FP-LBS: A Flexible Privacy Enhanced Location Based Group Services System Framework and Practice

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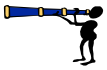
PENNSTATE 1855

Location Privacy vs. Service Flexibility

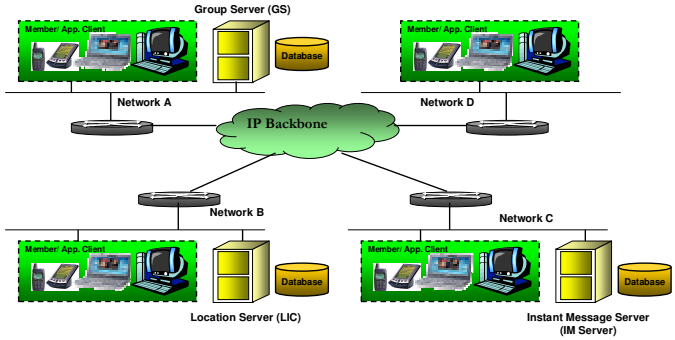


Location Privacy is critical to provide LBS

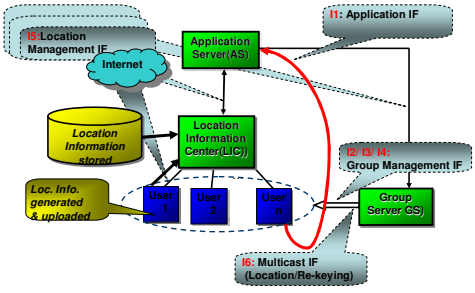
- user controlled location information access
- a group of entities defined by user to access its location information

- Flexible access to location information is important to support desirable service model and easy deployment
  - hierarchical coding of location information with different granularity
  - providing keys to the group members to decrypt location information

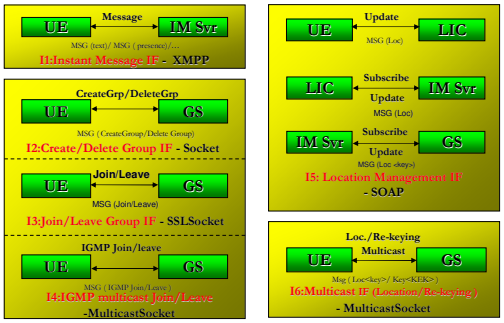
LBGS Network Diagram



LBGS System Interfaces



LBGS Interface Protocols



LBGS Implementation

Implementation platform: Java 2 Platform, J2SE 1.5.0

Group Management Practice:

- *KeyTree* package: LKH extension and 4 key tree schemes support
- *GServer* package: group management server implementation
- *GClient* package: group management client implementation

Application Integration:

- *IMServerExt* package: Wildfire IM Server development package based IM Server extension to support location sharing
- *plugin.locationgroups* package: Spark IM Client development package based client plugin to support location extension

Location Management:

- *LICServer* package: JSOAP develop. package based Location Server
- *Location* package: GPS location tracking / other location tracking

MIKEY and LKH

MIKEY as the basis of keying protocol

Two limitations of MIKEY:

- no hierarchy of group key servers support
- no re-keying support

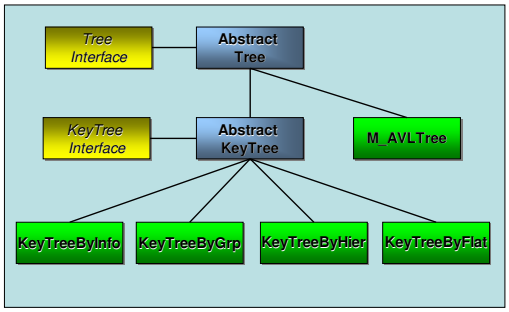
Basic Solution:

- apply LKH to MIKEY to improve scalability with re-keying

Further Extension – 4 schemes:

- Coding by Information Class
- Coding by Group/ Hierarchy Coding / Flat coding

KeyTree Class Hierarchy

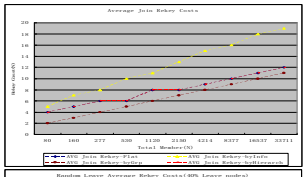


M_AVL Key Tree Algorithm

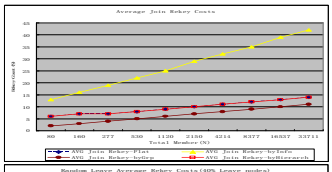
```
/*c is a new member's data */
Algorithm Insert( NodeData c){
1.  if ( tree is empty) {root = createTreeNode(c); return;}
2.  if (tree is full) {
3.      TreeNode e = createTreeNode(c);
4.      TreeNode itnode = createInternalNode();
5.      Current root becomes the left child of itnode;
6.      e becomes the right child of itnode;
7.      root = itnode;
8.  } else {/* if tree is not full*/
9.      TreeNode base = findInsertBase( );
10.     TreeNode e = createTreeNode(c);
11.     TreeNode itnode = createInternalNode();
12.     base becomes the left child of itnode;
13.     e becomes the right child of itnode;
14.     itnode becomes the child of base's parent ;
15. }
16. Update node information along the insertion path;
}

Algorithm findInsertBase(){
1.      TreeNode base = root;
2.      while (base is not leaf node){
3.        if ( (left or both subtrees of base have shallowest node)
4.          { base = base.left; }
5.        else { base = base.right;}
6.      }
7.      return base;
}
```

```
/*n is a member node */

Algorithm Remove( TreeNode n){
1.      if ( n == root) {root = null; return;}
2.      TreeNode base = n.parent;
3.      TreeNode base_gn = base.parent;
4.      TreeNode sn = n.getSibling();
5.      if (gn == root){/*remove a child of the root*/
6.        sn.parent = null;
7.        remove current root and n;
8.        root = sn;
9.      } else {
10.       sn becomes a child of base_gn;
11.       remove base and n;
12.     }
13.     Update node information along the remove path;
14.     rebalance();
}

Algorithm rebalance(){
1.      while ( root is not balance){
2.        /*Find the highest deepest balance subtree*/
3.        TreeNode bn = findHighestDeepestBalanceSubtree();
4.        /*Find the shallowest most unbalance subtree above bn*/
5.        TreeNode nbn = findShallowestUnbalanceSubtree();
6.        swap(bn, nbn);
7.        Update node information along the two paths;
8.      }
}
```

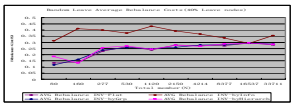
Performance Evaluation



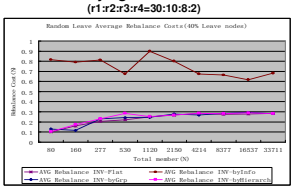
Hierarchical LKH re-keying overhead
(r1:r2:r3:r4=30:10:8:2)



Hierarchical LKH re-keying overhead
(r1:r2:r3:r4 = 2:8:10:30)



Leave re-keying rebalance overhead
(r1:r2:r3:r4=30:10:8:2)



Leave re-keying rebalance overhead
(r1:r2:r3:r4 = 2:8:10:30)

Realistic Application Practice and Analysis

Flexible Extension for Different Application:

Small Group Size(10's)

Sample application - *Instant Message Service*

- Small number of user update/Small number of user subscription
- Small number of re-keying: multicast or /uni-cast

Big Group Size(1000's)

Sample application - *Campus/Disaster/Emergency Service*

- Small number of location update/ large number of user subscription and message multicasts to large audience
- Large number of re-keying: multicast

Medium Group Size(100's)

Sample application – *IM/Game/Company Group Service*

- Medium number of location update/ Medium number of user subscription
- Medium number of re-keying: multicast

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