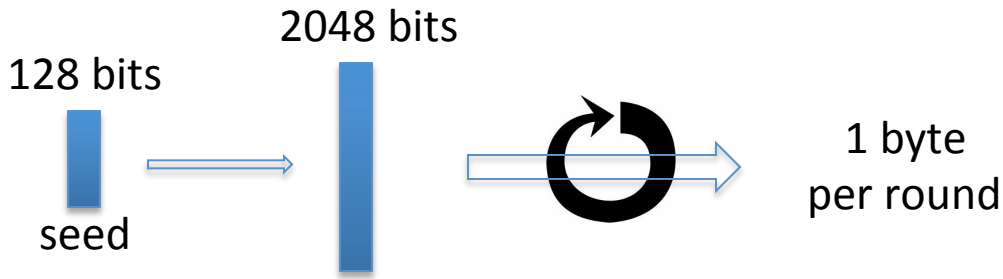
Stream ciphers

Real-world Stream Ciphers

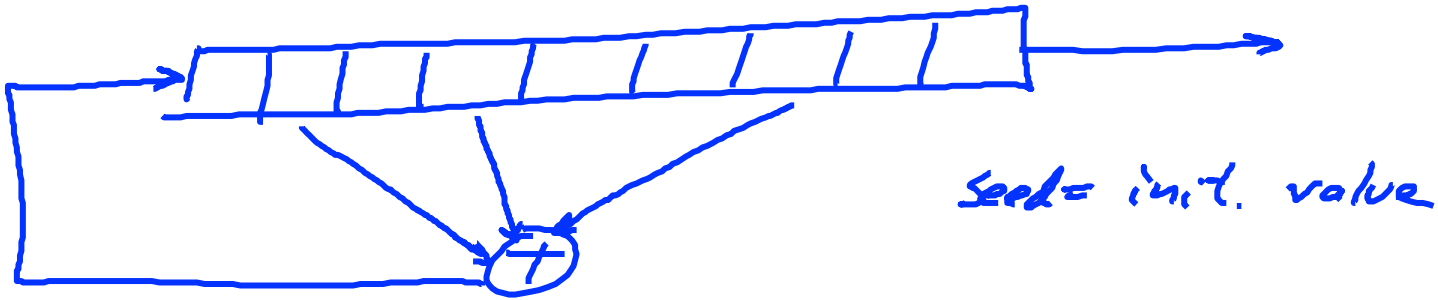
Old example (software): RC4 (1987)



- Used in HTTPS and WEP
- Weaknesses:
  1. Bias in initial output: $\Pr[\ 2^{nd}\ \text{byte} = 0\ ] = 2/256$
  2. Prob. of (0,0) is $1/256^2 + 1/256^3$
  3. Related key attacks

Old example (hardware): CSS (badly broken)

Linear feedback shift register (LFSR):



DVD encryption (CSS): 2 LFSRs

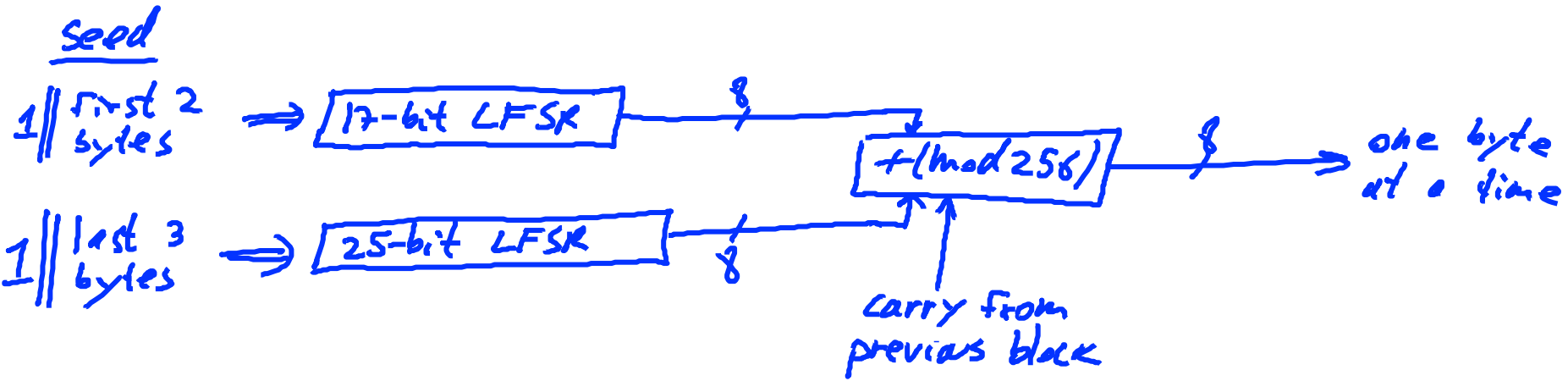
GSM encryption (A5/1,2): 3 LFSRs

Bluetooth (E0): 4 LFSRs

} all broken

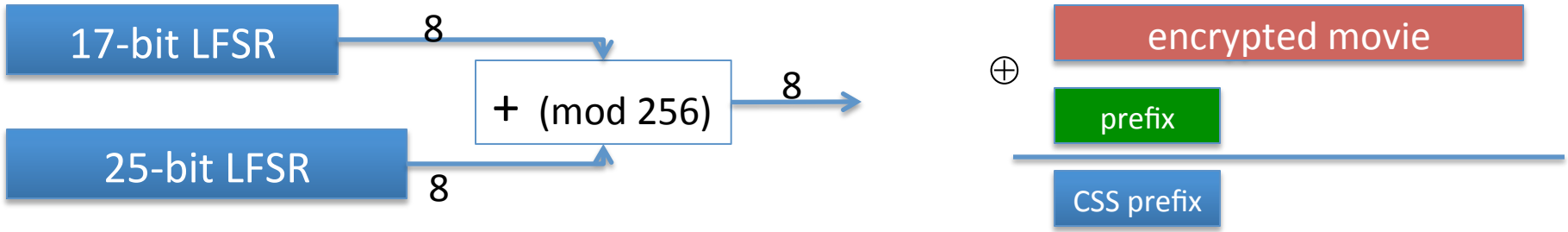
Old example (hardware): CSS (badly broken)

CSS: seed = 5 bytes = 40 bits



Easy to break in time $\simeq 2^{17}$

Cryptanalysis of CSS (2^{17} time attack)



For all possible initial settings of 17-bit LFSR do:

- Run 17-bit LFSR to get 20 bytes of output
- Subtract from CSS prefix ⇒ candidate 20 bytes output of 25-bit LFSR
- If consistent with 25-bit LFSR, found correct initial settings of both !!

Using key, generate entire CSS output

Modern stream ciphers: eStream

PRG: $\{0,1\}^s \times R \longrightarrow \{0,1\}^n$

seed

nonce

Nonce: a non-repeating value for a given key.

$E(k, m ; r) = m \oplus PRG(k ; r)$

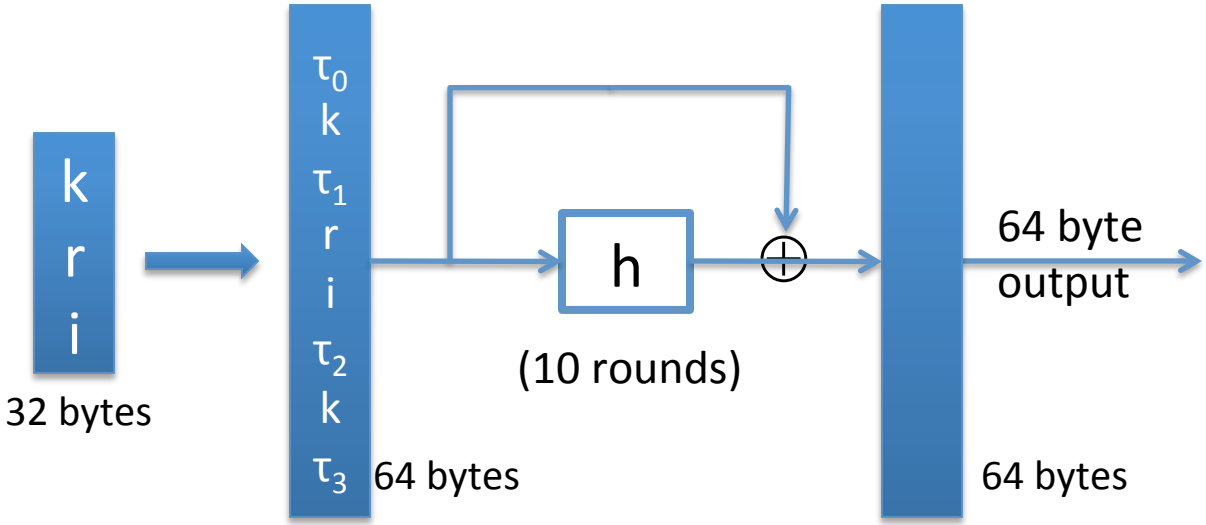
The pair (k,r) is never used more than once.

eStream: Salsa 20 (SW+HW)

Salsa20: $\{0,1\}^{128 \text{ or } 256} \times \{0,1\}^{64} \longrightarrow \{0,1\}^{n}$ (max $n = 2^{73}$ bits)

nonce

Salsa20(k ; r) := H(k , (r, 0)) || H(k , (r, 1)) || …



h: invertible function. designed to be fast on x86 (SSE2)

Is Salsa20 secure (unpredictable) ?

- Unknown: no known **provably** secure PRGs

- In reality: no known attacks better than exhaustive search

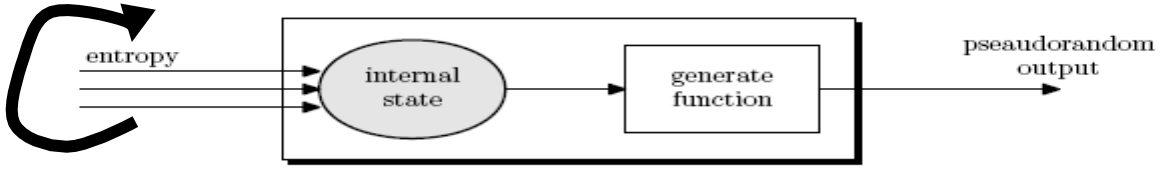
Performance:

Crypto++ 5.6.0 [Wei Dai]

AMD Opteron, 2.2 GHz (Linux)

	PRG	Speed (MB/sec)
	RC4	126
eStream	Salsa20/12	643
eStream	Sosemanuk	727

Generating Randomness (e.g. keys, IV)



Pseudo random generators in practice: (e.g. /dev/random)

- Continuously add entropy to internal state
- Entropy sources:
  - Hardware RNG: Intel **RdRand** inst. (Ivy Bridge). 3Gb/sec.
  - Timing: hardware interrupts (keyboard, mouse)

NIST SP 800-90: NIST approved generators

End of Segment