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: $s_1, s_2, ..., s_t$
  - 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: $G_i(x) = G(x|1)$, 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 $G_h(s_i) = G_h(s_j)$

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Basic BiBa Scheme

Balls (SEALs):

Bins (Range of $G_h$):

Signature
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
    - $1 - e^{-(t-1)/2N}$, where $N$ is range of hash function.

Security of BiBa Signature (Cont’d)

- Signer (with 1200 SEALs)
- Attacker (with 10 SEALs)

Graph showing probability of finding signatures versus number of balls.
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 $s_1, ..., s_t$
    - 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**

\[ S_{i,j} = F_{S_{i,j+1}}(K_{j+1}) \]

SEAL chains Salt chain

**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**

So if an 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?