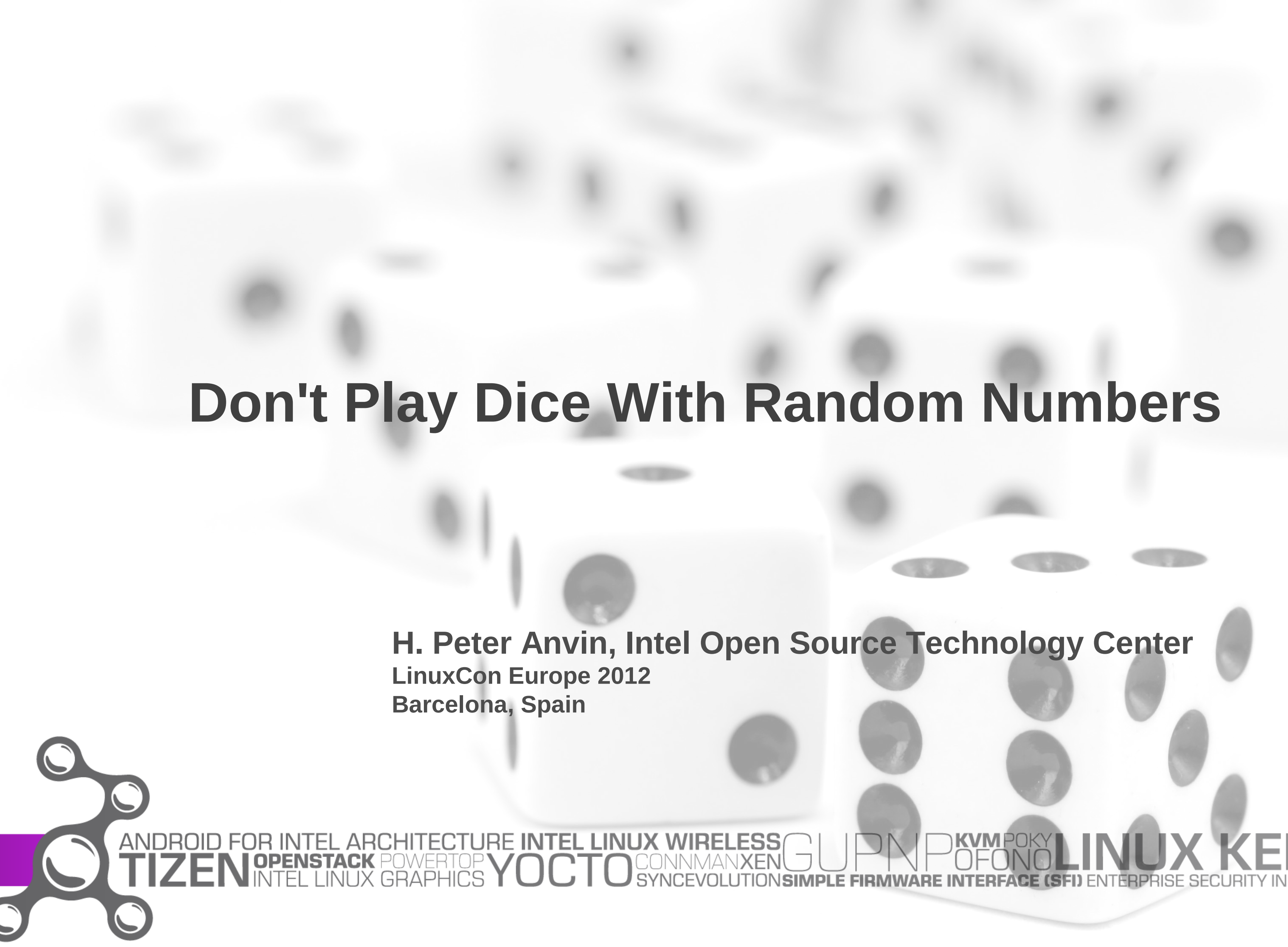


Don't Play Dice With Random Numbers

H. Peter Anvin, Intel Open Source Technology Center
LinuxCon Europe 2012
Barcelona, Spain

ANDROID FOR INTEL ARCHITECTURE INTEL LINUX WIRELESS GUPNP KVM POKY LINUX KE
TIZEN OPENSTACK POWERTOP INTEL LINUX GRAPHICS YOCTO CONNMAN XEN SYNCEVOLUTION OFONO SIMPLE FIRMWARE INTERFACE (SFI) ENTERPRISE SECURITY IN

Random numbers

- **Random numbers are used in...**
  - Games
  - Monte Carlo simulations
  - Security protocols
- Computers are not very random
  - Lots of effort goes into *eliminating* random behavior...
- “Good enough” randomness depends on the application
  - Security protocols have very high demands
  - Games usually not so much...

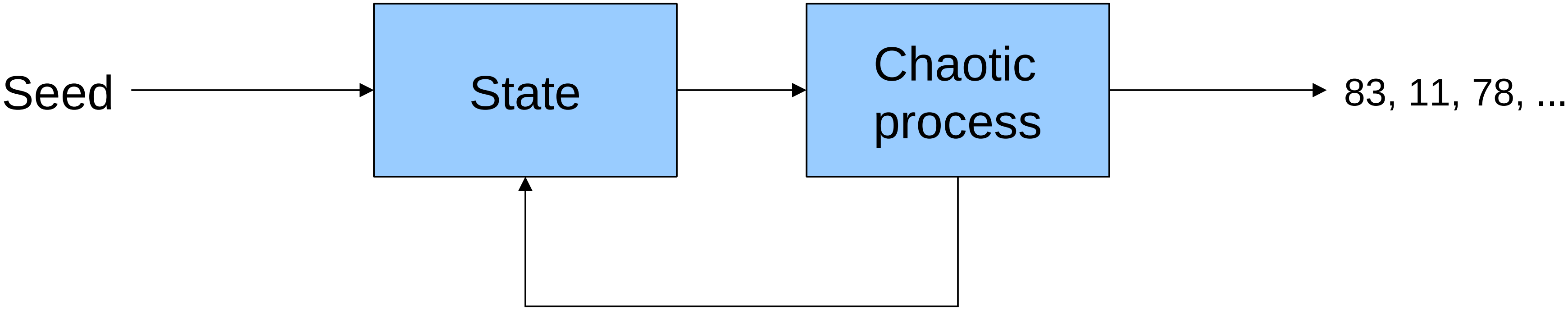
Randomness is subtle

- **Improper use**
  - A random number is only random once
  - Only random until the outcome is known
- **There are no tests for randomness!**
  - There are tests for *some types* of nonrandomness
  - General testing for randomness might be intractable (**P = BPP** conjecture)
  - Need to understand the failure modes of the source

What could possibly go wrong?

- **Weak keys**
  - Several serious vulnerabilities in Linux distros already
- **Key disclosure**
  - Recent PS3 hack
- **Identifier collisions**
  - UUIDs are probabilistically unique
- **...**

Pseudo-Random Number Generator



- **Statistical properties**
- **Cycle length**
- **Resistance to analysis (“security”)**

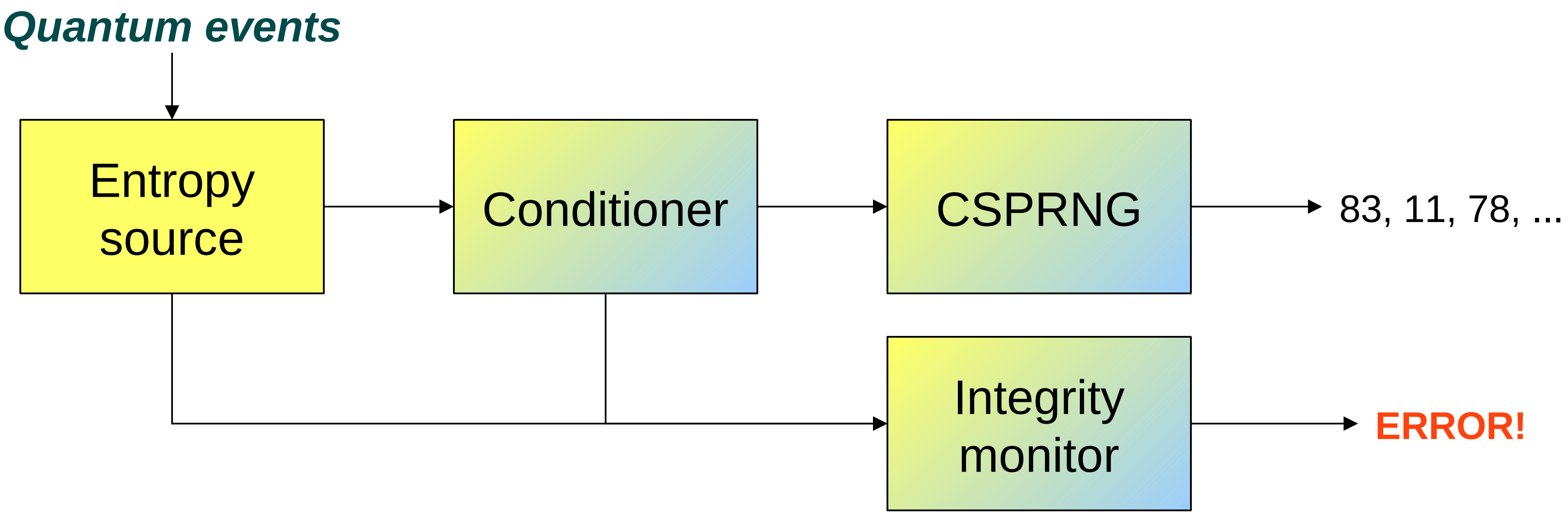
“God doesn't play dice.”

— Albert Einstein

“Wanna bet?”

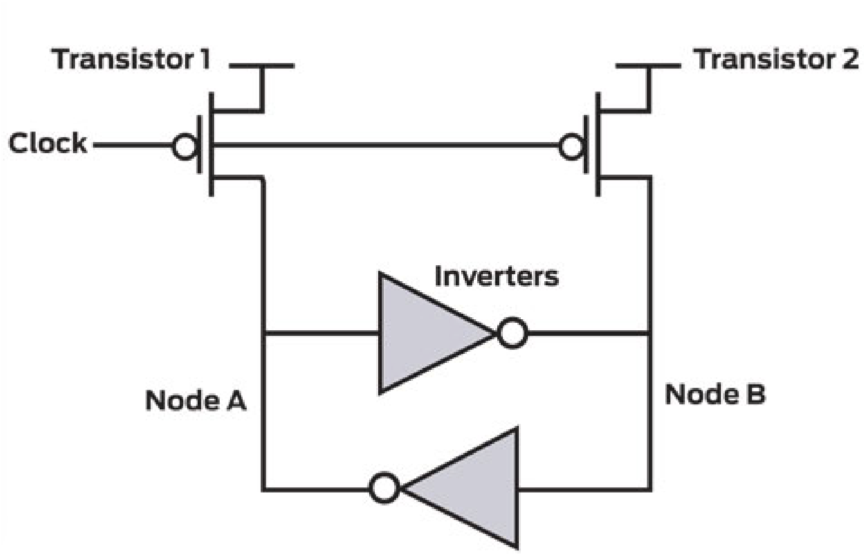
— God

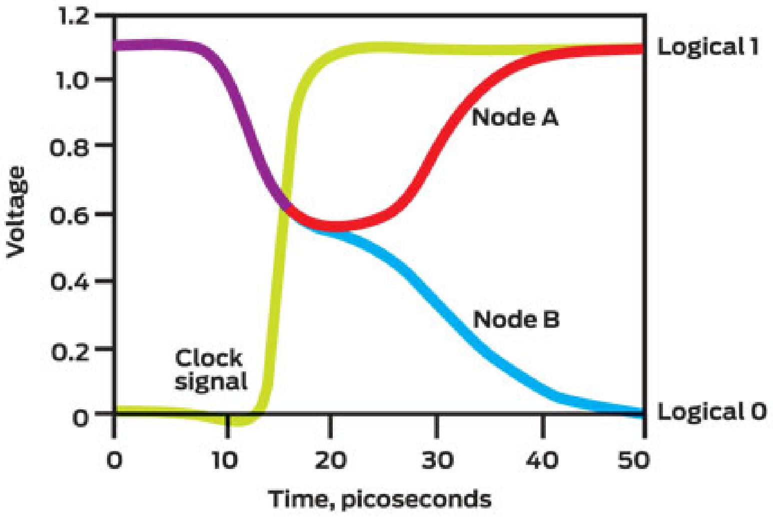
Hardware (true) Random Number Generator

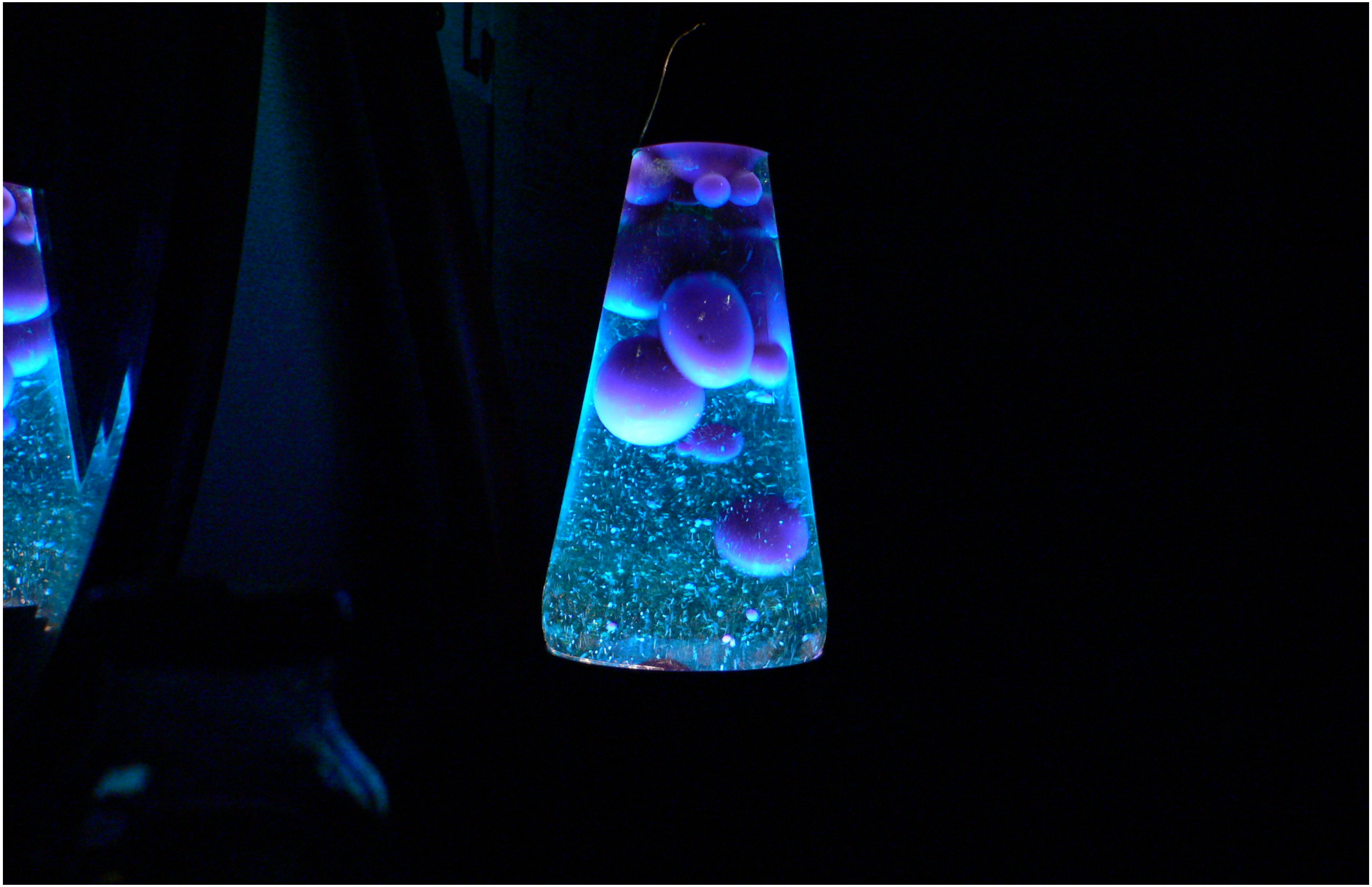


- **Bandwidth**
- **Resistance to observation (“security”)**
- **Failure modes**

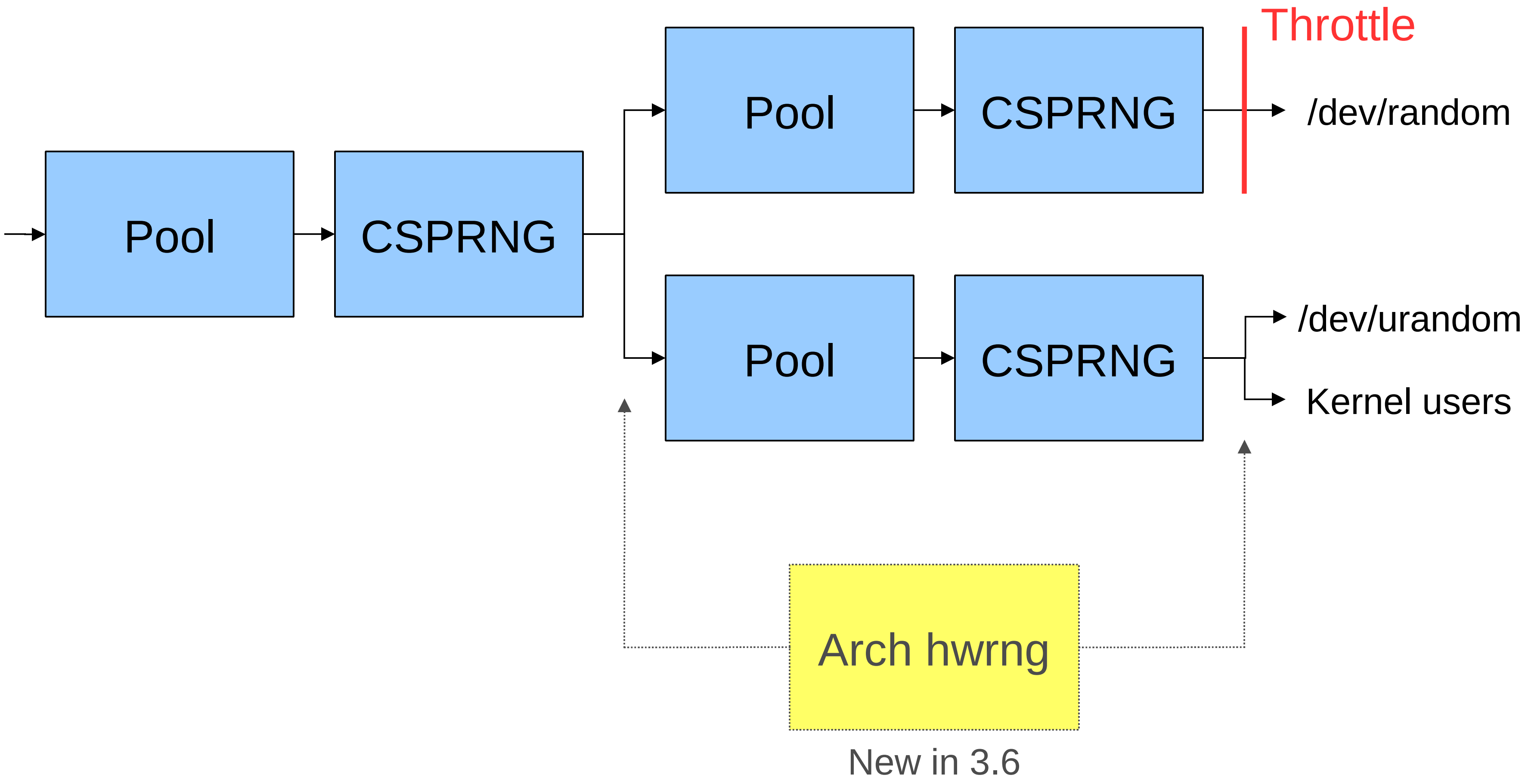
Intel Bull Mountain Technology (DRNG)



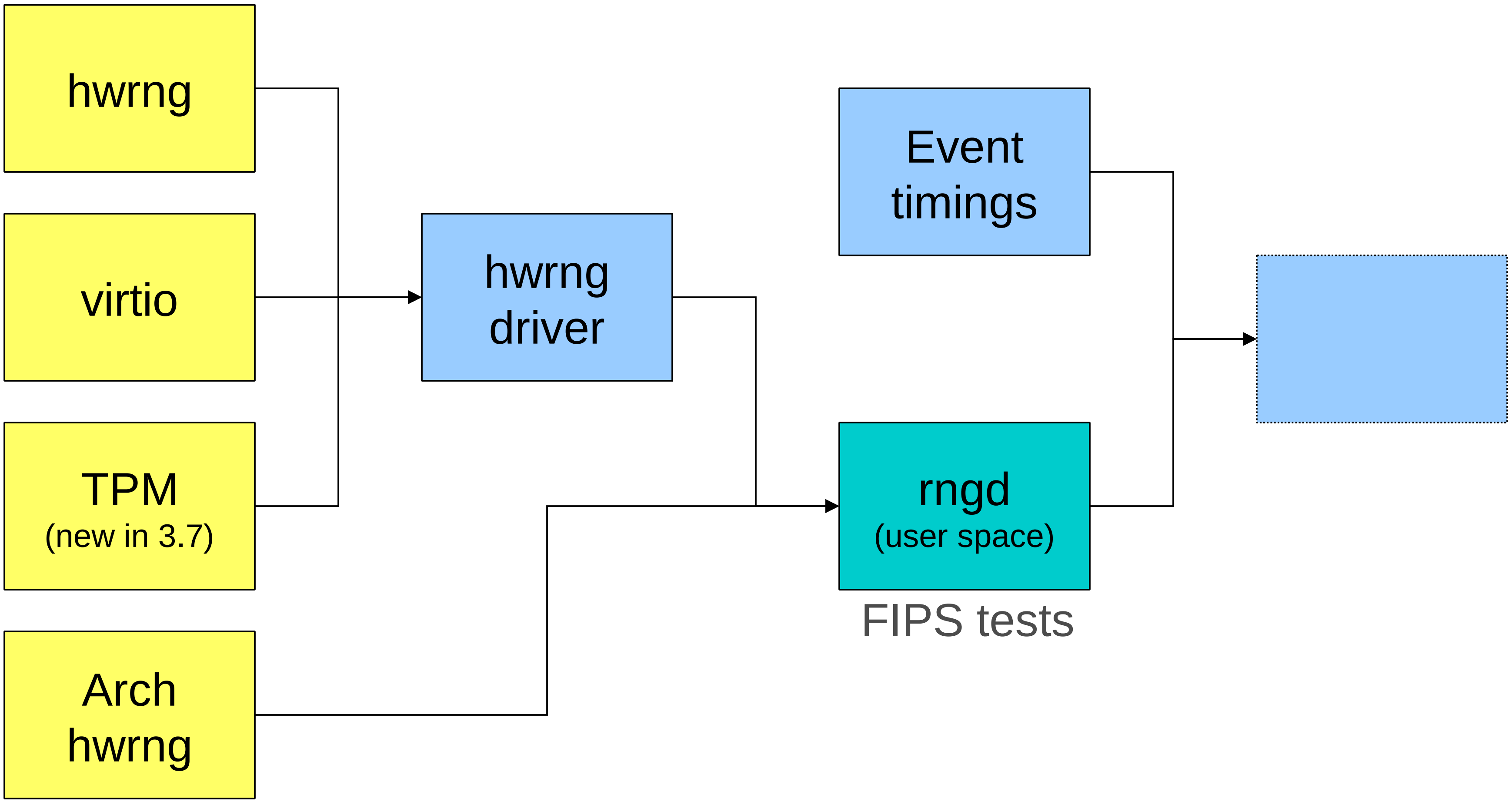




Linux Kernel Random Number Generator



Linux Kernel Random Number Generator Inputs



hwrng

virtio

TPM
(new in 3.7)

Arch hwrng

hwrng driver

Event timings

rngd
(user space)

FIPS tests

rngd

- Necessary to get full benefit from a hardware or virtio RNG
- *Should be started as early as possible*
- Versions < 4 had significant problems
  - Hopefully all fixed now
- TPM harvesting conflicts with TrouSerS unless **rng-tpm** is available
  - Upstream in 3.7, probably an easy backport
  - TPM may need to be “provisioned”
  - If you don't need TrouSerS, don't run **tcsd**

```
rngd -r /dev/urandom
```

HAVEGE

- **Claims to extract entropy from CPU indeterminism**
- Some people swear by it...
- Unclear to what extent it actually works
  - *“The source is so complex it is impossible to analyze”*
  - Self-tests pass even with the timer readout removed
- It probably does provide *some* entropy
  - Consider to what degree you are willing to trust it
- Can be run in parallel with **rngd**

Administrator recommendations

- **Make sure that rngd is running**
  - Version 4 or higher strongly recommended
  - If not by default, please complain to your distribution
  - Run as early as possible
    - Avoid zero-entropy situation on boot
- **Make sure TPM is available**
  - May have to be provisioned
  - If you don't need TrouSerS, don't run **tcsd**
- **haveged** can be a complement, but not an alternative
  - Consider how much you trust it...

Application writer recommendations

- **If you need *lots of randomness:***
  - Use a cryptographic library (OpenSSL, etc.)
  - A simple **librandom** may be available in the future
- **If you need *a little randomness:***
  - Use ***/dev/random*** if you would rather fail than be insecure
  - Use ***/dev/urandom*** if you need “good enough for most things”
- **Please conserve randomness**
  - Not everyone has a hardware random source yet...
  - Don't use buffered I/O unless you really need to!
- **Defer extraction as much as possible (especially daemons)**
  - Entropy may be scarce at boot

Future work

- **Policy interface**
  - Allow rngd bypass and possibly direct use of architectural hwrng
  - Discussed in principle at Kernel Summit 2012
  - Still being architected
- **Finish virtio-rng**
  - Kernel (guest) side complete since 2008
  - Host (Qemu/KVM) side still in progress
    - Got stalled several times
    - Hopefully will get committed to Qemu git this week or next

Copyright acknowledgments

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- *Diagram of Intel DRNG Entropy Source*
  - *© 2011 IEEE Spectrum*

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