PCP & Systemtap

An Intro to Performance Analysis Across Your Entire Network

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In Today's Talk

1. Introduction
2. Performance Co-Pilot
3. Demo
4. (Applause)
5. Systemtap
6. Demo
7. (More Applause)
8. Questions

Six Stages of Debugging (With Two Bonus)

1. That can't happen
2. That ~~can't~~ doesn't happen on my machine
3. That ~~doesn't~~ shouldn't happen
4. Why does that happen?
5. Oh, I see.
6. How did that ever work?
7. Who wrote that?!
8. Oh... I wrote that.

Credit: http://web.archive.org/web/20051027173148/http://www.68k.org/~jrc/old-blog/archives/000198.html

First Step is Acceptance...

But we're here to focus on

3. That shouldn't happen
4. Why does that happen?

In Other Words

Our main objectives are:

1. Early detection of a (potential) problem
2. Rapidly drill down & pinpoint issue in specific program

Analyzing Performance

How is this typically/historically done?

- rsyslog/syslog-ng/journald
- top/iostat/vmstat/ps
- Mixture of scripting languages (bash/perl/python)
- Specific tools vary per platform
- Proper analysis requires more context

Analyzing Performance

Introducing:

Performance Co-Pilot

Points of interest

- Unix-like component design
- Complements existing system functionality
- Cross platform
- Ubiquitous unit measurement
- Extremely extensible
- Open Source!

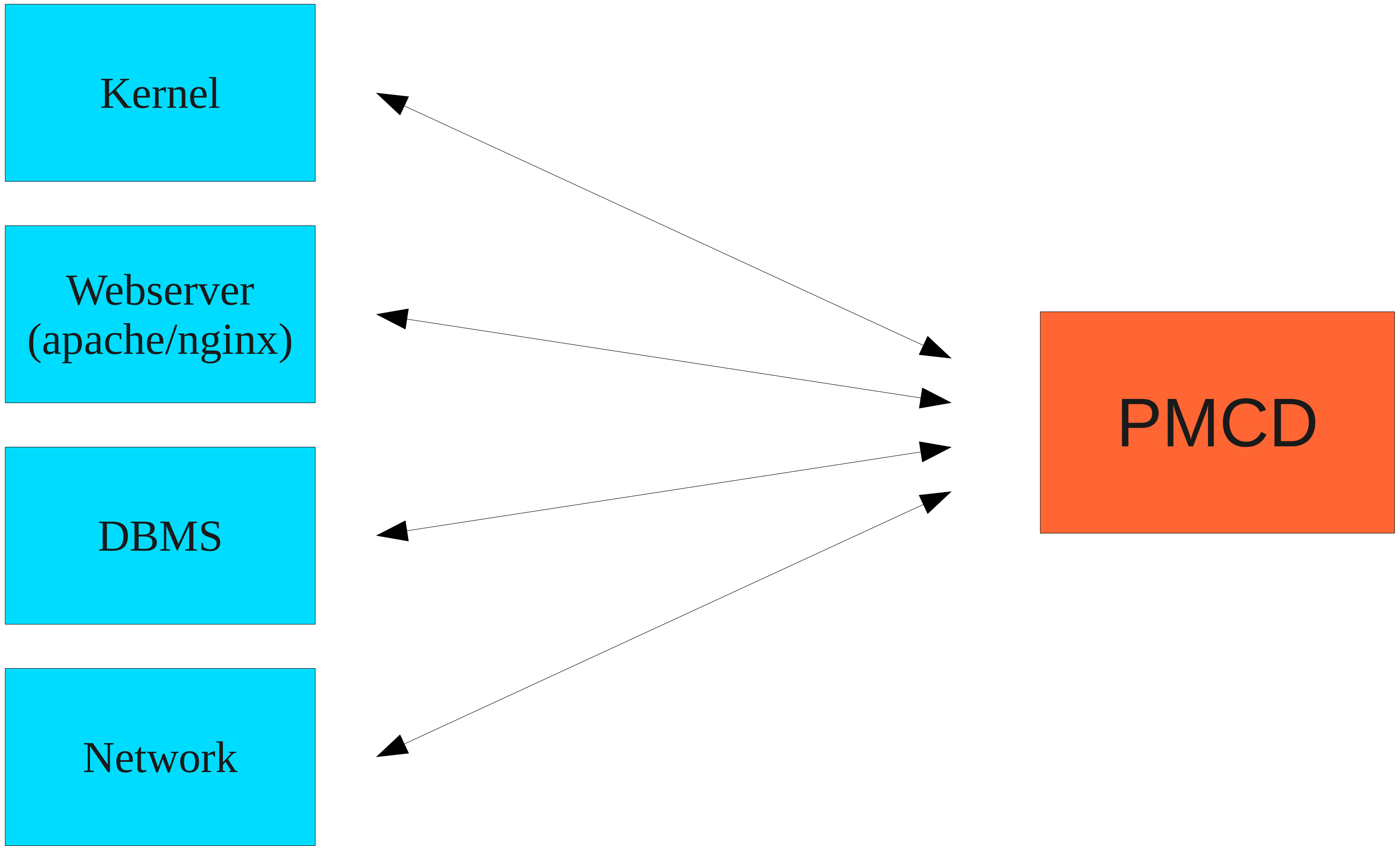
Performance Co-Pilot

At the core we have two basic components

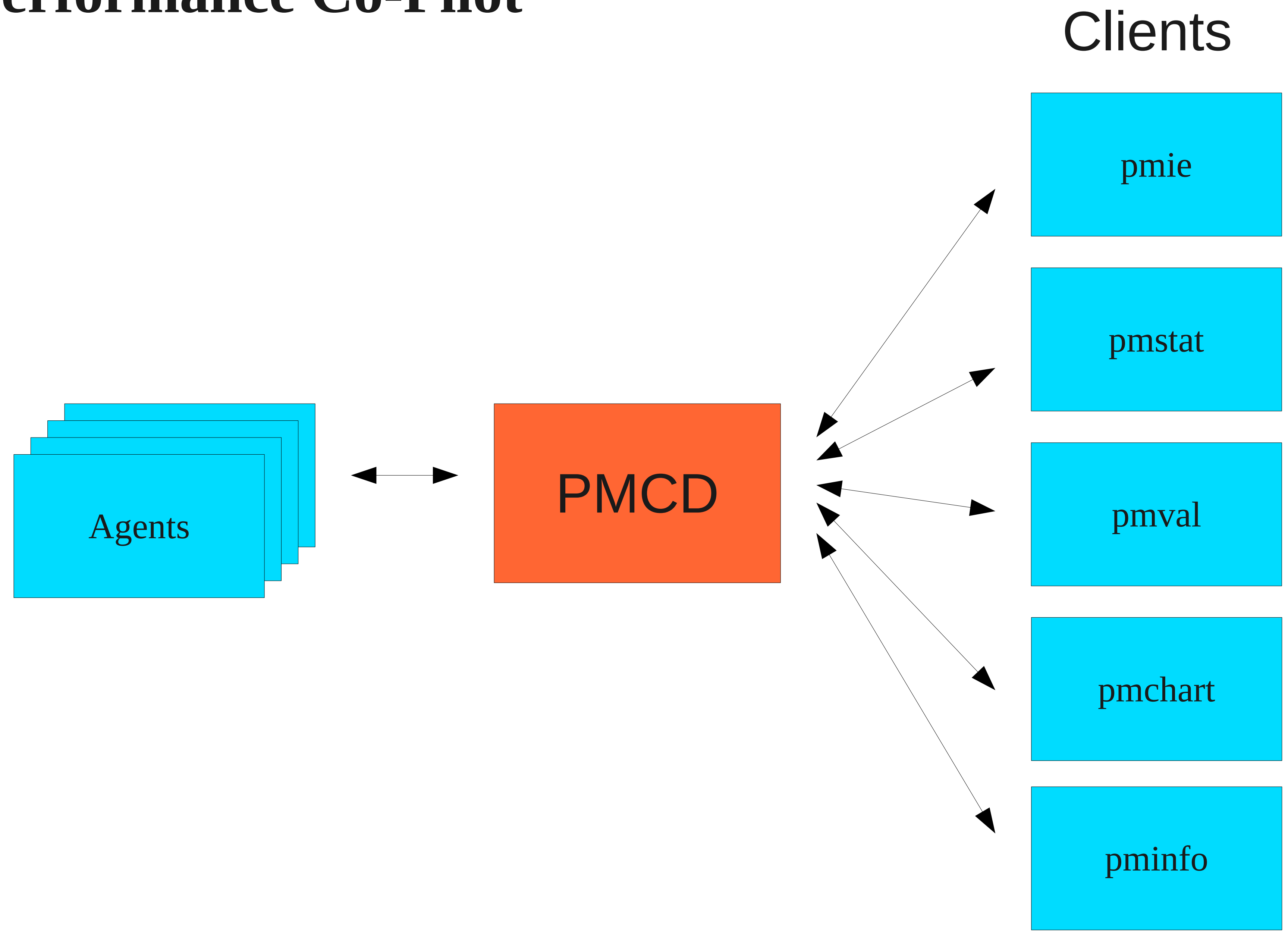
1. Agents
   Performance Metric Domain Agents
2. PMCD
   Performance Metric Collection Daemon

Performance Co-Pilot

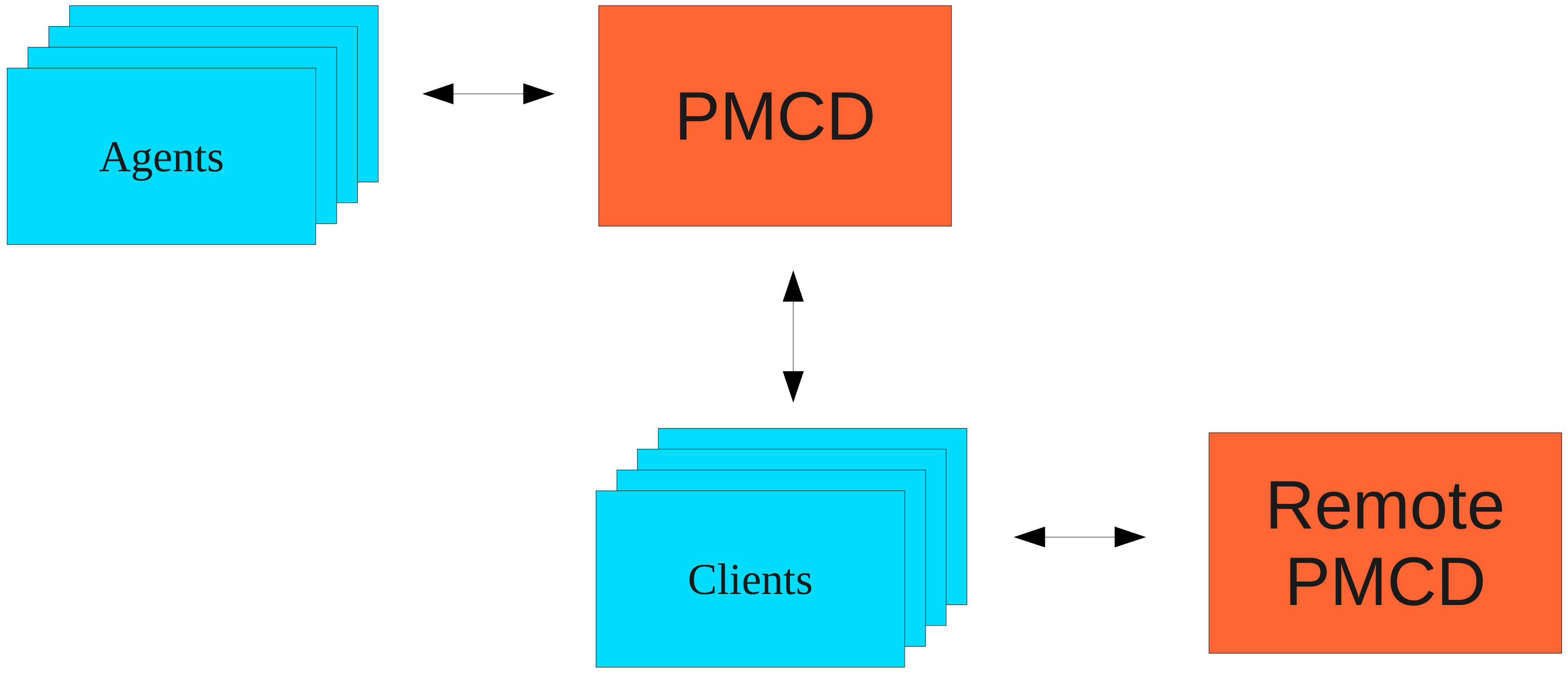
Agents



Performance Co-Pilot



Performance Co-Pilot



Performance Co-Pilot

Useful commands:

```
$ pcp
```

summary of PCP installation

```
$ pmstat -h <hostname>
```

high level system(s) overview

```
$ pmchart -c <config> -h <hostnames>
```

configurable metric chart

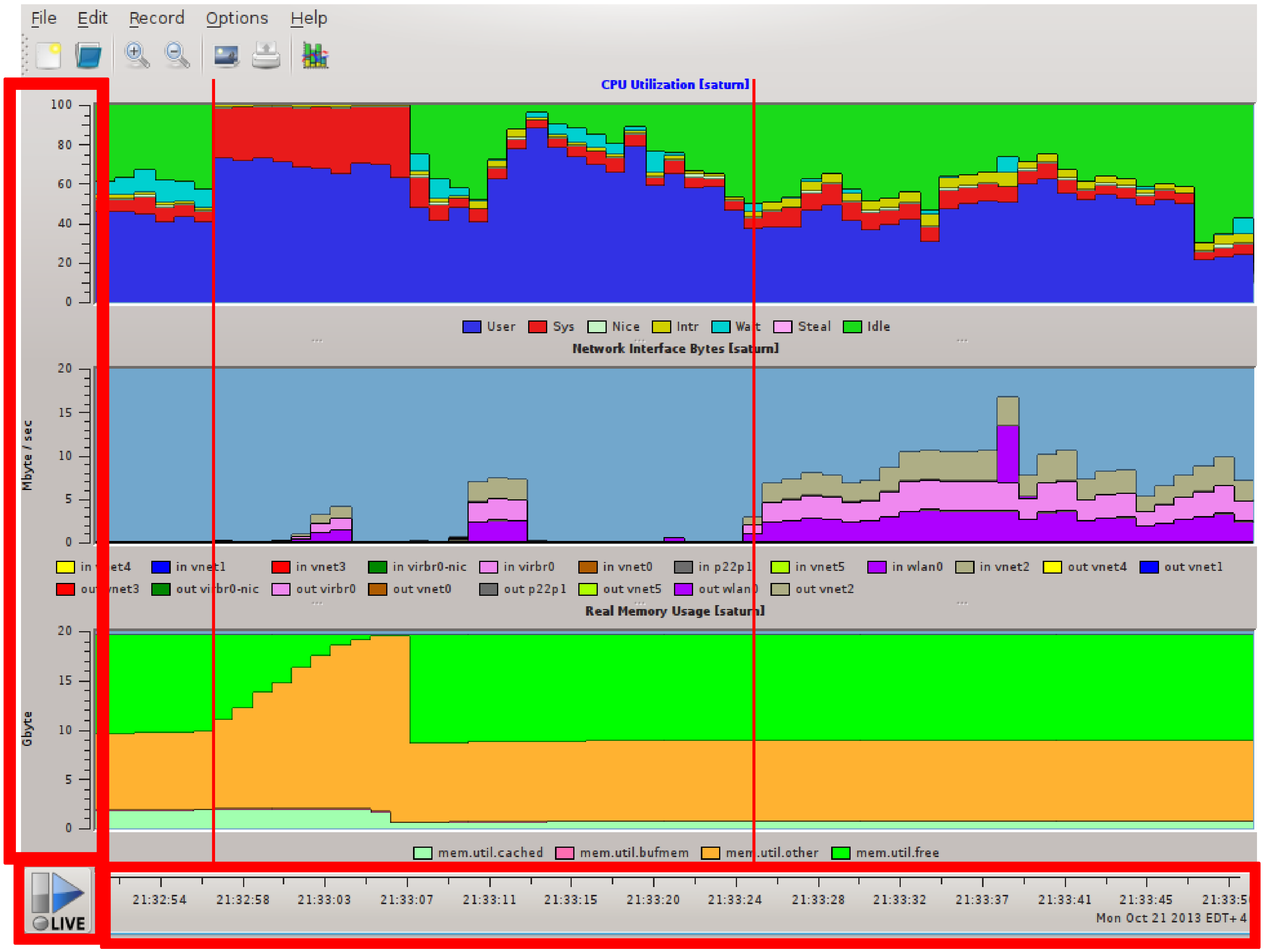
Performance Co-Pilot

```
[lberk@toium] $ pcp
Performance Co-Pilot configuration on localhost:
    platform: Linux toium 3.11.4-201.fc19.x86_64 #1 SMP Thu
    Oct 10 14:11:18 UTC 2013 x86_64
    hardware: 4 cpus, 1 disk, 1 node, 3841MB RAM
    timezone: EDT+4
    pmcd: Version 3.8.5-1, 8 agents, 1 client
    pmda: pmcd proc xfs linux mmv kvm bash systemd
    pmlogger: localhost: mysummary/20131022.19.06
```

Performance Co-Pilot

```
[lberk@saturn:~ (git::master)] $ pmstat -h toium.local -h earth.local -h saturn.local
@ Mon Oct 21 21:21:38 2013
Node     loadavg                memory       swap        io       system           cpu
           1 min   swpd    buff   cache    pi po    bi  bo     in     cs   us     sy   id
saturn      0.00      0  3069m 368400    0   0    0    0   100    125    0      0  100
toium       0.10      4 997600  5614m    0   0    6   86    88     93    0      0  100
earth       1.54      0  7857m  4646m    0   0    0    0 6564 8774   26      3   71
saturn      0.00      0  3069m 368400    0   0    0    0   117    147    0      0  100
toium       0.09      4 997600  5614m    0   0   41   77    69     82    0      0   99
earth       1.50      0  7857m  4646m    0   0    0   14 6656 8891   26      3   70
```

Performance Co-Pilot



Performance Co-Pilot

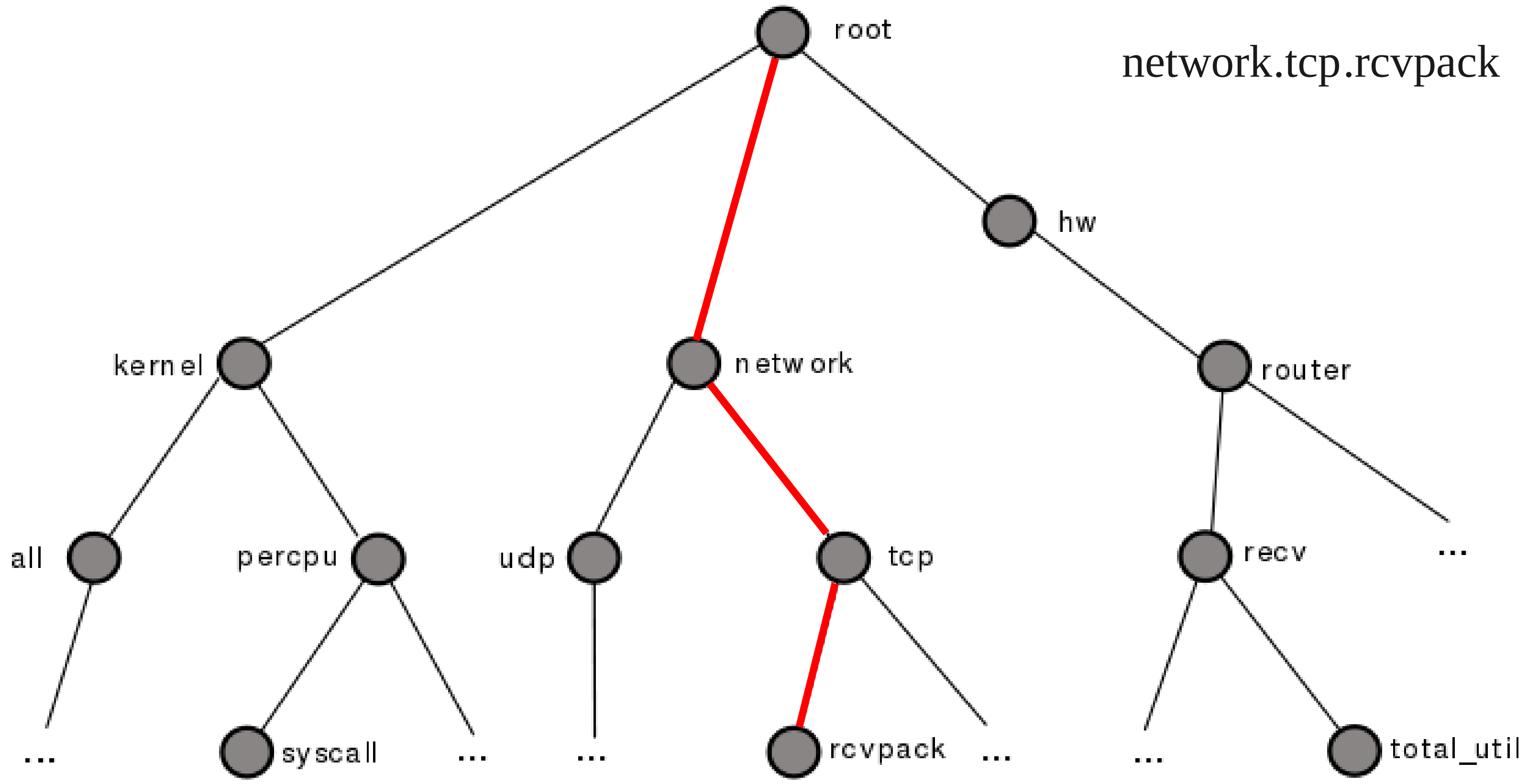
Great systems overview, but we need malleable, configurable metric tracking.

We have the technology!

Performance Co-Pilot

Performance Metrics Name Spaces

- Subsystem based hierarchical naming scheme



Performance Co-Pilot

A few more useful commands:

- $ pminfo -F
  - Full list of all available metrics
- $ pminfo -T -d <metric>
  - Query the metric with help info
- $ pmval <metric >
  - Query the current metric value

Performance Co-Pilot

Example outputs:

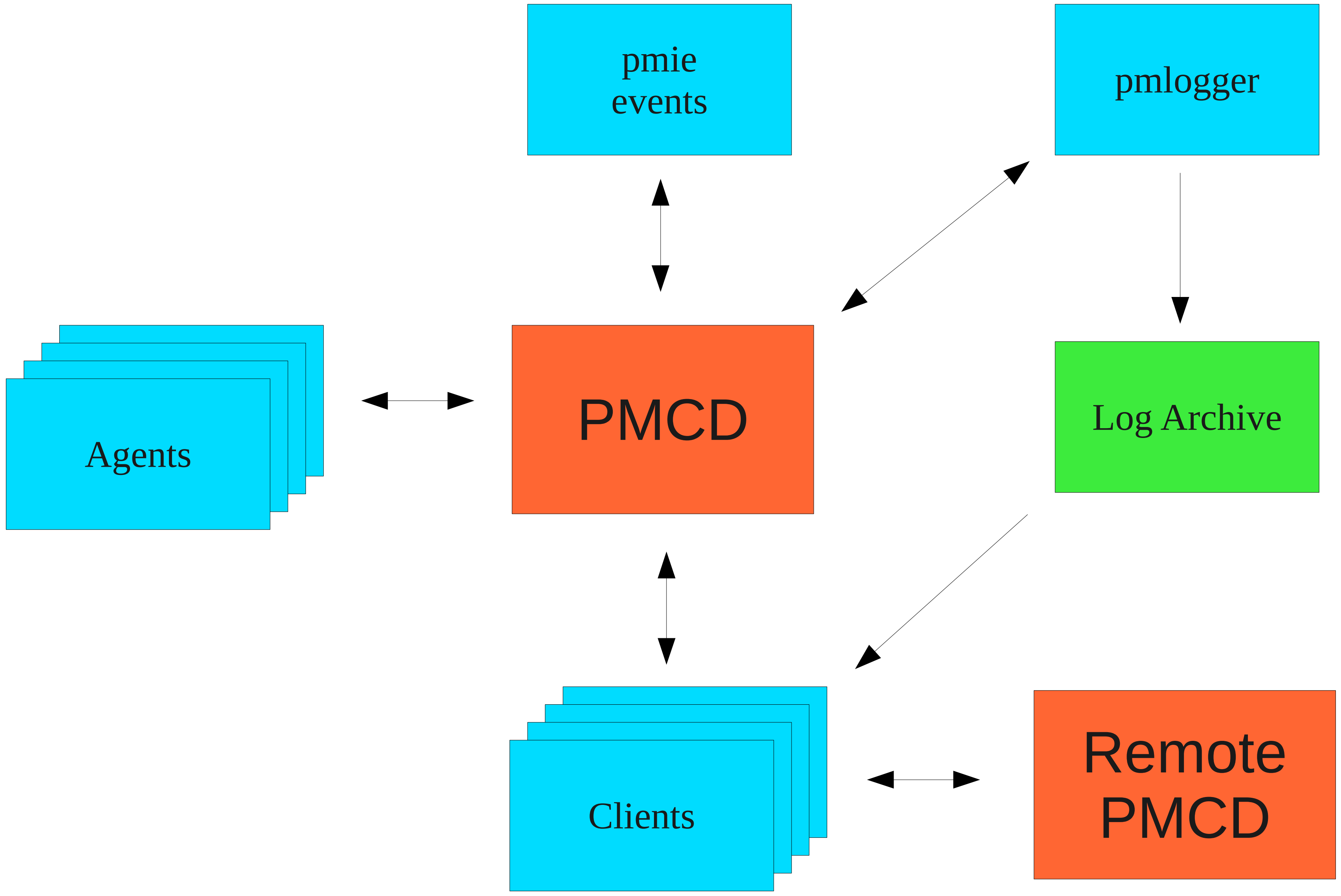
```
$ pminfo -T -d kernel.all.sysfork
    kernel.all.sysfork
    Data Type: 64-bit unsigned int
    Semantics: counter  Units: count
Help:
    fork rate metric from /proc/stat
```

Performance Co-Pilot

Example outputs:

```
$ pmval disk.all.write
    metric:    disk.all.write
    host:      localhost
    semantics: cumulative counter (converting to rate)
    units:     count (converting to count / sec)
    samples:   all
        0.0
        19.96
        95.67
        101.9
```

Performance Co-Pilot



Performance Co-Pilot

Performance Metrics Inference Engine

- Allow you to form metrics-based expressions for evaluation
- Ratios, counts, aggregates, conditionals
- Raise alarms, logging entries, shell commands
- Run on live data or logs
- Run rules across data from multiple hosts

Performance Co-Pilot

Possible expressions

- (disk.all.write / disk.all.total) * 100;
  - Percentage of disk operations that are writes
- disk.dev.total > 10 && disk.dev.write > disk.dev.read;
  - If total disk operations are greater than ten, **and**
  - there are more disk writes than reads

Performance Co-Pilot

Possible Rule

What if we want to know if ethernet stops functioning?

```
some_inst
    match_inst “^(eth|em)”
        network.interface.total.errors > 10 count / sec
-> syslog “Ethernet Errors” “ %i”
```

Performance Co-Pilot

Demo!

Performance Co-Pilot

Guiding principle on extensibility:

"If it is important for monitoring system performance, and you can measure it, you can easily integrate it into the PCP framework."

- someone famous
pcp user guide

Performance Co-Pilot

Several ways to extend PCP to your advantage

- Write your own agent
- Write your own gui/cli client (using pmapi)
- Directly adding sample/tracing instrumentation to application (using pcp library functionality)

Questions?

Performance Co-Pilot

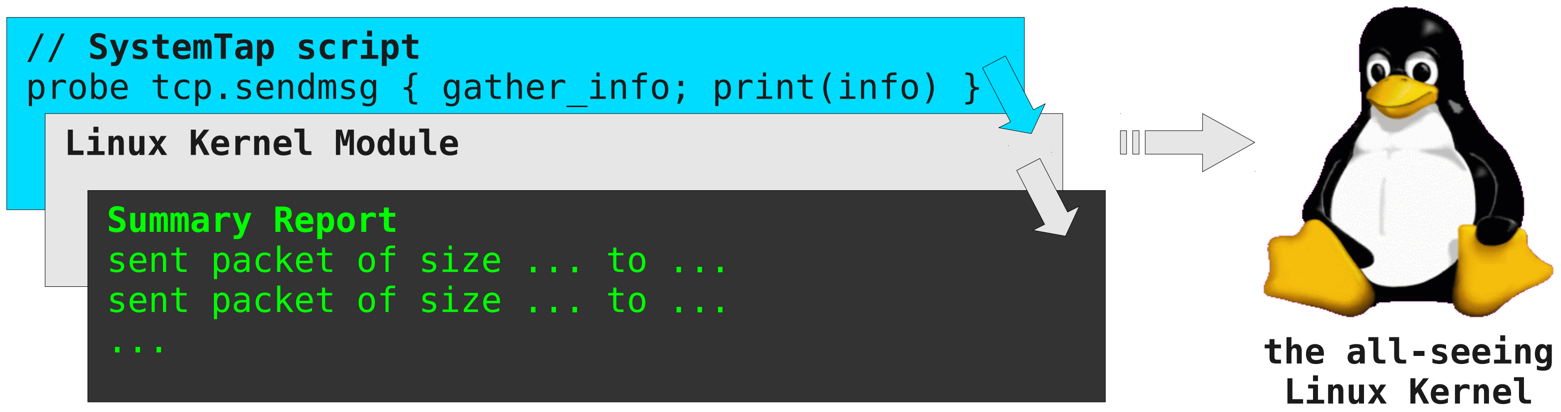
At this point we've hopefully:

- Detected the (potential) problem
- Identified the possible culprit(s)
- How do we know what's **causing** the issue?

systemtap

What is SystemTap?

- Common tools: tracers, profilers, and debuggers
    - SystemTap fills the gap between those
- Allows you to write scripts to observe all sorts of events on your machine
- Similar idea to DTrace



```
// SystemTap script
probe tcp.sendmsg { gather_info; print(info) }
```

```
Linux Kernel Module
```

```
Summary Report
sent packet of size ... to ...
sent packet of size ... to ...
...
```

Quick Introduction

- Scripts are run at probe points

```
probe <trigger> {
   <handler>
}
```

- Example: Hello World

```
probe begin {
   print("Hello, World!\n")
}
```

- Example: detect when ls is started

```
probe process(“ls”).begin {
   print("ls was started!\n”)
}
```

Probe Point Types

SystemTap supports many types of probe points

- Kernel/process probes on statements/functions

```
probe kernel.statement(“sys_read@fs/read_write.c:501”)

probe process(“/usr/bin/ls”).function(“main”)
```

- Java method probes

```
probe java(PID).class(“CLASSNAME”).method(“PATTERN”)
```

Probe Point Types

Other noteworthy types

- Perf probes
- Timer probes
- Netfilter probes
- SDT marker probes
- And many more...

To list all supported probe types:

```
$ stap --dump-probe-types
```

The Language

All the things you'd expect in a scripting language

- Variables, conditionals, loops, functions, arrays, casts, etc... similar to other high-level scripting languages

And a few nice-to-haves

- Tuple-keyed arrays and foreach loop
- Aggregates
- Macros
- Regex matching

Accessing Variables

Process/kernel probes can access context variables

```
probe kernel.function(“sys_write”)
```

We can use the -L option to find out what's available:

```
$ stap -L 'kernel.function(“sys_write”)'

kernel.function("SyS_write@fs/read_write.c:516") $fd:long
int $buf:long int $count:long int $ret:long int
```

Also useful to find functions:

```
$ stap -L 'process(“ls”).function(“*”)'
```

Tapsets – The Probe Library

Tapsets are libraries of high-level alias probes to help you write your scripts

```
probe syscall.write --> probe kernel.function(“sys_write”)
```

They also contain helper functions

```
probe syscall.write {
   printf(“write() was called with data %s\n”,
            user_string_n($buf, $count))
}
```

And helper variables

```
probe syscall.write {
   printf(“write() was called with args %s\n”, argstr)
}
```

Useful Tapset Functions and Variables

- Retrieving strings
- Retrieving main and function arguments

```
probe process(“ls”).function(“main”) {
   println(cmdline_str())
}
probe process(“nano”).function(“open_file”) {
   println($$parms$$)
}
```

- Retrieving probe point and function probed

```
probe process(“ls”).function(“*”) {
   printf(“probe point is %s\n”, pp())
   printf(“function is %s\n”, ppfunc())
}
```

Useful Tapset Functions and Variables

- Issue a system command

```
probe process(“ls”).function(“main”) {
   system(“echo main started!”)
}
```

- Filtering by PID using stap -x

```
probe syscall.write {
   if (pid() == target())
      printf(“process called write() with %s\n”,
         user_string_n($buf, $count))
}
```

And now for some fun!

SystemTap examples

/usr/bin/stress

Q: How does it work?

- What functions does it have?
- When I do

```
$ stress --cpu 3
```

  where does it spend its time stressing the CPU?

/usr/bin/stress

Q1: What functions does it have?

A1:
```
$ stap -L 'process(“stress”).function(“*”)'
```

/usr/bin/stress

Q2: Where does it spend its time stressing the CPU?

A2:

```
global funcs, cur = “main”

probe process.function(“*”) {
   cur = ppfunc()
}

probe timer.us(100) {
   funcs[cur]++
}

probe end {
   foreach (func in funcs-) {
      printf(“Spent %d us in %s\n”,
                funcs[func] * 100, func)
   }
}
```

/home/jlebon/my_app

```
#include <stdlib.h>
#include <limits.h>

short next_number() {
  static short counter = 0;
  return counter++;
}

void main(void)
{
   int i, state;
   for (i = 0; i < INT_MAX; i++) {
      state = next_number();
   }  if (state < 0)
}          system("echo `date +%s.%N` invalid state");
   }
}
```

returns a short, i.e.
counter ∈ (SHRT_MIN, SHRT_MAX)

called INT_MAX times

for demo

OK if on a system where sizeof(short) == sizeof(int)
Otherwise, state will wrap around before its time!
negative state = black hole created at CERN

/home/jlebon/my_app

- Can't fix and recompile!

  Q: How can we make sure that we never end up in an invalid (negative) state?

  A: Perfect job for SystemTap!

/home/jlebon/my_app

How can we use SystemTap for this?

```
12.  for (i = 0; i < INT_MAX; i++) {
13.        state = next_number();
```

1. Keep track of the state

```
probe process("./my_app")
       .statement("main@my_app.c:13")
```

2. Intercept when next_number() returns and watch for invalid transition

```
probe process("./my_app")
       .function("next_number").return
```

3. Reset counter to restart from a safe value

```
probe process("./my_app")
       .function("next_number")
```

/home/jlebon/my_app

```
global state, reset_counter

probe process("./my_app").statement("main@my_app.c:13") {
      state = $state
}

probe process("./my_app").function("next_number").return {
   if ($return < 0) {
      printf("Invalid state detected!\n")
      printf("About to go from %d to %d!\n", state, $return)
      printf("Resetting state to 0 and deploying LHC airbags!\n")
      $return = 0
      reset_counter = 1
   }
}

probe process("./my_app").function("next_number") {
      if (reset_counter) {
         $counter = 0
         reset_counter = 0
      }
}
```

Questions?

Get Involved!

- IRC: irc.freenode.net
  - #pcp
  - #systemtap
- Web:
  - http://oss.sgi.com/projects/pcp/
  - http://sourceware.org/systemtap
- Email:
  - systemtap@sourceware.org
  - pcp@oss.sgi.com

Get Involved!

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