CSC 580
Cryptography and Computer Security

Random Bit Generators
(Sections 8.1-8.3)

February 20, 2018

Overview

Today:

- HW 4 solution discussion
- Pseudorandom generation - concepts and simple techniques

Reminder: No class on Thursday (project work time!)

To do before next Tuesday:

- Do HW 5 (quiz next Thursday will come from *either* HW 4 or 5!)
- Read "Security Models" handout

What do we mean by "randomness"?

Common perception - random physical events

- Flipping a coin
- Rolling a die
- Blind draw from a bag

Some properties:

- Statistically uniform
  - Non-uniform randomness is possible, but less interesting in crypto
- Independence
- Unpredictability (next numbers can't be guessed)

Key concept: Entropy

- Measures amount of randomness from a random source
- Example 1: 64 true random bits has 64-bit of entropy
- Example 2: English language entropy is about 2-bits per letter

Random Number Generators

Delivers an unbounded-length sequence (stream)

TRNG - True Random Number Generator
- Sometimes called NRBG (non-deterministic random bit generator)
- Based on physical randomness
- OS can gather physical randomness - disk timing, mouse moves, …
  - /dev/random in Linux - ***blocking*** random source
- Can also be special-purpose device (noisy diode,... even a lava lamp)

PRNG - Pseudo Random Number Generator
- Sometimes called DRBG (deterministic random bit generator)
- Sequence computed from a **seed**
- Consumer of stream typically doesn't know seed
- Computing again with same seed gives same sequence (repeatable)

TRNG/PRNG hybrids
- True randomness "mixed in" to pseudorandom generator
- /dev/urandom in Linux - ***non-blocking*** random source

Some applications and properties

What properties are needed in different applications?

Application	*Good Statistics*	*Unpredictable (fwd)*	*Repeatable*
Random simulation	Must have	No need	Depends
Nonce	Must have	Must have	No need
Stream cipher	Must have	Must have	Must have

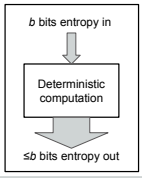
Observations
- Cannot use a TRNG for a stream cipher (can for others)
- All applications need good statistical properties (uniformity, independence)
- In crypto applications, unpredictability is important

A warning when thinking about PRNGs

If numbers are computed, they aren't random!

> *Anyone who considers arithmetical methods of producing random digits is, of course, in a state of sin. For, as has been pointed out several times, there is no such thing as a random number — there are only methods to produce random numbers, and a strict arithmetic procedure of course is not such a method.*
>
> - John von Neumann, 1951

Computation cannot increase entropy
- 1000 bits output from a PRNG with 16-bit seed has at most 16 bits of entropy!



Good PRNG Importance

Security often fails just because of bad PRNG use

Can fail because of either:

- Bad seeding (not random or not large enough)
- Bad algorithm

Example 1: The original SSL implementation (Netscape Navigator)

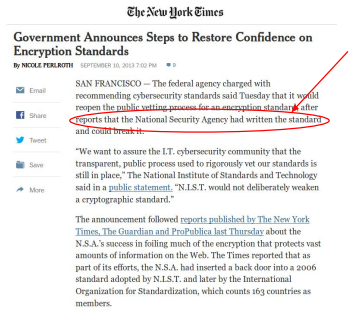
- Seeded with process id (15 bits) and current time (a few bits or uncertainty)
- Made cryptographic keys guessable - completely destroyed security

Example 2: Bad algorithm in NIST standards - Dual EC DRBG

- Exposed as a possible backdoor after Snowden leaks

Dual EC DRBG

The potential backdoor is exposed



The New York Times

Government Announces Steps to Restore Confidence on Encryption Standards

By NICOLE PERLROTH SEPTEMBER 10, 2013 7:02 PM

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SAN FRANCISCO — The federal agency charged with recommending cybersecurity standards said Tuesday that it would reopen the public vetting process for an encryption standard after reports that the National Security Agency had written the standard and could break it.

"We want to assure the I.T. cybersecurity community that the transparent, public process used to rigorously vet our standards is still in place," The National Institute of Standards and Technology said in a public statement. "N.I.S.T. would not deliberately weaken a cryptographic standard."

The announcement followed reports published by The New York Times, The Guardian and ProPublica last Thursday about the N.S.A.'s success in foiling much of the encryption that protects vast amounts of information on the Web. The Times reported that as part of its efforts, the N.S.A. had inserted a back door into a 2006 standard adopted by N.I.S.T. and later by the International Organization for Standardization, which counts 163 countries as members.

People have always worried about NSA backdoors - this one appears to have been real!

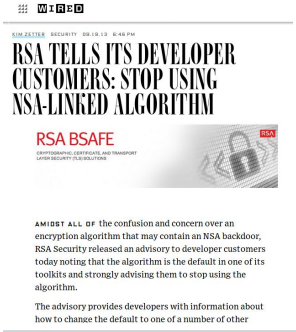
Was adopted by NIST as a standard.

Withdrawn from standard after discoveries

But… Dual EC DRBG is super-slow anyway - surely no one uses it… right?

Dual EC DRBG

Oops - people DID use it - maybe even unknowingly!



WIRED

KIM ZETTER SECURITY 09.19.13 6:46 PM

RSA TELLS ITS DEVELOPER CUSTOMERS: STOP USING NSA-LINKED ALGORITHM

RSA BSAFE

CRYPTOGRAPHIC, CERTIFICATE, AND TRANSPORT LAYER SECURITY (TLS) SOLUTIONS

AMIDST ALL OF the confusion and concern over an encryption algorithm that may contain an NSA backdoor, RSA Security released an advisory to developer customers today noting that the algorithm is the default in one of its toolkits and strongly advising them to stop using the algorithm.

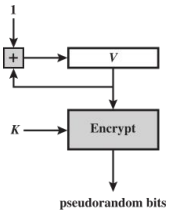
The advisory provides developers with information about how to change the default to one of a number of other

Not only used, but was the default DRBG in RSA's BSAFE library!

Fast PRNG from a block cipher

Widely-used technique: CTR mode

- Key and initial counter are seed
- Basically the XOR pad from CTR mode (ignoring plaintext)



Key property: If AES-CTR mode is a secure encryption scheme (technically, is IND-CPA secure) then this is a secure PRNG

To think about: If K is fixed and secret (embedded in hardware) and only V is the seed, can it be "backdoored" (HW problem)