Ubiquitous System Analysis Performance Co Pilot

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Red Hat
Oct. 23, 2014

redhat

Introduction

- PCP Overview
  - Introduction
  - Components
- Recent Developments
  - PAPI pmda
  - pmwebd
  - Deeper metrics
- Questions?

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

Introducing

Performance Co-Pilot

Points of interest

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

Performance Co-Pilot

Two Underlying Components

1) Performance Metric Domain Agents
2) Performance Metric Collection Daemon

Performance Co-Pilot

Two Underlying Components

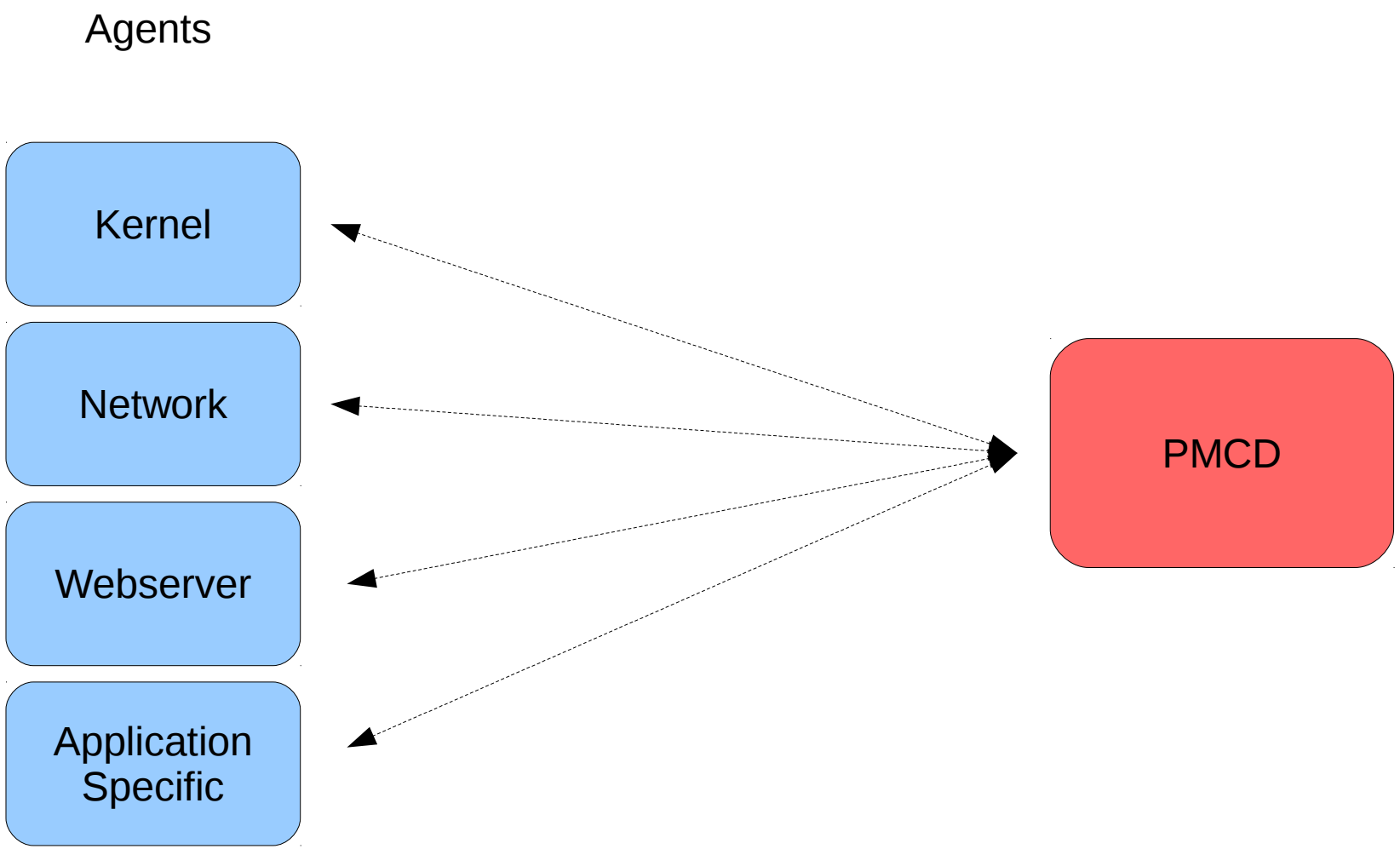
1) Agents
2) Performance Metric Collection Daemon

Performance Co-Pilot

Two Underlying Components

1) Agents
2) PMCD

Performance Co-Pilot



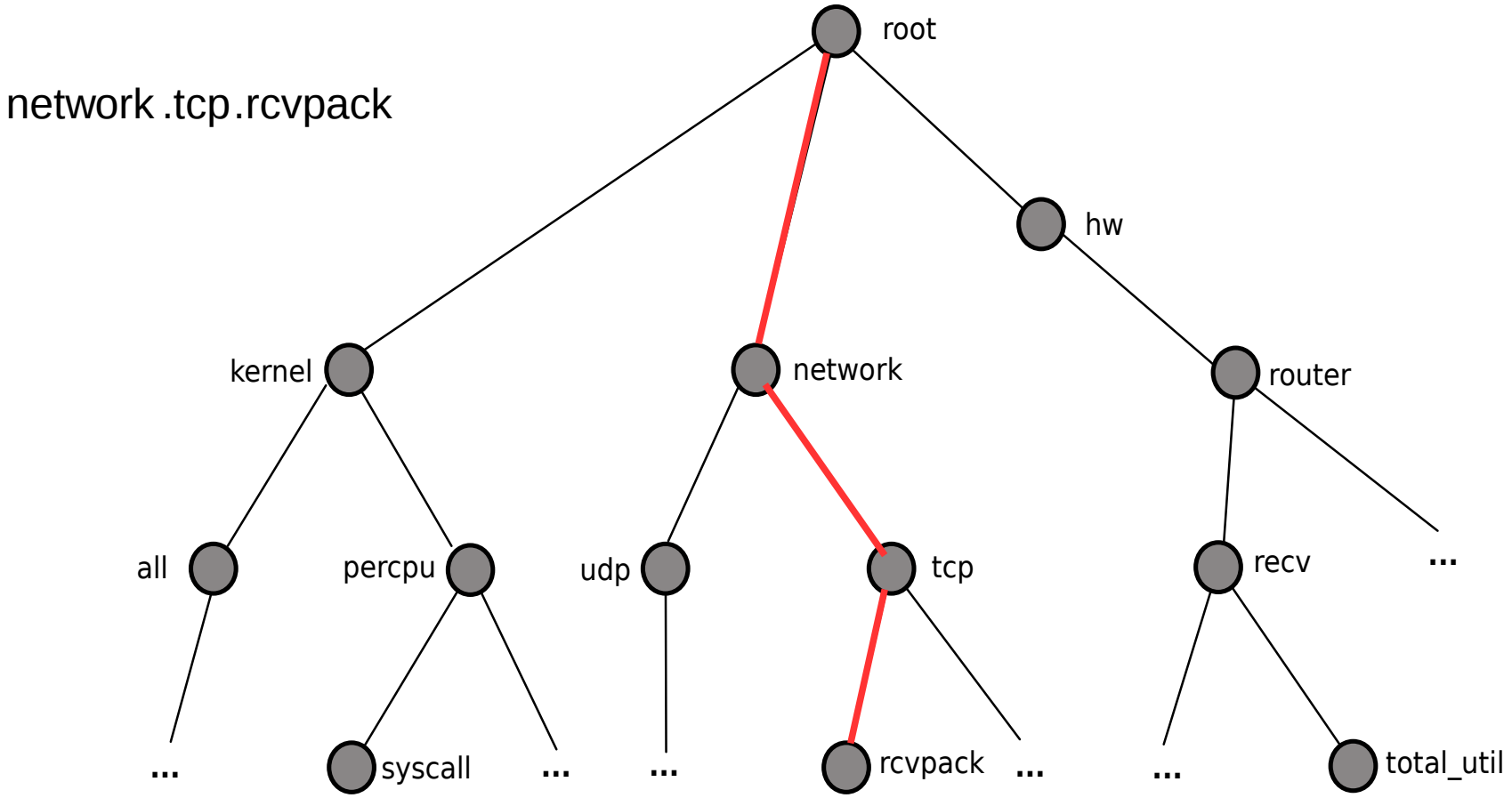
Performance Co-Pilot

Number of metrics exposed by agents?

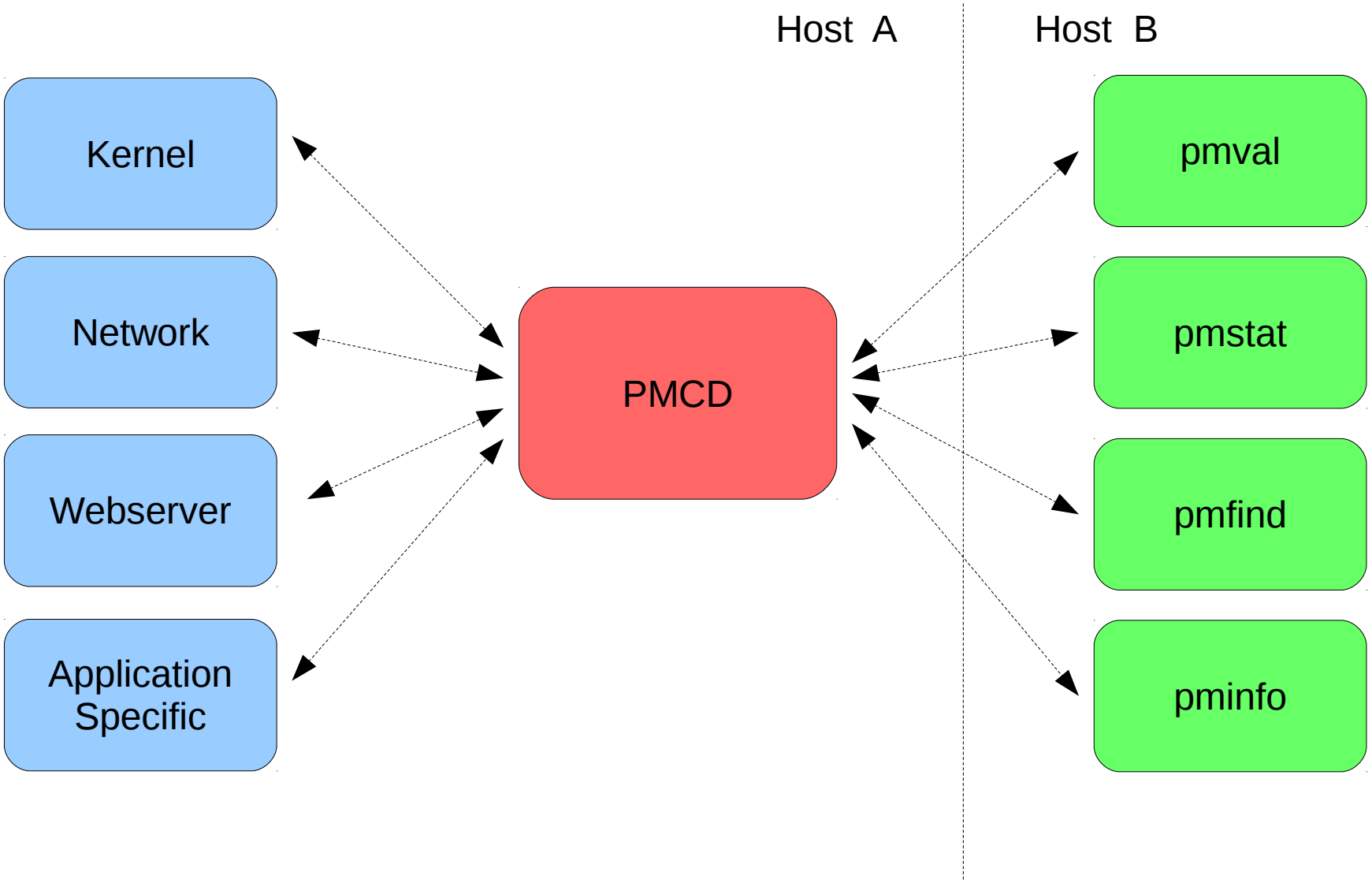
- A lot! (~1500 from a default fedora install)
- Huge variation in what they're measuring
- How do you reliably and predictably name them?

Performance Co-Pilot

- Performance Metric Name Space



Performance Co-Pilot



Performance Co-Pilot

Where to start?

pminfo – display information about metrics

```
$ pminfo -t
```

Performance Co-Pilot

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Performance Co-Pilot

Where to start?

pminfo – display information about metrics

```
$ pminfo -t papi
    papi.system.REF_CYC  [Reference cycles]
    papi.system.L3_TCA   [L3 cache accesses]
    papi.system.L2_TCA   [L2 cache accesses]
    papi.system.L3_TCH   [L3 cache hits]
    papi.system.L2_TCH   [L2 cache hits]
```

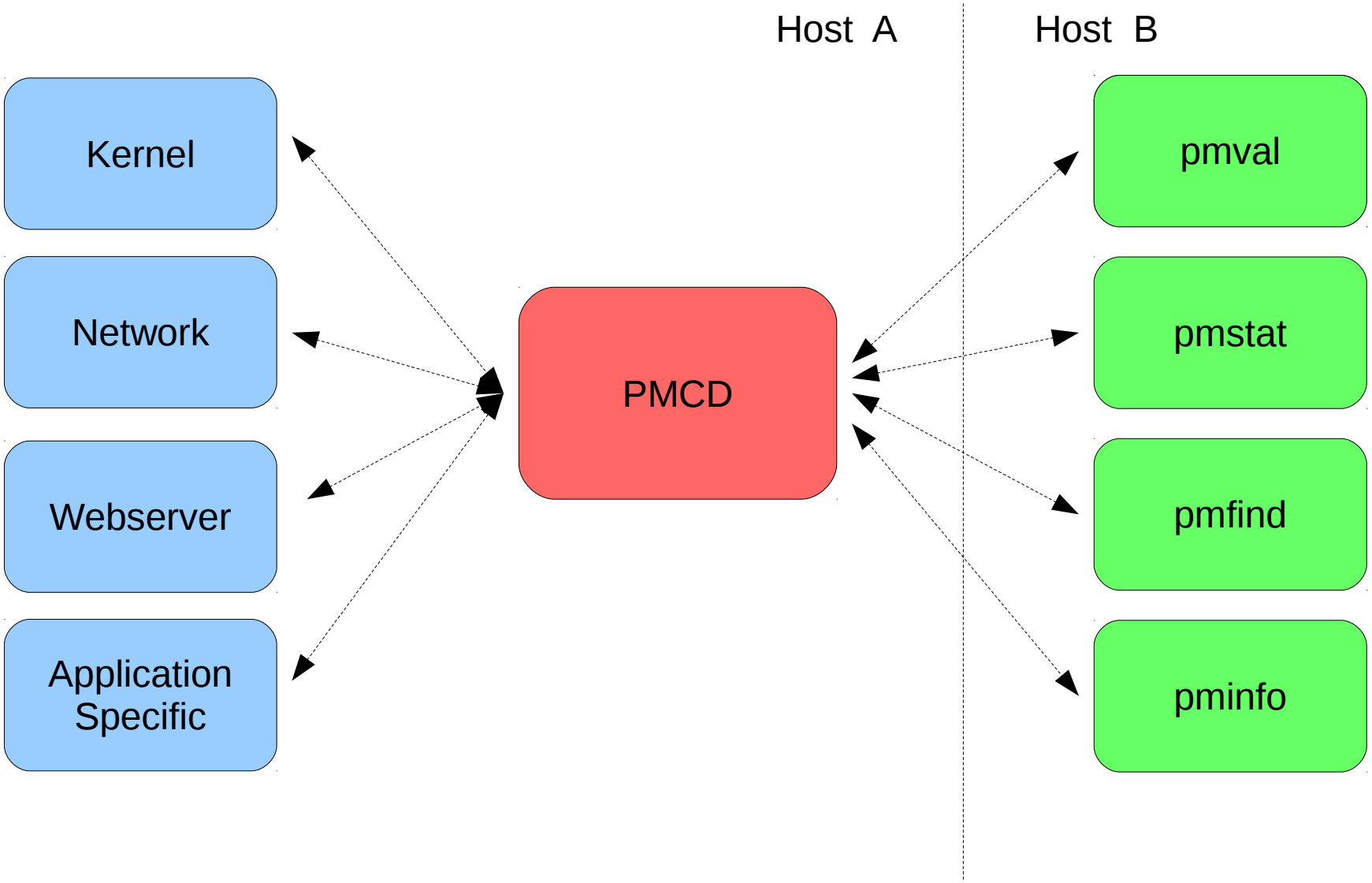
Performance Co-Pilot

Where to start?

pmval – current value of a metric

```
$ sudo pmval papi.system.TOT_CYC
    metric:    papi.system.TOT_CYC
    host:      toium
    semantics: cumulative counter (converting to rate)
    units:     none (converting to / sec)
    samples:   all
          7.869E+04
          9.186E+04
          9.240E+04
```

Performance Co-Pilot



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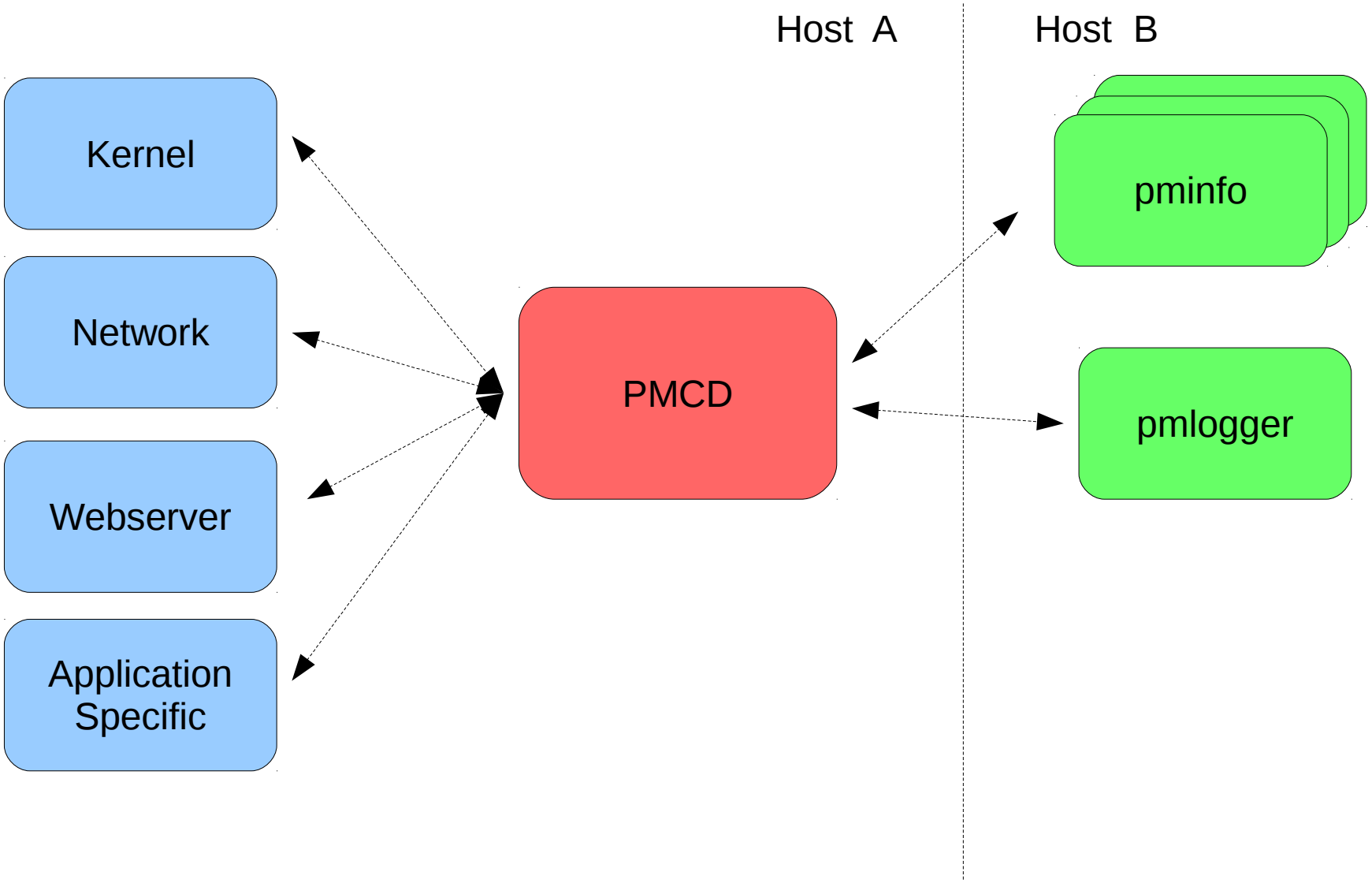

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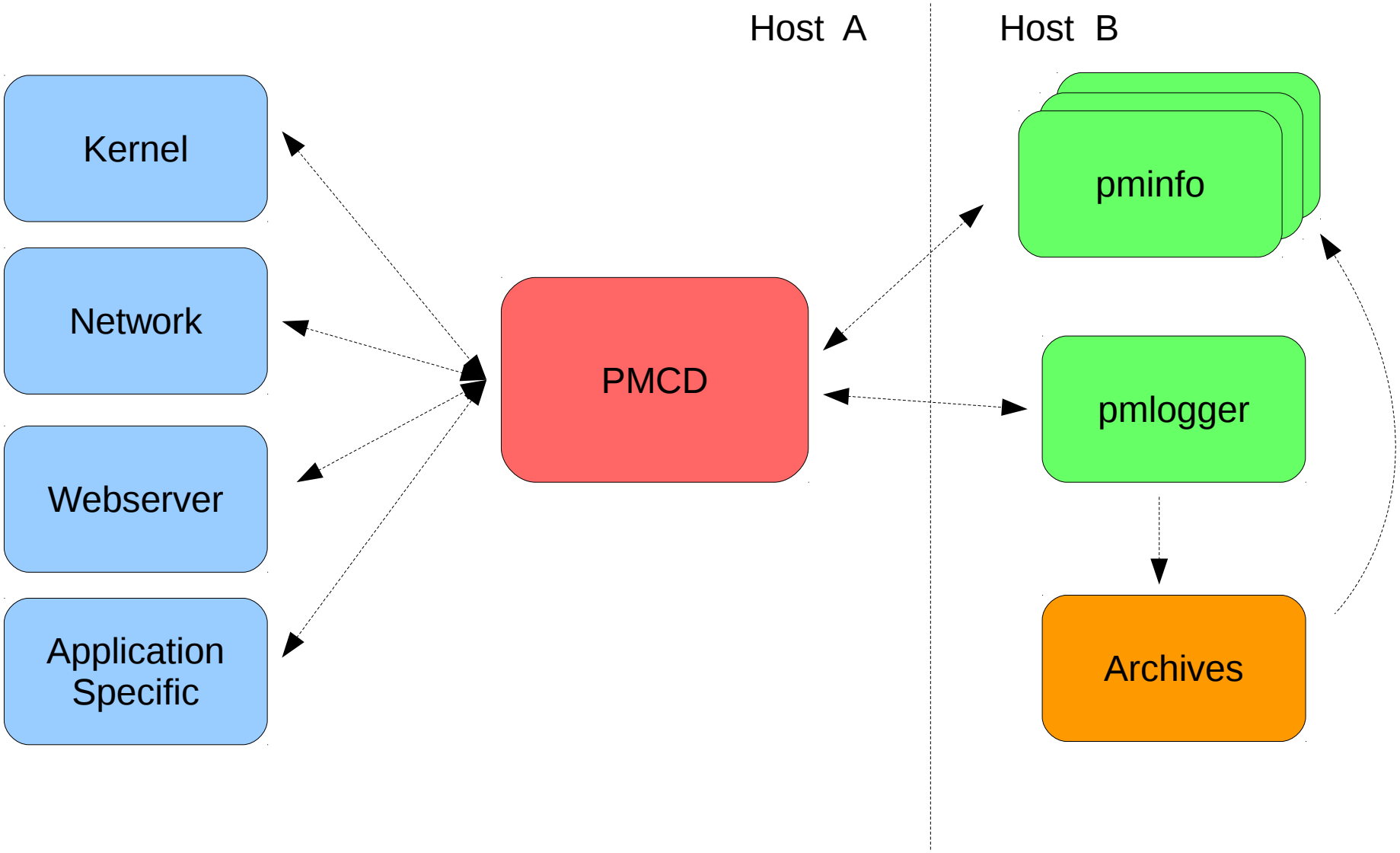

Performance Co-Pilot

pmlogger creates logs for future analysis

- Enables us to use tools on older data, retrospectively
- Default around 5mb a day, rotates and compresses
- Metrics organized, no need to stick them into elastic search

Performance Co-Pilot

- Recent and future developments
  - PAPI pmda
  - pmwebd
  - Enabling deeper system introspection

Performance Co-Pilot – Recent Developments

"Only two hard parts of computer science, cache invalidation, naming things, and off-by-one errors"

- Unknown

Performance Co-Pilot – Recent Developments

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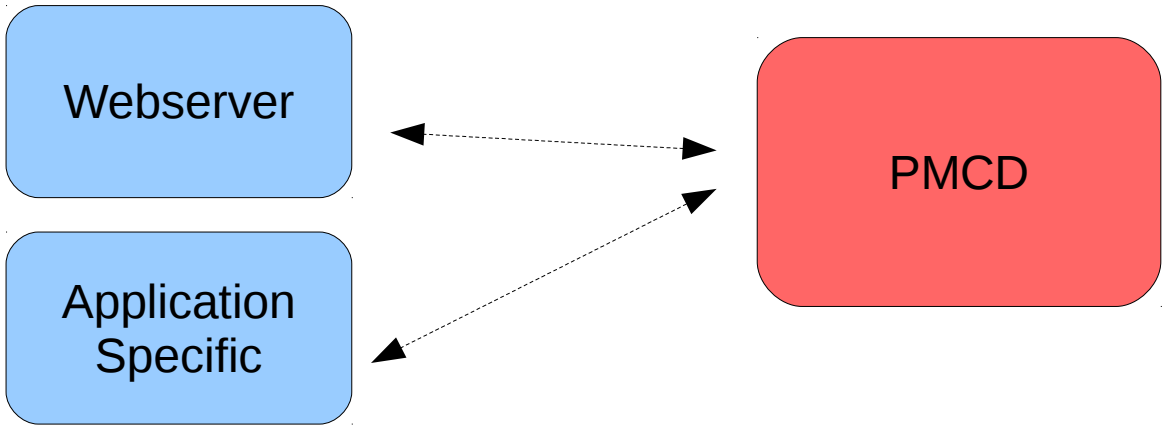
Performance Co-Pilot – Recent Developments

PAPI – Performance API

- Cross platform
- Uses dedicated hardware counters for perf metrics
  - Cache hits/misses, total instructions/cycles
- By writing a pmda (agent) for PAPI, we can expose these metrics



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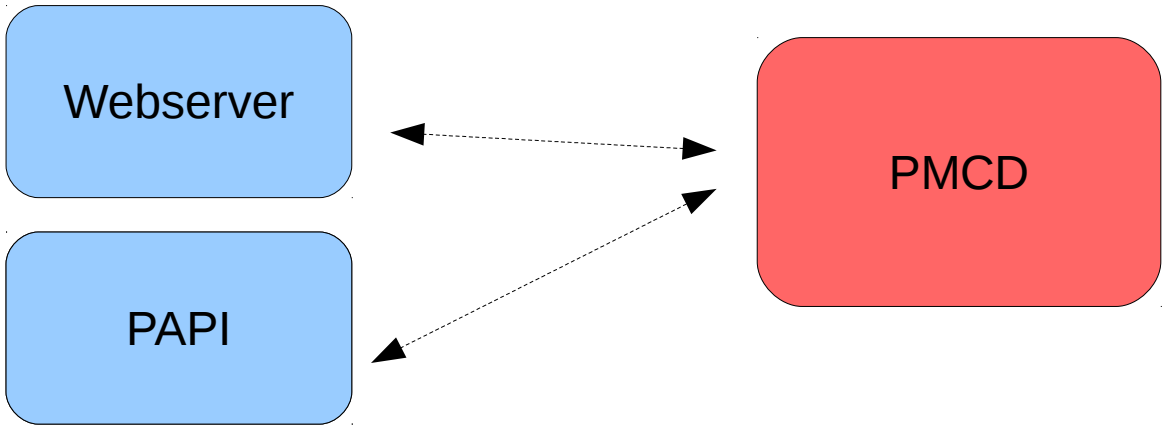

Performance Co-Pilot – Recent Developments

We could just view the raw values

```
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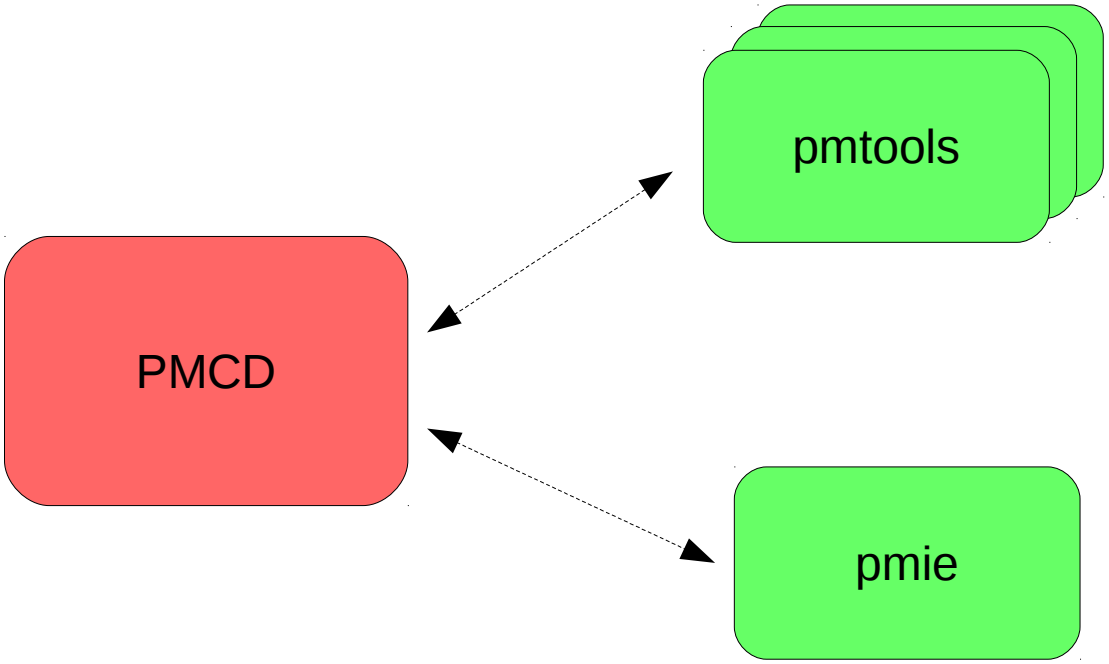
Performance Co-Pilot – Recent Developments

We could just view the raw values

- Ratios and relative percentages are more insightful
- Perfect for the pmie tool!



Performance Co-Pilot – Recent Developments

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 – Recent Developments

Example pmie expression:

```
(papi.system.L3_TCM / papi.system.TOT_INS)
```

Performance Co-Pilot – Recent Developments

Example pmie expression:

```
((papi.system.L3_TCM / papi.system.TOT_INS)
   * 100)
```

Performance Co-Pilot – Recent Developments

Example pmie expression:

```
((papi.system.L3_TCM / papi.system.TOT_INS)
   * 100) > 2
```

Performance Co-Pilot – Recent Developments

Example pmie expression:

```
some_inst

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   * 100) > 2
```

Performance Co-Pilot – Recent Developments

Example pmie expression:

```
some_inst

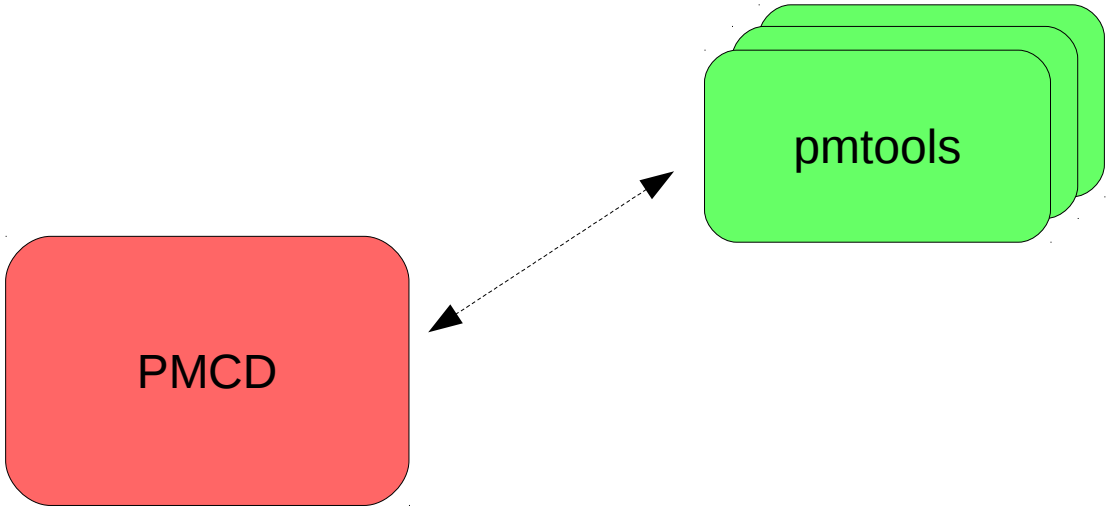
((papi.system.L3_TCM / papi.system.TOT_INS)
   * 100) > 2

-> syslog “Percentage of Level 3 Cache misses > 2%”
```

Performance Co-Pilot – Recent Developments

pmwebd

- We already ship a gui tool (pmchart)
- Several feature full graphing tools available
- PCP's architecture and design makes integration easy



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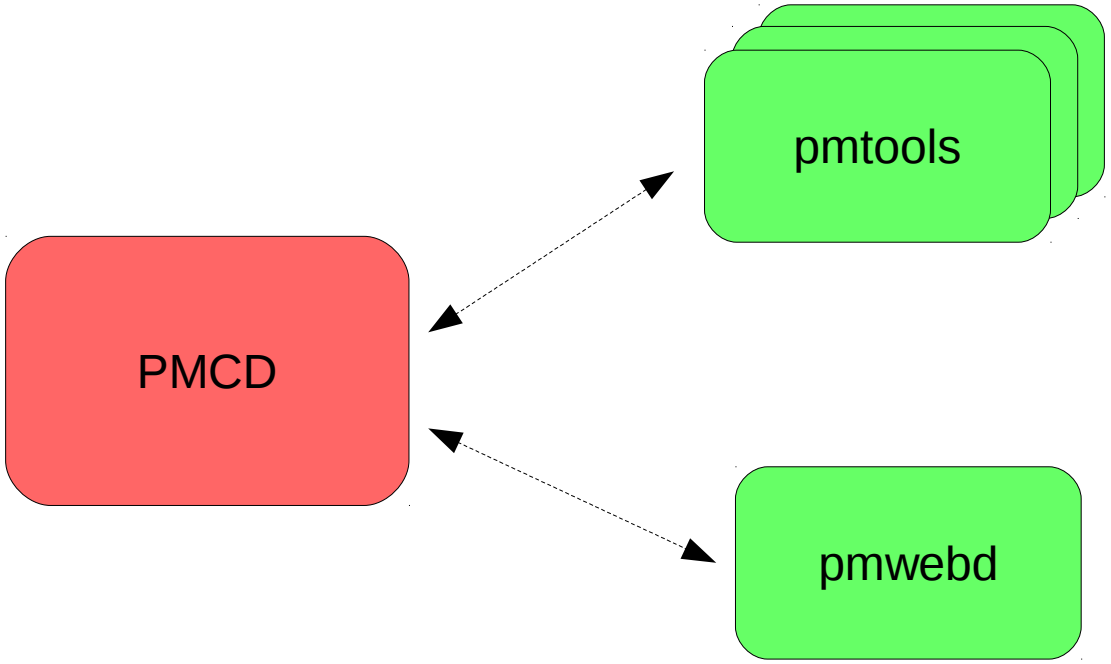

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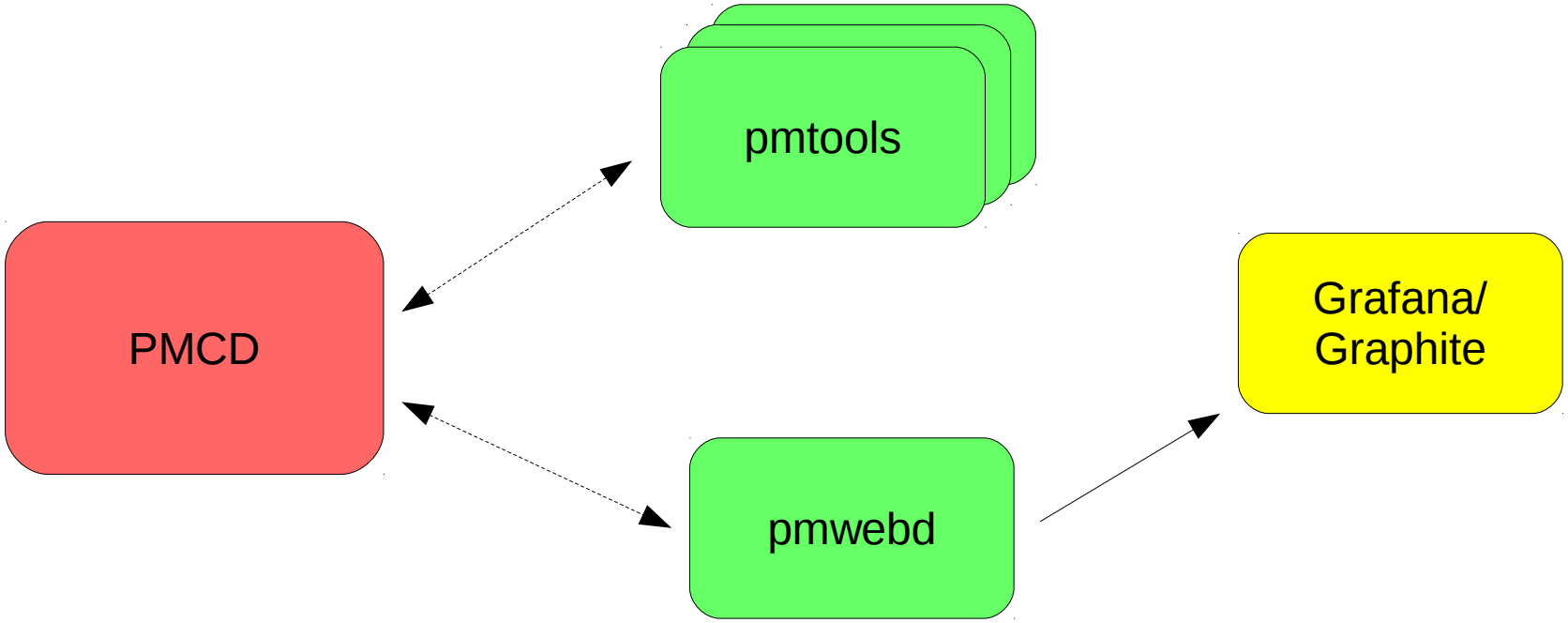

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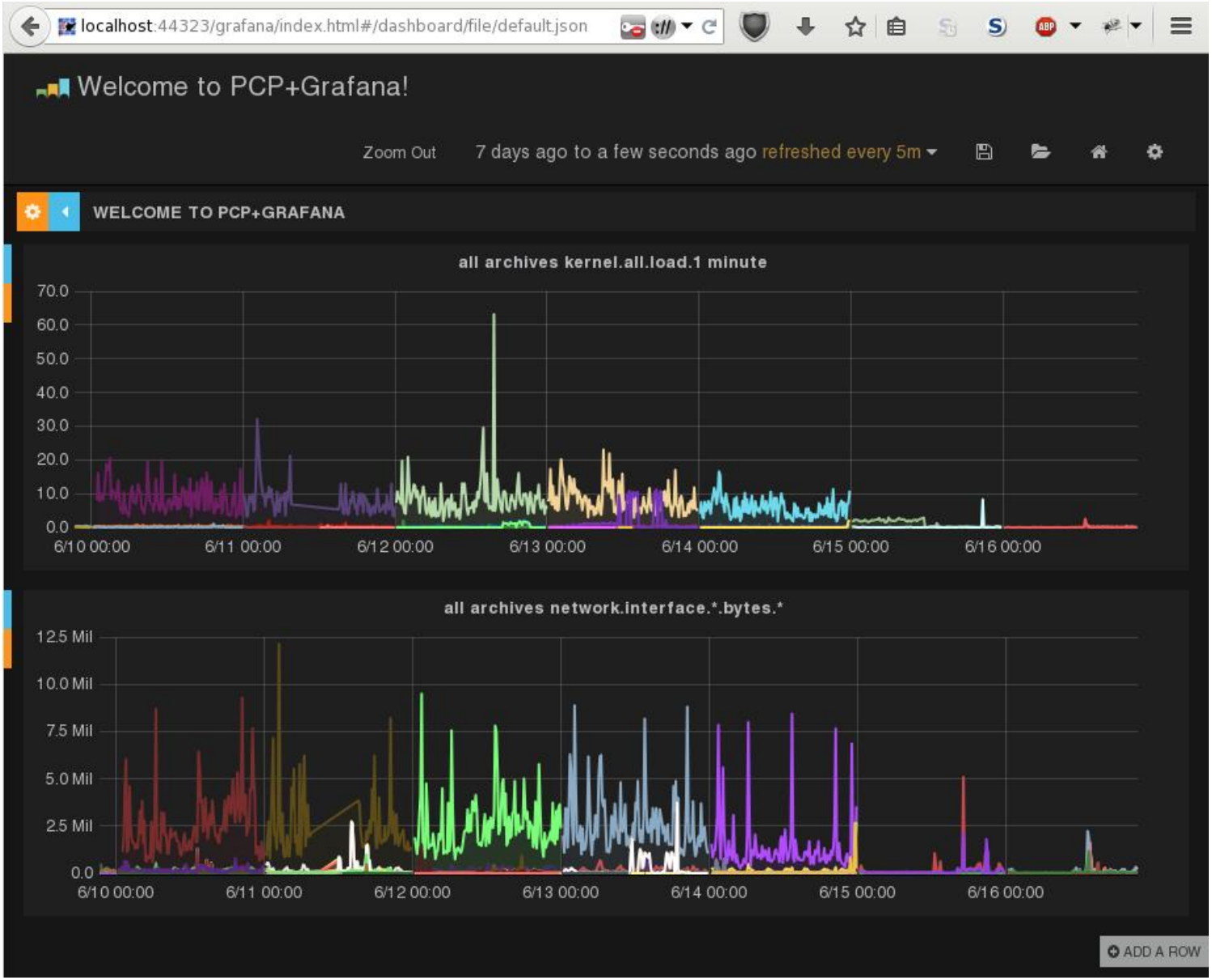

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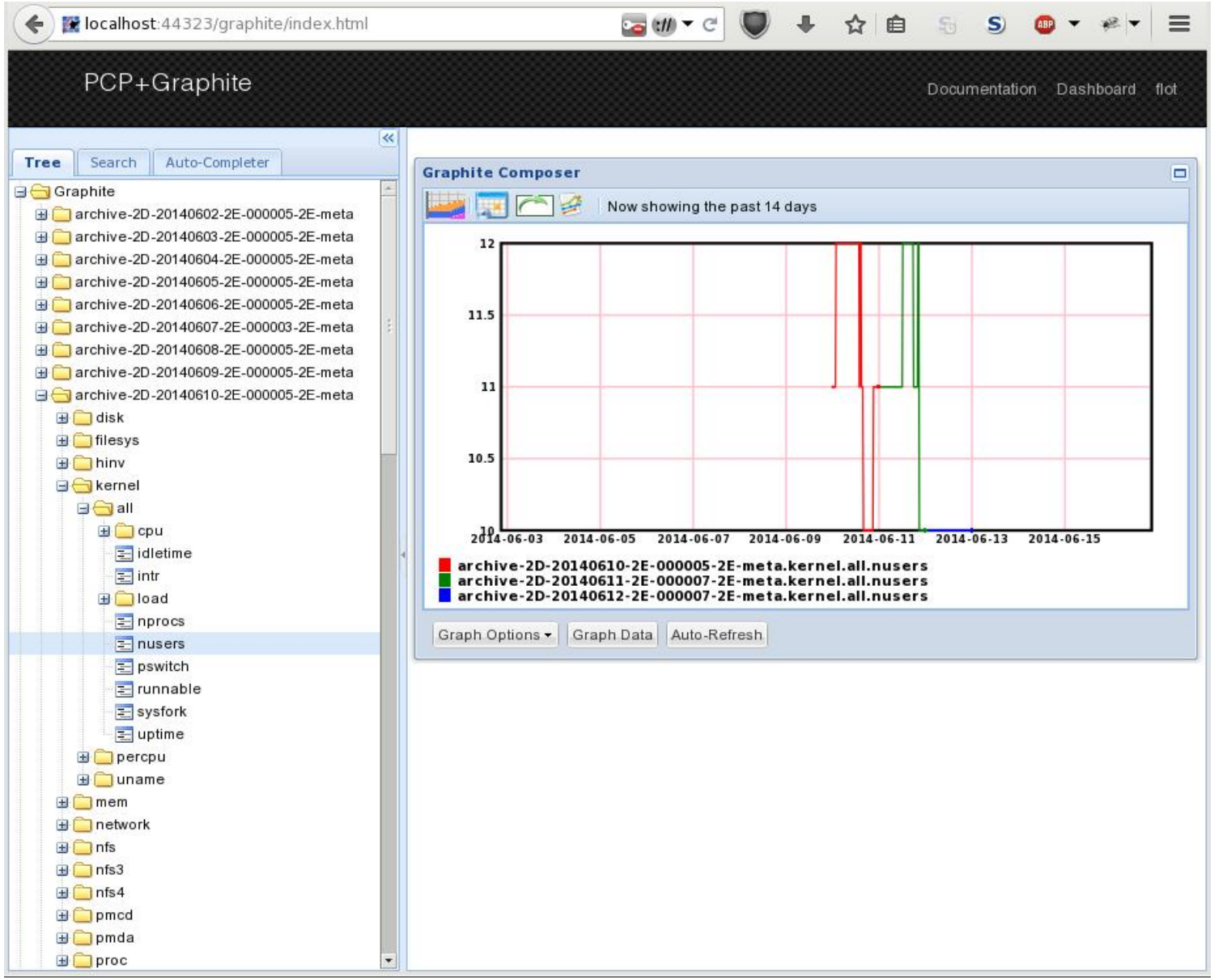


Performance Co-Pilot – Current Developments

PCP offers wide variety of metrics

- What if we want 'under the hood' metrics?
- Need a system-wide, tool with live data to help...

Introducing:

What is SystemTap

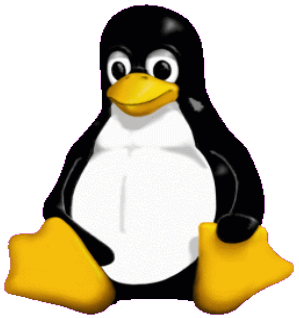
Tool for examining live system events

- Communicated through scripts
- Links the strengths of tracers, profilers, and debuggers.

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

Linux Kernel Module

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



the all-seeing Linux Kernel

Usage

Two major components of scripts:

1) Probe Points
2) Handlers

Example Probe

Simple Hello world

```
probe begin {
  println ("Hello, World!")
}
```

Or tracking when a new bash process is started

```
probe process("bash").function("main") {
  println("A bash process has started")
}
```

Example Probe

Or something a little more complicated:

- Listing functions in the order that a process calls them

```
$ cat bash_functioncalls.stp
probe process("bash").function("*").call {
    printf ("bash called function %s\n", ppfunc())
}

$ stap bash_functioncall.stp
bash called function _start
bash called function __libc_csu_init
bash called function _init
bash called function frame_dummy
bash called function register_tm_clones
bash called function main
bash called function xtrace_init
...
```

Getting Started

- Where do you start? Figure out what you can probe.
- If you don't know what probe points types there are:

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

java(number).class(string).method(string)
kernel.function(number)
module(string).statement(string)
process(string).function(string).callees
procfs(string).read
timer.usec(number)
...
```

Language

What can you include in handlers?

- Ordinary features you'd find in a language:
- Globals, locals, string, integers, loops, conditionals, functions, arrays, error handling and more

Additional, handy features:

- Associative arrays, foreach loop, aggregates, macros, regex matching

Probe Points

How does one start writing a script?

- Listing mode is a great starting point
- Lists possible probe points

```
$ stap -l 'process("stap").function("symbol_*")'

process("stap").function("symbol_fetcher@elaborate.cxx:1092")
process("stap").function("symbol_table@tapsets.cxx:424")
```

Context Variables

Probes can access context variables

```
$ stap -L 'kprocess.create'

kprocess.create task:long new_pid:long new_tid:long
$return:struct task_struct* $clone_flags:long unsigned int ...
```

The context variables start with “$”

Tapsets

A library for systemtap scripts

- Their purpose is provide a level of abstraction
- Users don't have to know the exact details

For example:

```
kprocess.create = kernel.function("copy_process").return
```

For a list of all the aliased probes

```
stap --dump-probe-alias
```

Tapsets

There are also helper functions

```
$ cat kprocess_list.stp
probe kprocess.create {
  printf ("Process %s was started\n", pid2execname(new_pid))
}

$ stap kprocess_list.stp
Process bash was started
Process bash was started
Process soffice.bin was started
Process soffice.bin was start
Process udisksd was started
Process firefox was started
```

For a list of available helper functions

```
stap –-dump-functions
```

Tapsets

And helper variables

```
$ cat helper_vars.stp
probe syscall.* {
    printf ("syscall: %s, parameters: %s\n",
              name, $$parms$$)
}

$ stap helper_vars.stp
syscall: read, parameters: fd=4 buf=140736613309360 count=8196
syscall: fcntl, parameters: fd=4 cmd=4 arg=32770
syscall: kill, parameters: pid=4200 sig=10
syscall: fcntl, parameters: fd=4 cmd=4 arg=34818
syscall: read, parameters: fd=4 buf=140736613309360 count=8196
syscall: fcntl, parameters: fd=4 cmd=4 arg=32770
syscall: pselect6, parameters: n=5 inp=140736613308976 outp=0
exp=0 tsp=0 sig=140736613308864
...
```

Example

terminator.c

```
 1:#include <stdlib.h>
 2:#include <stdio.h>
 3:
 4:int sleeper () {
 5:  static int num = 0;
 6:  sleep(1);
 7:  return num;
 8:}
 9:
10:int main () {
11:  int num = 0;
12:  while (num < 10) {
13:    num = sleeper ();
14:    printf("a second has passed\n");
15:  }
16:  printf("10 seconds have passed\n");
17:  return 0;
18:}
```

terminator.c

```
$ ./terminator
a second has passed
a second has passed
a second has passed
a second has passed
a second has passed
a second has passed
a second has passed
a second has passed
a second has passed
a second has passed
a second has passed
a second has passed
a second has passed
a second has passed
a second has passed
a second has passed
a second has passed
```

10th line == 10th second

terminator.c

Figure out what's going on

- Where to probe?
- Does function X ever call function Y? And with what parameters?
- What can be done if something's not quite right?

terminator.c

Where to probe?

```
$ stap -L 'process("terminator").function("*")'
```

Does main() ever call sleeper()?

- Check what functions main() calls.

```
$ stap -L 'process("terminator").function("main").callee("*")'

process("terminator").function("main@terminator.c:10").callee(
"sleeper@terminator.c:4") $num:int const
```

terminator.c

That was just a starting point!

- What determines when the loop ends?
- What about the return value from sleeper?

```
$ cat sleeper_return_check.stp

global old_num=-1

probe process("./terminator").function("sleeper").return {
  if ($num <= old_num)
    error("num is not increasing!")
  old_num = $num
}
```

terminator.c

Running the script

```
$ stap sleeper_return_check.stp -c ./terminator

a second has passed
a second has passed
ERROR: num is not increasing!
WARNING: Number of errors: 1, skipped probes: 0
WARNING: /home/ajakop/work/codebase/install/bin/staprun
exited with status: 1
Pass 5: run failed.  [man error::pass5]
```

Well, that explains things.

- So how can we fix this?

terminator.c

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14:    printf("a second has passed\n");
15:  }
16:  printf("10 seconds have passed\n");
17:  return 0;
18:}
```

num++; ?

terminator.c

Can't do that if the program can't be stopped.

- Alternative: write a script to do it!

```
$ cat fix_terminator.stp

global actual_num=-1

probe process("./terminator").function("sleeper").return {
  if ($num <= actual_num)
    {
      actual_num++
      $return = actual_num
    }
  else
    actual_num = $num
}
```

terminator.c

The result:

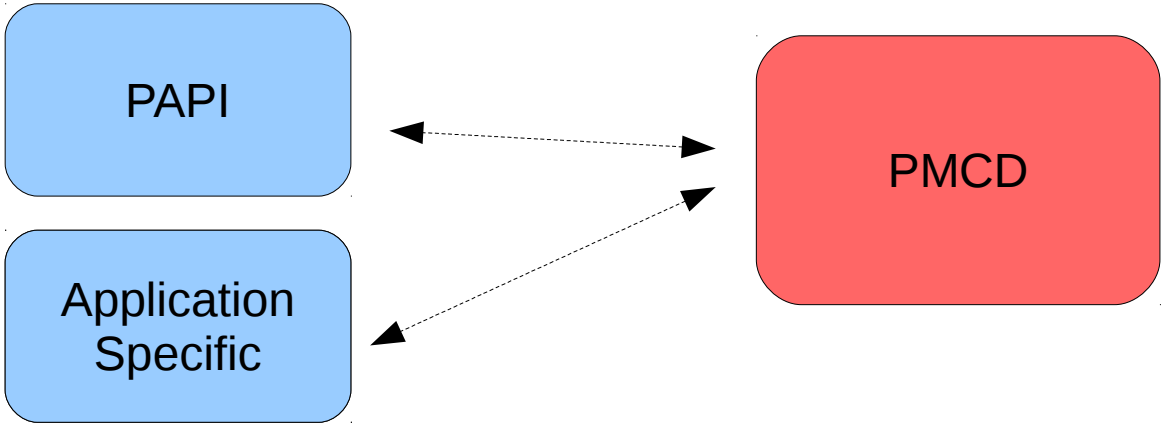
```
$ stap -g fix_terminator.stp -c ./terminator
a second has passed
a second has passed
a second has passed
a second has passed
a second has passed
a second has passed
a second has passed
a second has passed
a second has passed
a second has passed
a second has passed
10 seconds have passed
```

Yay! It worked!

Performance Co-Pilot – Current Developments

Systemtap fits the bill for what we need

- Malleable output
- Able to specify various probe points
- Exposes low level information, safely



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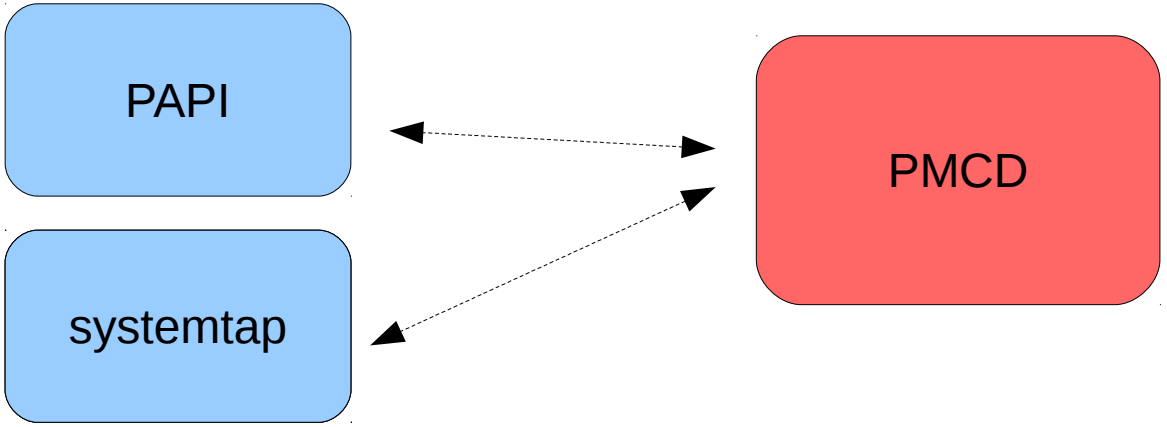
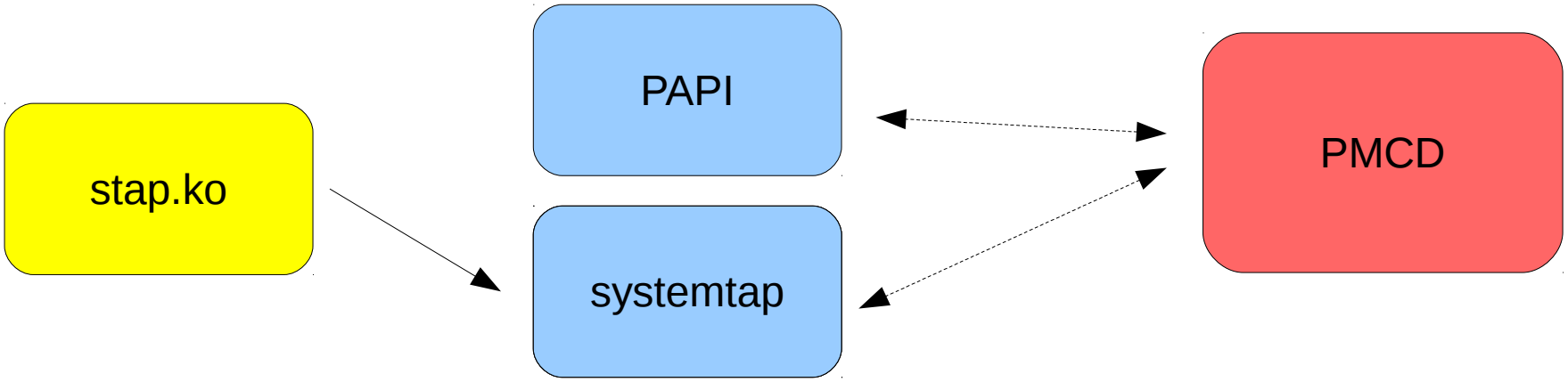


Performance Co-Pilot – Current Developments

Example

- Can we determine network latency on a network device?



Performance Co-Pilot – Current Developments

```
# stap ./net_xmit.stp eth0 dev1 dev2

# pminfo -df stap_json

stap_json.json.net_xmit_data.xmit_latency
    Data Type: 64-bit int  InDom: 130.0 0x20800000
    Semantics: counter  Units: none
    inst [0 or "dev1"] value 0
    inst [1 or "dev2"] value 0
    inst [2 or "eth0"] value 319


stap_json.json.net_xmit_data.xmit_count
    Data Type: 64-bit int  InDom: 130.0 0x20800000
    Semantics: counter  Units: none
    inst [0 or "dev1"] value 0
    inst [1 or "dev2"] value 0
    inst [2 or "eth0"] value 2304551
```

Performance Co-Pilot

Questions?

Get Involved!

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

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