RandShare: Small-Scale Unbiasable Randomness Protocol

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Semester Project

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Outline

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Public Randomness

Applications:

- **Random selection**: lotteries, sweepstakes, jury selection, voting and election audits
- **Games**: shuffled decks, team assignments
- **Protocols**: parameters, IVs, nonces, sharding
- **Crypto**: challenges for NZKP, authentication protocols, cut-and-choose methods, “nothing up my sleeves” numbers

Public Randomness Approaches Without Trusted Parties:

- **Bitcoin** (Bonneau, 2015)
- **Slow cryptographic hash functions** (Lenstra, 2015)
- **Financial data** (Clark, 2010)


High-entropy
Scalability
Availability
What makes a «good» randomness ?
Verifiability
Unpredictability
Unbiasability

Towards unbiasable randomness

	Availability	Unpredictability	Unbiasability	Verifiability	Scalability
Strawman I	✗	✗	✗	✗	✗
Strawman II	✗	✓	✗	✗	✗
Strawman III	✓	✓	✓	✗	✗

Strawman I

Idea: Combine random inputs of all participants.

Problem: Last node controls the output.

Strawman II

Idea: Commit-then-reveal random inputs.

Problem: Dishonest nodes can choose not to reveal.

Strawman III

Idea: Secret-share random inputs.

Problem: Dishonest nodes can send bad shares.

RandShare

	Availability	Unpredictability	Unbiasability	Verifiability	Scalability
RandShare	✓	✓	✓	✗	✗

Idea: Strawman III + Verifiable Secret Sharing (Feldman, 1987)

Problems:

- Not scalable: $O(n^3)$ communication/computation complexity
- Not publicly verifiable

RandSharePVSS

Idea: RandShare + PVSS

- Publicly Verifiable Secret Sharing (PVSS)
  - Each node computes the collective string along with a transcript of the protocol run that includes all the shares used in the construction of the random output and proofs of their validity.

For the rest of the presentation, n will denote number of nodes,

$f = n/3$ the number of faulty nodes and $t = f+1$ the threshold.

Nodes only accept messages with a correct identifier, and a tracker ensures that we handle only one message per node per step.

RandSharePVSS

- Share Distribution

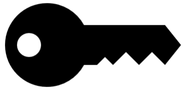
- Secret splitting
- Encryption then distribution with a proof
- Check received shares against their proof, discard it if not verified
- Done when $f+t$ of them are received from every other node

- Voting Process

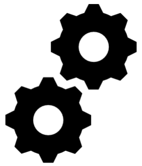
- t secrets are enough for unpredictability
  - Choose a subset of servers
- Vote for a node depends on how many correct shares we received from it
- If a node receives too many negative votes, then it is discarded

RandSharePVSS

- Share Decryption



- Secret Recovery



- Decryption then distribution to nodes kept after voting process
- When receiving a decrypted share from another node, check it against its proof
- Done when at least t decrypted shares are collected and verified from every node

- Recover secrets through Lagrange interpolation
- Combine them to create the collective string
- Output it along with the transcript consisting of shares used and their proofs

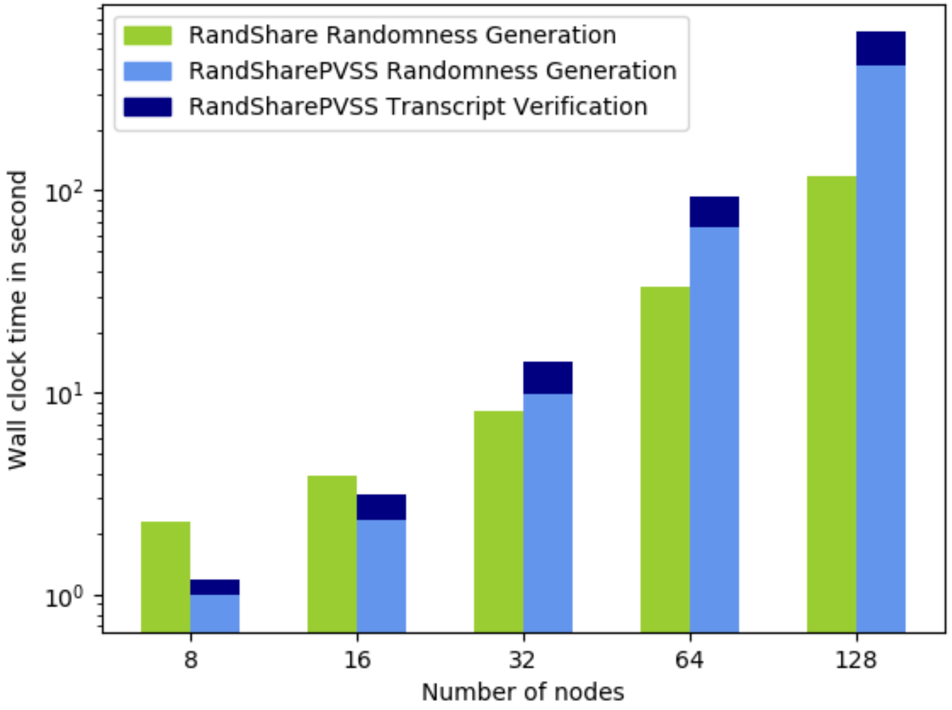
Security properties

	Availability	Unpredictability	Unbiasability	Verifiability	Scalability
Strawman I	✗	✗	✗	✗	✗
Strawman II	✗	✓	✗	✗	✗
Strawman III	✓	✓	✓	✗	✗
RandShare	✓	✓	✓	✗	✗
RandSharePVSS	✓	✓	✓	✓	✗

Experimental Results

Implementation in Go, based on DEDIS code (Crypto library ; Network library ; Cothority framework).

Deterlab Setup : 10 machines, each equipped with an Intel(R) Xeon(R) E3-1260L quad-core processor running at 2.4 GHz, 16GB of RAM, and imposed 200 ms round-trip latencies on all communication links.



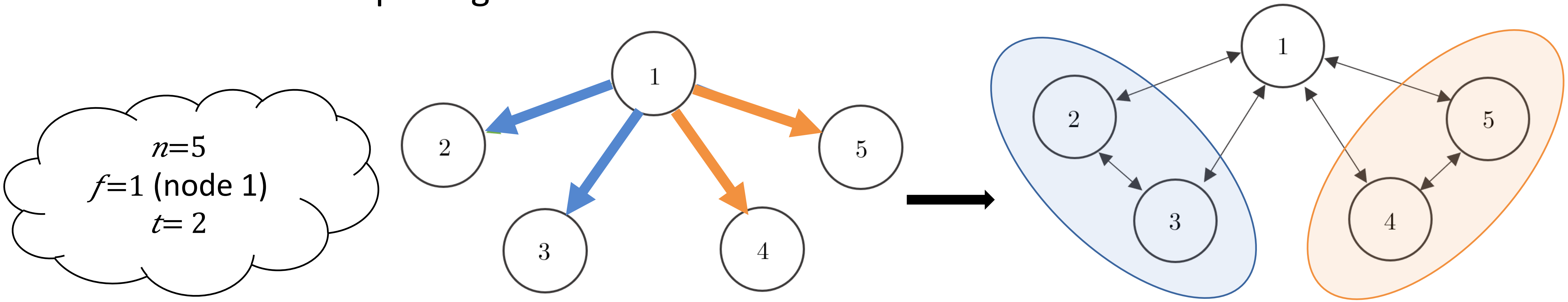
Total wall-clock time of a protocol run

Demo

github.com/dedis/student_17_randomness

Limitations

- Lack of scalability
  - All-to-all communication pattern
  - PVSS is computationally expensive
- Attacks
  - Impersonation
  - Network Splitting



Future Work

- Scale
  - SCRAPE
- Signing
  - (t, n)-Threshold Schnorr Signature.
- Network Splitting Attack
  - Collective string combines $2 \cdot f + 1$ secrets instead of $f + 1$