Authenticating streamed data in the presence of random packet loss

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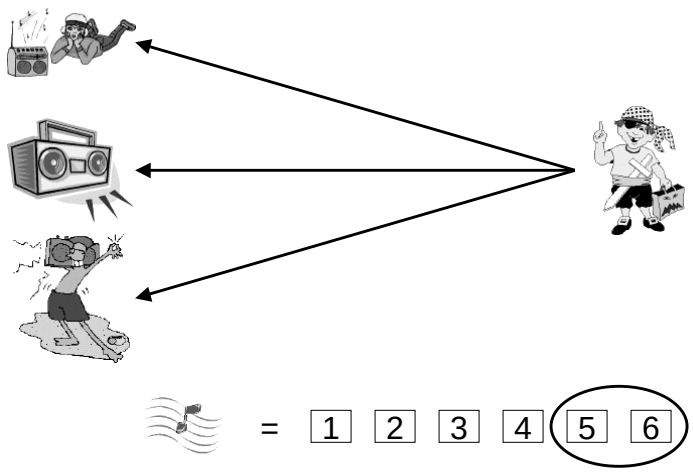
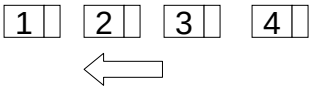
Internet Radio Station



Signing Streams

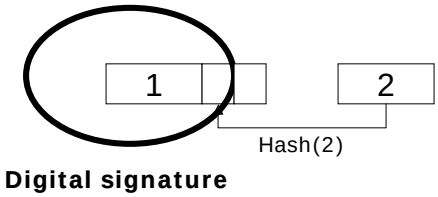
- Goal: authenticity, non-repudiation
  - Digital Signature
- 3 requirements for signing streams
  - 'On the fly' authentication
  - Low overhead (computation and communication)
  - Robustness (resist packet loss)

Sign each packet



- Sign each packet (RSA, DSA,...)
- Properties
  - + Immediate authentication
  - + Robust: packets individually verifiable
  - **- Computational load too high**
- Optimization
  - Maximum: 100 signatures / second

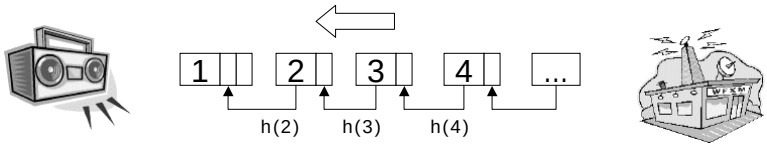
Amortization: hash function



- Collision-resistant hash function h:
Given h(x), hard to find y such that h(x)=h(y)

- Hash 100 times faster than digital signature

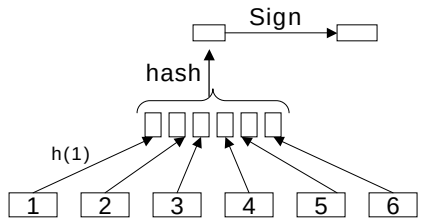
Hash chain (Gennaro, Rohatgi)



- Sender processes the stream backwards
  - Append the hash of P_{i+1} to P_i
  - Sign only the first packet
- Properties
  - + Immediate authentication
  - + Extremely efficient:
    - **1 hash computation / packet**
  - **- Vulnerable to packet loss**

Packet groups (Wong & Lam)

- Sender:



(Simple Example)

- Packet 3 is sent as: 3 1 2 4 5 6
- Robust against packet-loss
- Trade-off
  - More packets per group: buffering, communication overhead
  - Fewer packets per group: computational overhead

Recap

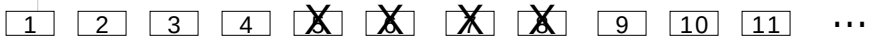
- Started with a hash chain
  - Immediate authentication
  - Low computation and communication overhead
  - **Vulnerable to packet loss**
  - **Offline streams only**
- Improvement: Wong and Lam
  - Immediate authentication
  - **Higher computation and communication overhead (trade-off)**
  - Resists packet loss
  - Some buffering on sender side, none on receiver side

The Scheme

- Existing solutions
  - Resistant to packet loss
  - Trade-off between Computation/Communication cost
- Communication overhead *matters*:
- We propose a solution which is
  - Resistant to **average** loss
  - New trade-off: computational cost and authentication speed

The scheme (contd)

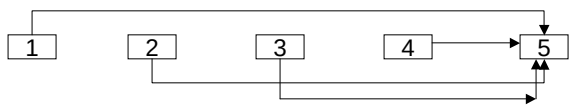
- Model of packet loss
  - Bursts (UDP)
  - Goal: maximize length of single worst-case burst
  - Resists multiple bursts



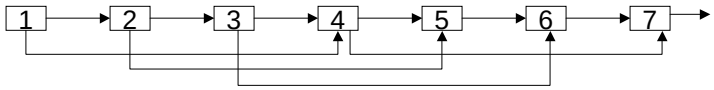
- Authentication
  - complete

Hash chain with redundancy

- Divide the stream into sequences of fixed length (say 50 or 100 packets)
- The last packet in each sequence is signed (and is presumed never lost)
- Property: the signature on the last packet 'covers' the hash of every packet in the sequence



No Packet Buffering On Sender-Side



Example: chain of strength 3

- Chain of strength a: the hash of packet P_i is appended to two other packets: P_{i+1} and P_{i+a}
- Only the last packet is signed.

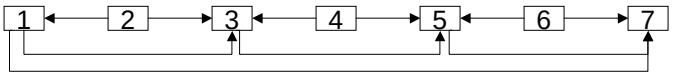
Characteristics of a Chain

- Sender:
  - Buffers 1 packet
  - Stores a hashes

- Receiver
  - Buffers 2 hashes
  - Can authenticate at the end of the sequence

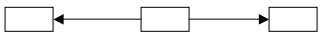
- Resistance to loss
  - Maximum burst length = a-1

With Packet Buffering on the Sender Side



Example: augmented chain of strength 3

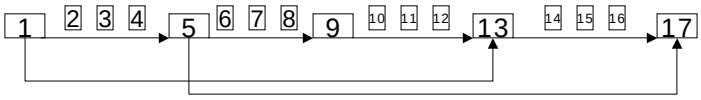
- If the sender can buffer a single packet:



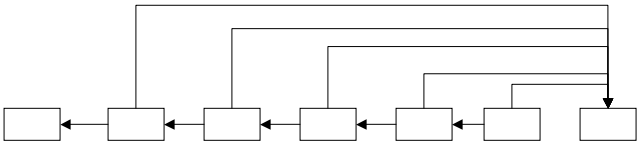
Generalization

- Sender buffers:
  - p packets
  - h hashes

Insert new packets in-between

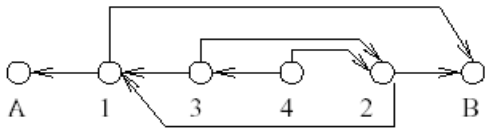


Stage 1

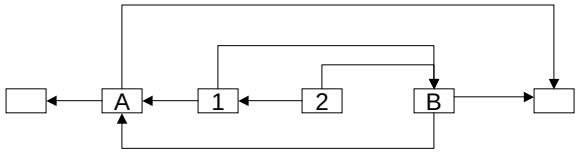


- Very simple to implement
- Optimally resistant to loss
- But: the maximum number of hashes appended to a packet grows linearly with p

Stage 2



- Recursive embedding



Characteristics

- Sender
  - Buffers p packets
  - Hash buffer of size h = a+p
- Receiver
  - Buffers (p+3)/2 hashes
- Resistance to loss:
  - maximum burst length =p(a-1)

Conclusion

- Efficient stream authentication scheme.
- Strength: resistance to random loss (bursts)
- New trade-off: between computational complexity and time to authentication