BISHOP FOX

Untwisting the Mersenne Twister

KILLING PRNGS

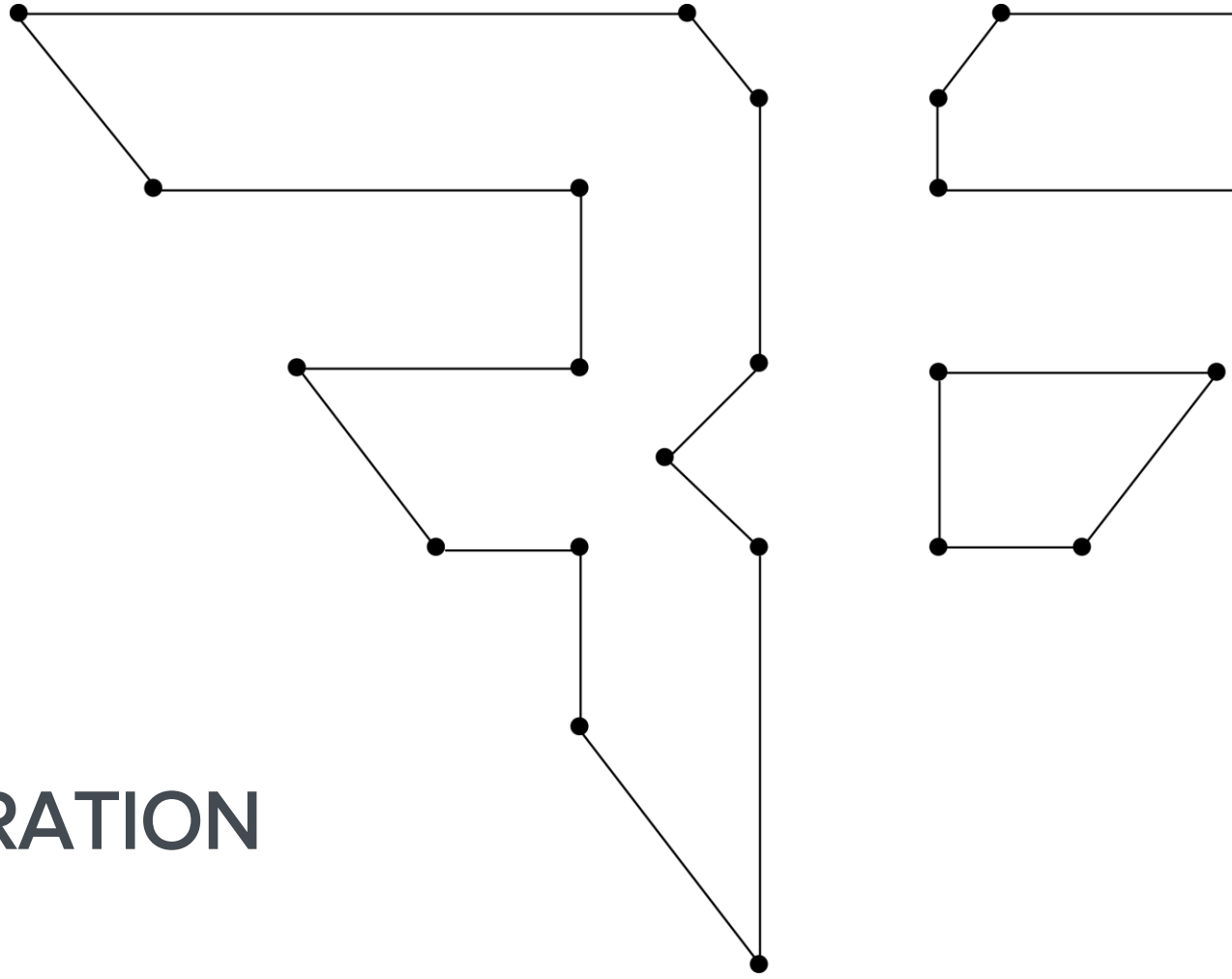
November 5, 2014

WHOAMI

UNTWISTING THE MERSENNE TWISTER

Bishop Fox

- Dan Petro
  Sr. Security Analyst
  - *PHX 2600*
  - *Nova / Honeyd*
  - *Rickmote*
- Moloch
  Security Associate
  - *Root the Box*
  - *[buffer]overflow*
  - *iSpy*



DEMONSTRATION

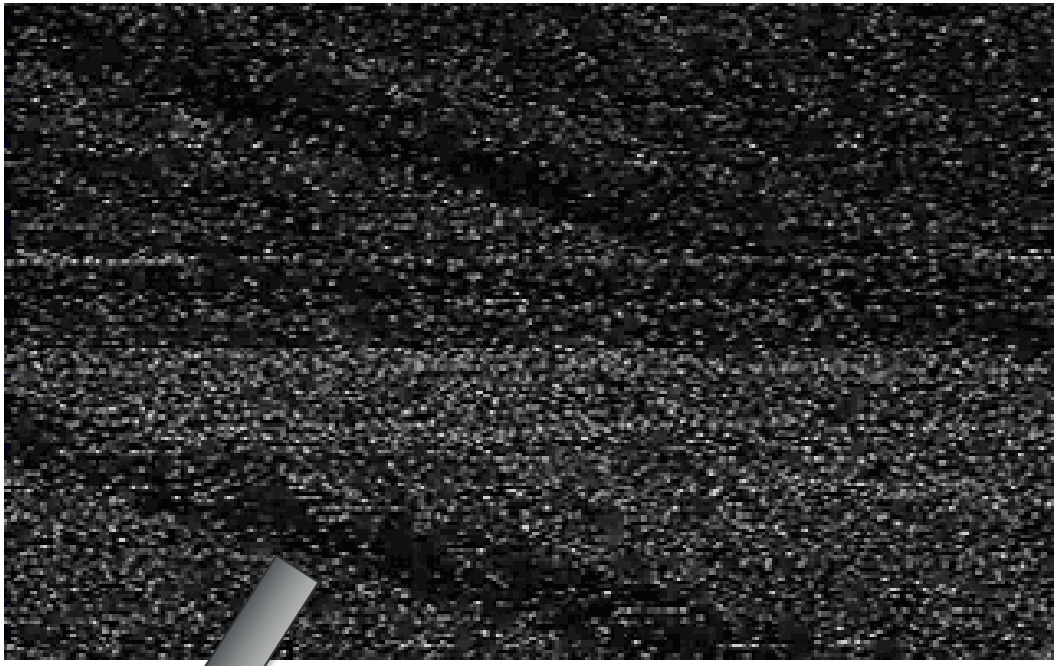
CROSS FINGERS

WHAT IS PSEUDORANDOM

A QUICK HISTORY LESSON

Nature

BY THE NUMBERS



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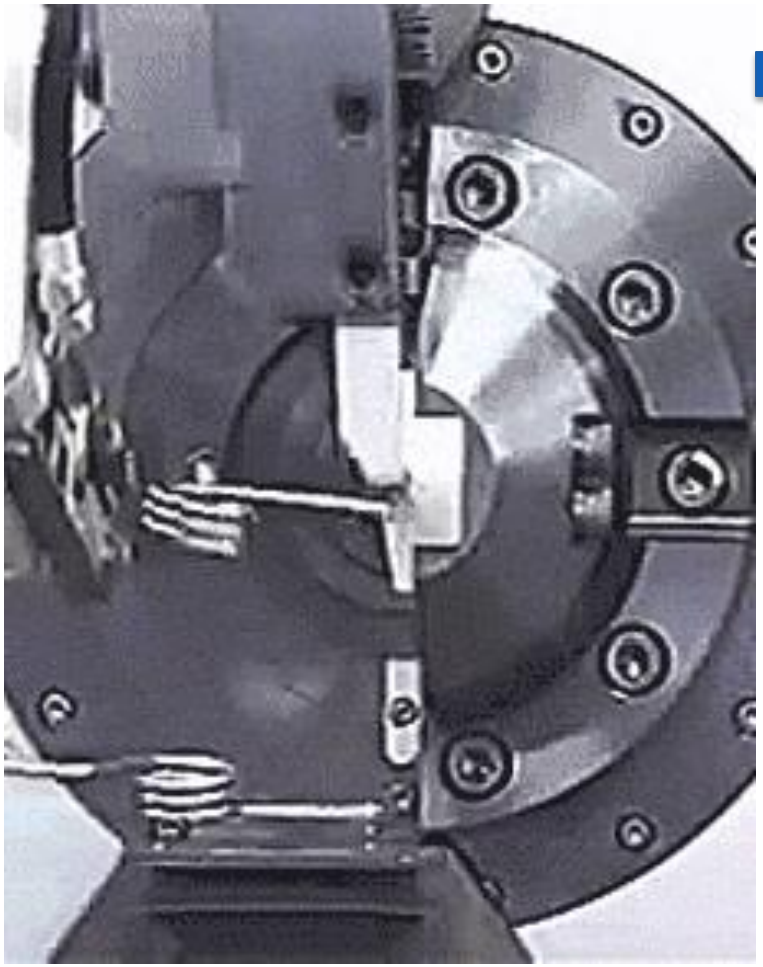
Machines

DETERMINISTIC



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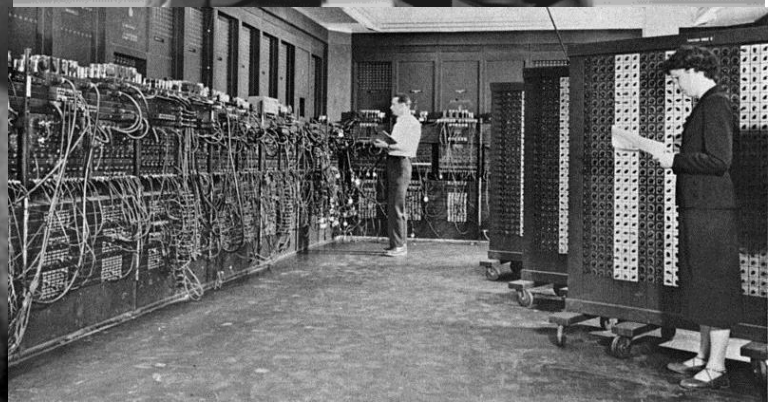
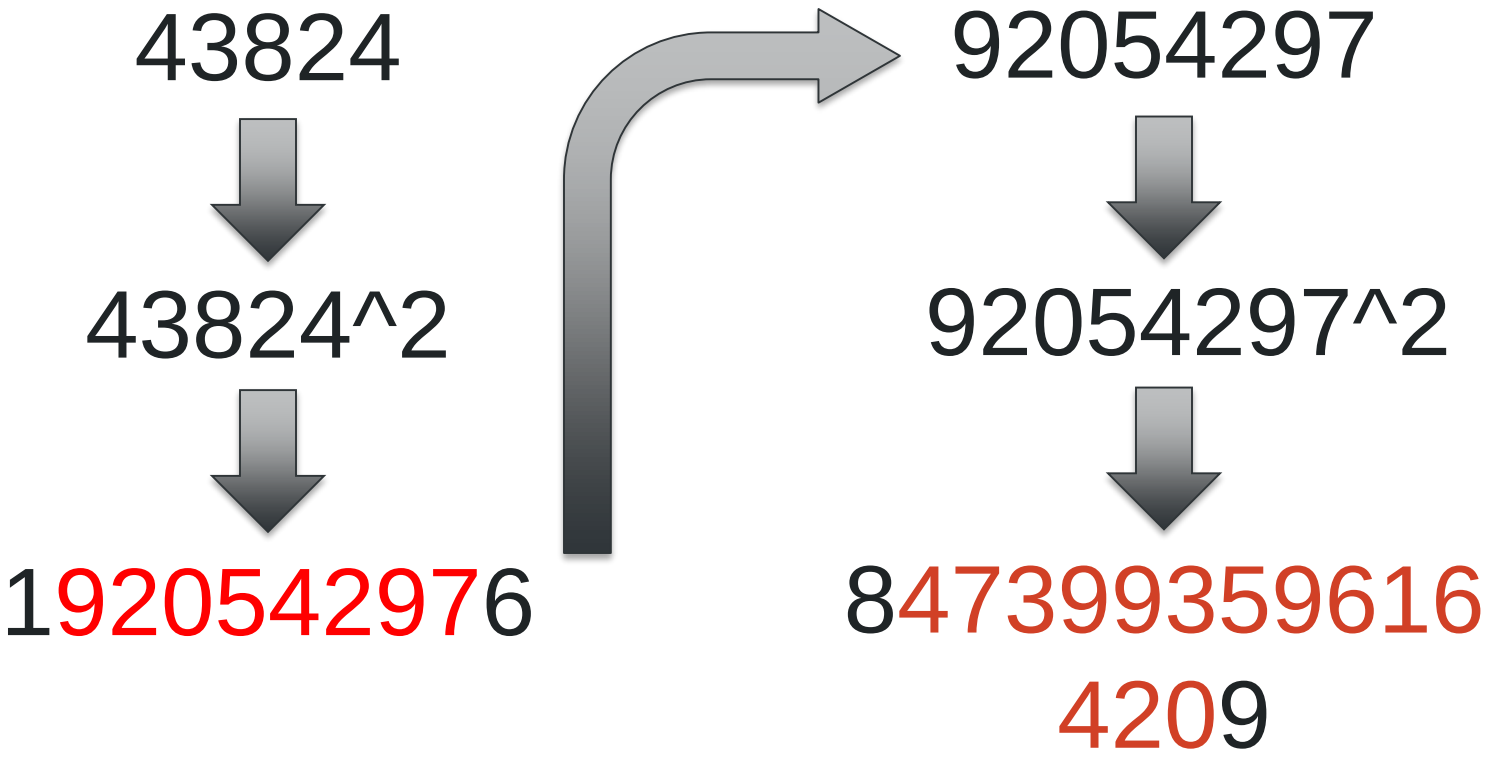
Early Pseudorandom Generators

JOHN VON NEUMAN



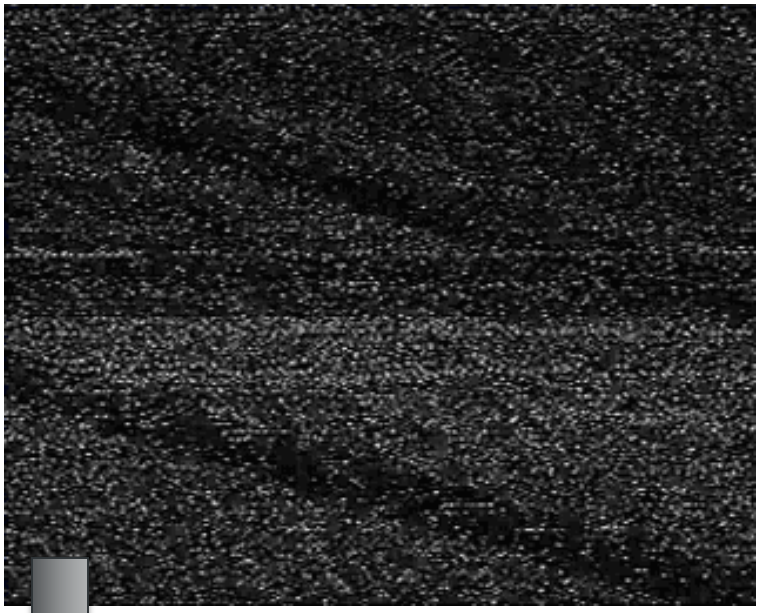
Middle Squares Method

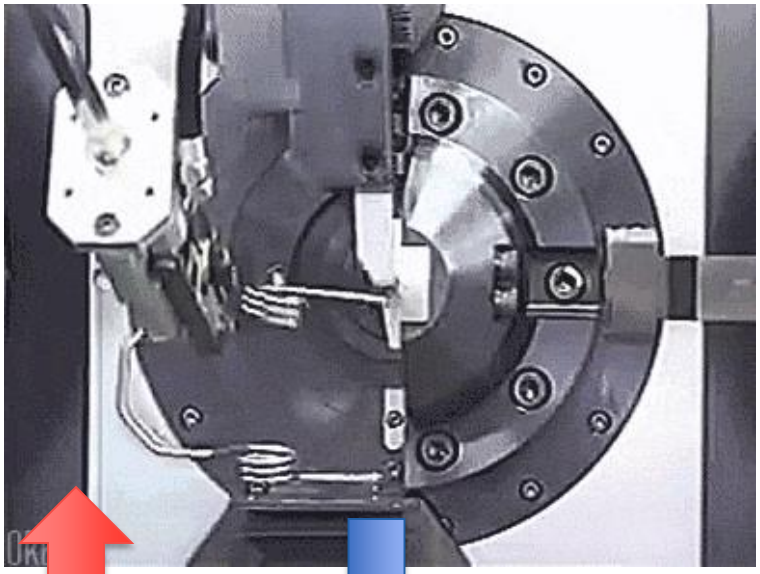
PRNG



Random vs. Pseudorandom

DETERMINISTIC RANDOMNESS





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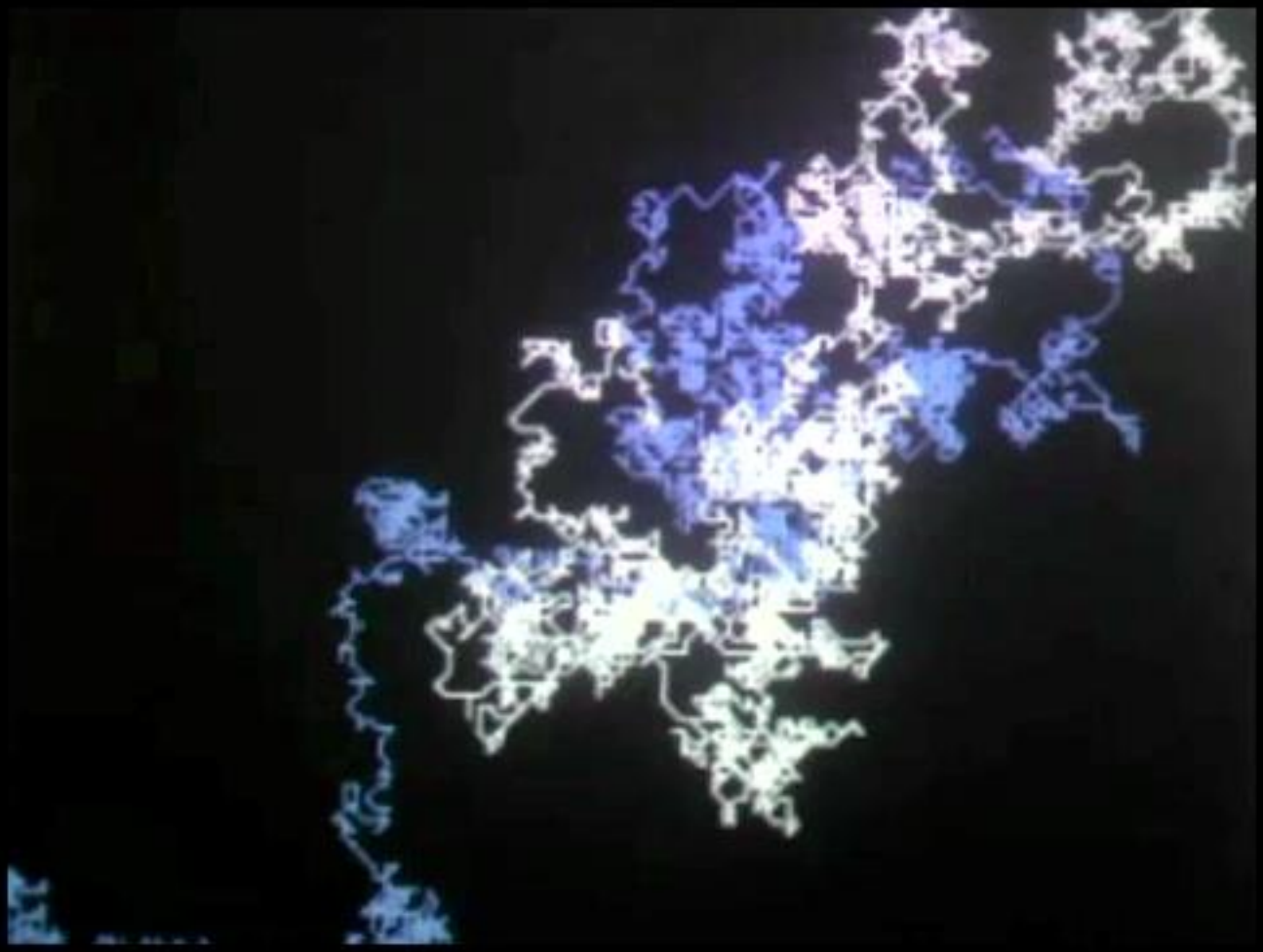


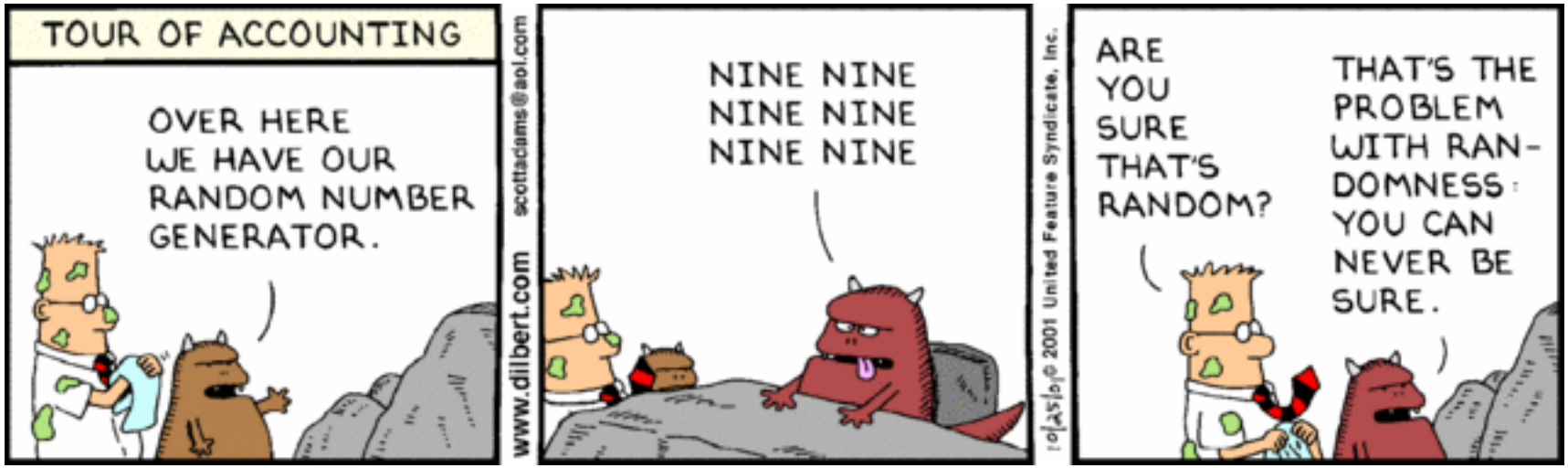
PRNG Period Size

THE MERSENNE TWISTER

(2^19937)-1 =

Can you be sure?

EVALUATING RANDOMNESS



The Die Hard Tests

TESTING RANDOMNESS

Die Hard Randomness Tests

999999999999 …

- Birthday attacks
- “Craps” tests
- Count the 1s
- Monkey tests
- Parking lot tests
- Squeeze tests
- Etc.

SEEDS

HOW DO THEY WORK?

Do You Want Vulns?

CHOOSING A “SECURE” SEED

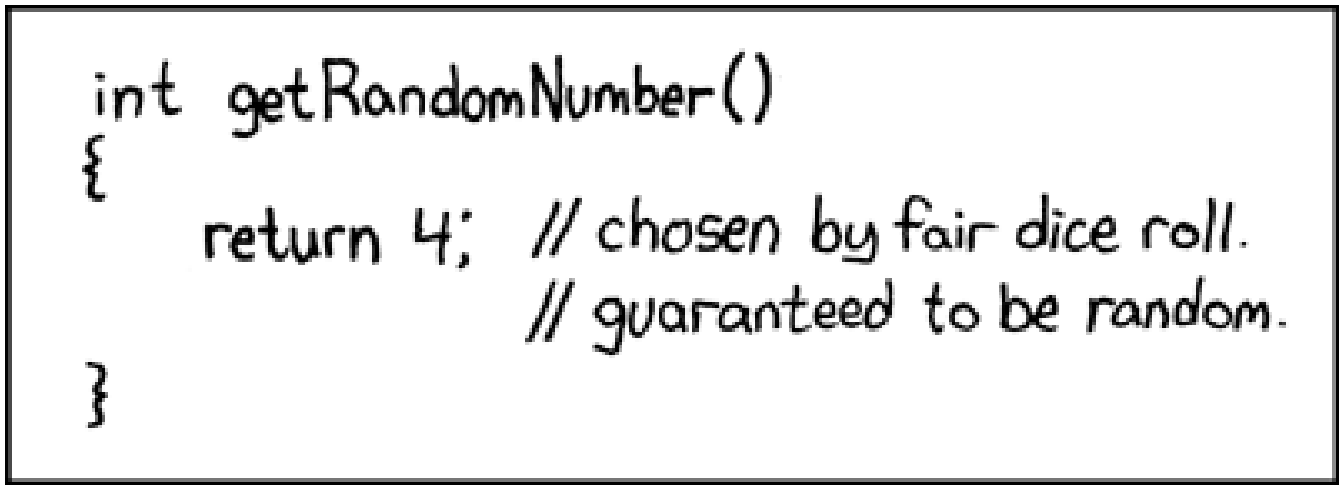
- Time
- PIDs
- Stack memory
- Hardcoded “random” seed
- Combinations of any of the above

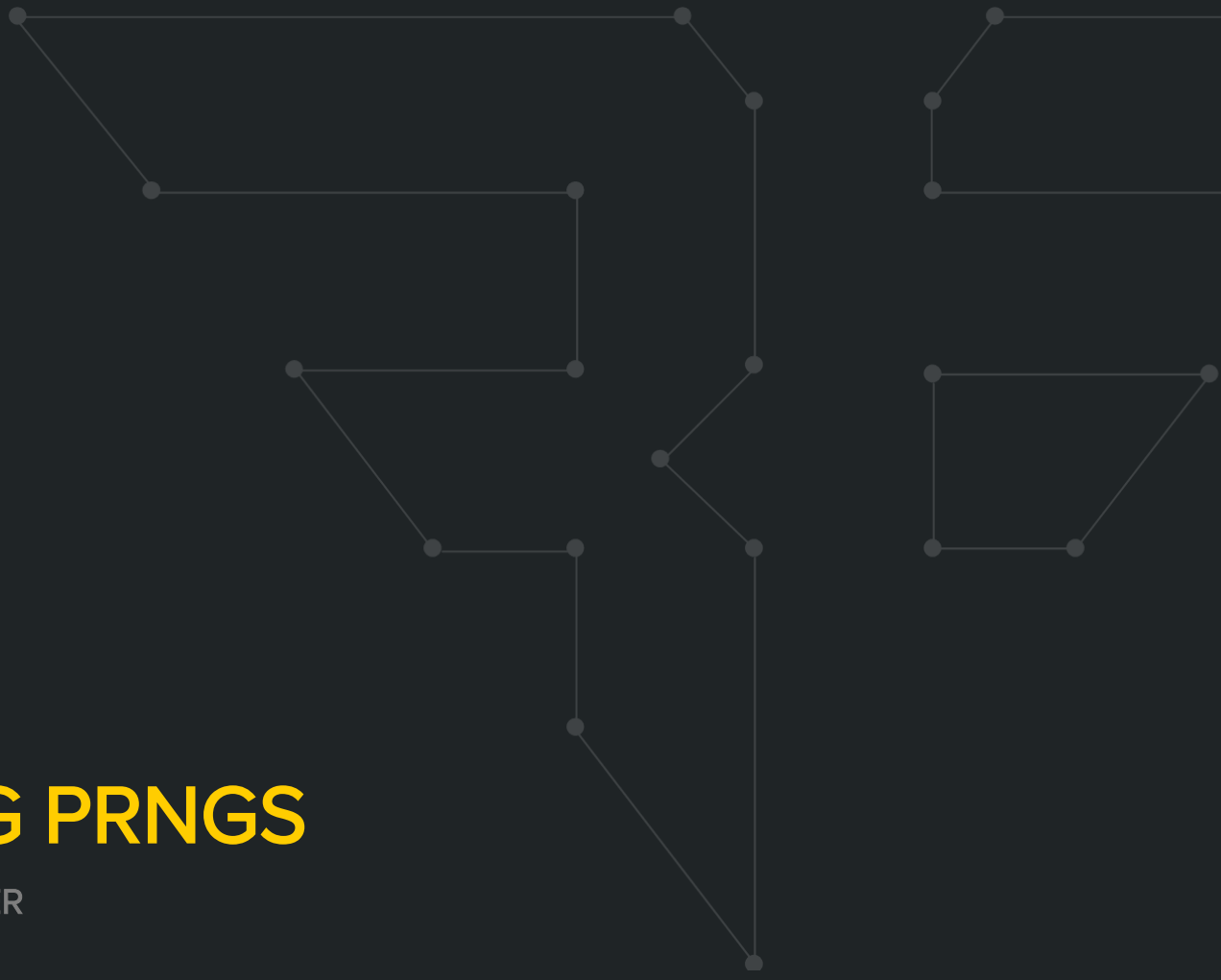
Vulns.

THAT’S HOW YOU GET THEM

Sony's ECC Random

EVALUATING RANDOMNESS





ATTACKING PRNGS

UNTWISTING THE TWISTER

Bruteforce

EVEN CHOOSING A SEED WELL CAN'T SAVE YOU

- 32 bit seeds on most algorithms
  - 4,294,967,296 values
  - Enumerable
- Offline attack
  - Limited only by CPU power
- Timestamp based seeds
  - 31,557,600 values

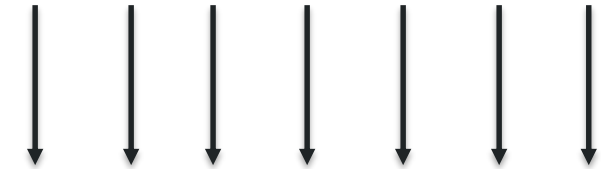
Algorithm

USED IN UNTIWSTER

- Given set of observed numbers
  - 42, 61, 27, 75, 89, 34, 12
- Calculate random numbers
  - One by one
  - Compare to head of observed list
  - If it matches, look for the next observed #
  - Continue until match is found
- Allows for missing values
  - Don’t have to be sequential

Algorithm

USED IN UNTIWSTER



42, 61, 27, 75, 89, 34, 12

45, 33, 42, 97, 61, 27, 75, 49, 51, 89 34, 12,

,

Problem of Depth

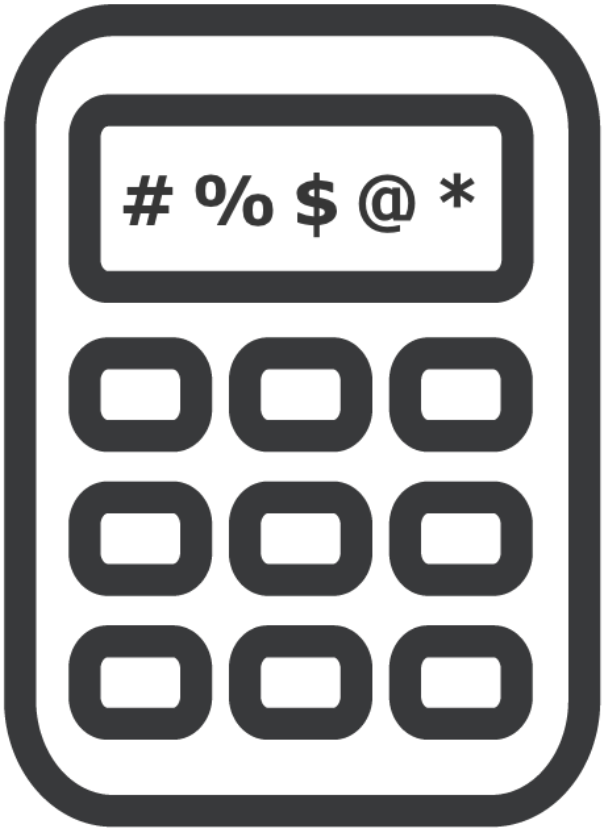
WHERE TO HALT

- How do you know you're deep enough?
  - Maybe the correct numbers are just about to appear
  - Haven't yet
- Halting problem
  - Depth is given as input
  - Give up after depth is explored
- Efficiency vs Completeness Tradeoff

State Inference

MATH IS HARD

- Crack RNG state
  - Predict future and past values
  - Without knowing the seed!
- Much easier with sequential numbers
  - Current implementation requires it*
- Small state size helps, too



glibc rand()

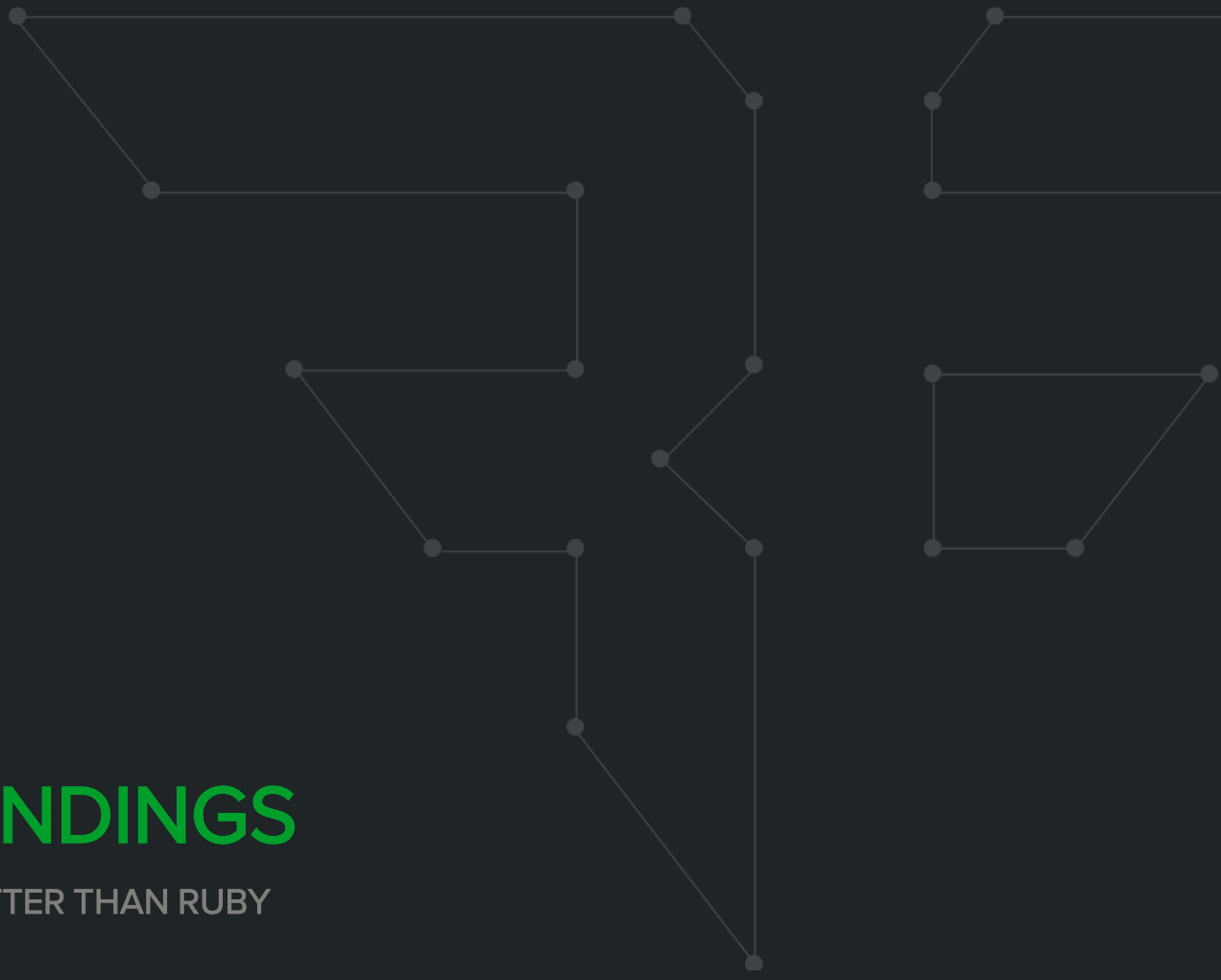
MATH IS HARD

- **Very simple algorithm**
  - r[i] = r[i-3] + r[i-31]
  - With the LSB chopped off
- **Produces 31 bit numbers**
  - Internal state has 32 bit numbers
- **Observe 32 sequential numbers**
  - This IS the internal state
  - Missing the LSBs

glibc rand()

MATH IS HARD

- **LSB reconstruction**
- **Guess-and-check**
  - Use state to predict random numbers
  - Measure how well it predicts
  - Try with 0 and 1 LSB
  - Go with the better guess!
- **Boolean Algebra**
  - Really long Boolean equation
  - Only guaranteed for ~132 consecutive outputs



PYTHON BINDINGS

BECAUSE PYTHON IS BETTER THAN RUBY

The Python GIL

THREADING ISSUES IN PYTHON

- Bytes codes do not execute concurrently
- The GIL is not going anywhere
- Threads are still useful for certain tasks, but not performance

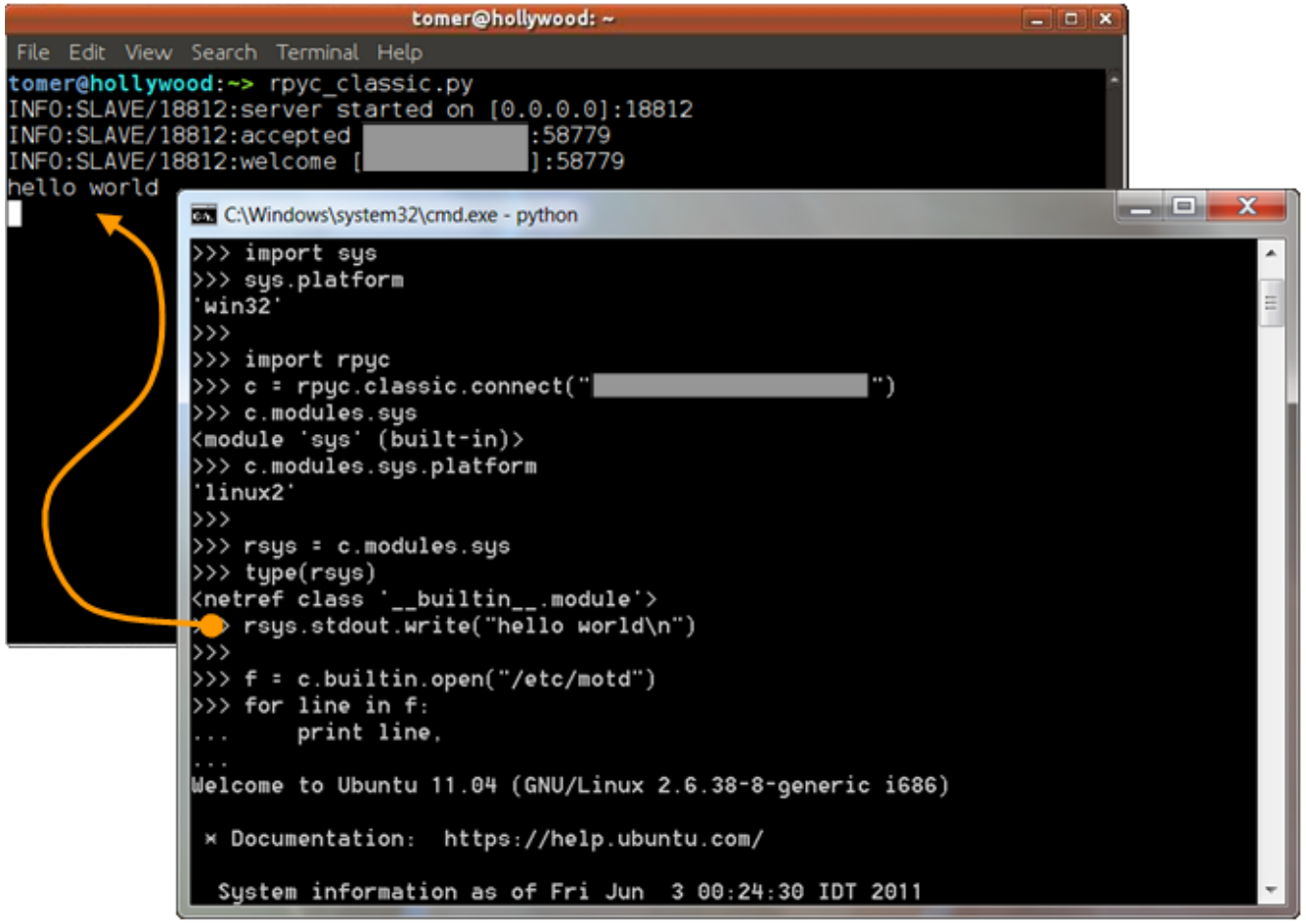
Code Sample

THE C++ // PYTHON BRIDGE

```
    /* Suspend Python's thread, so we can use native C++ threads */

    PyThreadState* pyThreadState = PyEval_SaveThread();

    StartBruteForce(threads, answers, (double) minimumConfidence,
lowerBoundSeed, upperBoundSeed, depth, rng);



    /* Clean up and restore Python thread state */

    PyEval_RestoreThread(pyThreadState);

    pyThreadState = NULL;
```

Distributed Computing

REMOTE PYTHON CALL



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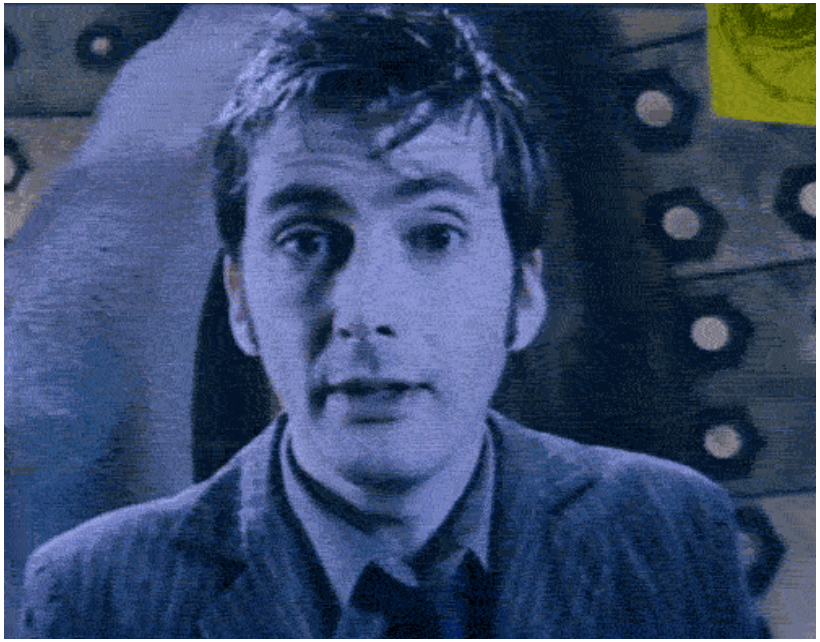

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