Distributed Authenticated Key Generation for Mobile Ad hoc Networks
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Introduction

- Assumptions
  - Mobile ad hoc network - no fixed nodes or links
  - Many-to-many group communication using multicasting
  - Nodes have only partial trust in each other
  - No trusted third party (except maybe during initialization)
  - Nodes are capable of generating uniformly distributed Fractional Keys
  - Nodes are capable of masking their Fractional Keys to form Hidden Fractional Keys

- Problem
  - Implement a provably secure distributed key generation scheme to generate and distribute a shared key for the group without revealing individual secrets

- Design Goals
  - No time stamps or time synchronization between nodes
  - Minimize possibility of using Denial of Service (DoS) attacks
  - Avoid unnecessary encryptions
  - Minimize use of Public-key based computation
  - Minimize computation and communication overhead

- Achievements
  - Developed a contributory key generation protocol that is collusion-free and does not require exponentiation
  - Developed a version of the above protocol with distributed authentication
  - Developed Auxiliary Key Agreement (AKA) protocol to improve efficiency under dynamic group membership
  - Developed optimized version of AKA using Logical Key Trees
  - Proved protocol security using BAN logic

Contributory Key Generation

- Adversary model
  - Passive attacker who can observe all messages but cannot create or alter messages

- Features
  - Computationally efficient
  - Collision-free: member’s fractional key is secret unless all the others collude against him

- Drawbacks
  - Vulnerable to active attack - HKFs are not authenticated
  - Inefficient for membership change - entire protocol must be rerun when a member joins or leaves

- Protocol description
  - Initialization:
    - Group Initiator distributes One Time Pads to group members. These are the Key Encrypting Keys for the first round.
    - Initiator also reveals the sum of all the One Time Pads to each member. This is the Group Key for the first round.

  - Key Generation:
    - Each member generates a Fractional Key.
    - The Fractional Key is encrypted with the Key Encrypting Key to obtain a Hidden Fractional Key.
    - The members announce their Hidden Fractional Keys.
    - Each member combines the Hidden Fractional Keys and removes the combined effect of the Key Encrypting Keys to obtain the new Group Key. Thus the Group Key is the sum of the Fractional Keys.
    - Each member obtains their new Key Encrypting Key by removing the effect of their Fractional Key from the new Group Key

Auxiliary Key Agreement

- Features
  - Member join:
    - Centralized version: A random subset of members is given new One Time Pads. The remaining members are given the new binding parameter
    - Distributed version: New member finds a “sponsor” to help him generate a new One Time Pad and to update the binding parameters.
  - Member Revocation:
    - Centralized version: Same as member join
    - Distributed version: Retain authenticated key generation starting at member N+1

Enhancements for Efficiency

- Centralized version can be made more efficient for satellite environments
  - Use a Logical Key Tree for protocol messages
  - MAC keys precomputed and distributed by Security Manager

Authenticated Contributory Key Generation

- Adversary model
  - Active attacker who can observe all messages, and insert, drop or modify protocol messages

- Additional Assumptions
  - Public Key Infrastructure exists
  - Attack cannot break one-way hash or compromise PKI

- Protocol Guarantees
  - External attacker cannot lead group members into forming an incorrect key.
  - In other words the protocol provides key authentication
  - External attackers cannot cause denial of service in a broadcast medium assuming that he cannot control the link layer.

- Features
  - Centralized version is collusion-free. Distributed version is collusion-resistant (a minimum number of people must collude to be successful)

- Protocol description
  - Members first mutually authenticate and establish shared keys using PKI
  - Initialization:
    - One-time pads are encrypted, then concatenated with an SKEY-based nonce and digitally signed.

  - Key Generation:
    - In place of a Key Encrypting Key each member has a binding parameter
    - The HKF messages also include a digital signature, which includes the binding parameter to ensure freshness