NC STATE UNIVERSITY Computer Science

CSC 774 Advanced Network Security

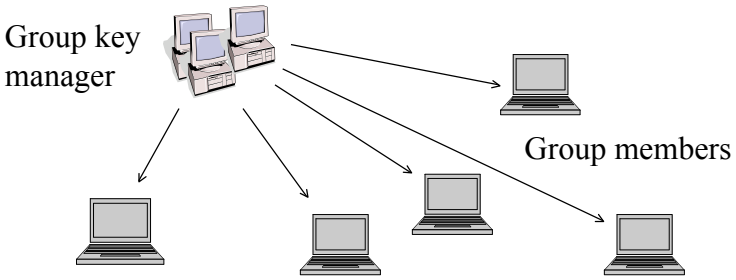
Topic 5.3 Group Key Distribution

Acknowledgment: Slides on LKH were originally provided by Dr. Wensheng Zhang at Iowa State.

Outline

- Overview of group key distribution
- A naïve solution
- Iolus: A Framework for Scalable Secure Multicasting
- Logical key hierarchy (LKH)

Group Key Distribution



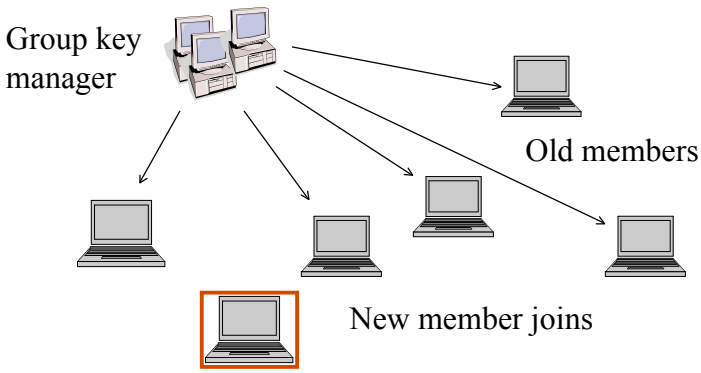
- Group session keys are determined by the group manager
  - Usually used for large groups.

A Naïve Solution

- Use a separate secure unicast connection from the group manager to EACH group member.
- Requirement
  - Each client shares a unique key with the controller.
- Poor scalability:
  - n-1 secure unicast connections
  - n secret keys

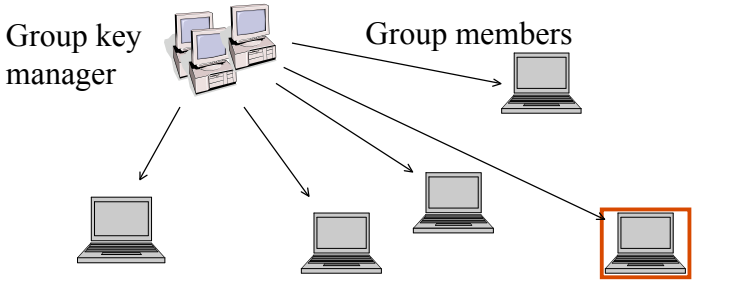
Problems Specific to Group Communication

- "1 affects n" problem
  - The actions of one member affects the entire group



Problems Specific to Group Communication (Cont'd)

- "1 does not equal n" problem
  - Cannot deal with the group as a whole
  - Must consider the conflicting demands of members on an individual basis

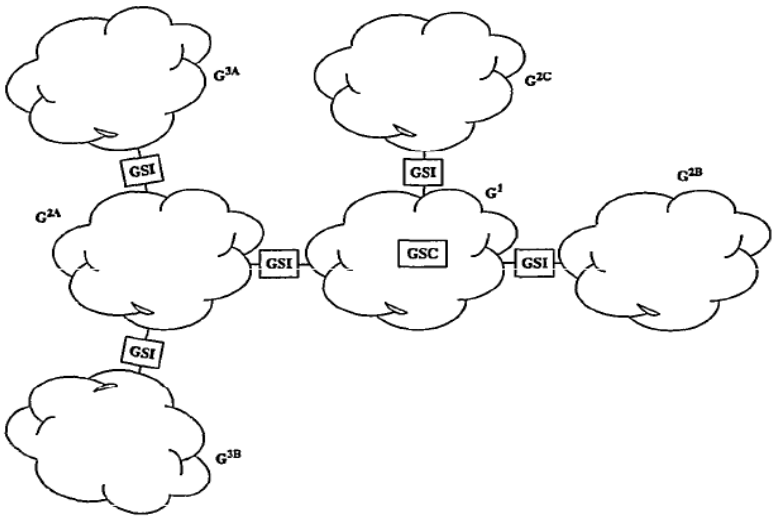


Example: Cannot use the old group key to distribute the new group key.

Iolus

- Divide a large group into smaller groups
- Introduce entities that manage and connect the subgroups
  - Group security controllers (GSC)
    - Control the entire group
  - Group security intermediaries (GSI)
    - Control the subgroups on behalf of GSC
  - GSC and GSI are both referred to as group security agent (GSA)
  - With GSC as the root, GSAs form a hierarchy of subgroups
    - A lower-level GSA is a member of the group headed by the higher-level GSA

Iolus (Cont'd)



Iolus (Cont'd)

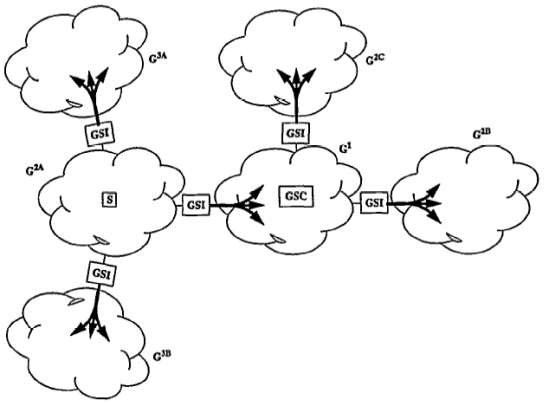
- Joins
  - GSA generates $K_{GSA\text{-}MBR}$
  - Store this key along with other information
  - Send $K_{GSA\text{-}MBR}$ to the new member in a secure channel
  - Generate a new group key K'_G
  - Send $\{K'_G\}K_G$ to the group
  - Send K'_G to the new member in a secure channel

Iolus (Cont'd)

- Leaves
  - Generate a new group key K'_G
  - Send K'_G to each member MBR individually in the secure channel encrypted with $K_{GSA\text{-}MBR}$

Iolus (Cont'd)

- Data transmission
  - Data retransmitted within each subgroup



Iolus (Cont'd)

- Iolus for group key management
  - Replace the data with the group key in data transmission

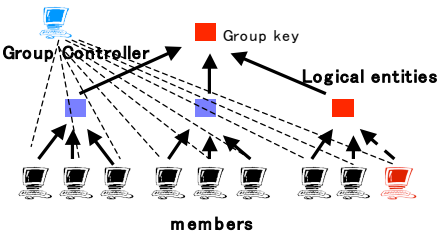
Key Tree Approaches

- Two types of keys
  - SEKs (Session Encryption Key)
  - KEKs (Key Encryption Key)
- A Group Controller constructs a tree based hierarchy of KEKs

N: number of members

D: tree degree

$1 + \frac{\ln(N)}{\ln(d)}$ depth

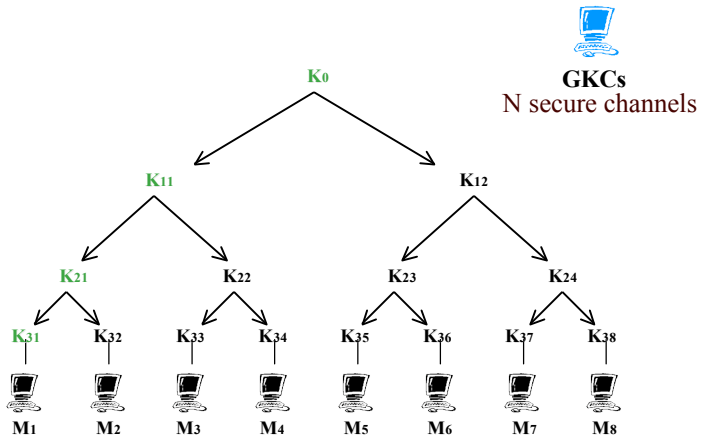


Logical Key Hierarchy (LKH)

- Keys are organized in a (logical) hierarchical tree
  - Group key is located at the root
  - Key encryption keys are the non-root, non-leave nodes
  - Members are located at the leaves
- Updates the group key and the key encryption key by means of the encryption of key-nodes
- Rekey with only O(logN) messages

LKH (Cont'd)

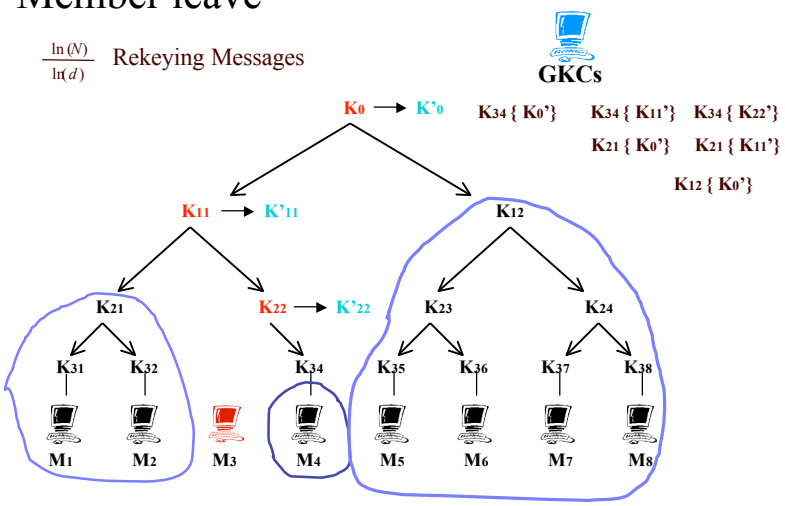
- Initialization



LKH (Cont'd)

- Member leave

$\frac{\ln(N)}{\ln(d)}$ Rekeying Messages



LKH (Cont'd)

- Member join

$\frac{\ln(N)}{\ln(d)}$ Rekeying messages