

<RDF:Description about="urn:mozilla:package:stockticker”
...
c:author="Jeremy Gillick"
c:authorURL="http://jgillick.nettripper.com/"
c:description="Shows your favorite stocks in a
  customized ticker."
c:displayName="StockTicker 0.4.2”
```

Performance

- Log Inflation:
  - File system meta-data operations
  - Deleting Mozilla directory (rm -rf) generates 1432 MB of log data
- Debug Execution Time:
  - Grows logarithmically
  - 20 seconds to conduct a single probe

Take away

- *Can we automate system administrator tasks?*
- *Partially!*

THANK YOU