Ntimed — A NTPD replacement

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!sdrawkcab si klat sihT :BN

* What is Ntimed going to be

* What is Ntimed right now

* Why did the world need Ntimed

* What's wrong with NTPD ?

Ntimed — what’s the plan ?

* Ntimed-client -- ”steer my clock”

  Tiny, easily portable, DWIM.

* Ntimed-slave -- ”relay time service”

  Lightweight, robust, resilient, policy.

* Ntimed-master -- ”primary time service”

  The full monty.

* License = BSD 2-clause

Ntimed-master -- ”primary time service”

Target: Time-nuts, Time-lords &c

Task: Turn time-machinery (GPS, Atoms, Quasars)
       into Network time suppliers

Protocols: NTP (later: PTP)

Size: < 30KLOC

Status: Planned

Ntimed-master architecture

* A program for experimental science

* Python for high-level science-bits
    (see: GNUradio — it works)
    Clock-selection
    Clock-discipline/PLL
    Clock-modelling
    Policy

* Real time and protocol bits in C
    Security, Performance etc.

* Sandboxing
    Refclock code in separate ”jail” processes
    Refclocks in any language you like

Ntimed-slave -- ”relay time service”

Target: 2-3 per datacenter/ISP/VPN/...

Task: Import time-service into environment

Protocols: Outside: NTP Inside: NTP (PTP ?)

Size: < 20KLOC

Status: 33% (=ntimed-client)

Ntimed-slave architecture

1 thread -> acquire time
    = Ntimed-client
    Possibly: + more policy controls

1 thread per interface -> deliver time

1 CLI thread for operation/monitoring

”thread” likely ”sub-process” for jail/security

Focus: Operations, Statistics & Monitoring
    ie: Spot clients with wrong time.

Ntimed-client -- ”steer my clock”

Target: All computers in the world

Task: Put the system right on time

Protocols: NTP (later: PTP)

Size: < 10KLOC

Status: Prerelease

Ntimed-client architecture

Single thread, TODO list scheduling

Components:

- Server management
  - DNS, which servers, how many servers.
- Clock Estimation
  - Based on triangular pdfs
- Clock steering
  - Adaptive PLL
- Kernel Interface
  - Get(), Step(), Steer(), Sleep()
- Leap Second mitigation
  - If, When, How

Green Computing

Single- vs. Multithreading

I'm a big fan of multithreading

My other projects are FreeBSD and Varnish

But Ntimed basically does:

```
while (1) {
    sleep(x);
    send_packet();
    receive_packet();
    do_math();
    if (needed)
        adjust_kernel_clock();
}
```

Ntimed-client security calculus

Privileged Interactions:

- Adjust kernel timescale

Unprivleged interactions:

- Send & Receive UDP packets
- Write logfiles
- Send syslog messages

Ntimed-client attack surface

NTP packets are 48 bytes, fixed format & numerical

-> no scope for string based exploits

Numbers are in integer format

-> no scope for IEEE-754 exception exploits

All RX packets discarded, except one reply for each packet we send.

-> DoS surface/loading is minimal

Sandboxing is not free

Adds complexity

- Create trusted channels between jails

Sandboxes scale badly with portability

- fork(2) + setuid(2) + chroot(2)
- jail(2)
- MAC(2)
- POSIX Acls
- CAPSICUM
- Solaris Privileges
- SELinux
- Windows ?

Ntimed-client is not sandboxed

Cost/Benefit analysis came out negative.

(This decision will be revisited periodically)

If UNIX kernel-timekeeping was file-desc based

ie: /dev/kernel_time

Ntimed-client could just drop privs after open.

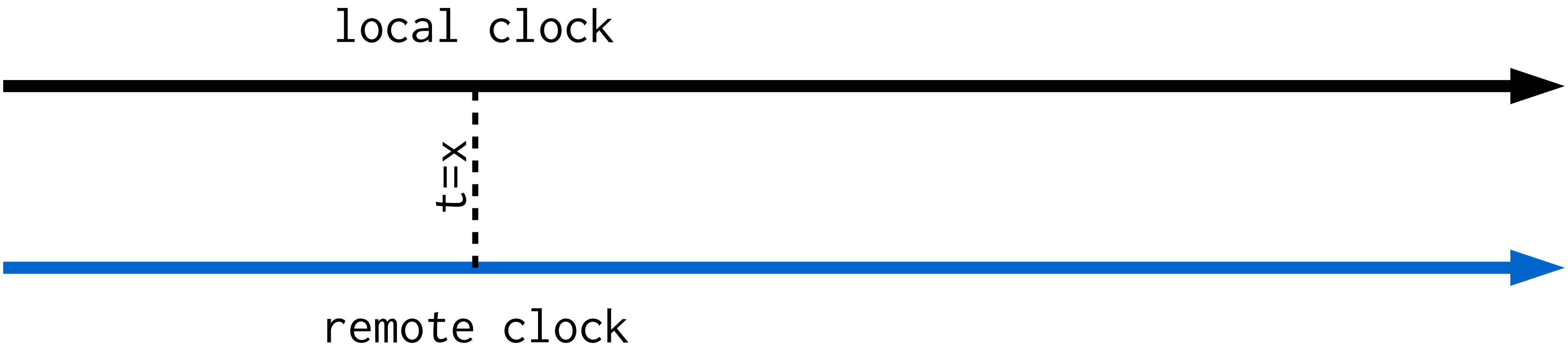
Server Management

DNS, which servers, how many servers

- Used servers: Fast poll, unused: slow poll
- If DNS returns 10 servers, which do you use ?
- What happens when DNS response changes ?
- Incomplete.
- Discussions ongoing with pool.ntp.org

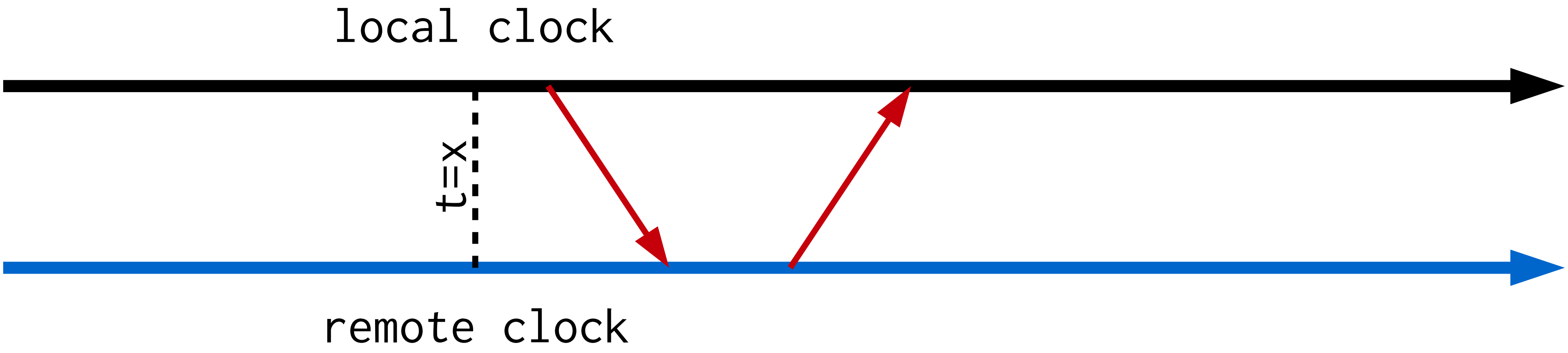
Clock Estimation

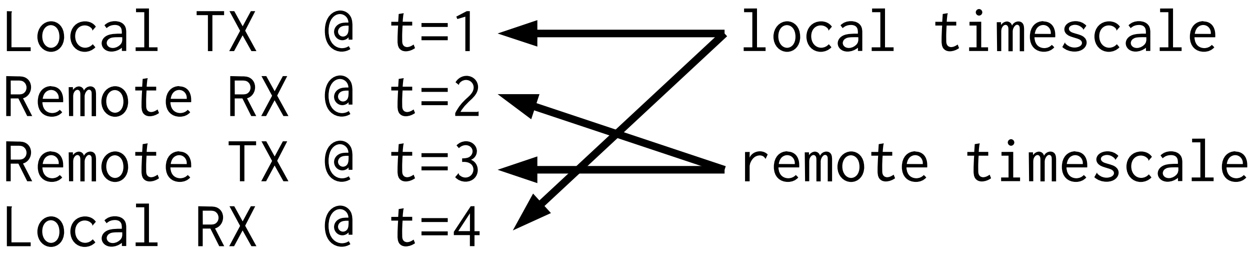
We have two timescales, we <u>think</u> they are the same



Clock Estimation

Lets send a packet and ask the other guy





Local TX @ t=1
Remote RX @ t=2
Remote TX @ t=3
Local RX @ t=4

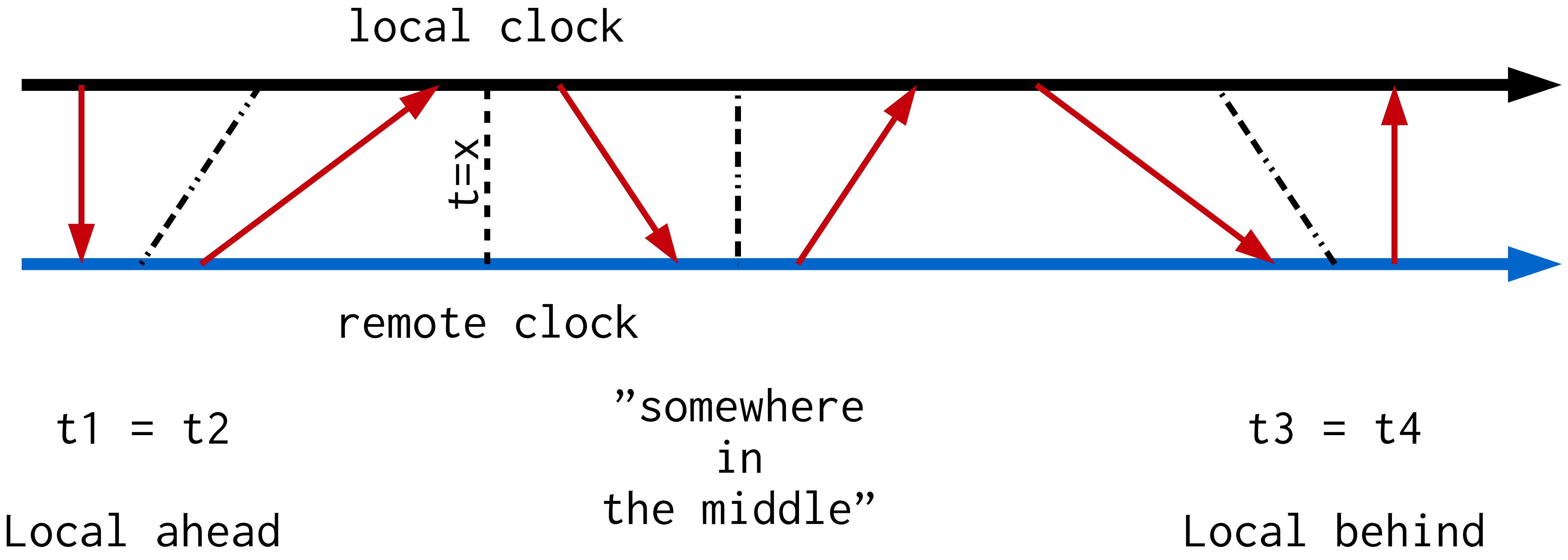
local timescale

remote timescale

We know: t=1 ≤ (t=2, t=3) ≤ t=4

Clock Estimation

Ok, so that wasn't so precise...



local clock

t=x

remote clock

t1 = t2

Local ahead

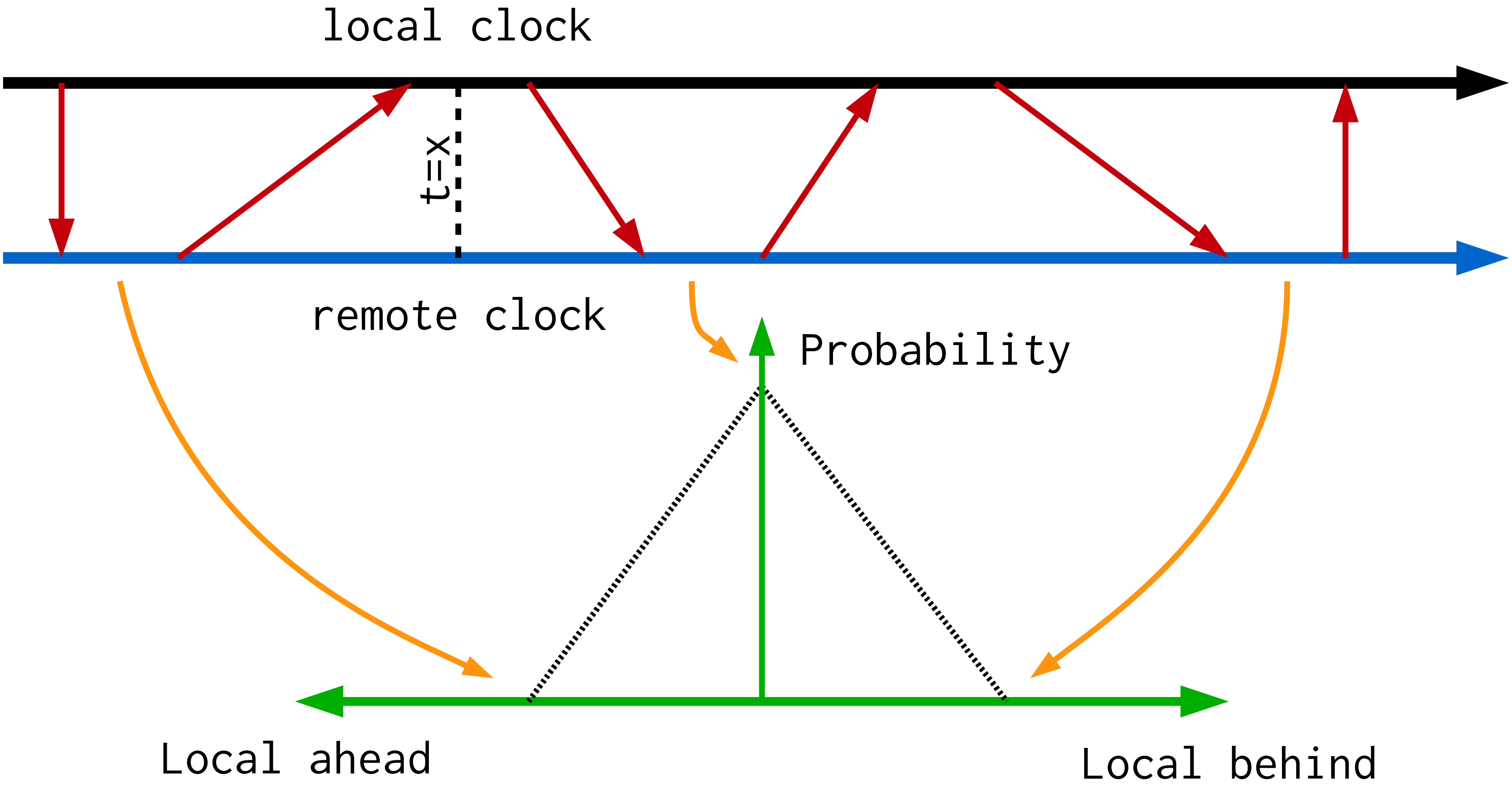
"somewhere
in
the middle"

t3 = t4

Local behind

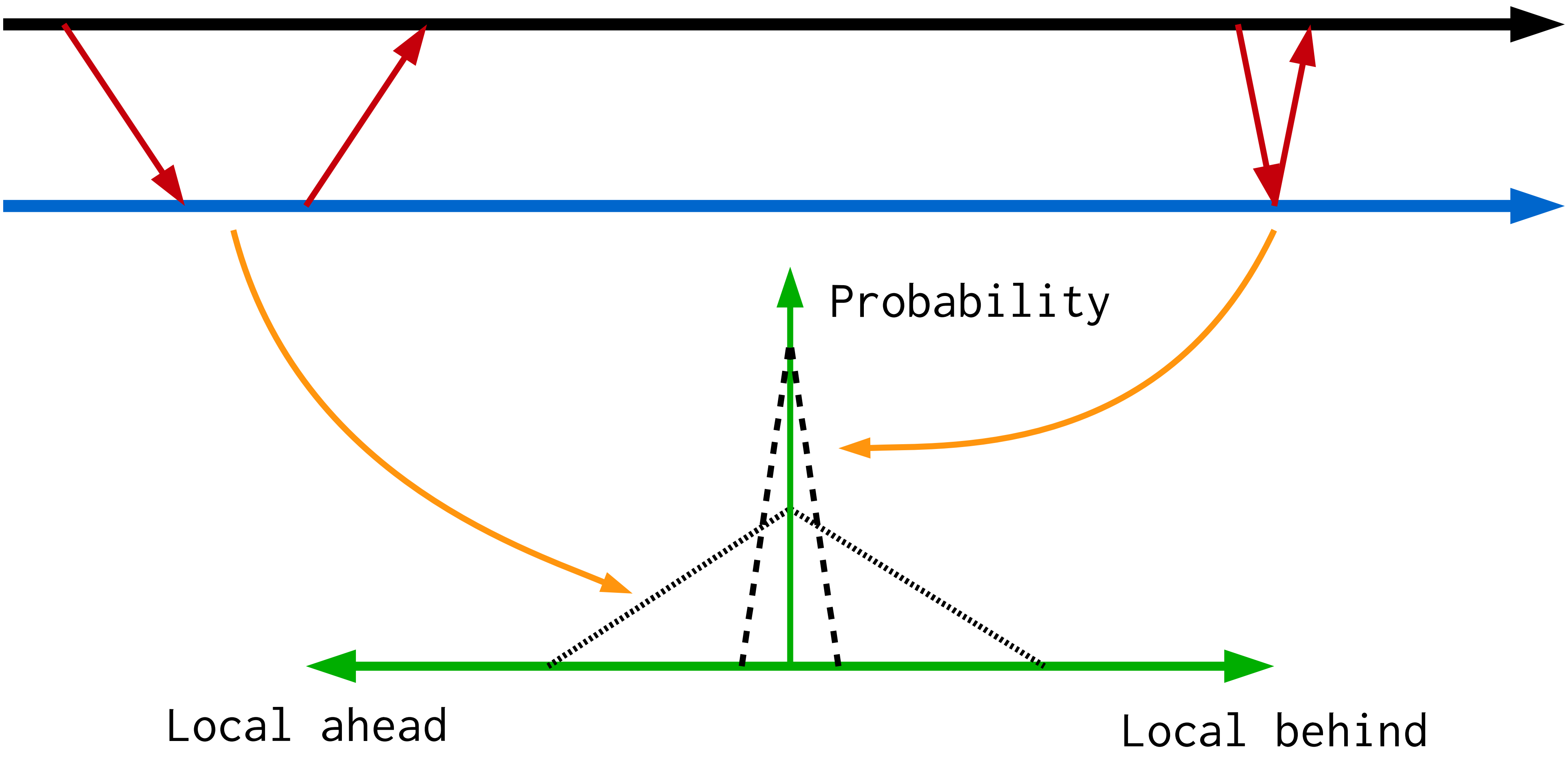
Clock Estimation

Triangular Probability Distribution Functions



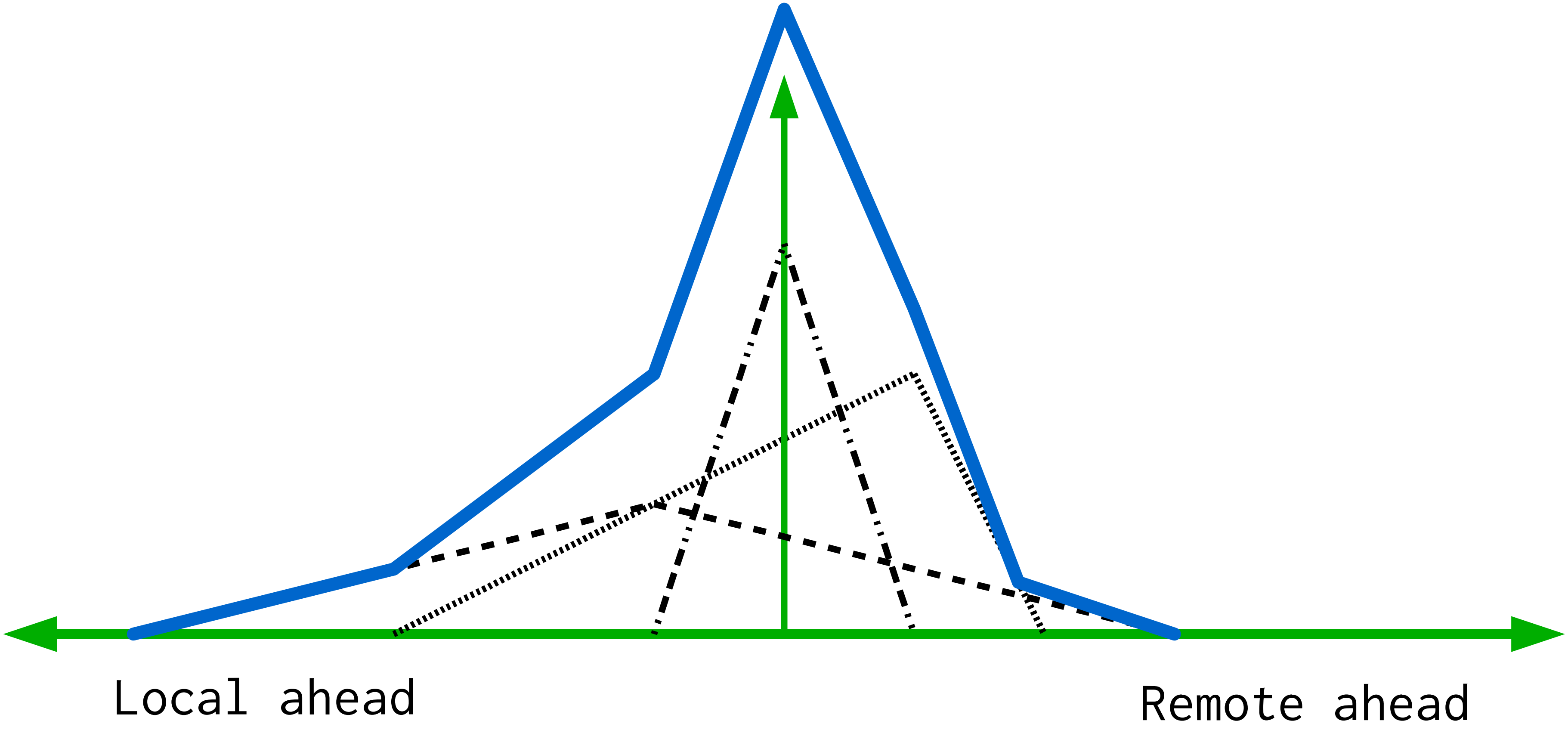
Clock Estimation

Lower TTL = sharper TPDF

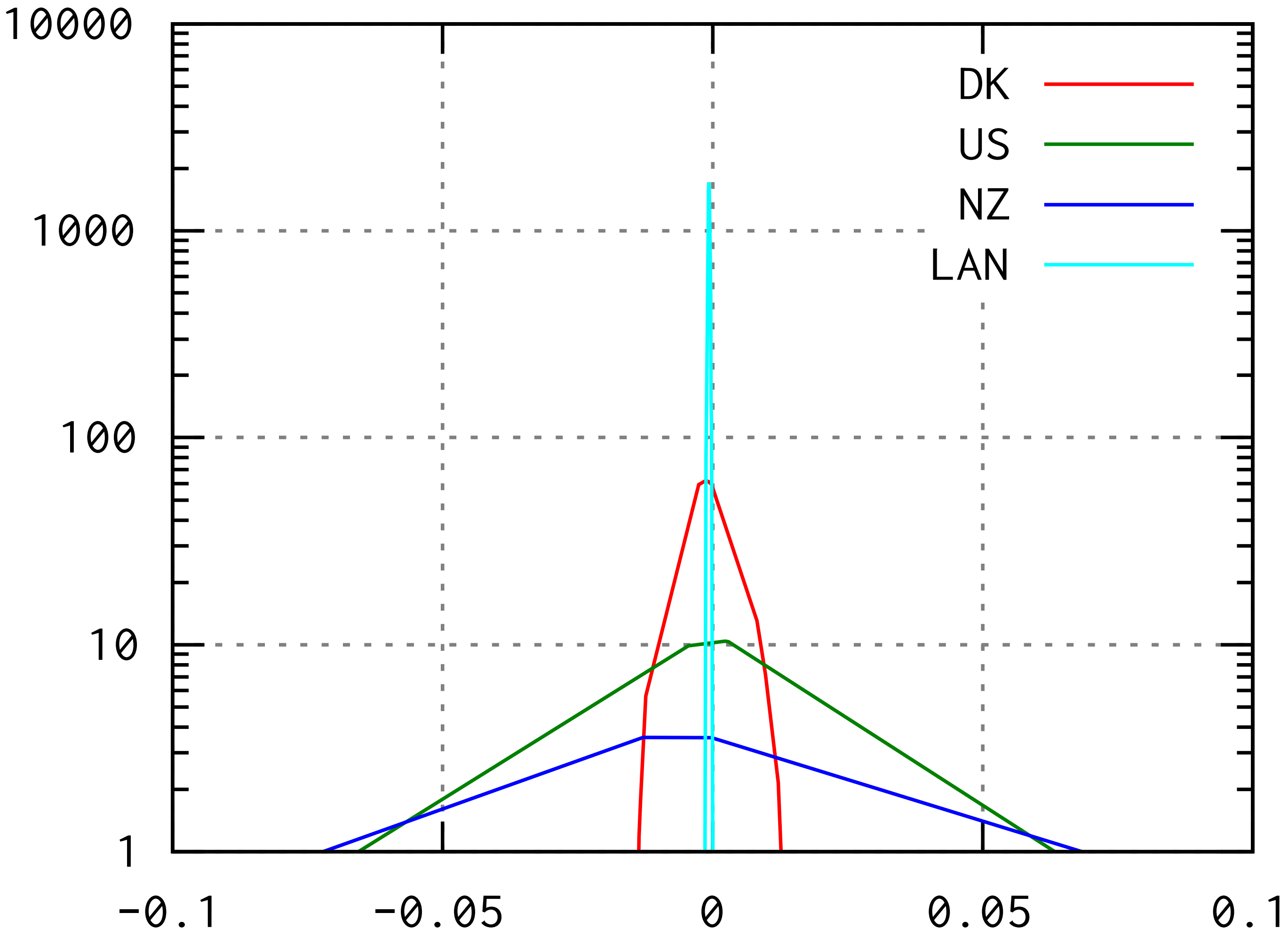


Clock Estimation

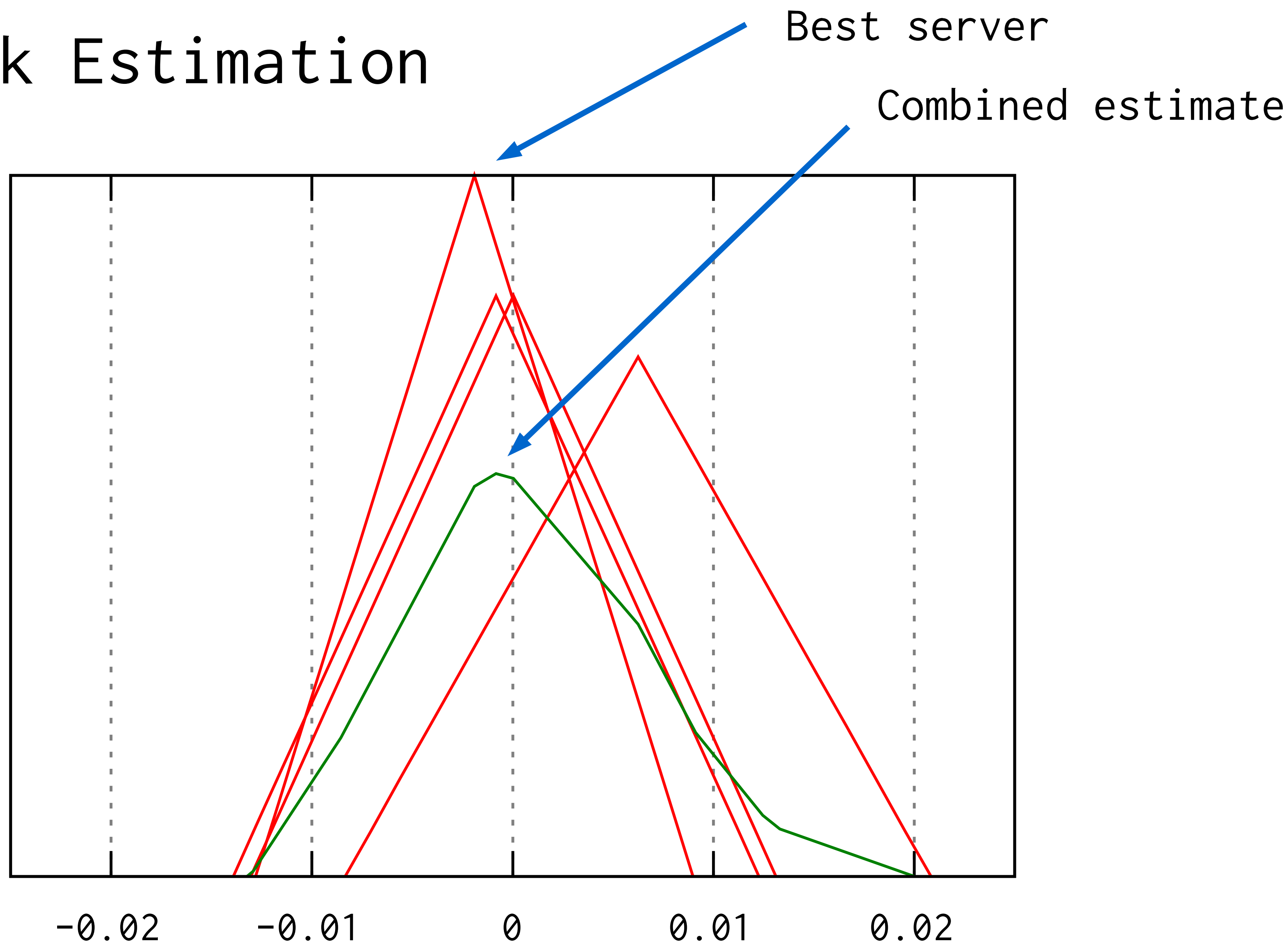
Ask N servers get N replies, do math...



Clock Estimation



Clock Estimation


Best server

Combined estimate

Clock steering

Adaptive PLL

Computer clocks are strange beasts

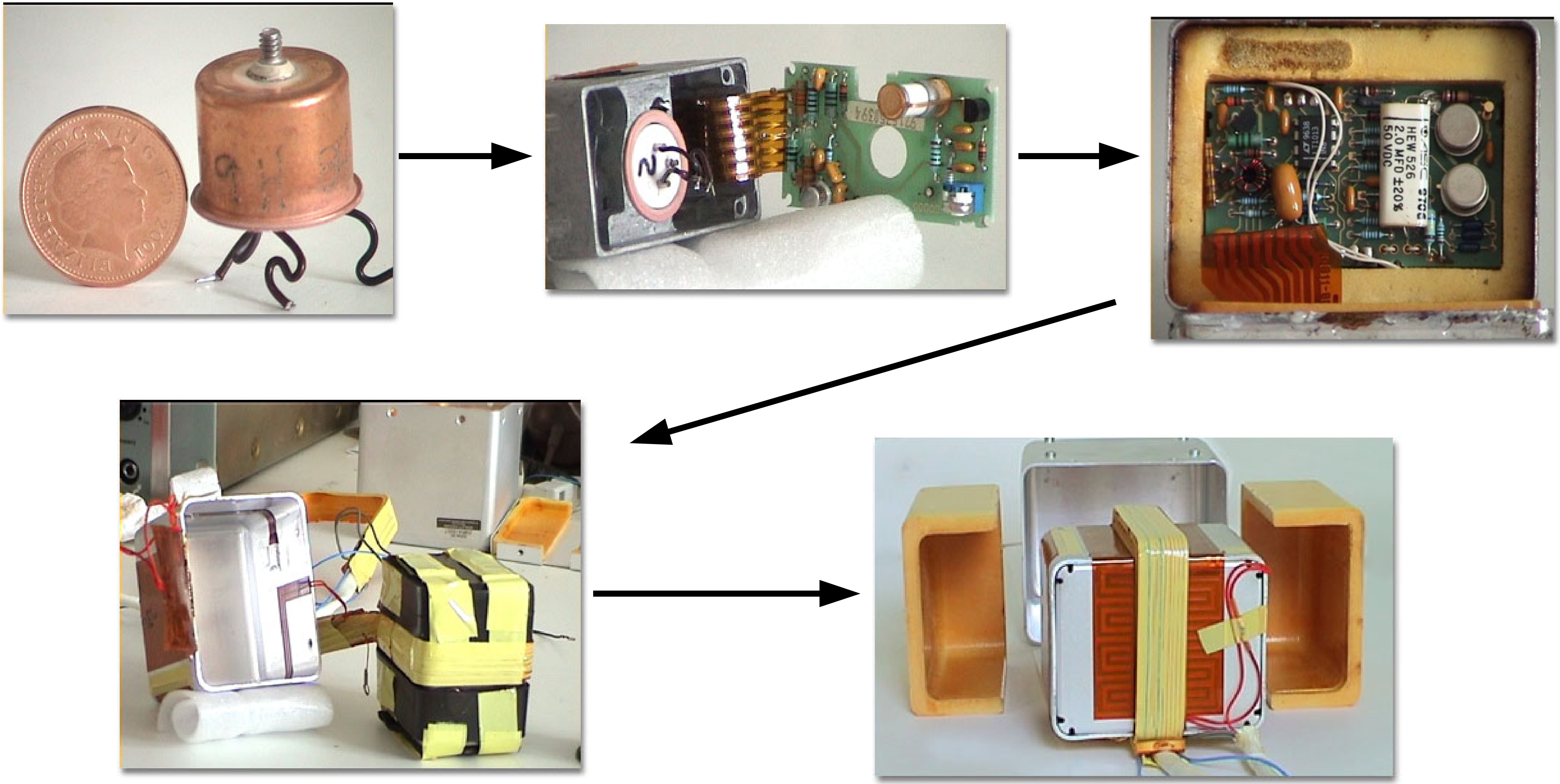
Not built for timekeeping

Routinely travel in time/space

* VM’s migrating to different hardware

* Suspend/Resume

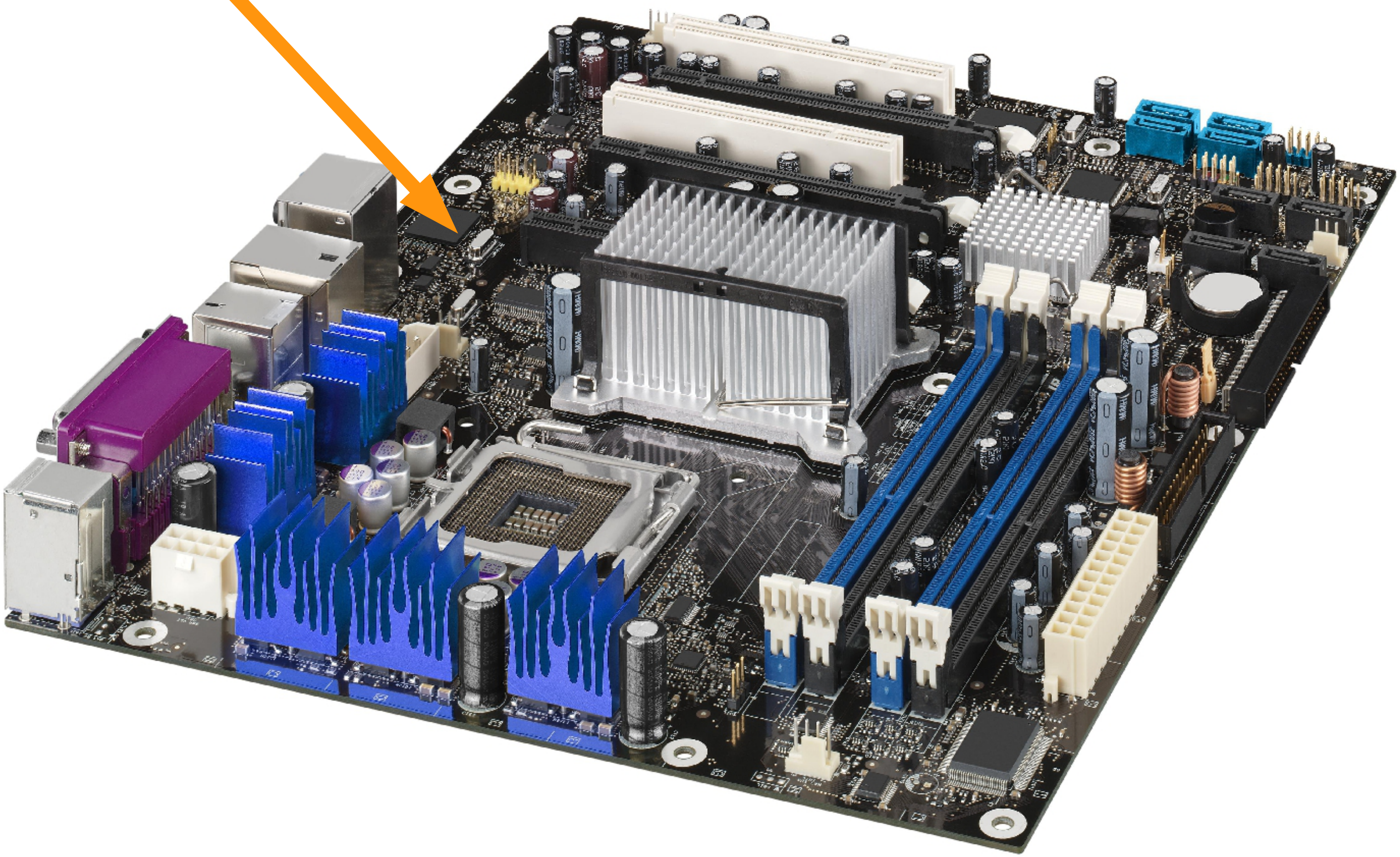
How time-nuts treat Quartz Crystals



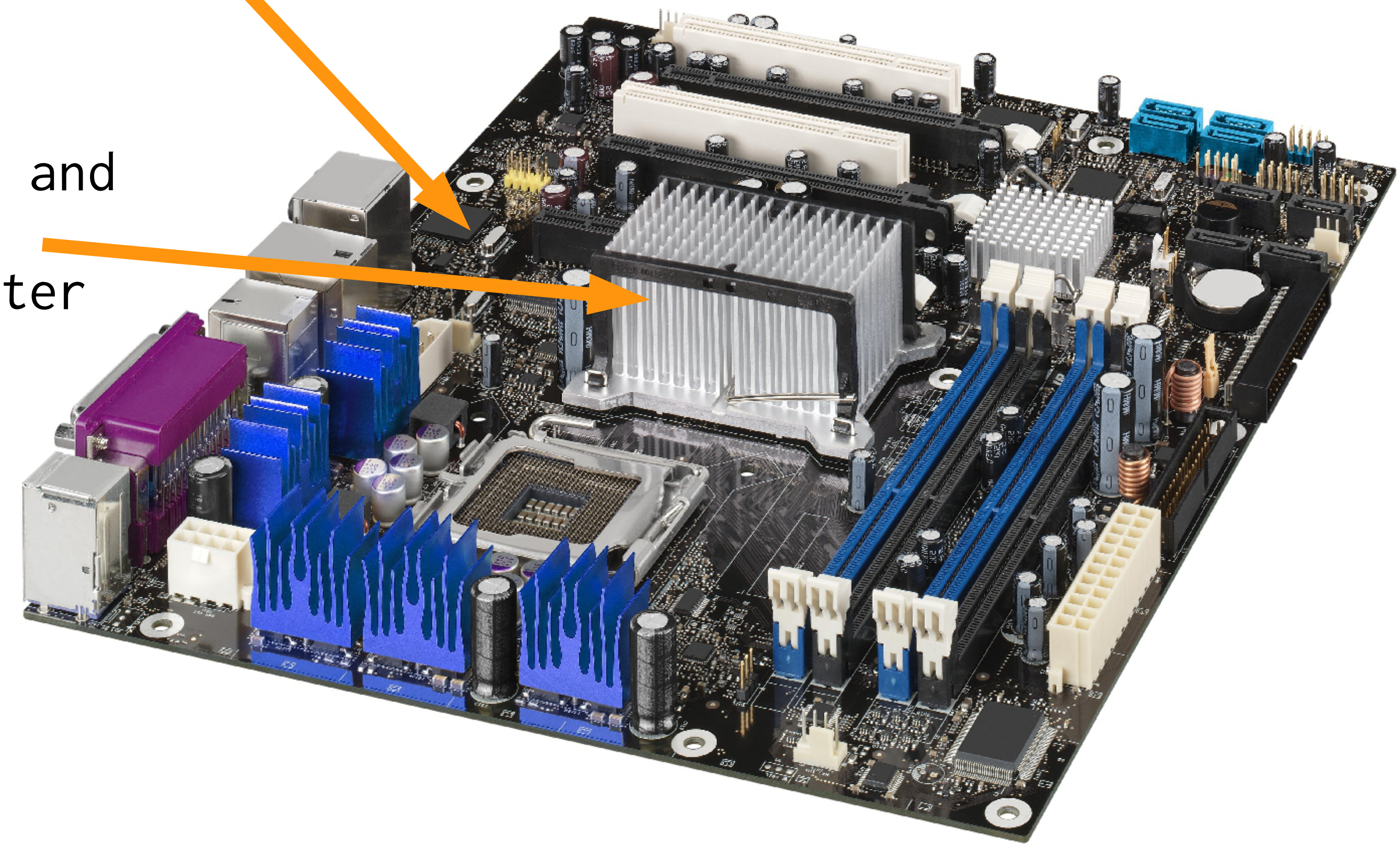
Photos: Steve Smith, G8LMX

How PCs treat Quartz Crystals

Crystal, (5 cents)



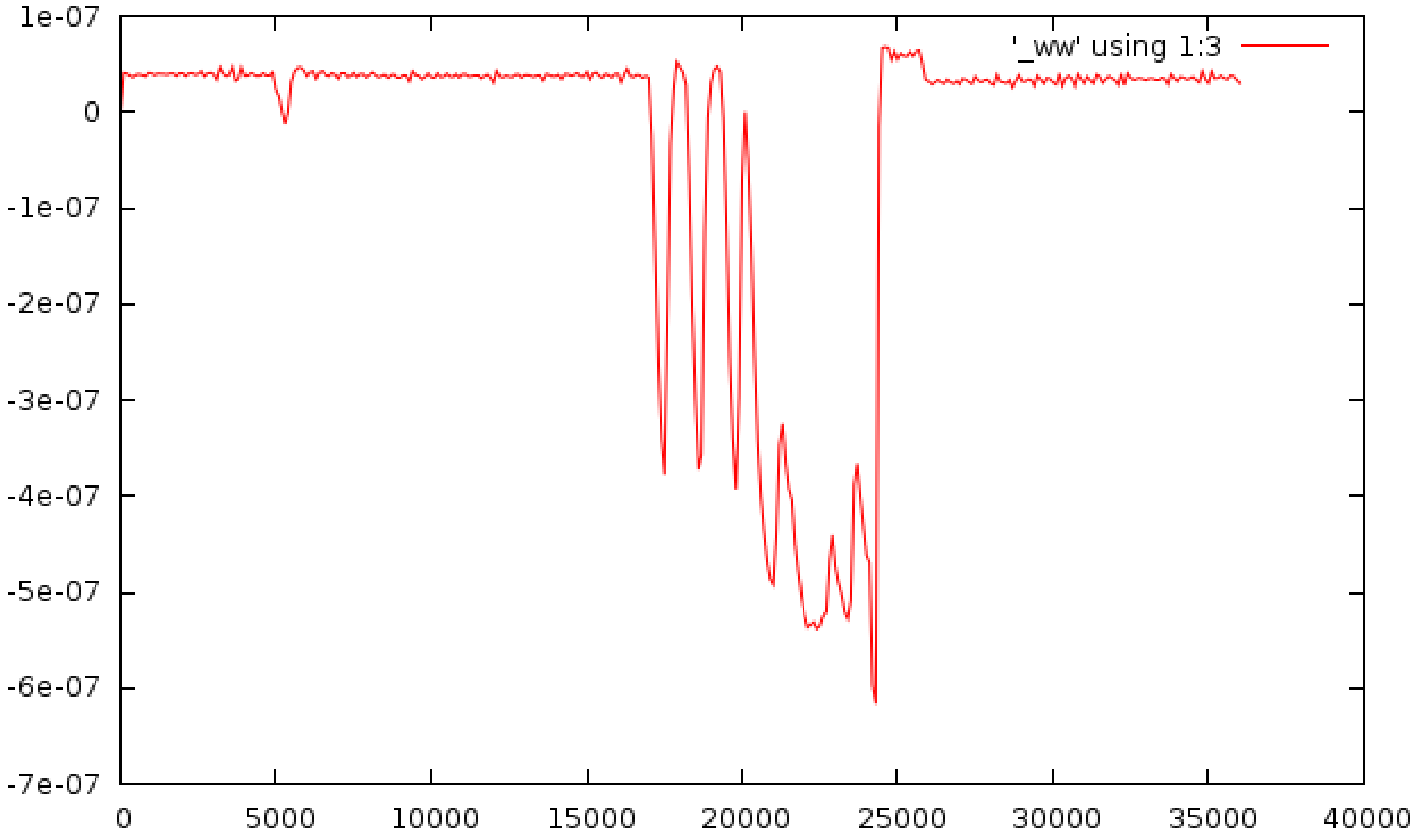
How PCs treat Quartz Crystals



Crystal, (5 cents)

100 W variable and
unpredicatable
electrical heater

Clock steering



Kernel Interface

Deliberately kept minimal for portability

Get() -- Tell me the time
clock_gettime(3) / gettimeofday(3)

Step() -- Set the time (right now!)
clock_settime(3) / settimeofday(3)

Steer() -- Adjust the rate of time (frequency)
ntp_adjtime(3)

Sleep() -- Wake me up later
sleep(3)/usleep(3)

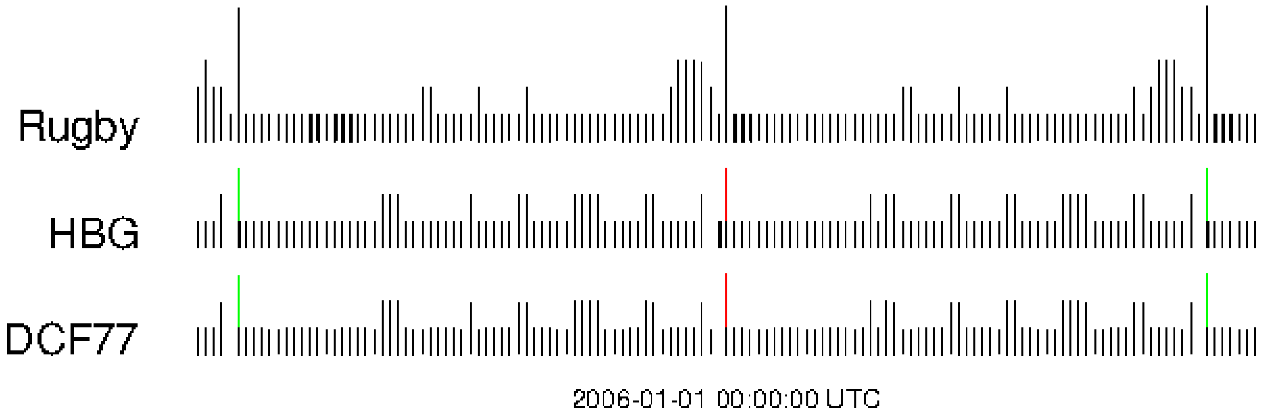
Leap Second Mitigation

If, When, How.

NTP servers are historically bad at this

Limited room for client creativity

”Leap-Smear” is *NOT* a client activity



Paris, 5 January 2015

Bulletin C 49

To authorities responsible for the measurement and distribution of time

UTC TIME STEP
on the 1st of July 2015

A positive leap second will be introduced at the end of June 2015.
The sequence of dates of the UTC second markers will be:

2015 June 30,	23h 59m 59s
2015 June 30,	23h 59m 60s
2015 July 1,	0h 0m 0s

The difference between UTC and the International Atomic Time TAI is:

from 2012 July 1,	0h UTC, to 2015 July 1 0h UTC	: UTC-TAI = - 35s
from 2015 July 1,	0h UTC, until further notice	: UTC-TAI = - 36s

Daniel Gambis
Head
Earth Orientation Center of IERS
Observatoire de Paris, France

Leap Second Mitigation

Pondering DNS based ”Bulletin-C service”

```
$ dig bulletin-c.example.com
bulletin-c.example.com 86400 IN A 244.20.141.253
[...]

    1111 + [y*12+m] + [dut1] + [leap] + [crc8]
    w=4    w=9        w=7      w=2      w=8

244.8.140.197  -> @ y2015m01  dut1=35 +0
244.20.141.253 -> @ y2015m07  dut1=35 +1
244.8.144.63   -> @ y2015m12  dut1=36 +0
```

Portable client: Only getaddrinfo(3) needed

Green computing considerations

2014Q2 server sales: 2 million
Assume 100W per server
Assume 25% runs Ntimed-client
Assume Ntimed-client uses 0.1% of resources

2e6 * .25 * 0.001 = 500 servers 100%

500 servers * 0.1kW = 50 kW

50 kW * ½ year = 220 MWh

200 Mwh ≅ 110 t CO_2 emissions

What is Ntimed right now ?

Ntimed-client prereleased at github:

https://github.com/bsdphk/Ntimed

Works, but missing:
Server mgt.
Leap second mitigation

```
$ cat *.[ch] | wc -l
    4669
```

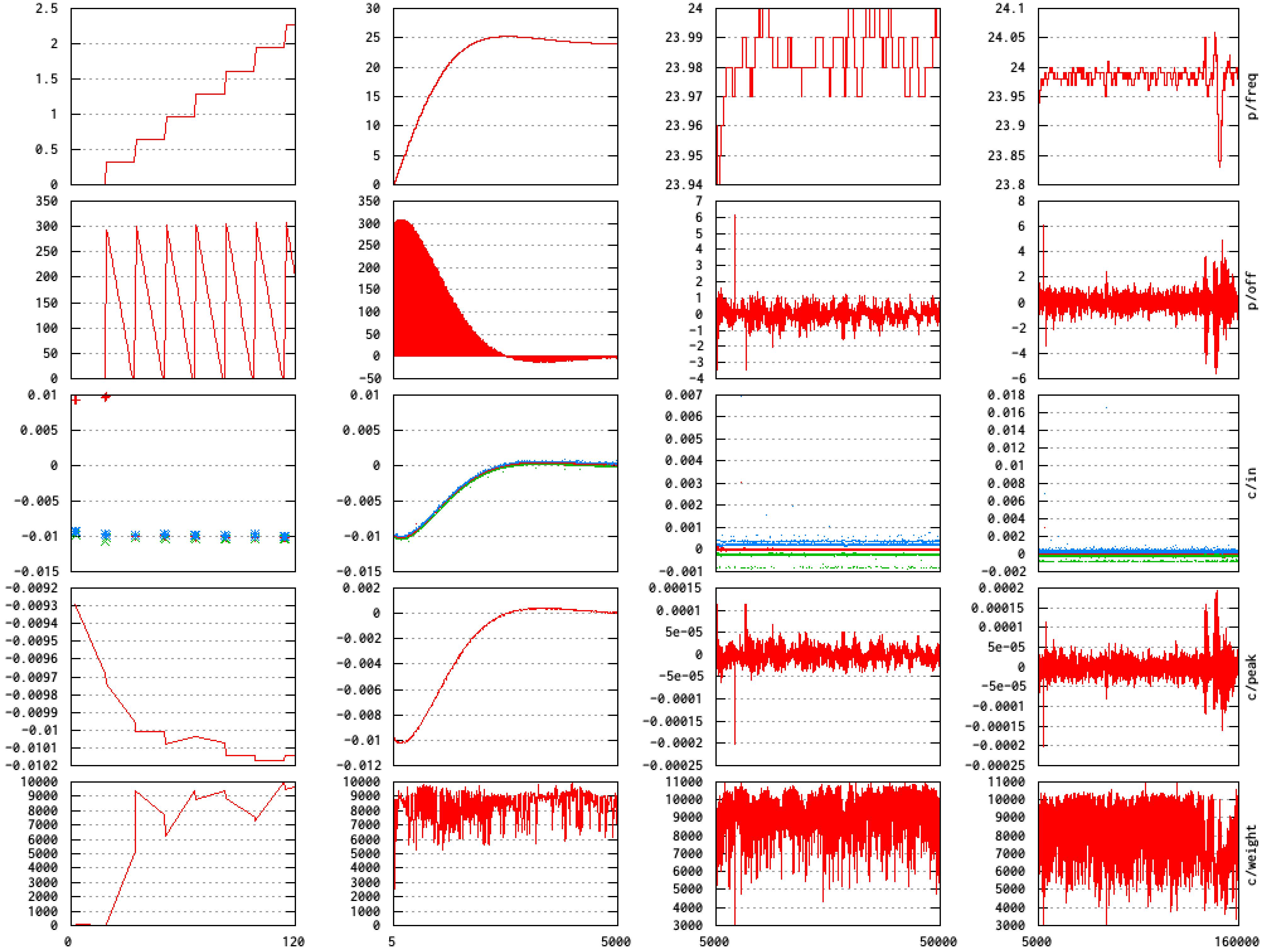
Written in ”Varnish Style”:
Max paranoia (356 lines contains asserts)
FlexeLint clean

What is Ntimed right now ?

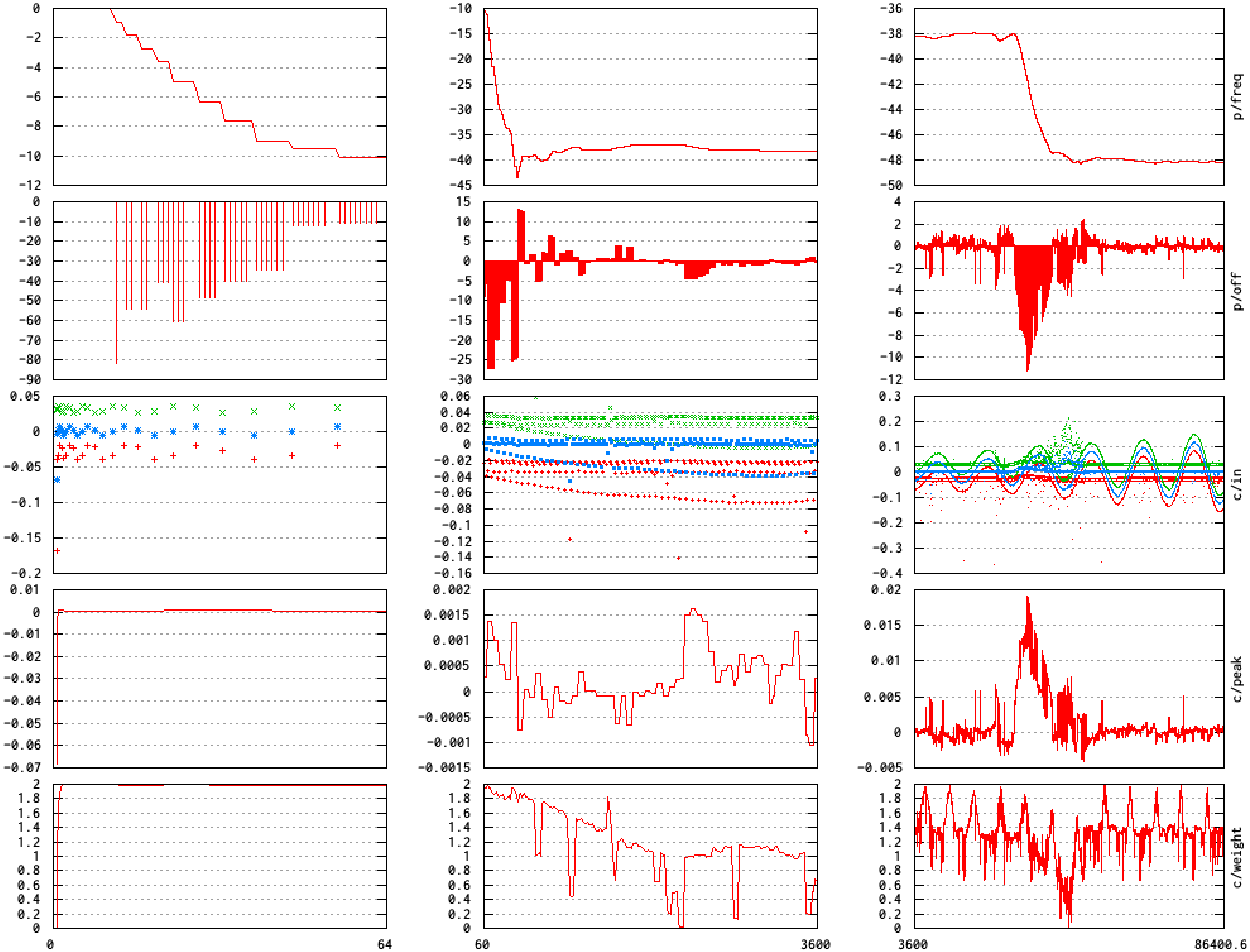
Portability:

Known good:	FreeBSD, Various Linuxen
Known bad:	OS/X (kernel support)
Not quite clear:	Solaris, NetBSD, OpenBSD

```
$ time sh configure
Found bsd.prog.mk, will use it.
Makefile generated, remember to run 'make depend'
0.000u 0.011s 0:00.01 100.0%    0+0k 1+0io 12pf+0w
```



2.5
2
1.5
1
0.5
0
30
25
20
15
10
5
0
24
23.99
23.98
23.97
23.96
23.95
23.94
24.1
24.05
24
23.95
23.9
23.85
23.8
p/freq
350
300
250
200
150
100
50
0
350
300
250
200
150
100
50
0
-50
7
6
5
4
3
2
1
0
-1
-2
-3
-4
8
6
4
2
0
-2
-4
-6
p/off
0.01
0.005
0
-0.005
-0.01
-0.015
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
-0.001
0.018
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
-0.002
c/in
-0.0092
-0.0093
-0.0094
-0.0095
-0.0096
-0.0097
-0.0098
-0.0099
-0.01
-0.0101
-0.0102
0.002
0
-0.002
-0.004
-0.006
-0.008
-0.01
-0.012
0.00015
0.0001
5e-05
0
-5e-05
-0.0001
-0.00015
-0.0002
-0.00025
0.0002
0.00015
0.0001
5e-05
0
-5e-05
-0.0001
-0.00015
-0.0002
-0.00025
c/peak
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
11000
10000
9000
8000
7000
6000
5000
4000
3000
c/weight
0
120
5
5000
5000
50000
5000
160000



p/freq
p/off
c/in
c/peak
c/weight
0
-2
-4
-6
-8
-10
-12
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
0.05
0
-0.05
-0.1
-0.15
-0.2
0.01
0
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
-0.07
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
64
-10
-15
-20
-25
-30
-35
-40
-45
15
10
5
0
-5
-10
-15
-20
-25
-30
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
-0.14
-0.16
0.002
0.0015
0.001
0.0005
0
-0.0005
-0.001
-0.0015
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
60
3600
-36
-38
-40
-42
-44
-46
-48
-50
4
2
0
-2
-4
-6
-8
-10
-12
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
0.02
0.015
0.01
0.005
0
-0.005
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
3600
86400.6

Why did the world need Ntimed ?

Short answer:

HEARTBLEED

Long answer:

Critical FOSS projects are understaffed, overworked, and unable to do a competent job.

Post-HEARTBLEED The Linux Foundation spotted the NTPD project as one of these, and threw some funding at the problem.

... or rather: At Harlan and me.

So why didn’t you just fix NTPD ?

I tried, I really tried!

But...

```
$ find . -name '*.[ch]' -print | wc -l
     828
$ find . -name '*.[ch]' -print | xargs cat | wc -l
  363194
```

I spent many weeks trying to find out where to stick the knife in...

NTPD is doomed

I could have renovated NTPD, but it would not be cost or time efficient.

Many advantages to a fresh start:

- Eradicate the many woo-doo workarounds
- Eliminate outdated assumptions
- Lay down good security architecture up front (rather than it being the far end goal)

Is NTPD safe ?

Right now ? Yes, I think so.

In the long term ? No.

What's wrong with NTPD

Copyright (C) 1970-2014 The University of Delaware

If 1970 is correct: (Harlan ?)

- Led Zeppelin IV (1971)
- Last Sean Connery James Bond Movie (1971)
- Muppet Show didn't exist for another four years

RFC778 18 april 1981

- Indiana Jones: Raiders of the Lost Ark
- Das Boot
- Suzanne Vega ”Toms Diner”
- Jean-Michell Jarre ”Magnetic Fields”
- Kraftwerk ”Computer World”
- Electric Light Orchestra ”Time”
- ABBA ”The Visitors”

It runs on PDP/11 with FUZZBALL OS

Initially it made sense to have one big program

NTPD has grown and grown and grown...

Lots of contributor code with approx 1 user.

Refclocks for stuff eBay has never heard of

It just got out of hand...

How do you even test this ?

NTPD used to have a simulation mode.

Could test some of the math.

I tried to resurrect it, but it had been buried in well intentioned changes.

Probably because only Dave and I ever used it...

NTPD was Daves program

And he cares a lot about timekeeping...

That is why I managed to get the ”nanokernel” past his review and into NTPD

But he doesn’t care about other stuff...

Which is why none of my other patches made it.

The problem with saints...

Dave failed to arrange a succession as his eye-sight deteriorated.

Harlan Stenn tried to hold the bits together

Created Network Time Foundation

... Which kept NTPD alive and ticking

... on life-support.

A personal note of thanks