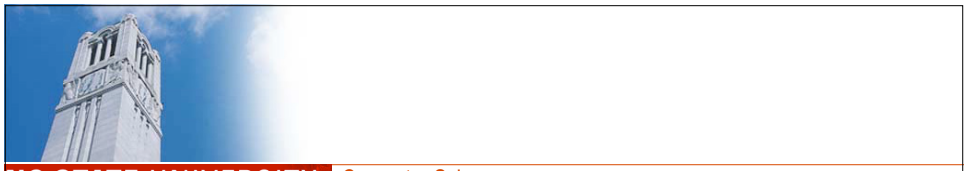


NC STATE UNIVERSITY Computer Science

CSC 774 Advanced Network Security

Topic 4.2 BiBa

Overview

- BiBa stands for "Bins and Balls"
  - Use one-way functions without trapdoors (e.g., hash functions)
- BiBa signature scheme
- BiBa broadcast authentication protocol

BiBa Signature Scheme

- Precompute of SEALs
  - SEAL: SElf Authenticating vaLues
- Signature generation
  - Exploit SEALs and the difficulty of finding collisions under hash functions
- Signature verification
  - Verify SEAL
  - Verify collisions

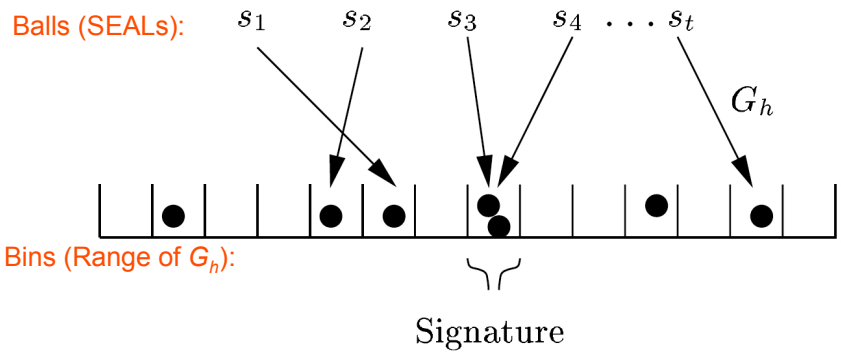
SEAL

- Each SEAL is randomly generated
- Given a SEAL s, the signer computes $f_s = F_s(0)$, where F_s is a PRF
  - f_s is the commitment to s
  - f_s is authenticated to all possible verifiers (e.g., through a RSA signature or pre-distribution)
- In BiBa, the signer has t pre-computed SEALs
  - SEALs: $s_1, s_2, \ldots, s_t$
  - All SEALs are authenticated to all verifiers

BiBa Signature: Intuition

- Sign message m
  - Compute hash $h = H(m)$, where H is a hash function
  - Consider a hash function family G_h, whose range is 0, n-1
    - Example: $G_1(x) = G(x|1)$, where G is SHA1
  - Compute G_h for all SEALs $s_1, \ldots, s_t$
    - That is, $G_h(s_1), G_h(s_2), \ldots, G_h(s_t)$
  - Look for a 2-way collision of SEALs
    - $G_h(s_i) = G_h(s_j)$ with $s_i \neq s_j$
  - The pair $<s_i, s_j>$ forms the signature
- Signature verification
  - Compute hash $h = H(m)$
  - Verify $s_i \neq s_j$ and $G_h(s_i) = G_h(s_j)$

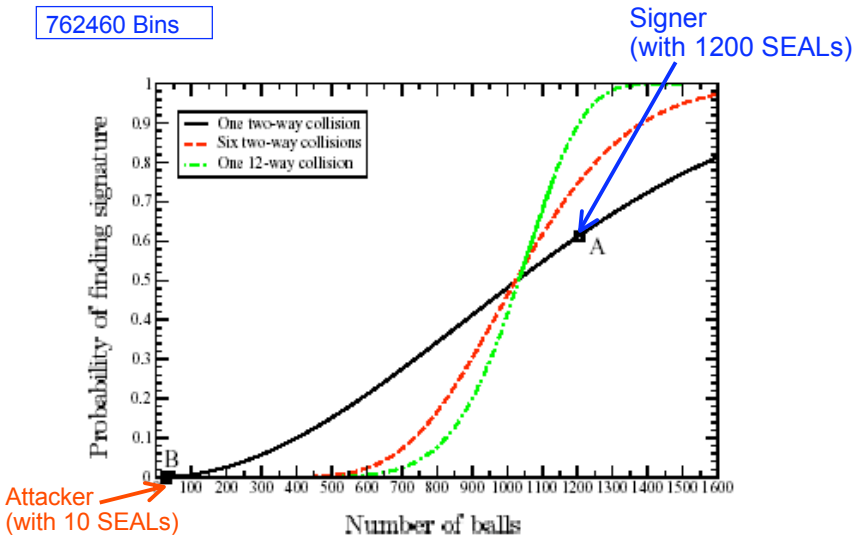
Basic BiBa Scheme



Security of BiBa Signature

- Security comes from
  - The difficulty of finding *k*-way collisions for one-way functions
  - The asymmetric property that the signer has more SEALs than the adversary
    - Signer can easily generate the BiBa signatures with high probability while adversary can't.
- Exploits the birthday paradox
  - Probability that there is at least one collision of the hashes of *t* random messages is approximately
    - $1 - e^{-t(t-1)/2N}$, where N is range of hash function.

Security of BiBa Signature (Cont'd)



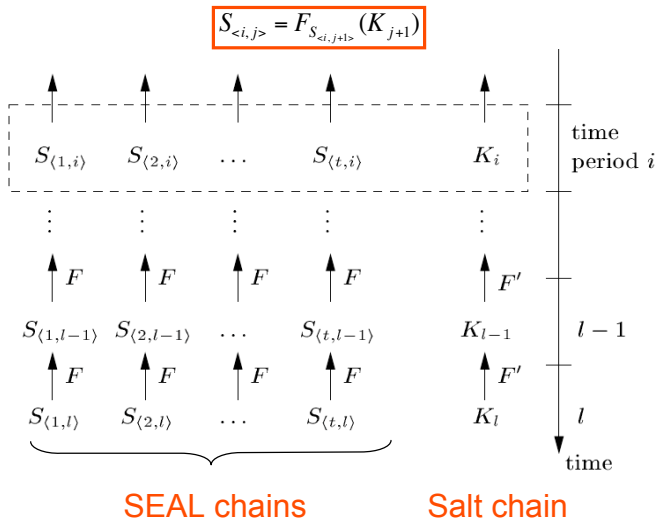
BiBa Signature Scheme

- Basic scheme
  - Signer is not guaranteed to find a signature
- BiBa Signature
  - Sign message *m*
    - $h=H(m|c)$, where c is a counter starting from 0
    - c is incremented if no signature is found
    - Compute G_h for all SEALs $s_1, \ldots, s_t$
    - Look for a *k*-way collision of SEALs
  - Verify signature
    - Verify the *k* SEALs are distinct
    - Verify that they have the same image

BiBa Broadcast Authentication Protocol

- Sender needs to authenticate potentially infinite stream of messages
- Sender can only disclose a small number of SEALs before attacker would have enough to forge signature
  - Limit the number of messages that can be signed
- Solution
  - SEAL chains
    - Combination of SEALs and TESLA

SEAL Chains

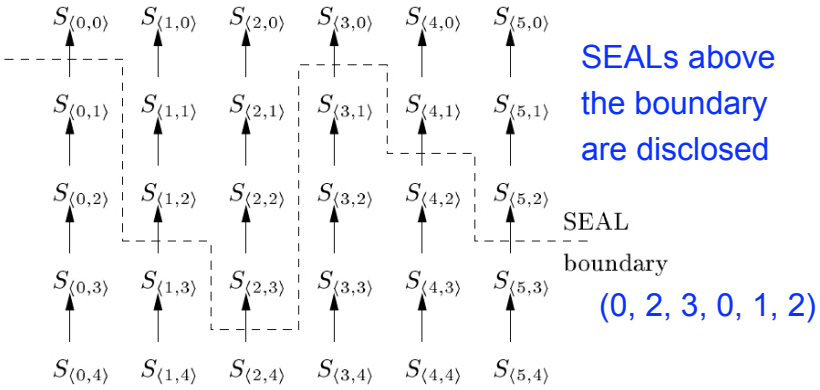


Limitation of BiBa Broadcast Authentication

- High receiver computation overhead
  - Most of the SEALs are not used
  - To authenticate a SEAL, each receiver needs to recompute many SEALs in a one-way SEAL chain

Extension A

- SEAL boundary



SEALs above the boundary are disclosed

(0, 2, 3, 0, 1, 2)

- If attacker slows down the traffic to the receivers, …
- Packet losses

Extension B

- To tolerate packet losses
  - Add SEAL boundary information to packets
  - More communication overhead, but also more robust
- Receivers still need to know the sending rate
  - Why?