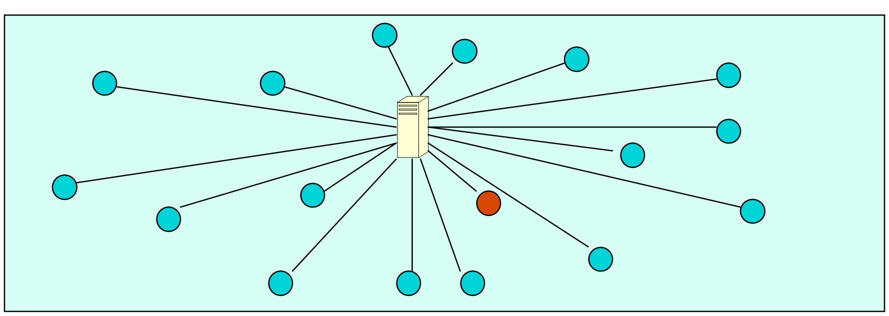
NC STATE UNIVERSITY Computer Science

CSC 774 Advanced Network Security

Topic 4. Broadcast Authentication

What Is Broadcast Authentication?

- One sender; multiple receivers
  - All receivers need to authenticate messages from the sender.



Challenges in Broadcast Authentication

- Can we use symmetric cryptography in the same way as in point-to-point authentication?
- How about public key cryptography?
  - Effectiveness?
  - Cost?
- Research in broadcast authentication
  - Reduce the number of public key cryptographic operations

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Topic 4.1 TESLA and EMSS

Outline

- Two Schemes
  - TESLA
    - Sender Authentication
    - Strong loss robustness
    - High Scalability
    - Minimal overhead
  - EMSS
    - Non-Repudiation
    - High loss robustness
    - Low overhead

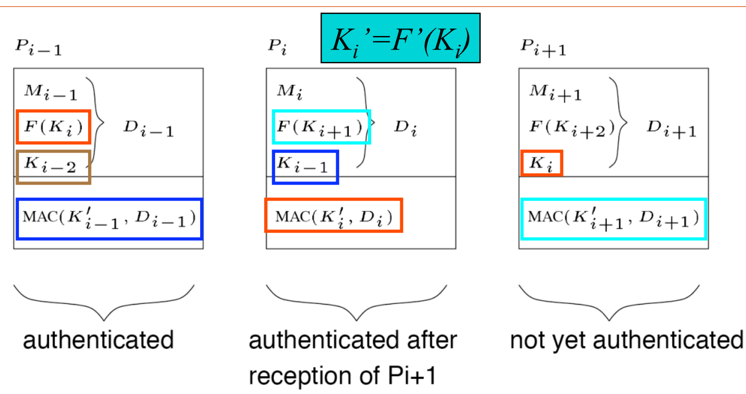
TESLA - Properties

- Low computational overhead
- Low per packet communication overhead
- Arbitrary packet loss tolerated
- Unidirectional data flow
- No sender side buffering
- High guarantee of authentication
- Freshness of data

TESLA – Overview

- Timed Efficient Stream Loss–tolerant Authentication
- Based on *timed and delayed release of keys* by the sender
- Sender commits to a random key *K* and transmits it to the receivers without revealing it
- Sender attaches a MAC to the next packet P_i with *K* as the MAC key
- Sender releases the key in packet P_{i+1} and receiver uses this key *K* to verify P_i
- Need a security assurance

TESLA – Scheme I



- Each packet P_{i+1} authenticates P_i
- Problems?
  - Security? Robustness?

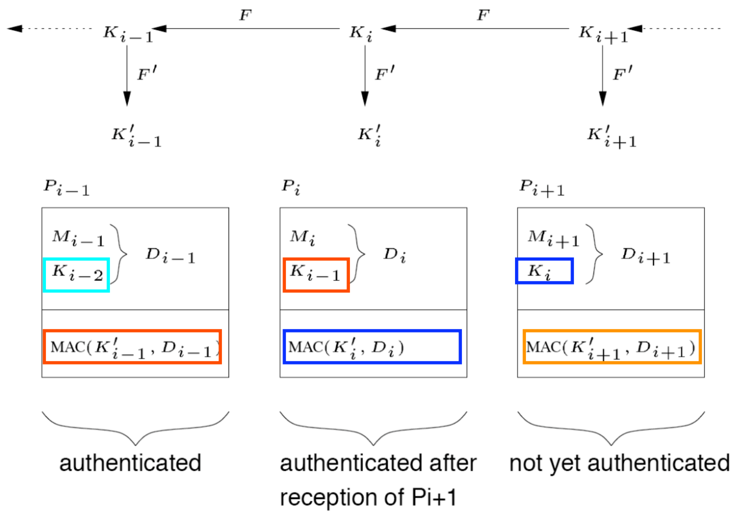
TESLA – Scheme I (Cont'd)

- If attacker gets P_{i+1} before receiver gets P_i, it can forge P_i
- Security Condition
  - $ArrT_i + \delta_t < T_{i+1}$
  - Sender's clock is no more than δ_t seconds ahead of that of the receivers
  - One simple way: constant data rate
- Packet loss not tolerated

TESLA – Scheme II

- Generate a sequence of keys { K_i } with one-way function *F*
- $F^v(x) = F^{v-1}(F(x))$
- $K_o = F^n (K_n)$
- $K_i = F^{n-i}(K_n)$
- Attacker cannot invert *F* or compute any K_j given $K_{i,}$ where $j>i$
- Receiver can compute all K_j from K_i, where $j < i$
  - $K_j = F^{i-j} (K_i); K'_i = F' (K_i)$

TESLA – Scheme II (Cont'd)



TESLA – Scheme III

- Remaining problems with Scheme II
  - Inefficient for fast packet rates
  - Sender cannot send P_{i+1} until all receivers receive P_i
- Scheme III
  - Does not require that sender wait for receiver to get P_i before it sends P_{i+1}
  - Basic idea: Disclose K_i in P_{i+d} instead of P_{i+1}

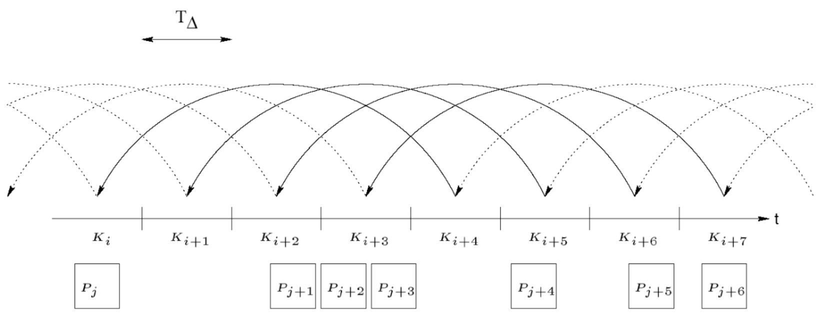
TESLA – Scheme III (Cont'd)

- Disclosure delay $d = \lceil(\delta_{tMax} + d_{NMax})r\rceil$
  - δ_{tMax}: maximum clock discrepancy
  - d_{NMax}: maximum network delay
  - r: packet rate
- Security Condition:
  - $ArrT_i + \delta_t < T_{i+d}$
- Question:
  - Does choosing a large *d* affect the security?

TESLA – Scheme IV

- Deals with dynamic transmission rates
- Divide time into intervals
- Use the same K_i to compute the MAC of all packets in the same interval i
- All packets in the same interval disclose the key K_{i-d}
- Achieve key disclosure based on intervals rather than on packet indexes

TESLA – Scheme IV (Cont'd)



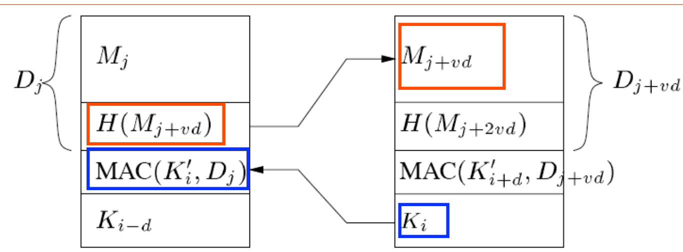
TESLA – Scheme IV (Cont'd)

- Interval index: $i = (t - T_o)/T_\Delta$
- $K_i' = F'(K_i)$ for each packet in interval i
- $P_j = < M_j, i, K_{i-d}, MAC(K_i', M_j) >$
- Security condition:
  - $i + d > i'$
  - $i' = (t_j + \delta_t - T_o)/T_\Delta$
    - i' is the farthest interval the sender can be in

TESLA – Scheme V

- In Scheme IV:
  - A small *d* will force remote users to drop packets
  - A large *d* will cause unacceptable delay for fast receivers
- Scheme V
  - Use multiple authentication chains with different values of *d*
- Receiver verifies one security condition for each chain C_i, and drops the packet is none is satisfied

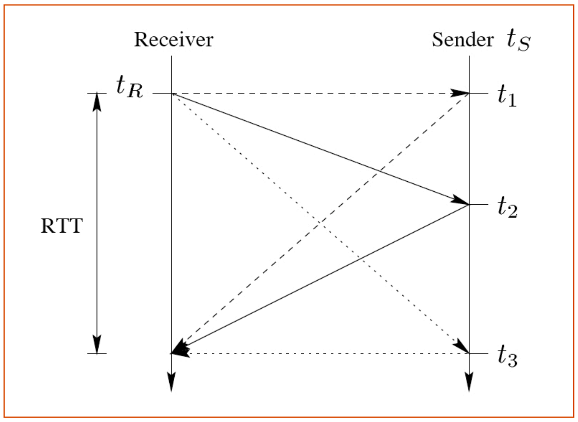
TESLA--Immediate Authentication



- M_{j+vd} can be immediately authenticated once packet *j* is authenticated
- Not to be confused with packet *j+vd* being authenticated

TESLA – Initial Time Synchronization

- $R \rightarrow S$: Nonce
- $S \rightarrow R$: {Sender Time t_S, Nonce, …}K_s^{-1}



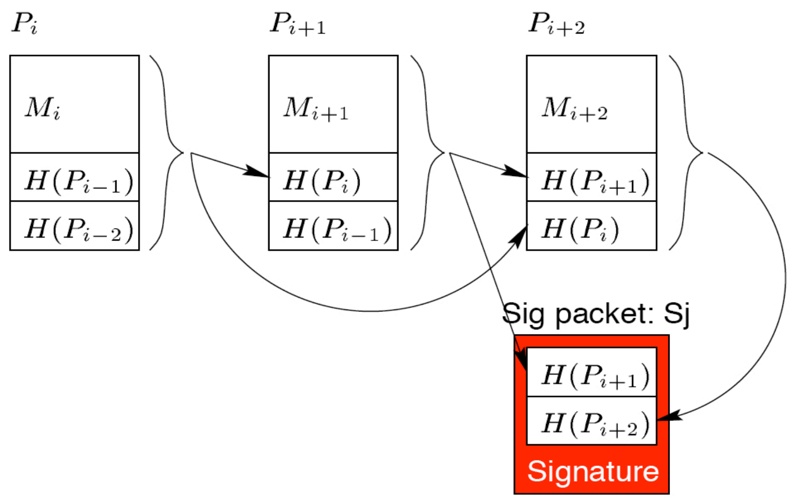
R only cares the maximum time value at *S*.

Max clock discrepancy: $\Delta_T = t_S - t_R$

EMSS

- Efficient Multichained Streamed Signature
- Useful where
  - Non Repudiation required
  - Time synchronization may be a problem
- Based on signing a small no. of special packets in the stream
- Each packet linked to a signed packet via multiple hash chains

EMSS – Basic Signature Scheme



EMSS – Basic Signature Scheme (Cont'd)

- Sender sends periodic signature packets
- P_i is verifiable if there exists a path from P_i to any signature packet S_j

EMSS – Extended Scheme

- Basic scheme has too much redundancy
- Split hash into *k* chunks, where any *k'* chunks are sufficient to allow the receivers to validate the information
  - Rabin's Information Dispersal Algorithm
  - Some upper few bits of hash
- Requires any *k'* out of *k* packets to arrive
- More robust