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Development of Multilevel Distributed Database Architecture for Solving (GSM) Centralized Database Accessing Problem in Nigeria

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Abstract
Telecommunication is the basis of economic and political growth of any society. Since the advent of GSM in Nigeria, different operator have been battling with diverse challenges which erupted as a result of GSM growth and increased in number of GSM users. These challenges result in calls delay and poor quality of service which can be link to central database system. In this research work, a multilevel distributed database architecture for GSM network in Nigeria was developed and propose. It explores the use of the analytical model and numerical calling process algorithms for each location. The call arrival rate traffic to a database system is determine using mapping process ranging from state to region and finally to the center.
Keywords: key Communication, Architecture, multi-level, centralized, network

1. Introduction

The development in commerce and telecommunications industry all over the world is very rapid as one innovation replaces another in a moment. The major breakthrough is the wireless telephone system which comes in as fixed wireless telephone lines or the Global System for Mobile Communications (GSM) (Azubuike and Obiefuna, 2014; Jorg *et al*., 2009). Good multi-levels distributed database architecture system is able to cater for the problem arose from the database at the centre level of the present GSM architecture (GuoHui *et al*., 2001; Ravi and Yi-Bing, 1995). The performance of the network has a direct impact on the revenues. The Nigeria Communication Commission (NCC) is bringing pressure to the operators to step up the quality of service offered Nigerians (Shoewu and Edeko, 2011) and also engage contractors to conduct comparative analyses of the quality of service offered by each of the operators. Delay in services, call drop, call establishment failure due to network traffic jam have been the major challenges facing GSM network in Nigeria. Distributed database architecture was introduced by Andrew et al. (Andrew *et al*. 1993). These necessitate for decentralisation of the database, from the centre to the zone and from the zone to the state this will assist in reducing the heavy load on the centre database. Previous research worked show number of researchers who have adopted distributed database architecture to addressed GSM problem (Nath and Kumar, 2013; Mohsin *et al., 2010;* Emmah *et al. 2015;*Hongxia and Weifeng, 2009*;* Akyildiz *et al., 1999*).

Delay in services or call drop, call set-up failure or traffic jam occurs when many mobile/GSM users want to use a channel for making a call or when users want to access the centralized database at the same time in order to establish a call (Fulani, 2011). As a matter of fact, the data of the callee needs to be accessed from the central base station controller (BSC) and make sure that the caller and the callee have their entries and information at the centre.

These are necessary both for location update and registration of the subscribers of an operator. This service required good, secured and reliable distributed database architecture for effective data management in GSM. Moreover, it has been generally observed that many subscribers spend more than necessary in terms of billing due to network failure. Some subscribers will continually redial until they get connected or discouraged. This work focused generally on call management in a GSM controlled environment. The incoming call and outgoing call especially when the subscriber moves from one place to another.

2. Multi-Level Decentralized Database GSM Architecture

The designed GSM database Architecture is suitable to manage the GSM databases in Nigeria. The architecture is of three levels with many branches which are based on Ravi and Yi-Bing, 1995. The centre level (DC), the middle level (Dr1) and the lower level (Ds2). Each Ds2 interest is to control a registration area (RA) where a user can roam freely without triggering registrations. Also, Ds2 is located in the mobile switching center (MSC), which performs call processing on origination or termination calls. A number of Ds2's are grouped into one Dr1 and severalDr1's are connected to a single Dc of an operator. The centre level (Dc) represents the database at the base station switching center of the GSM Architecture. This database consist of all information of the subscribers of an operator, for example, the operator can be MTN or GLO in Nigeria GSM environment.

Dr1 and Dc have a switch, called the signal transfer point (STP) that provides routing for message exchange across various location databases. The Dc maintains the service profile for all users currently in its network service area, and maintains entry for each user in the global mobile system network. The entry contains a pointer

to a Dr1 where the user record that contains a pointer to the Ds2 with which the user is currently associated. The middle-level database has the duplicate of all the information or data at the centre level this make the design to be centralized-Decentralized database architecture and the middle levels represent the zonal level that is, the database of all the subscribers at a particular zone in Nigeria. There is six geopolitical zone in Nigeria. North West (NW), North East (NE), North Central (NC), South-South (SS), South West (SW) and South East (SE), as shown in Table1. The over 30,000 GSM users database are spread into these regions in Nigeria for easy accessibility. Data are searched for in the zonal bases especially when the call originated within the zone, there will be no need of going to the centre database. This reduces signalling traffic as well as traffic jam and the response time is shorter. Each Dr1 has an entry for every currently residing user, storing a pointer to the Ds2 the user is currently visiting. Every D2 has a copy of the service profiles of the users currently roaming within its area. With this architecture, the frequency of queries to the higher level databases is greatly reduced due to the locality of calling and mobility patterns.

The lower level database is when the zonal databases are distributed to the states within a zone. Each state in a zone has their equivalent database consisting of all the data and the information of the subscribers at the zonal levels. This will ease access to the state database wherever a call is originating within the state. Observing the configuration of the proposed database, the following advantages are noticed over centralized database; low billing, reduction of traffic at the zone(central) level, load are distributed moderately on the database at each level, there is no need of going to the centre before establishing a call and as a result saves a lot of time.

3. Analytical Model of the Decentralized

JThe analytical model of the proposed Decentralized database addresses issue concerning the access rate to the levels database using mapping to reduce the number of users accessing it and the delay in call establishment of the database architecture.

Due to a large number of GSM users, it has been shown that the arrival rate traffic to a database system can be approximated by a mapping process and assumed that service time (response time) of a database follow a general distribution.

$$D_c = \{r_1, r_2, r_3, ...r_n\} \quad (1)$$

$$r_i = \{S_{i1}, S_{i2}, S_{i3}, ...S_{ik}\} \quad (2)$$

$$S_{ij} \Rightarrow r_i \Rightarrow D_c \quad (3)$$

The regional database which comprises of r_1, r_2, …,r_n are mapped onto Central Database (Dc) and state database which comprises of S_{i1}, S_{i2}, S_{i3}…,S_{ik} are mapped onto the regional database, therefore, where D_c is Central, r is the region, and S stand for the state.

The proposed Decentralized Database representation showed in the Figure 1 described the mathematical model. ob-shop production refers to a manufacturing environment that produces goods in small batches according to customer specifications.

3.1 Algorithm for Call Processing

The algorithm for the proposed used for call processing establishment on the GSM network is presented here.

1. START
2. SET CODES
3. WHILE SERVICE-TRUE
4. GET CALL SIGNAL
5. IF CALLEE INFO EXIST IN STATE
6. ESTABLISH CALL
7. GO TO 20
8. ELSE
9. IF CALL = CALL OUTSIDE THE STATE
10. GET STATE ZONE
11. POINTER = STATE IN Region
12. GO TO 6
13. ELSE
14. IF CALL = CALL OUTSIDE THE ZONE
15. GET CALLE INFO AT DC
16. GO TO 6
17. ELSE
18. IF CALL = CALL OUTSIDE THE DC
19. THEN CALL = ANOTHER OPERATOR DS

20. STOP

4. System Implementation

The purpose of the implementation phase is to translate the software design into the source code. Each component of the design is implemented as a program module. The end-product of this phase is a set of a program module that has been individually tested. Each module is unit tested to determine the correct working of all the individual modules. It involved testing each module in isolation as this is the most efficient way to debug the error identified at this stage.

All program code is implemented using C# (pronounced' C-sharp') programming language a Microsoft oriented language. The system is designed to run on specifically the.Net platform and all other operating system that make use of this technology. The system sits on top of the Microsoft.Net platform with C# which is the combination of.Net framework and relational database management system (SQL SERVER).

The integration was carried out incrementally over a number of steps during which a partially integrated system is tested and a set of the previously tested module is added to it.

Figure (3-7) depicts the platform for user registration, work station and call processing.

Information on the phone number, full name, sex, date of birth, state of residence which contains the list of the state, geopolitical zone contains under user registration page (Figure 3). GSM users register their number and provide the required information on this platform.

Figure 4 shows the workstation which comprises:

(i) Connection Panel: This Panel has two frames (frame1 and frame 2) both frames have channels ranging from channel 1 to channel 8. Each channel is active whenever the call is in progress between the users.

(ii) Call Centre: Within the call centre, there are call list, select caller state (the caller state consist of all the list of states in Nigeria such as Ondo, Ogun, Anambra, Abuja, Ekiti, Lagos and so on., Select Number, Dail and Drop.

(iii) Select Caller State: This is the state where the caller is making a call. It consists all the state in the Country.

(iv) Select Number: This also consists all the registered GSM numbers in the Country under an Operator such as GLO, AIRTEL, MTN, and so on.

(v) Call list: Dial number appear here

(vi) Current State Database (DB): Called registered number will be located at the current state database, if the caller and the called number is within the same state, the called registered number will be located at the current State Database.

(vii) Region DB: Here, the call between the caller and Called number is from different State but the same Region which is middle- level DB.

(viii) Central DB: If the caller and called number is not from the same zone, the calls are registered here.

Figure 5 shows the example of called process within the state. Here caller is calling from Ondo State and called number (08067117237) resident and is within Ondo State

In Figure 6, a caller resides in Ondo state calling a GSM number resident in Ekiti state. The call will register in a regional database since both the caller and callee reside in a different state but the same zone.

Figure 7 shows called establishment between caller and callee living in the different zone. Here the caller lives in Borno state (North East Zone) and the callee resides in Kaduna State (North-West zone). The called will be established in a central database of multi-level architecture.

Subscriber ID	State of residence	Geopolitical Zone
S_1	Ondo	South-West
S_2	Ekiti	South-West
S_3	Enugu	South-East
S_4	Kaduna	North-West
S_5	Kogi	North-Central
S_6	Bayelsa	South-South
S_7	Anambra	South-East
S_8	Lagos	South-West
S_9	Kastina	North-West
S_10	Bauchi	North-East
S_11	Abia	South-East
S_12	Cross-River	South-South
S_13	Delta	South-South
S_14	Yobe	North-East
S_15	Taraba	North-East
S_16	Jigawa	North-West
S_17	Kwara	North-Central

S_18 Plateau North-Central
S_19 Federal Capital Territory North-Central
S_20 Osun South-West
S_21 Imo South-East
S_22 Edo South-South

Table 2 consists the example of GSM subscriber identification with the state where they registered and corresponding geopolitical zone. The table consists of the total numbers of twenty-two (22) subscribers denoted with Si. Table 3 shows the detailed of called establishment between the caller and callee. In the multi-levels database, the call is within the state, outside the state but within the zone or outside the zone. Out of twenty-two subscribers in Table 3, only seven (7) called were established in the central database (Central DB) for multilevel distributed database architecture. Percentage of called established for the twenty-two subscribers in the multi-level distributed database are summarised in Figure 8.

5. Conclusion

Multilevel distributed database architecture for GSM had been successfully developed and implemented using C#.Net programming language. The records of each GSM users are stored/ registered in the resident state database, resident zone database and the central database. The proposed decentralized database addresses issue concerning the access rate to the levels database and also reduce the number of users accessing the central database. The result shows that the number of subscribers accessing the central database has been drastically reduced.

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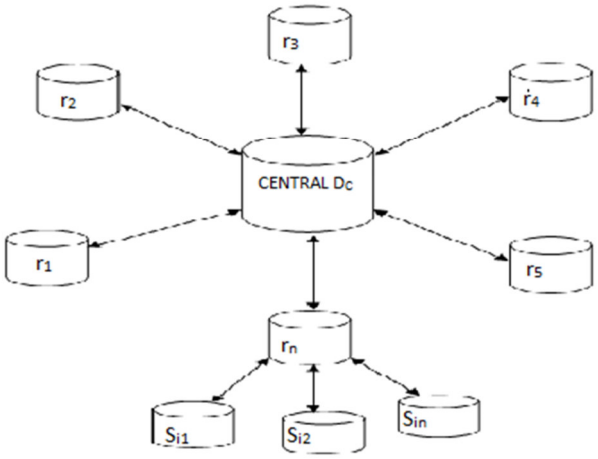

Fig. 1. Proposed Decentralized Database

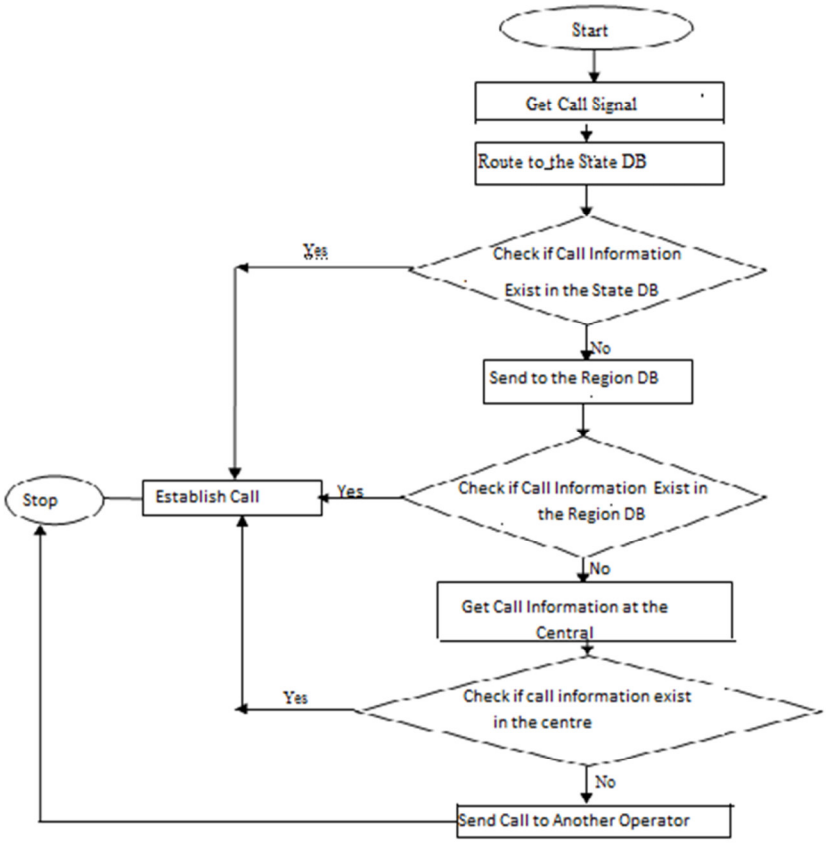

Fig. 2. Process of calls establishment

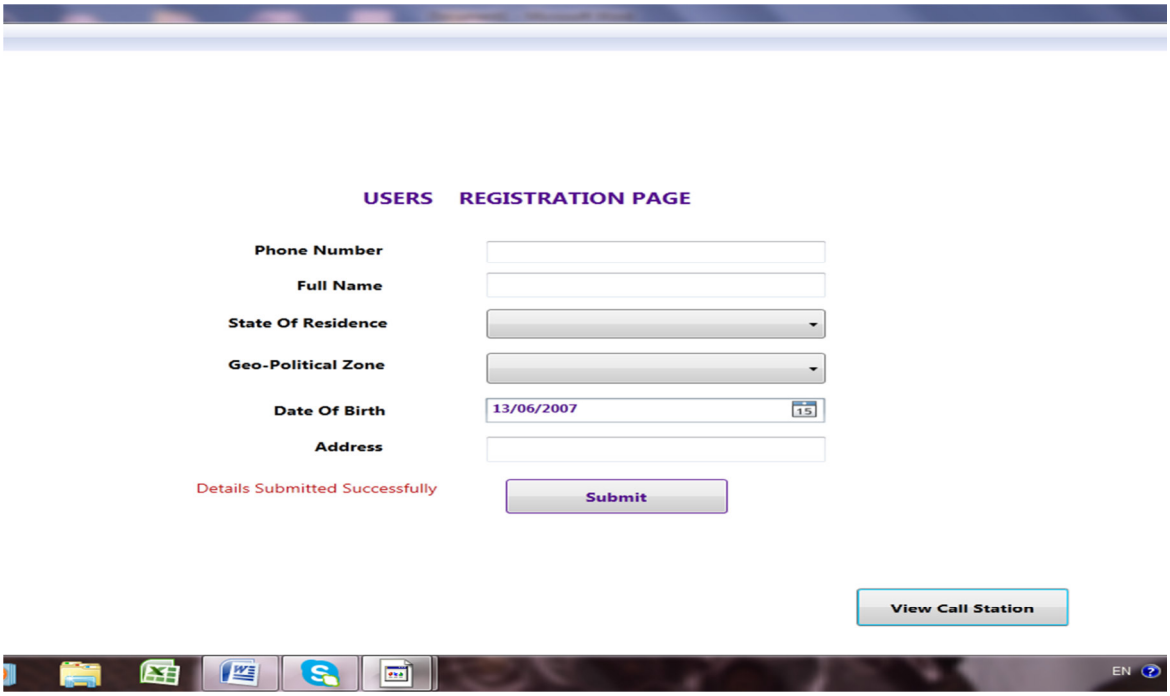

Fig.3. User Registration Page

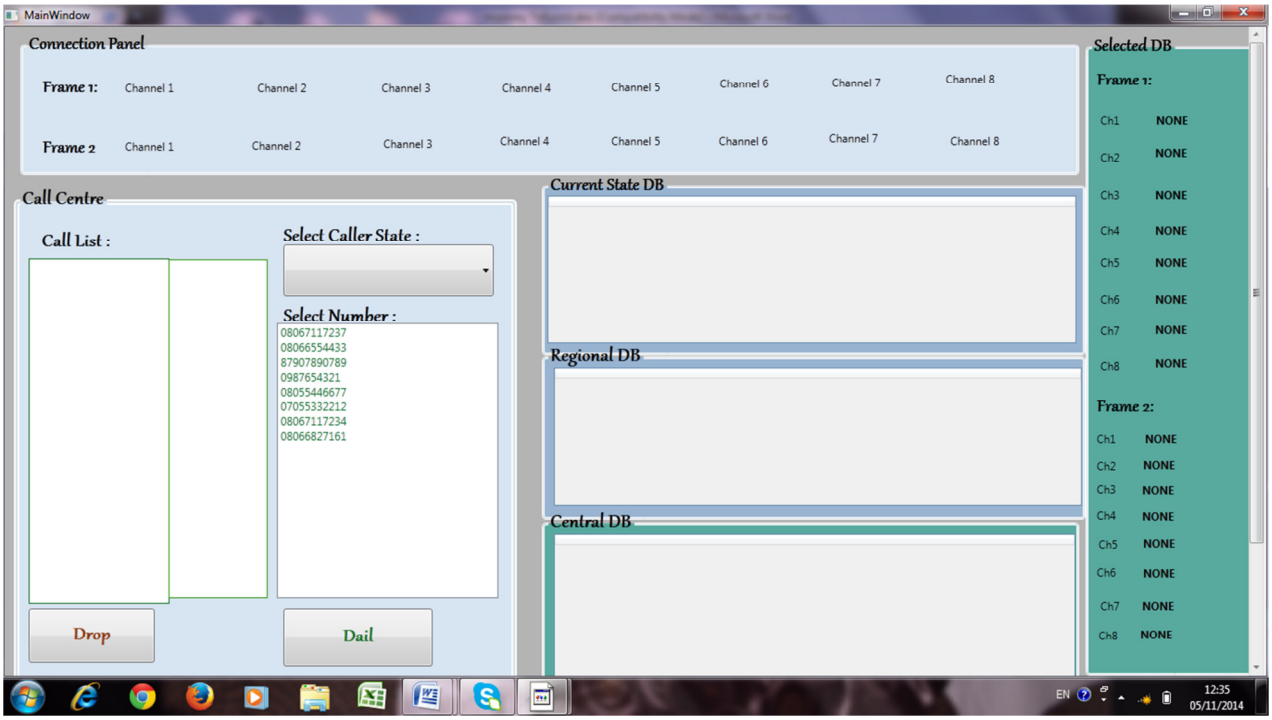

Fig. 4. Workstation

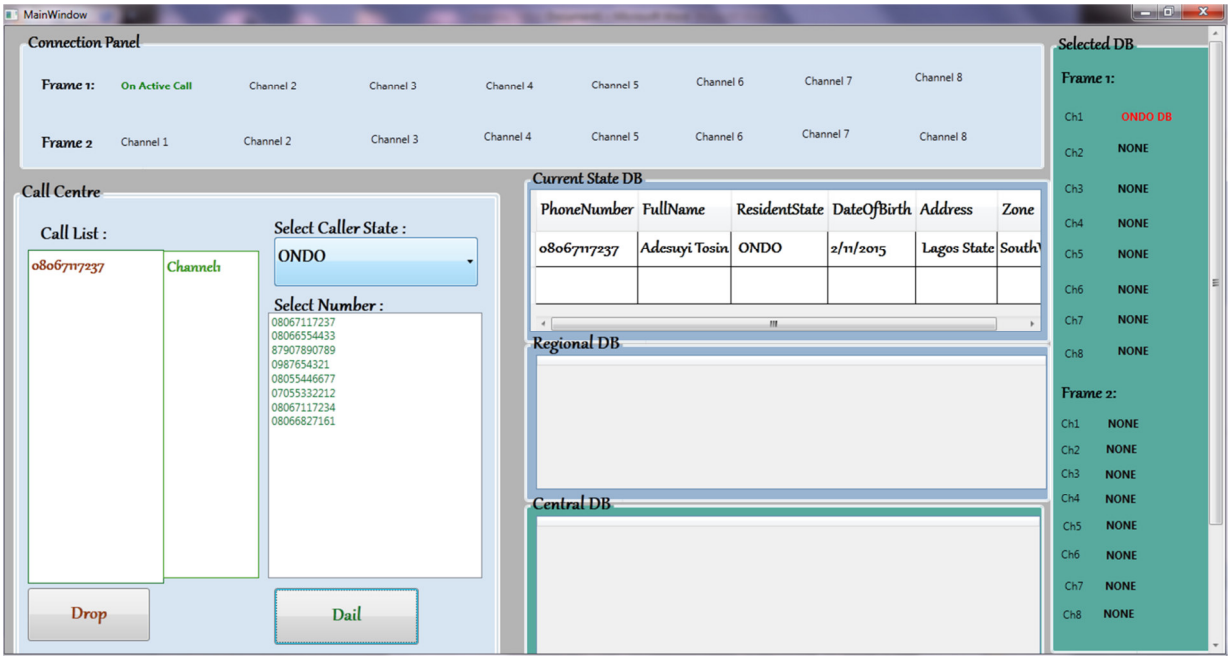

Fig. 5. : Call establishment within the state

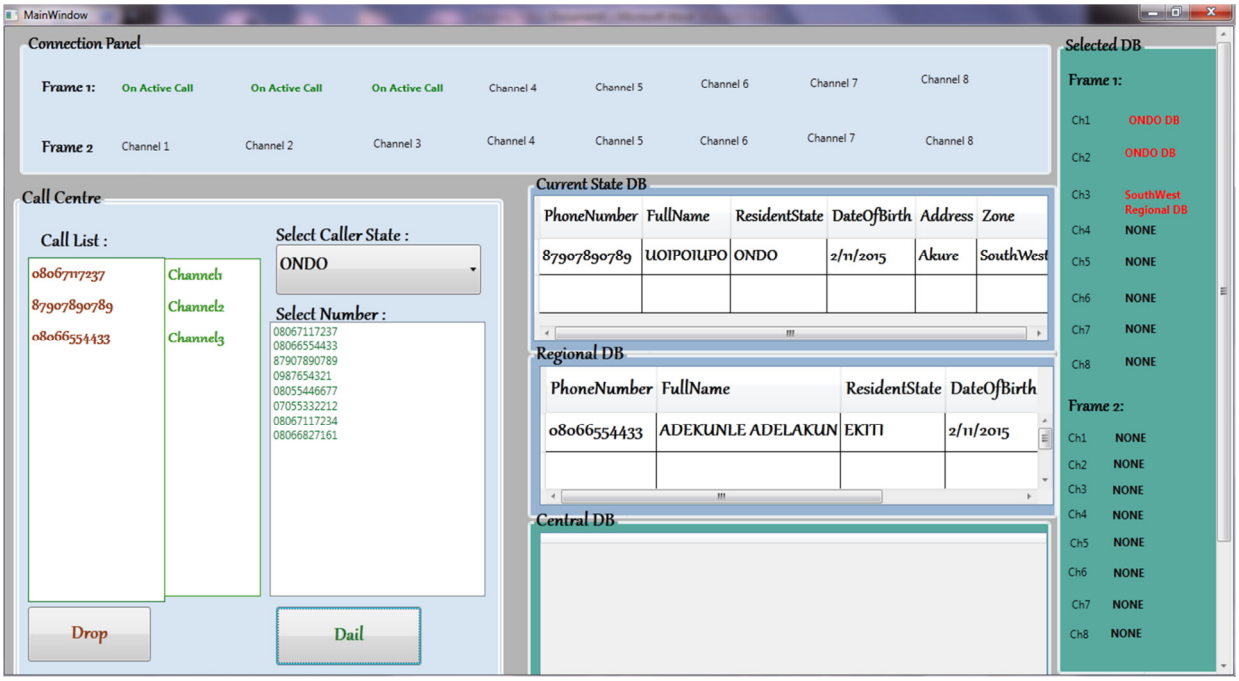

Fig. 6. Call outside the state but within the region

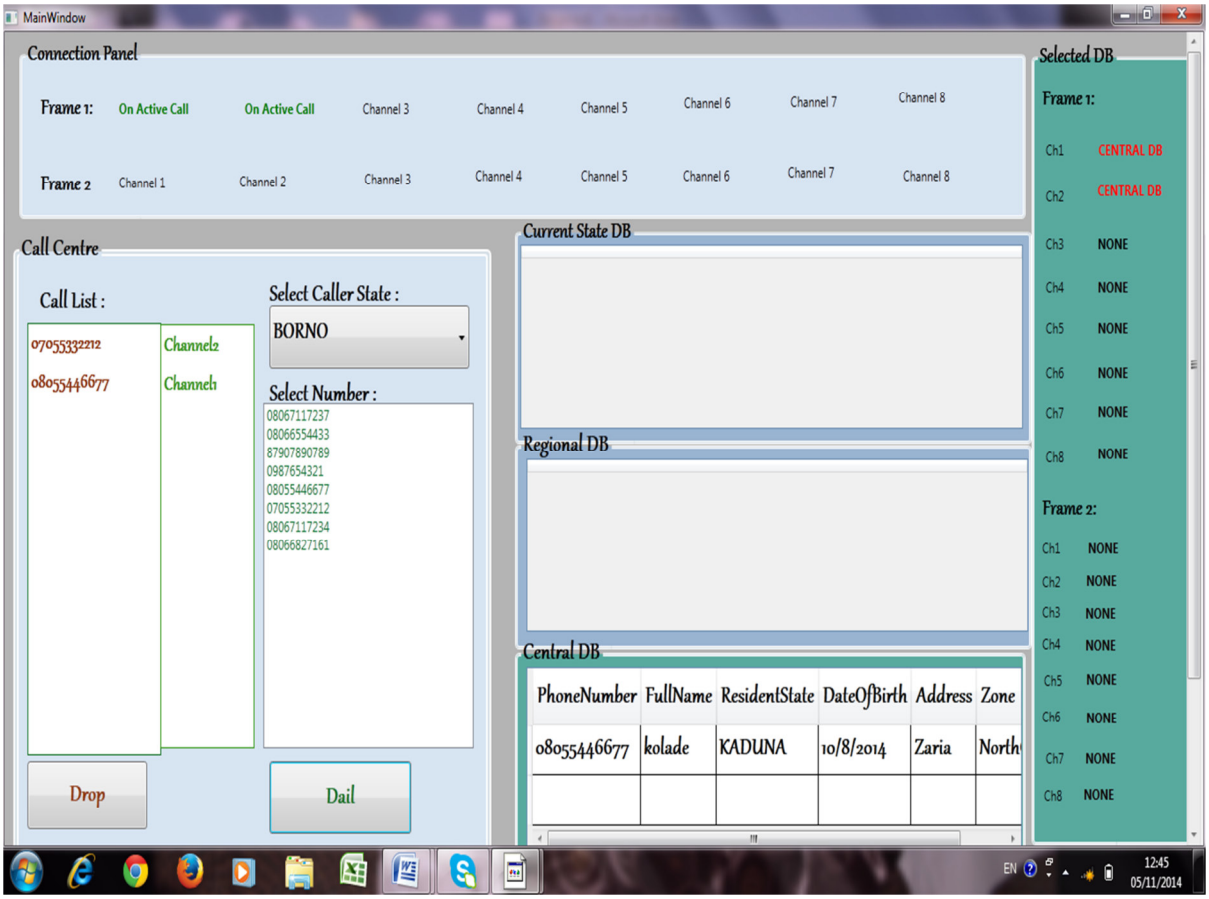

Fig.7. Call outside the region

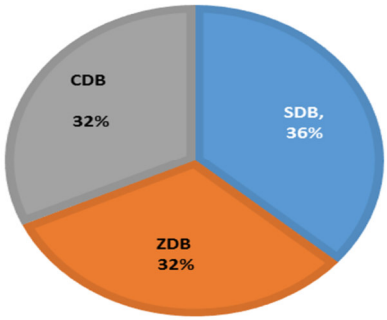

Fig. 8. Examples of calls established in modelled database

Legend: SDB State Database
ZDB Zone Database
CDB Central Database

Table 1. Nigeria Geographic Zone

Geopolitical Zone	States
1. North-Central	Benue, Kogi, Kwara, Nasarawa. Niger, Plateau, and Federal Capital Territory
2. North-Eastern	Adamawa, Bauchi, Borno, Gombe, Taraba and Yobe.
3. North-Western	Jigawa, Kaduna, , Kastina, Kebbi, Sokoto and Zamfara.
4. South-Eastern	Abia, Anambra, Ebonyi, Enugu and Imo
5. South-South	Akwa Ibom Bayelsa, Cross River, Delta, Edo and Rivers.
6. South-Western	Lagos, Ogun, Oyo, Ondo, Osun, Ekiti

Table 2 List of Subscribers and state of residence along with their zone

Subscriber ID	State of residence	Geopolitical Zone
S_1	Ondo	South-West
S_2	Ekiti	South-West
S_3	Enugu	South-East
S_4	Kaduna	North-West
S_5	Kogi	North-Central
S_6	Bayelsa	South-South
S_7	Anambra	South-East
S_8	Lagos	South-West
S_9	Kastina	North-West
S_{10}	Bauchi	North-East
S_{11}	Abia	South-East
S_{12}	Cross-River	South-South
S_{13}	Delta	South-South
S_{14}	Yobe	North-East
S_{15}	Taraba	North-East
S_{16}	Jigawa	North-West
S_{17}	Kwara	North-Central
S_{18}	Plateau	North-Central
S_{19}	Federal Capital Territory	North-Central
S_{20}	Osun	South-West
S_{21}	Imo	South-East
S_{22}	Edo	South-South

Table 3: List of Callers connection Establishment Location

Subscriber ID	Within the State	Outside State but Within Zone	Outside Zone	Database Connection Establishment
S_1	Y	N	N	ONDO DB
S_2	N	N	Y	CENTRAL DB
S_3	Y	N	N	ENUGU DB
S_4	N	Y	N	NRTH-CENTRAL DB
S_5	N	Y	N	NRTH-CENTRAL DB
S_6	N	N	Y	CENTRAL DB
S_7	Y	N	N	ANAMBRA DB
S_8	N	Y	N	SOUTH-WEST DB
S_9	N	N	Y	CENTRAL DB
S_{10}	Y	N	N	BAUCH DB
S_{11}	N	Y	N	SOUTH-EAST DB
S_{12}	N	N	Y	CENTRAL DB
S_{13}	Y	N	N	DELTA DB
S_{14}	N	N	Y	CENTRAL DB
S_{15}	N	Y	N	NRTH-EAST DB
S_{16}	Y	N	N	JIGAWA DB
S_{17}	N	N	Y	CENTRAL DB
S_{18}	N	Y	N	NRTH CENTRAL DB
S_{19}	Y	N	N	FEDERAL CAPITAL DB
S_{20}	N	N	Y	CENTRAL DB
S_{21}	N	Y	N	SOUTH EAST DB
S_{22}	Y	N	N	EDO DB