ISSN:0975-9646
C. HariChandana et al, / (IJCSIT) International Journal of Computer Science and Information Technologies, Vol. 2 (4) , 2011, 1612-1617

A Three Level Tree Structure Database Architecture for Global Roaming in Mobile Networks

C. HariChandana, A. Sudhir Babu

Department of Computer Science & Engineering, PVP Siddhartha Institute of Technology
Vijayawada, Andhra Pradesh, India

***Abstract*— The basic necessary service in mobile networks is global roaming, where personal mobility, terminal mobility and portability in service provider should be supported for making global roaming seamless in future generation. In the current application if a user moves from one country to other or to other continent user needs to pay roaming chargers to the operator and as the data resides in the home country which makes delays in the call procedures. But in the proposed application it benefits the user by making the number as a local number where ever the user travels. To implement such a global mobile system, a location independent scheme is needed. This scheme requires a large centralized database to connect all non geographical PTNs in order to capture larger number of people who are going to subscribe in future. So designing efficient database architecture to support location independent scheme with acceptable loads in future is an important issue in the cellular mobile systems. Firstly, tree structured one-root database architecture is designed to support seamless global roaming but practically it's inefficient. It gives more loads in updating the current locations of the mobile users and increases delay in location tracking. In this proposed distributed multi-tree database architecture with three-level tree structure helps in reducing the database loading, signal trafficking in location registration and finally in delivery of call procedure which makes the database operations easier because this architecture is based on location independent scheme and also gives support to track location in the global mobile system.**

Keywords—**Personal Telecommunication Number, Mobile Terminal, Global Title Translation**

I. INTRODUCTION

The main aim of the project is to simulate the proposed multi-tree database architecture acceptable for future mobile networks. The project is developed in such a way that it is easy for user to know the mobile registration process and call setup process. The project is developed on the basis of the server and client interaction application. The application of the client is capable of mobile registration, call setup from source mobile to destination mobile if both reside in the same application itself. The server application registers the entire client application and capable of connecting source and destination mobile numbers residing in different client applications running in same or different systems.

A. Background

One of the most essential functions for global roaming is managing the location of the mobile users. It has various operations in different databases, which should record the information by all the users who are moving from one location to another. There are two types of databases used for location tracking in current cellular communication systems such as home location register (HLR) and visitor location register (VLR). Each mobile network has a home location register (HLR) where the service profiles of the mobile subscriber like location of the current users and the type of service these users are using. Mobile terminal resides in the Visitor locations register (VLR) and also manage the copy of the mobile terminals profile. Mobile switching center (MSC) is combined with the VLR which is used to control the group of registration areas [1].

If the mobile terminal changes its registration area, the HLR should be able in a position to update the new place and the old VLR deregister the mobile terminal. After the mobile terminal being registered in a new area, to receive the incoming call the HLR of the called mobile is queried to the VLR which is serving the terminal. Then the called HLR sends request to the MSC to get the routing address. Thereby MSC generated a temporarily based local directory number in the mobile terminal which is sent back and referred to as HLR. This called HLR sends the information to the so called MSC and then the connection is setup by using SS7 network. And also the MSC/VLR needs the GTT which is referred to as Global Title Translation to get the mobile terminals home location register (HLR) address. So to find and update the mobile users profile by using this two-level database architecture for large number of users gives very heavy load and higher user density so it become infeasible [10].

B. Aims and Objectives

This thesis mainly aims at: (i) Research different aspects related to cellular mobile communication, especially database architecture of the system. (ii) Creating distributed database architecture for global roaming in mobile networks. The main objectives of this thesis are: (a) Study and understand the database architecture of the current cellular communication system. (b) Study and analyze the call setup, location registration and roaming in the existing cellular mobile communication system. (c) Review the strategies applied to overcome the drawbacks in the existing cellular communication system. (d) Proposing the multi-tree database architecture for global roaming in mobile networks. (e) Analyze, design the proposed multi-tree database architecture using Visual Basic .NET as a front end and SQL Server as back end.

C. Research Problems

In recent years the cellular mobile communication is increasingly used. Whenever the mobile user moves from one place to another place the service providers and service profile will be changed. The mobile user should register his location in the new area and the routing for that user,

maintaining the service profile when the mobile users move frequently, provides more overhead to the database which increases the load and the users PTN will be changed. In order to avoid these problems the many researchers focused on creating the centralized database architecture. Among the centralized database the one with the proposed architecture that is the one with multi-tree database helps in reducing loads in desired database, and makes it easy for location registration in a new area.

D. Research Methods

The present researchers find it hard to design and maintain centralized architecture database in mobile networking for global roaming. So it increases the interest in research and to provide an appropriate database for global roaming. In this project I have designed the multi-tree database architecture with centralized nature using Visual Basic .NET. This design shows how the centralized database can maintain each user registration, service profiles, call setup and location update.

II. REVIEW OF EXITING DATABASE ARCHITECTURE

Many researchers have proposed this database architecture design in cellular mobile system for many of the location management. Currently existing architecture is two-level database architecture. To make global roaming seamless, existing architecture has some issues. When mobile users move from one location to another, location registration and call delivery procedure will be changed. Two main drawbacks in the existing system are signaling overhead in call delivery and increasing database access load in location registration.

Two main strategies such as auxiliary strategy and distributed strategy has been proposed on the bases of the 2 level databases namely architectural and the other is hierarchal respectively [6]**.** To reduce database loads and signaling traffic, auxiliary strategy is used.

A. Auxiliary Strategies

1) Caching Strategy: This strategy is introduced in two-level database architecture by *Seshadri mohan et.al.* [13].This strategy is also known as *per-user caching,* for locating the mobile users who is changing the registration area in cellular mobile communication service. The caching strategy is applied to the basic location strategy which is used in the existing IS standards mainly the IS-41 and the GSM, with an idea of reducing the loads in the database, and reducing the signal in the networking, memory costs and the CPU processing. Due to the reduction of cost, this strategy becomes increasingly attractive. This strategy is more important for that user who receives calls frequently with respect to the rate at which the user changes its registration areas. For each entry in cache the location information of mobile terminals is created in signal transfer point. If any other call is arrived for the same mobile terminal, it reuses the information which is cached already. Then it forwards the call to the VLR which is mentioned in the cache. A hit occurs if the mobile user is not moved from that VLR otherwise a miss occurs. If miss occurs then the call delivery procedure of two-level database architecture has to be followed to find the mobile user, which increases the call setup delay. So this approach is inefficient if the mobile users changing the location more often [13].

2) Replication Strategy: This strategy is introduced in two-level database architecture by *Sung-Hwa LIM and Jai-Hoon KIM* [14], to reduce the call delivery delay. In this approach at selected databases, the mobile user's location information is replicated. So that, without querying the HLR, the replicated database can be routed for the calls to the mobile users who are originated from the previous service areas. All databases that are replicated have to be updated, when the mobile terminal changes its location. Especially for highly mobile users this method increases the signaling traffic and database load [6].

3) Forwarding Strategy: This strategy is introduced in two-level database architecture by *Ravi-Jain and Yi-Bing Lin* [6]. This strategy is also known as forwarding strategy "per-user", which is used in locating the mobile users while changing their registration area. By using this forward strategy, calls directed to a specified user will first help in dealing with the mobile user's HLR in order to find out the first VLR, where the users of the mobile are been registered. Then a chain of forwarding pointers to the current VLR mobile users is been mapped. In this approach, the mobile users tend to change their areas of registration pointer is used to forward the call from old VLR to new VLR. The HLR is queried first, when an incoming call arrives to that mobile terminal into order to get the old VLR then it forwards to the new VLR. So this approach reduces the location updates but the call setup delay is increased. This is also inefficient for the future mobile networks [6].

4) Anchoring Strategy: This strategy is introduced *Joseph S. M. Ho and Ian F. Akyildiz [11]*. This is strategy also known as '*local anchoring*' scheme used for tracking the location in personal communications network (PCN). The main motivation of this scheme is to reduce signal costing in comparison with the location management strategy that is in IS-41 and GSM standards. The number of messages for location registration between the HLR and the VLR is reduced by reporting the change in the location to a nearby VLR which is in other words called as LA (Local Anchor) on behalf of the

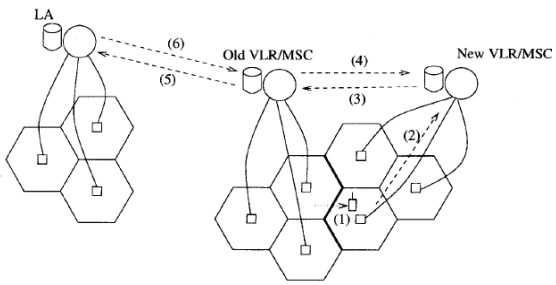

Fig. 1 Reporting Location change to the LA [11].

HLR. This method helps in successfully reducing the signal costing for tracking the location when the arrival of the calls is very low when compared with the rate of mobility. A new local anchoring scheme is introduced dynamically, which is used to select the local anchor (LA) dynamically so that the

anticipated cost for call delivery and location registration can be further reduced. In this, a pointer is maintained by the HLR which points the local anchor. Whenever the call is detected by HLR it forwards into the local anchors. Then it requests for TLDN to the VLR which is servicing for mobile terminal due to one extra database in anchor, the call delivery time is increased. So this is not efficient method.

Based on these arguments it's concluded that auxiliary strategies reduces only certain thing it's not fully meets the future requirements. Obviously a centralized database is required to reduce the access rate and to support large no of users.

B. Distributed Strategies

1) Hierarchical Database Architecture: In order to reduce the access loads on an upper level database three-level database architecture is designed by *Joseph S. M. Ho and Ian F. Akyildiz [12],* which distributes the loads into the lower level database. In between the HLR and VLR cellular system an extra level database is added called directory registers (DS) is introduced. The rate of access to the HLR is been by the DR, because it distributes the location information periodically to the associated mobile terminal using distribution strategy [12].

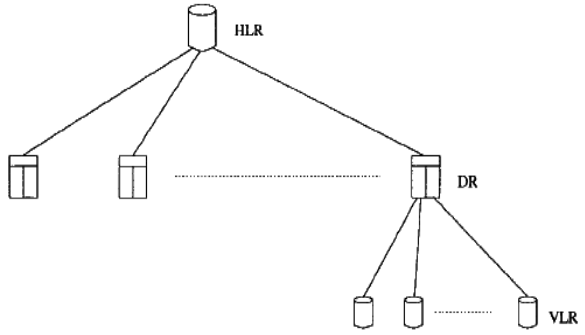

Fig. 2 Hierarchical Database Architecture [12].

This method lowers the probability of inter-Directory Area movement and thus results in additional reduction in database access and the signaling and costs. This location management method depends on the newly added directory registers (DR) to distribute the Mobile Terminals (MT) location information. All further processing, such as finding the location information distribution strategies, are handled by the Directory registers (DR). The distribution strategy for each mobile terminal (MT) can be determined independently at the local directory register (DR) by using the information existing at the serving Visitor Location Register (VLR). As a result, centralized control is not necessary.

2) Multi-level Database Architecture: For tracking the location of the mobile terminals, multi-level hierarchical database architecture was introduced. However it is similar to the phone number plan, in which a new number is allocated to the mobile terminal whenever it changes its services area. Similarly in order to identify whether a mobile terminal is location dependent or not a numbering plan is identified [11].

3) Distributed Database Based On IEEE 802.6 MAN: Current centralized database architectures are likely to be unsuitable for managing the expected mobile users for future. Three-levels of database mobile architecture network have been introduced based on the location numbering independent plan. The previously designed databases has some common drawbacks, which has only one root centralized database to maintain all the service profiles of the mobile users. It is impractical to store & maintain a database globally due to expected large number of users. Entire system will be affected in the crash of root database [11].

A distributed architecture based on the IEEE 802.6 Metropolitan Area Network (MAN) was introduced by *Andrew D. Malyan et.al, [8]* to meet expected Personal communication service (PCS) needs. A system is used to estimate MAN coverage in metropolitan areas, and is used to reveal coverage of around 50 city blocks per MAN. Distributed mobile user database architecture is used to assist call setup, tracking of handoffs and roamers. It is only acceptable in wide mobile systems like MAN.

A three level multi-tree database system is proposed, which increases the database system more sophisticated, by the use of additional nodes in it. Extra nodes in the global mobile system are necessary to deploy in different countries.

III. SYSTEM ANALYSIS

A. Existing System

Two-level database architecture is being used in the present cellular mobile systems to manage the locations of the mobile users. Each base station has two database namely called HLR & VLR. In this system one of the database called HLR is used to maintain the service mobile of the mobile terminals and also includes the profile of real-time locations of the mobile clients. Visitor location register maintains the record of the mobile users currently resides within the cell. When the registration area of the mobile client changes from one area to the other, the profile of the new mobile terminal is added in to the VLR and HLR needs to be updated [10].

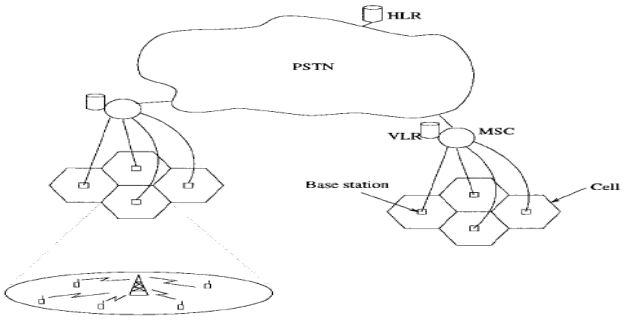

Fig.3 PCN signalling network architecture [12].

In locating the mobile client original VLR will be queried first. If it is not residing in that VLR, then a request will be sent to the mobile terminals HLR. Although there are many serious performance problems it is not suitable for the new applications and not scalable. Because it has to maintain a huge amount of information with regards to the mobile users move from one location to another, in existing system has major disadvantages such as roaming can be expensive, database inconvenience and does not have mobile freedom for global wise.

B. Proposed System

The proposed system is a multi-tree database architecture which consists of number of three level tree structure database subsystems. Tree structure can be increased more than three but it may give longer delays in call delivery and location registration. Communication takes place through the root database of each database subsystems. Each database subsystems are connected through ATM networks, PSTN (public switched telephone network) or any other networks. This system is more efficient, scalable and robust than existing system.

Multi-tree Database Architecture: The recommended multi-tree database architecture for tracking proposed location of mobile users is a multi-tree structure which consists of three levels. Each 1 tree is known as database subsystem. And these various databases represent different network operations possibly by different service providers. Public switched telephone network (PSTN) or ATM network is used to interconnect all the database subsystems in the architecture. All the mobile terminals in the database subsystems are communicate through their root databases.
Multi-operator environment is supported by this architecture. Each database subsystems consists three different databases namely DB0, DB1, and DB2, in which the functions of DB0 and DB2 in similar to HLR and VLR in two level database architecture, respectively without any trigging registration the mobile users can roam freely because the registration areas are controlled by DB2. Mobile switching center is situated along with DB2 which is used to perform the process of call orientation and termination. A collection of BD2s are grouped in to one DB1 and the entire DB1 are joined in to a single DB0. To exchange messages between various location databases a switch is used, namely called STP. Routing function is done by switch STP.

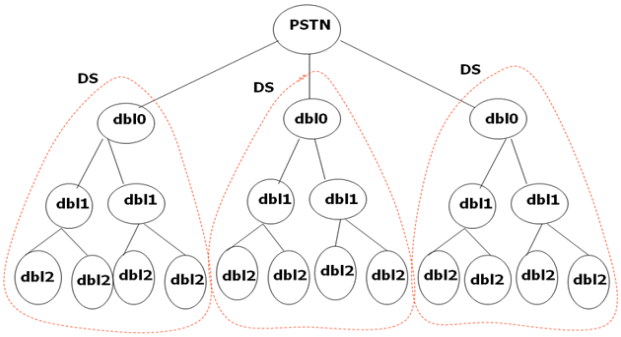

Fig. 4 Multi-tree database architecture

Currently residing mobile user's service profile information's are maintained in DB0 of its corresponding service area. And DB2 contains the service mobile users who are currently roaming in that particular area. Due to the locality of calling and mobility patterns, there is a reduction in the frequency of query calls in this particular architecture. Although the location updating is not local, the DBO is one of the largest centralized databases which need to be visited. So the end-to-end delay in this system is increased in this location registration and call setup. The access time is proportional to the number of subscribers who also increased the end to end delays in order to reduce these delays the database level in the should be limited.

C. Location Registration and Call Delivery Procedures

1) Location registration procedure: Location registration is quiet important aspect because that's the thing which lets us know where the customer is exactly now so based on that operator needs to provide service to make sure that he is not left out without connection. Whenever the user changes the location the reports will be sent based on this procedure. It is explained based on the assumption of DB2 controls only one registration area (RA). DB2 has the ability to control more than one registration area in real time applications. The proposed architecture consists of three database levels such as DB0, DB1and DB2. The procedure for updating of the location in the mobile system globally is explained as below.

Step1: when the user moves from one location to another, a request message for registering into to the new location is sent to the associated DB2. Then DB2 send a request message for controlling this particular area of registration. If the user is allowed to enter into the DB1, and later go to step 2 otherwise go to step 3.
Step2: If the DB1 allows the new user to enter means that the same DB1 is controlling the new and old DB2. After entering into the new location the DB1 replaces the pointer for user's entry from old one to new. So the higher level database is not queried. The cancellation message will be sent to the old location, then go to step 8.
Step3: From step1, if the user is not allowed to enter into that DB1 which shows that the user moved from one DB1 to another. An entry is added in the index file to the new DB1 to point out the new DB2 user. And the higher level database DB0 will be updated.
Step4: The user service profile is verified in the higher level database DB0 if it does not exist which indicates that the user entering into the new subsystem. Then go to step 5a Otherwise user's service profile will be updated by DB0 in order to point out the new DB1 and the old registration will be cancelled. Then go to step7.
Step 5(a): The user service profile will be requested by the new and old DBO.
Step 5(b): The user profile will be stored in new DB0 and the pointer points to the new DB1. And the new DB2 will also get the service profile copy.
Step6 (a): The service profile user will be sent back from DB0 to new DB0.
Step 6(b): In the index file of old DB0 updates the user entry to point to the new DB0and the data file deletes the service profile from the database. And the old DB1 registration will be cancelled.
Step7: The index entry of the user will be deleted from the old DB1 and it sends the cancellation message for deregister to old DB2.
Step8: A user's service profile copy is sent to the new DB2 if the old DB2 and the new DB2 resides in the same database subsystem (DS). The DB2 old removes the service profile and index entry of the user.
Step 9: the new DB2 creates the user service profile and sets up an index entry for the user after receiving the user's service profile.

Based on the location registration procedure, it shows that whenever the user changes its database subsystem (DS)

only the old and new DB0 is in operation others remains in the same. Unlike forwarding strategy the forwarding pointer chain is generated to the corresponding DB0s. due to this procedure the length of the forwarding pointer is increased so that the delay also increases. When compared to the single root hierarchical database architecture it's more efficient and scalable. Synchronization of DB0 is necessary to contain the delay in call as a mobile terminal (MT) changes its database registration. There exists a trade-off between the call setup delay of inter-DS calls and overhead of DB0 synchronization.

If synchronization strategy is adopted, when the user moves from one database subsystem to another, the index files of DB0s are need to be updated. On each DS change, the database access load and will be increased in a short time. If the synchronization strategy is not applied the forwarding pointer length chain will be increased upon the DS changes. On-demand synchronization strategy is the best solution for this problem which adjusts the chain during the call delivery. In partial synchronization strategy, when the MT changes its database subsystem (DS) a selected group of DB0s are updated which generates high cal rates to the moving mobile terminal (MT). On comparison, the partial synchronization strategy reduces the setup delay and signaling traffic.

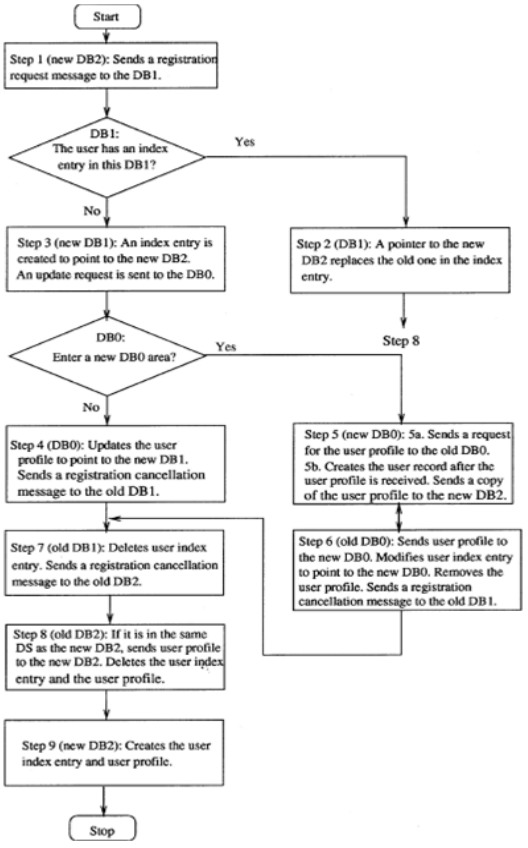

Fig. 5 Flowchart for Location Registration Procedure

2) Call Delivery Procedure: The procedure for call delivery is performed, whenever the call is arriving from the caller. Call setup is done by using the following procedure,
Step1: The availability of the index entry is verified in the DB2, detection of the call in the caller's MNC. If it is detected go to step 5 and the query is not required for DB0 and DB1. Otherwise the query will be sent back to the corresponding DB1, then go to step 2. *Step 2:* Availability of index file entry for the caller is verified in DB1. If it is available, go to step 4 and the query to the DB0 is not required. Otherwise, the associated DB0 will be queried, then go to step 3. *Step 3:* The DB0 checks whether the caller is corresponds to one of its DB1s.If true the routing address request is passed to DB0 to DB1, then go to step 4 otherwise go to step 7. *Step 4:* The caller's DB2 is determined by DB1 and send to DB2 a query in requesting for the routing address. *Step 5:* TLDN will be given to the caller and it sends to the calling MSC after finding the caller in DB2. *Step6:* sets up the connection between the called MSC and calling MSC. *Step7:* The query will be sent to the corresponding DB0 changes to DS if the caller is residing to another DS. The searching process is repeated from step 3.
Based on the procedure for location registration and the call set up its concluded that GTT is not required. But when the overall system cost is reduced it simplifies the deployment of the proposed strategy.

IV. SYSTEM STUDY

A. Feasibility Study

The feasibility of the project is analyzed in this phase and business proposal is put forth with a very general plan for the project and some cost estimates. During system analysis the feasibility study of the proposed system is to be carried out. This is to ensure that the proposed system is not a burden. For feasibility analysis, some understanding of the major requirements for the system is essential. Three key considerations involved in the feasibility analysis are

1) Economical Feasibility: Organization's economic capabilities were also taken into considerations while doing this system study. As every organization have limit on the expenditure and the proposed system should satisfy according to the requirements. Thus the working system lies within the budget by using the freely available technologies [9]. Only the customized products had to be purchased.

2) Technical Feasibility: This study is carried out to check the technical feasibility, that is, the technical requirements of the system. Any system developed must not have a high demand on the available technical resources. This will lead to high demands on the available technical resources. This will lead to high demands being placed on the client. The developed system must have a modest requirement, as only minimal or null changes are required for implementing this system [4].

3) Social Feasibility: The aspect of study is to check the level of acceptance of the system by the user. This includes the process of training the user to use the system efficiently. The user must not feel threatened by the system, instead must accept it as a necessity [4]. The level of acceptance by the users solely depends on the methods that are employed to educate the user about the system and to make him familiar with it. His level of confidence must be raised so that he is also able to make some constructive criticism, which is welcomed, as he is the final user of the system.

V. CONCLUSION AND FUTURE WORKS

The application simulates the proposed multi-tree database architecture for location database management based on location independent PTNs scheme. The efficient database architecture is designed with three level tree structures to support large number of users. Location registration and call delivery procedure of the proposed database architecture achieves the high throughput by reducing the end-to-end delays. When compared to two-level database architecture the proposed multi-tree database is more robust, scalable and efficient because it supports higher user density and reduces the signaling load in location registration and call setup. When compared to one-root database architecture it's more reliable because it's easy to expand and maintain multi-operator environment of a global mobile system. In one root database architecture, if the root is crashed the whole database will be affected. It's very difficult to retrieve back. In the proposed architecture it's easy to retrieve the crashed the database and it will not affect the whole database systems. Eventually, the mobile users can move around the world without changing their PTN number as well as the service profile.

REFERENCES

1. GuoHui Li, Kam-Yiu Lam and Tei-Wei Kuo (2001) "*Location Update Generation in Cellular Mobile Computing Systems"* Department of Computer Science, City University of Hong Kong, Kowloon, Hong Kong.
2. Zuji Mao and Christos Douligeris (2000) "*Performance Evaluation of Location Information Distribution Strategies for Mobility Tracking"* Department of Electrical and Computer Engineering, University of Miami, Coral Gables, USA.
3. Akira Idoue, *et al. (2003) "Global Roaming among Mobile IP Networks Operated by Different Operatoristrative Domains"* KDDI R&D Laboratories, Inc. Saitama, Japan.
4. Ronald Beaubrun, *et al. (2002) "Global Roaming Management in the Next-Generation Wireless Systems"* Mobile Computing and Networking Research Laboratory (LARIM), Department of Computer Engineering, Canada.
5. Borgaonkar Ravishankar, Harishankar M.V. (2008) "*Roaming Issues in 3GPP Security Architecture and Solution Using UMM Architecture"* Royal Institute of Technology, Sweden.
6. Ravi Jain and Yi-Bing Lin (1995) *"An Auxiliary User Location Strategy Employing Forwarding Pointers to Reduce Network Impacts of PCS"* Applied Research, Bellcore, Morristown.
7. Nirmala Shenoy, (2005) *"A Framework for seamless Roaming across cellular and wireless local area networks"* Rochester Institute of Technology.
8. Andrew D.Malayan, C.M.Leung and Robert W.Donaldson (1993) *"Network Architecture and signaling for wireless personal communication"*.IEEE journal on selected areas in communications, Vol.11.
9. Seshadri mohan and Ravi Jain (1994) *"Two user location strategies for personal communications services*, IEEE personal communications.
10. *Xiaoxin Qiu and victor O.K.Li (1994), "Performance Analysis of PCS Mobility Management Database system",* Department of Electrical Engineering systems, University of Southern California.
11. *Joseph S.M and Ian F.Akyilidz (1996), "Local Anchor Scheme for reducing Signalling costs in Personal communications Networks",* IEEE/ACM transactions on networking.
12. *Joseph S.M and Ian F.Akyilidz (1997), "Dynamic Hierarchical Database Architecture for Location Management in PCS Networks",* IEEE/ACM transactions on networking.
13. Seshadri Mohan, et.al, *"A Caching Strategy to Reduce Network Impacts of PCS",* IEEE journal on selected areas in communications, vol. 12.
14. Sung-Hwa LIM and Jai-Hoon KIM, *"Optimal Server Replication Schemes to Reduce Location Management Cost in Cellular Network",* Ajou University, Suwon, South Korea.
15. *Zuji Mao, Member, IEEE, and Christos Douligeris, Senior Member,* NO. 1, FEBRUARY 2004, *IEEE* VOL. 12,
16. McMonnies, A. (2002) *"Object-oriented programming in Visual Basic.NET",* Pearson Education, and ISBN: 81-297-0649-0.
17. Shapiro, R.J. (2002) *"The Complete Reference Visual Basic .NET",* Tata McGraw-Hill.
18. Robert D.Schneider, Jettey R.Garbus, *"Optimizing SQL Server",* Second Edition, Pearson Education Asia, ISBN: 981-4035-20-3.