Microsoft Research TechFest 2011 the & in R&D

Nuggets of Pseudorandomness

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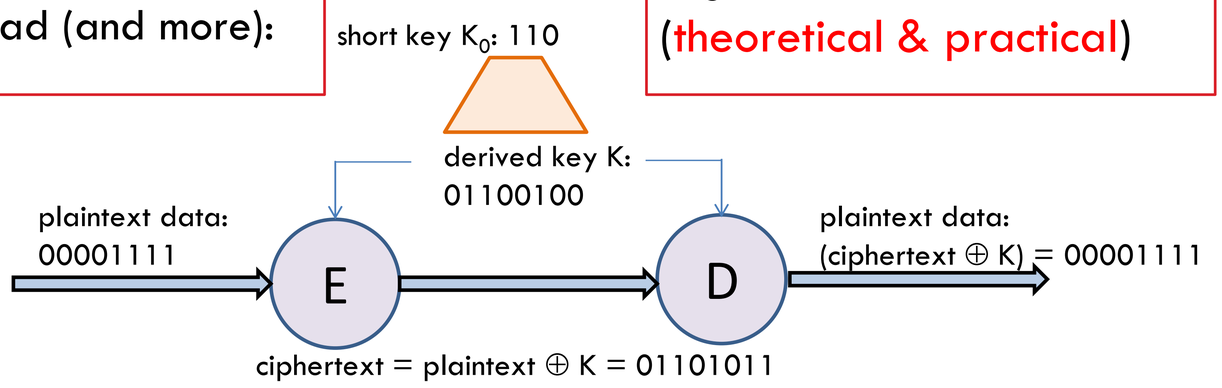
1 Cryptography: Good Pseudorandom Generators are Crucial

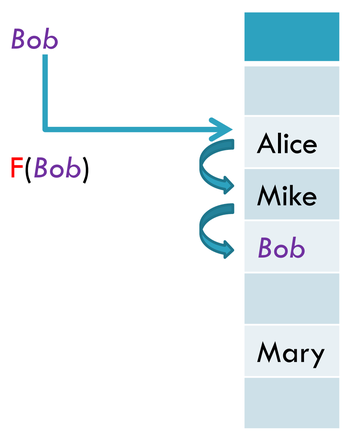
- With them, we have one-time pad (and more):



- Without, keys are bad, algorithms are worthless (theoretical & practical)

2 Data Structures & Hash Functions

Linear Probing:



- If F is random then insertion time and query time are O(1) (in expectation).
- But where do you store a random function ?!? Derandomize!
- Heuristic: use SHA1, MD4, …
- Recently (2007): 5-wise independent functions are sufficient*
- Similar considerations all over: bloom filters, cuckoo hashing, bit-vectors, …

3 Weak Sources & Randomness Extractors

- Available random bits are biased and correlated
- Von Neumann sources:

$b_1 b_2 \ldots b_i \ldots$ are i.i.d. 0/1 variables and $b_i = 1$ with *some* probability $p < 1$ then translate

$01 \longrightarrow 1$

$10 \longrightarrow 0$

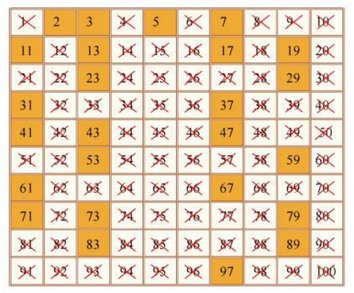


- Randomness Extractors produce randomness from general weak sources, many other applications

4 Algorithms: Can Randomness Save Time or Memory?

- Conjecture - No* (*moderate overheads may still apply)
- Examples of derandomization:

Primality Testing in Polynomial Time



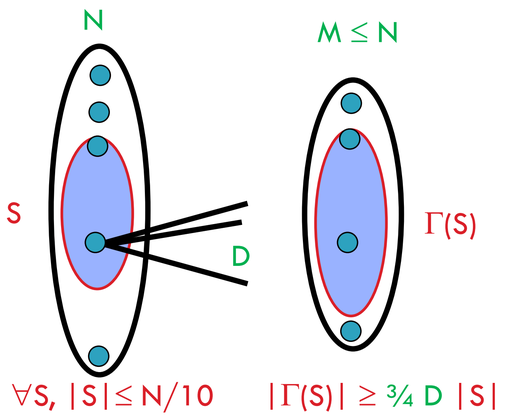
Graph Connectivity logarithmic Memory



- Holdouts: Identity testing, approximation algorithms, …

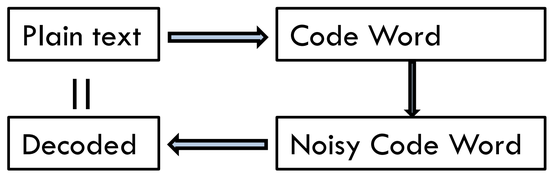
5 Expander Graphs

Sparse Graphs that are highly connected:

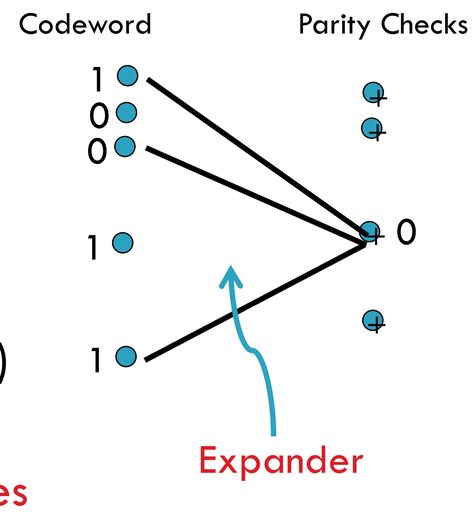


- Some useful properties:
  - Random walk rapidly mixing
  - Most outgoing edges are "unique" (great for routing)
  - Very fault tolerant
- Many applications: networking and sorting networks, cryptography, data structures, complexity & proof theory, …

6 Expander Codes



- Minimum distance ≥ K
- Constant rate and relative distance (can be made very good)
- Simple Decoding Algorithm in Linear Time & log n parallel phases



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