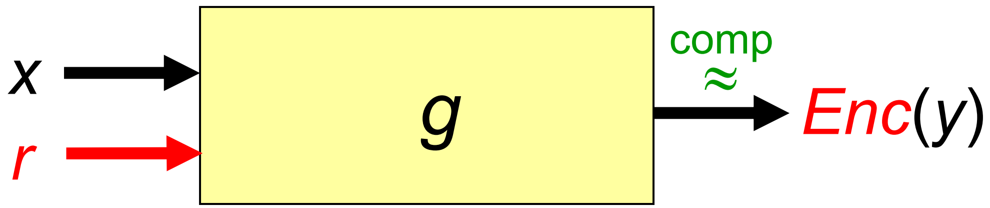
Outline

1. (Long) Introduction
2. Randomized Polynomials (w/applications to round-efficient MPC)
3. Randomized Encodings w/applications to NC^0 Cryptography
4. Constant Input Locality
5. Computational Randomized Encodings (w/applications)
6. NC^0 Linear Stretch PRG (w/applications)

Computationally Private Encodings

- Known: $f \in NC^1, \oplus L$ → encoding in NC^0
- Goal: $f \in P$ → encoding in NC^0
- Idea: relax encoding requirement



- Respects security of most primitives
- Thm: $f \in P$ → computational encoding in NC^0_4
  assuming "easy PRG" (min-PRG $\in \oplus L$)

  ✓ "Easy PRG" can be based on factoring, discrete-log, lattices

App 1: Relaxed Assumptions for Crypto in NC^0

- Using perfect comp. encoding:

OWF
Assuming “easy PRG”
PRG
Hash
Sym-Enc
PK-Enc
Signature
Commit
NIZK

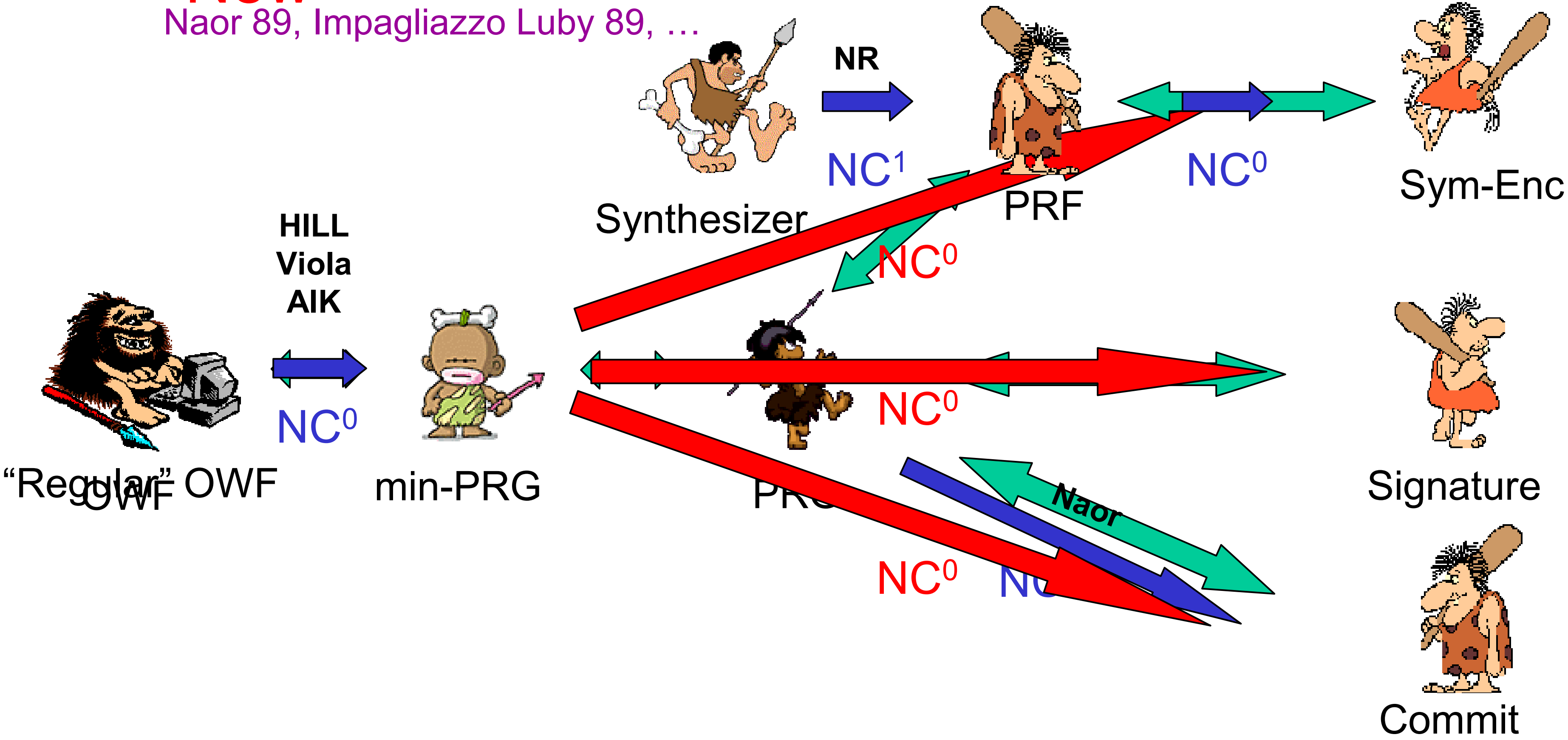
exist $\oplus L$ $\Rightarrow$

OWF
OWP
PRG
Hash
Sym-Enc
PK-Enc
Signature
Commit
NIZK

$\in NC^0$

App 2: Parallel Reductions Between Primitives

- Thm: All are equivalent under poly-time reductions
- What about NC reductions?
- Blum Micali 82, Yao 82, Levin 85, Goldreich Krawczyk Luby 88, Håstad Impagliazzo Levin Luby 90, Goldreich Micali 84, Goldreich Goldwasser Micali 84, Goldwasser Micali Rivest 84, Bellare Micali 88, Naor Yung 89, Rompel 90, Naor 89, Impagliazzo Luby 89, …
- Much less is known….
- New



App 3: Secure Multiparty Computation

In case you don’t insist on unconditional security…

- Securely evaluating an arbitrary function *f efficiently* reduces to securely evaluating deg-3 polynomials

  … assuming an “easy PRG”

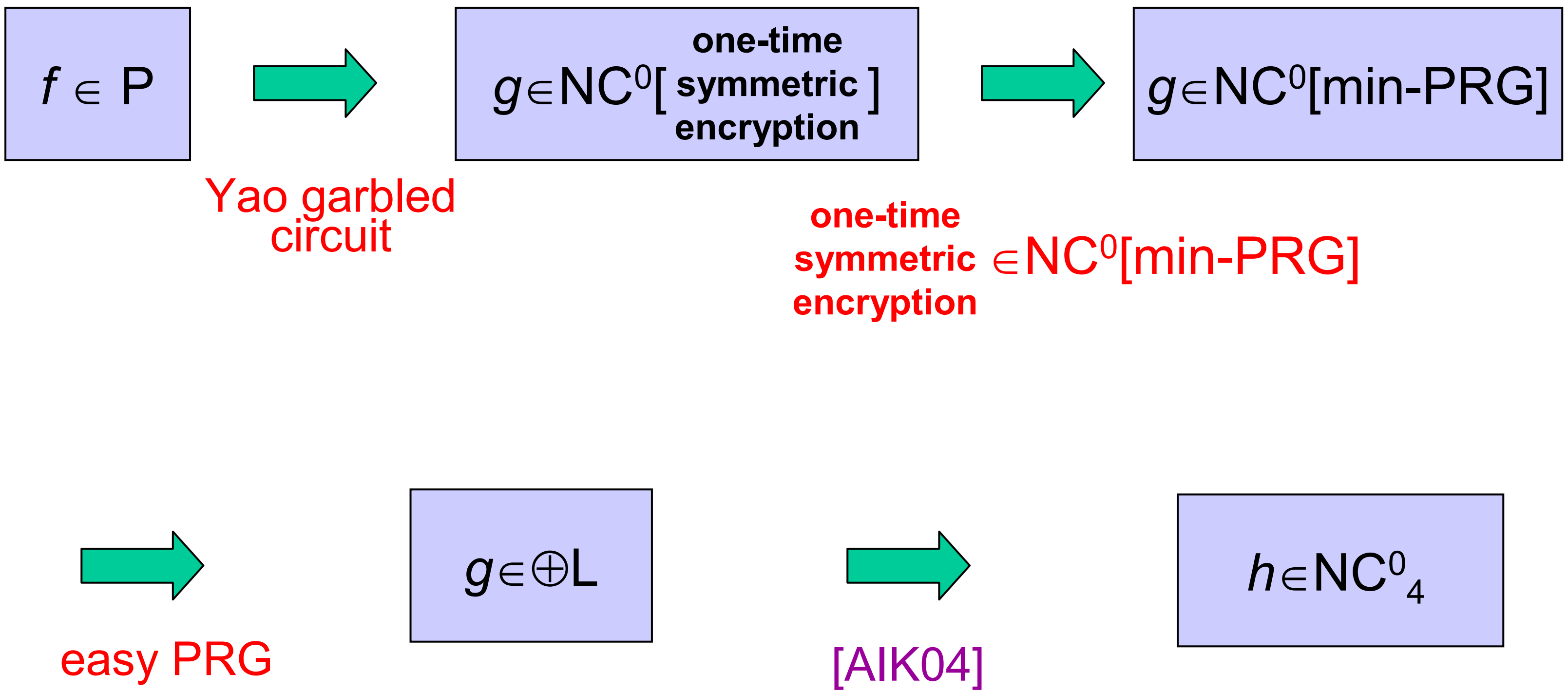
- In particular:

  Basic MPC protocols (e.g., BGW88, CDM00) imply constant-round *computationally* secure MPC for *every f.*

  Known assuming *any* PRG [BMR90,DI05]; however, current approach is simpler and can be made more efficient [DI06].

Proof Outline

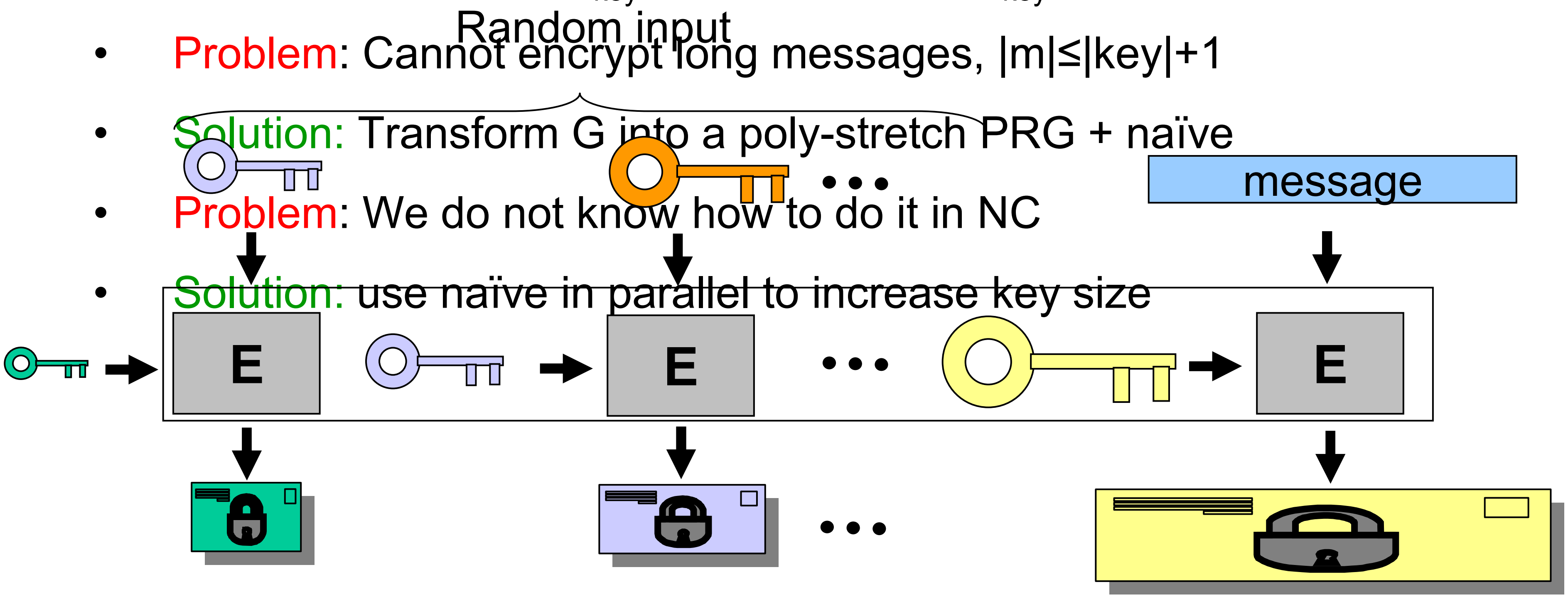
Thm. "easy PRG" $\Rightarrow$ encoding in NC^0 for all $f \in P$



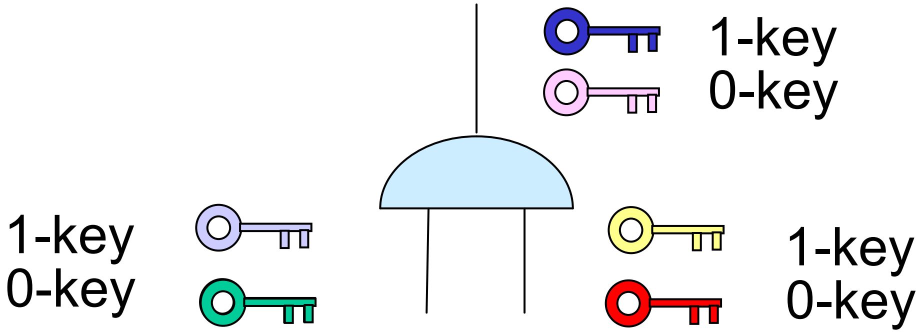
Step 1: Min-PRG $\underset{NC^0}{\Rightarrow}$ OTSE

Sol: use naïve construction in parallel to increase key size

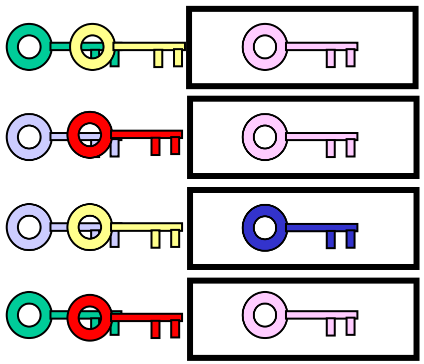
- Naïve construction: $E_{key}(m)= G(key)\oplus m$, $D_{key}(c)=G(key)\oplus c$
- Problem: Cannot encrypt long messages, $|m|\leq|key|+1$
- Solution: Transform G into a poly-stretch PRG + naïve
- Problem: We do not know how to do it in NC
- Solution: use naïve in parallel to increase key size



Step 2: Garbled Circuit Construction



- Pair of random colored keys for each wire
- For each input wire, key corresponding to its value is revealed
- Color semantics of output wires are revealed
- Garbled gates:



Step 2: Garbled Circuit Construction

Implementing locks

- (one-time) symmetric encryption

➔ computational privacy, works for any circuit

- one-time pads

➔ information-theoretic privacy, efficient only for log-depth circuits

- Garbled gates: