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Superior Performance of Fibonacci Title Translation to Global Title Translation in Database Operations of Modern GSM Network Architecture

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Abstract

This research investigates attributes of Fibonacci database search methodology vis-a-vis current techniques of Global Title Translation with its attendant signalling overheads, poor quality services and frequent break downs in GSM network architecture. A new search approach, Fibonacci technique is adopted. The outcome is highly significant as call-dropping is drastically reduced.

Key words: Database, Fibonacci, Translation, Network, Architecture communication.

1.0 Introduction

Several architectural designs of GSM have been in place, all geared to accentuate smooth execution and real-time transmission of data/information. Each of these has equally been powered by one of: Local Anchor Algorithm (LAA), Forwarding and Resetting Algorithm (FRA), and Paging and Locating Algorithm (PLA) apart from the Interim Standard - 41(IS-41), rated **1.0**. On the same scale the rest are rated thus: LAA (3) =**0.48**, FRA (3) =**0.41**, PLA (3) =**0.29**.PLA (n) is a movement based location update scheme discovered in 1996 by Noerped et al. Under this scheme a mobile user performs a location update to the Home Location Register (HLR) only when the distance between the agent and the current Visitor Location Register (VLR) is greater than or equal to a predetermined distance value n. In the next-generation wireless systems, hierarchical location scheme was proposed (Internet, 2006). The design consisted of multiple databases throughout the network coverage area Figure 1. This uses routers, transit link and information while utilising facilities of distributed database technique whereby Global, Fragmentation and Allocation schema are at the top level respectively, (Shiva et al, 1995).

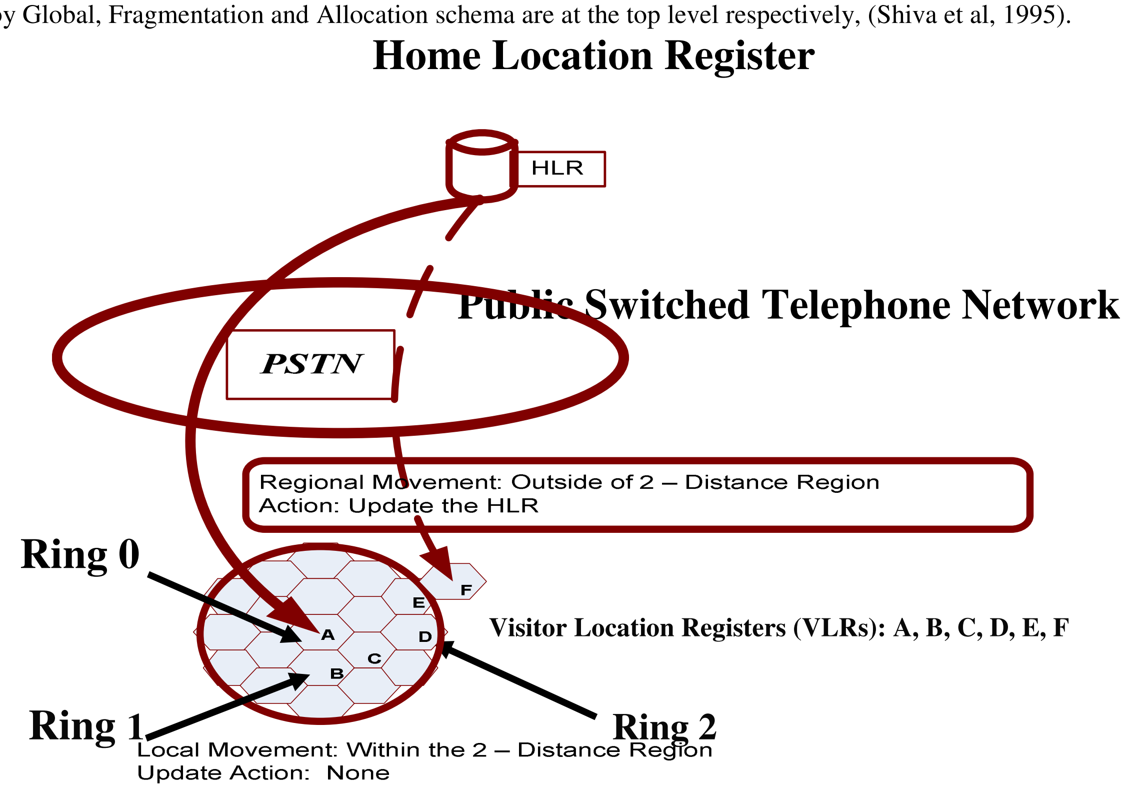


Figure 1: Update operations under paging and location algorithm

Courtesy: British Computer Society (2002)

In Figure 1. above, assume that n=3,VLR A is the agent initially and Short Distance First, (SDF) partitioning scheme is used to divide the registration areas into ring areas such that VLR A is in ring 0, VLRs B and C are in ring 1, and VLRs D and E are in ring 2. When the mobile user makes a local movement with a distance away from A of less than n=3 e.g. to B, C, D, or E, no location update operation is performed and the agent remains unchanged. However, when the Mobile Station (MS) makes a regional move, e.g. to VLR F, the distance from A (the agent) to F, is now agent, n=3. An update operation must be performed by the HLR in this call, now VLR F becomes the new agent, (Jain et al, 1995), (IS-41, 1995). The GSM signalling platform, called signal system No.7 (SS7) of International Telecommunication Union (ITU) monitors, hosts, synchronizes and acts with dispatch. This system consists of Mobile Switching Center, (MSC) and the Home Location Register (HLR) (Anatharam et al, 1994). This forms a subset of the external Public Switched Telephone Network (PSTN) which is the backbone of the whole system. Figure 2 depicts the structural design setup.

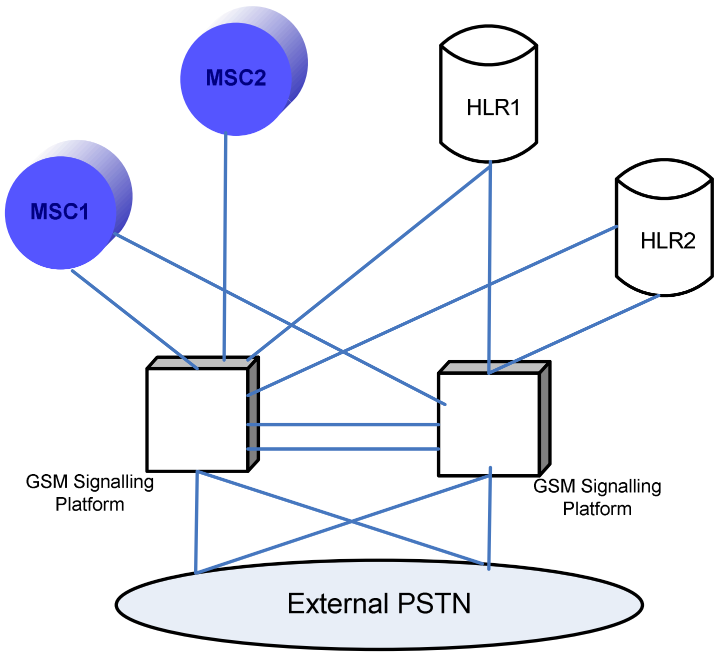


Figure 2: Signal system No.7 (SS7) Backbone

Courtesy: Performance Technologies, Inc., (2005)

Home Location Register (HLR): Database that contains semi permanent Mobile subscriber information i.e. the entire subscriber base:

- **IMSI**-International Mobile Subscriber Identity
- **SS Inf**.-Service subscription Information
- **L Inf**.-Location Information
- **S Res**.-Service Restriction
- **SUP. S Inf**. –Supplementary Services Information
- **Handles SS7** Transaction with MSC and VLR

- **Initiates** transactions with VLR to complete incoming calls to update subscriber data. Usually one HLR exists with traditional wireless network design.

Visitor Location Register (VLR): Database with temporary Information about mobile subscribers that are currently located in a given MSC services area but whose HLR is elsewhere. VLR provides Mobile Services Registration Number (MSRN) among the following:

- IMSI- International Mobile Subscriber Identity

  (**MCC**-(3 digits), **MNC** (2digits), **MSIN** (10 digits))

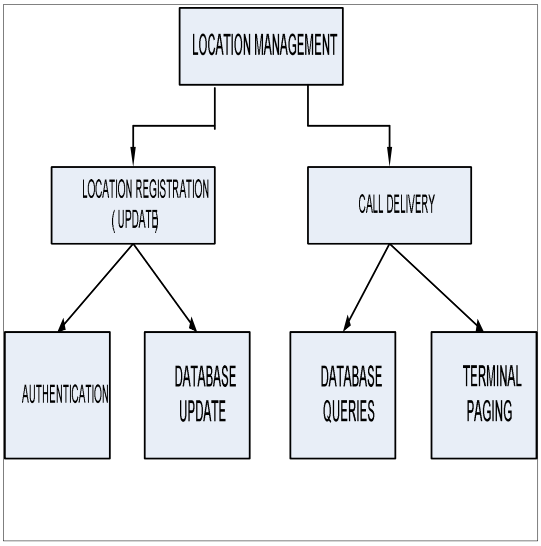
- **ISDN**- Integrated System Digital Network

- **MSISDN**- Mobile Subscriber ISDN- Dial able Number.

Mobile Switching Centre (MSC): Stores Global Title Translation (GTT) tables that are used to determine the HLR associated with the MSISDN. Having determined the appropriate HLR address, the MSC sends a routing information request to it. The HLR, on receipt of the routing information request, maps the MSISDN to the IMSI, and ascertains the subscriber's profile including the current VLR at which the subscriber is registered. The HLR then queries the VLR for a Mobile Station Roaming Number (MSRN) – essentially an ISDN telephone number at which the mobile subscriber can currently be reached-this number is valid only for one call. The HLR generates a response message which includes the MSRN and sends it back across the SS7 network to the MSC. Finally the MSC attempts to complete the call using the MSRN provided.

2.0 Location and Handover Management Operations (Global Title Translation)

In this multiple distributed database scheme, HLR and VLR databases are responsible for location management operations, namely: locate roaming terminals in order to deliver data packets i.e. function for static scenario, location update, Figure 5(a), while the MSC is responsible for the handover and transfer management operations Figure 5(b) of the overall communication i.e. maintain connection with terminals moving into new areas, function for dynamic scenario, handover, (Lee et al, 2005). As soon as location update is completed, authentication and database update commence simultaneously while location registration update operations commence call delivery and database queries with its attendant terminal paging and house keeping, (Uzoh, 2008). All the above operations /activities take place using synchronous technique in the database and on completion; this is transferred to handover management operations of the MSC. Here the trio: Initiation, New connection generation and Dataflow control begin operations. While initiation complies with user movement and network conditions, New Connection Generation settles for Resource allocation and Connection routing and Dataflow and Control handles Buffering and Multicast operations. All these take place under PLA environment. The search, retrieval and despatch operations in the databases, HLR, VLR, are carried out using sequential/synchronous approach (Uzoh, 2008). This results to the present inefficiency and delays being experienced on our GSM networks.



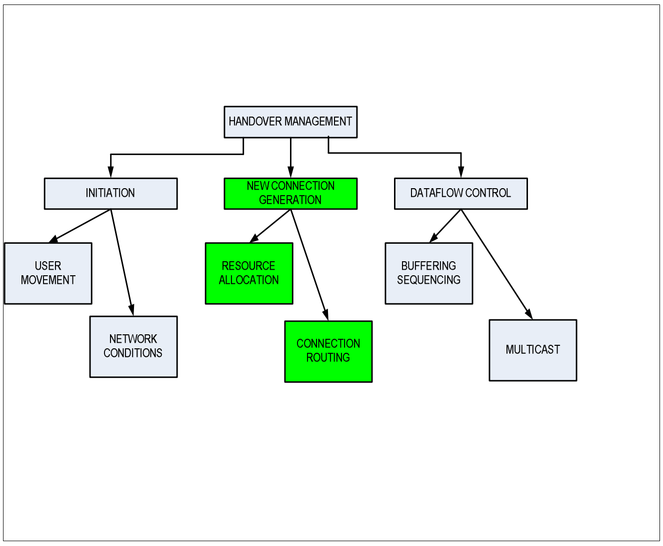


Figure 3(a) Location management operations Figure 3(b) Handover management operations

Table 2.2: Sequential random numbers representing prototype GTT figures

Direction of search →

5334240198135376	**289562463760376**	**7747400999069214**	**76072359085083**
7090378999710083	**4140326976776123**	**7904800176620483**	**9619531631469727**
562368631362915	**3640186786651611**	**7671116590499878**	**5924582481384277**
2981654405593872	**6478211879730225**	**2793420553207398**	**8246021270751953**
9860931634902955	**2268660068511963**	**9800032377243042**	**5338730812072754**
9994145631790161	**1570391654968262**	**1000522375106812**	**7988843917846684**
564917087554932	**3820106983184814**	**9485710859298706**	**4013743400573731**
60441517829895	**6465871334075928**	**4127668142318726**	**3262062072753906**
2075611352920532	**5833590030670166**	**457971453666687**	**2613682746887207**
3789025545120239	**919377088546753**	**627642035484314**	**9797382354736328**
6944853067398071	**8348171710968017**	**5433605909347534**	**4302611351013184**
5024539232254028	**4629800319671631**	**4048341512680054**	**5559349060058594**
9790779352188111	**3902914524078369**	**4898947477340698**	**474459171295166**
6287518739700317	**1563022136688232**	**6544994115829468**	**3904714584350586**

783995270729065	**753688097000122**	**8327301740646363**	**2103686332702637**
1054526567459106	**1282498836517334**	**5367940664291382**	**5440139770507813**
8189356327056885	**6789133548736572**	**3570231199264527**	**7043957710266113**
5302125215530395	**7577292919158936**	**4618743658065796**	**2076272964477539**
9542906284332275	**1698734760284424**	**9792983531951904**	**272946834564209**
7506877183914184	**6736466884613038**	**89896559715271**	**3227176666259766**
2972580194473266	**4804747104644775**	**3406065702438355**	**4824280738830566**
8645344972610473	**7549083232879639**	**3310168981552124**	**8069133758544922**
4100366830825805	**1146233081817627**	**6202095746994019**	**1492457389831543**
2194091081619263	**130420446395874**	**3453916311264038**	**9229545593261719**
4064213037490845	**8262255191802978**		**7090378999710083**

Courtesy: (Uzoh, 2008) Table 1: Synchronous Data Search

The average time spent before the required item is accessed from the database is governed by the following formula, hence the greater the number, n, the worse the time complexity, O(n+1) i.e. the function describing how much time it will take the algorithm to execute the parameters of its input.

$$\sum_{i=0}^{n} (n-i+1) = (n+1)/2 \quad \text{(avg. no. of key comparisons)}$$

where $i \leq n$,

i is variable and **n**, number of items or data in the database.

3. Fibonacci Title Translation (FTT)

Here the search in the database for appropriate data is carried out asynchronously with prevision in such a way that the required data are assessed in real time and subsequent activities executed simultaneously. For clarity of purpose the Fibonacci sequence of first twenty values are presented: **0,1,1,2,3,5,8,13,21,34,55,89,144,233,377, 610, 987, 1597, 2584, 4181**.etc

Where $F_0 = 0$

$F_1 = 1$

$F_i = F_{i-1} + F_{i-2}$ i 2 ≥

Program implementation (using C#, [C-sharp] Language)-system model for simulating Fibonacci sequences (Uzoh, 2008)[appendix I and II]

The algorithm (Fibonacci):

The first comparison key, K is made with F [fi-1].key, with the following outcomes:

(i) K<f[Fi-1].key in which case sub file from 1 to Fi-1 is searched and this file has one less than a Fibonacci number of records.

(ii) K = f [Fi-1].key in which case the search terminates successfully.

(iii) K > f[Fi-1].key in which case the sub file from F_{i-1} to F_{n-1} is searched and the size of this sub file is: $\mathbf{F_i-1-(F_{i-1}+1) + 1=F_i-F_{i-1}-1 = F_{i-2}-1}$

On implementation the assumption is that the array has length $F_{n-1}(N=F_a-1)$. Both preceding Fibonacci numbers are divided and compare ‘item’ to the element at the position F_{n-2}.If ‘item’ is greater than the element the search proceeds in the right subset, otherwise in the left subset and so down to the leaves by applying addition/subtraction arithmetic operation, Figure 6.

Structure

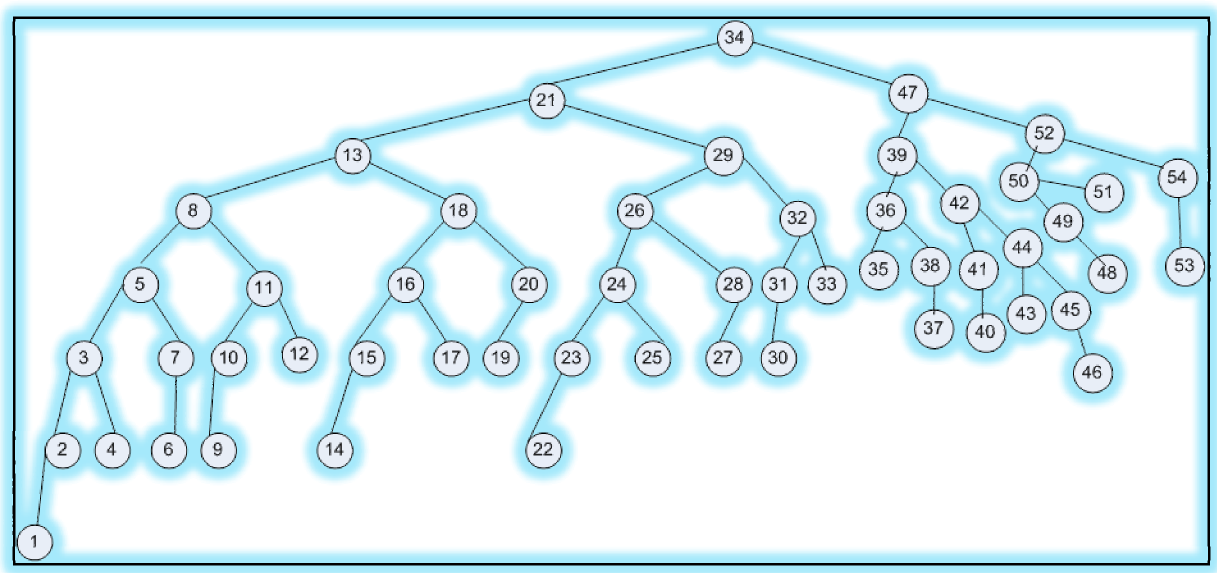


Figure 4: Asynchronous Data Search from Database Tree-like Structure.

Required data items from the database of 54-node simplified example, are accessed almost directly using the asynchronous technique described above, Fibonacci Search Tree-like structure. Table 2 gives results of four[A,B,C,D],different database searches with the two search methods. In each case Fibonacci (FTT) search has the least time complexity and so has higher rate of delivery than Seqsrch (GTT) method. The accompanying graphs of the **key comparisons and time complexity** results depict the superior quality of Fibonacci search (FTT) over sequential search (GTT). Here it is note worthy that International Telecommunication Union (ITU) bench mark for **100000** subscribers mean delay time in processing call handling request is **1** sec; and location update **2** sec.(Jun-Zhaosun et al, 2001), (Noerped et al, 1996), (Ho et al, 1997), (Levy et al, 1999).

Table 2

A		1000000 SUBSCRIBERS		
SEARCH TYPE	**KEY COMPARISON**	**VALUE**	**TIME COMPLEXITY**	**TIME IN MILI SECONDS**
SEQSERCH (GTT)	**(n+1)/2**	**500000**	O(n)	960
FIBSRCH (FTT)	**$\log_2$ n-1**	**14**	O(log(n))	4.5

B		**500000 SUBSCRIBERS**		
SEQSERCH(GTT)	**(n+1)/2**	**250000**	O(n)	475
FIBSRCH(FTT)	**Log_2 n-1**	**12**	O(log(n))	4.2
C		**100000 SUBSCRIBERS**		
SEQSERCH(GTT)	**(n+1)/2**	**50000**	**O(n)**	**95**
FIBSRCH (FTT)	**Log_2 n-1**	**12**	**O(log(n))**	**3.7**
D		**50000 SUBSCRIBERS**		
SEQSERCH (GTT)	**(n+1)/2**	**25000**	O(n)	45
FIBSRCH (FTT)	**Log2 n-1**	**9**	O(log(n))	2.7

SEARCH/METHOD	**% KEY COMPARISON SUMMARY VALUES**
SEQSERCH(GTT)	**50**
FIBSRCH(FTT)	**8.97**

Table 2: Key comparison/value versus Time Complexity/mili seconds for Four Databases

The four subscriber databases of1000000, 500000, 100000 and 50000, Table 2 above, with respective key comparison values and corresponding time complexities in miliseconds; [Ms-] are shown. Further analysis of the time complexity values above; reveal that on the average, sequential search, (GTT) would take **394** mili seconds, [Ms-] to process **1.65**million subscribers whereas Fibonacci search, (FTT) takes **4** mili seconds [Ms^-] to process same number of subscribers. Of significant importance is time complexity for processing 100000 subscribers by both search methods [95ms^- and 3.7ms^-] respectively, from table 2. Here it is evident that FTT out classes GTT in all ramifications and even the ITU bench mark of **1Ms^-** for reading and **2Ms^-** for update, for the same database of subscribers.

4. Parameters of Performance

Table 3 explicitly shows seven performance indices that vividly exhibit that FTT out-performs GTT of current GSM. The first index of: (Read, Write, & Update) operations, the three taken separately costs GTT, respectively (3, 6, 10) ms^- i.e. **19ms^-** whereas it costs FTT the three together, **0.74 ms^-**. Other parameters considered in the table are: Buffer size, Data packets, Processing method, Propagation delay, Link transmission rate and the 7th parameter, Queue Service only has same method; First in First Out, (FIFO). From Table 3, Nos. 1-6, show that FTT in each case has exceptional performance compared with GTT of current GSM operations. Significant attribute of FTT is the propagation delay which is rated at more than twelve times Speed of Light ($3.0x10^8M^{-s}$) followed by transmission rate of 1648.64k bits s^{-1} (Uzoh, 2008).

Table 3

PARAMETERS	GTT	FTT
//////////////////////	//////////////////	//////////////////
1. Read, Write, Update	**(3, 6, 10) 19ms⁻**	**0.74ms⁻.**
2. Buffer size	**Fixed at beginning of Simulation**	**Extensible during simulation**
3. Data packets	**Packet loss**	**No packet loss**
4. Processing	Sequential	**Parallel/Simultaneous**
5. Propagation delay	**½(3.0 x 10^8M^{-s})**	**12.84(3.0 x 10^8M^{-s})**
6. Link transmission rate	**64k bits s^{-1}**	**1648.64k bits s^{-1}**
7. Queue service	**FIFO**	**FIFO**

Table 3. Performance Indices

5. Distributed Functional Plain Model of Fibonacci Meta Data

Distributed functional Plain Model of FTT enables it operate with Meta data objects and hence out-classes GTT that operates with static database objects. It interacts sporadically with its various components, meta objects shown in Figure 7, namely: Service Management Access Function (SMAF), Service Management Function (SMF), Service Creation Environmental Function (SCEF), Service Data Function (SDF), Service Control Function (SCF), Specialised Resource Function (SRF), Service Switching Function (SSF), Call Control Access Function (CCAF), and Call Control Function (CCF). These are termed service functions (Sivagnanasundaram, 1997), (ITU, Q1204), (ITU, Q1214). The ionized elements, Meta Data, having their points of initiation (POI) and points of return (POR) move and dash sporadically to their destinations, (Doughlas et al, 2002), (ITU, Q1205). Here once again FTT replaces GTT as Meta data objects function at several times the speed of Light.

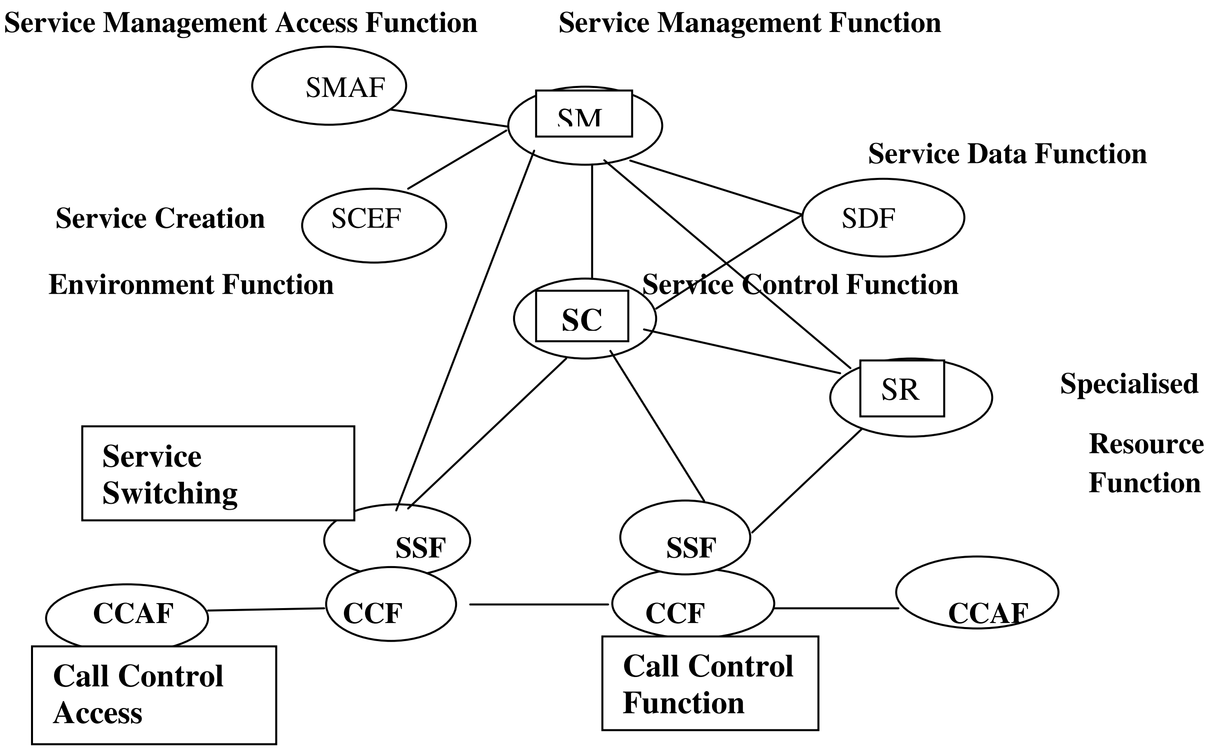


Figure 5: Meta Data Objects

5. Conclusion

Time Complexity Graph of performance and Key comparison summary values of time complexities for the two search techniques, Table 2, in resonance has the same result. Whereas FTT performs the search in less than 10 mili seconds, **8.97ms**$^-$precisely**, GTT** takes **50** ms$^-$ for the same search. Hence Figure 8.Above summarises and concludes the assumption that FTT has superior search technique (satellite) than GTT and recall that FTT searches at speed of more than 12 times speed of Light(3.0x 10^8)Ms$^-$ while GTT searches at half [½(3.0x10^8)Ms$^-$]speed of Light, together with several other evidences already sited in this paper.

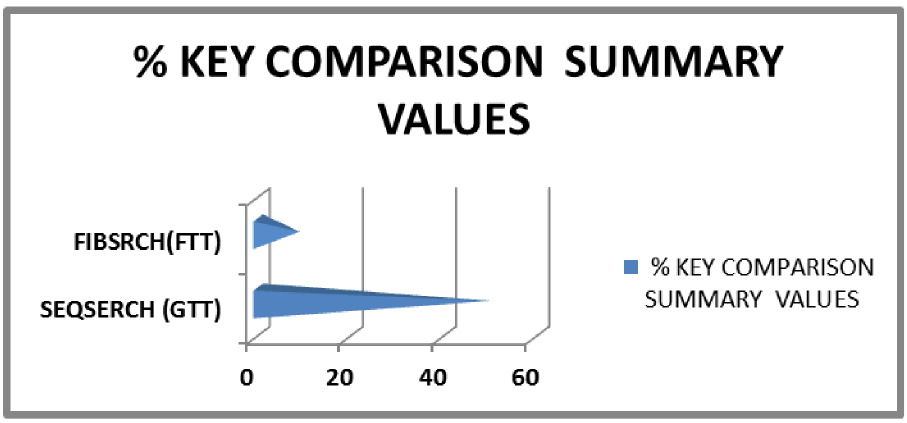


Figure 6: Time Complexity Graph of Performance

Fibonacci Title Translation (FTT) applies asynchronous parallel algorithm in its execution technique whereas Global Title Translation (GTT) applies synchronous parallel algorithm. In the former, the processes never wait for inputs at any time but continue execution or terminate according to whatever information is currently contained in the global variables. In the latter, GTT processes have to wait until a current process ends before a new one begins and hence with its synchronized parallel algorithm, the penalty, λ_n is large, where n is the number of items being processed in the database. When n is large, λ_n is large.

Where $\lambda = T/t$, T=mean time (t)

taken by the synchronized stage at any process and T is the random variable.

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