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Efficiency Improvement of Outbound Call Route Selection on IP-PBX Using KNN with USSD

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Abstract: Even though selecting the outbound call route on IP-PBX System in original form with fixed channel and pattern matching techniques was accurate, it caused high network traffic on the GSM network. The purpose of this research was to resolve this problem by using K-Nearest Neighbor (KNN) technique in database mining together with Unstructured Supplementary Service Data (USSD). The results of this research showed that using the proposed technique with a SIM3000CZ Microcontroller board was able to select the outbound call route correctly according to the name of network operators. It also reduced network traffic between the operators. Moreover, using KNN technique and database mining was able to decrease overhead caused by the procedure of USSD technique in selecting the outbound call route.

Key words: Asterisk, USSD, unstructured supplementary service data, IP-PBX, GSM, outbound call routing, data mining, KNN, K-nearest neighbor

INTRODUCTION

Currently, researches on route selection using various types of routing protocol play an increasing role in telecommunication and internet whether it is on the mobile ad hoc networks (Ahmed *et al*., 2012) and wireless sensor network (Fdili *et al*., 2012) or the architectural design of the 5G routing network (Tudzarov and Janevski, 2011). The same can also be said about the routing of the IP-PBX telephony system used today. The IP-PBX telephony system has become very popular because the price of the system has gone down while the efficiency has increased. For these reasons, many organizations have increasingly switched the former private branch exchange system to IP-PBX. Although, IP-PBX telephony system is much more efficient, two outbound call route selection techniques used by the system the outbound call indicating the correct route and pattern matching are not good enough. This is because both techniques cannot choose the route by referring to the network's gateway. The majority of outbound calls from the IP-PBX phone system to the terminal phone number that the users require are fixed to use the channel which is connected with mobile phone on fixed line terminal. The call is then forwarded called to the terminal phone number. This connection does not enable the users to know which network of phone number is required to be called. This has led to a problem of IP-PBX not being able to select an appropriate route efficiently.

Several years ago, a few groups of researchers studied and researched about selecting the outbound call route by using various techniques such as routing the outbound call by using a data mining technique called K-Nearest Neighbors (KNN) (Suwannaraj, 2012). This technique uses the algorithm to classify the information that can be used to select an appropriate route. One of the authors has used algorithms with data mining to assist in choosing the route by using decision tree technique. The accuracy of this method that classifies the destination phone number by using the algorithm is at a good level but its accuracy level depends on the quantity of phone numbers which are stored in a database. Some researchers choose the outbound call method by using the analysis of DTMF (Dual Tone Multi Frequency) tone technique to operate the engine to run at the specified duties or command and control the remote devices to follow the order by sending two frequency signals simultaneously (Mahler *et al*., 2012). In this case, choosing the route by sending DTMF signal is suitable for the command when the length of its key press is not very long. Selecting the outbound call route of some researchers is the technique on voice over IP technology which applies the protocol of the source devices (Voznak *et al*., 2010) such as SIP, MGCP and H.323. This method must be worked together with a server that supports the protocol that is used to select the route.

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Due to the mentioned limitations of the existing techniques, researchers propose a new method for choosing an outbound call route on IP-PBX System by using a technique called Unstructured Supplementary Service Data or USSD (Sanganagouda, 2011; Suwannaraj and Boonkrang, 2013).

IP-PBX background knowledge

IP-PBX: IP-PBX (Internet Protocol-Private Branch Exchange) is the Private Branch Exchange Telephony System that runs on internet protocol. Its properties are similar to a PBX phone system used in the office. It is used to receive the external call which is connected to the internal extension to communicate with each other. This IP-PBX mainly supports such protocols as SIP (Session Initiation Protocol), IAX (Inter-Asterisk eXchange Protocol) and SCCP (Skinny Client Control Protocol). Currently, the most widely used IP-PBX System is asterisk. It is the software that acts as an IP-PBX or soft-switch that includes all the capabilities of a typical PBX. Asterisk is able to run on a lot of architectures such as Linux, Sun Solaris, FreeBSD operating system in this experiment (Suwannaraj, 2008).

Outbound call routing in IP-PBX: Current IP-PBX phone systems running on asterisk have two settings for outbound call patterns. The first technique is fixed channel of outbound call that identifies the call to the available channels such as channel 1 or 2. With this technique, the route for outgoing calls has already been pre-specified. The problem with it is the inflexibility and inscalability. The second technique is pattern matching where the outbound number is checked whether or not its header matches the known structures. In this case, if the prefix phone numbers are identical, it will be assigned to make an outbound call following the identified channel. For example, if the mobile phone number for calling out is 0816605372, the system will set pattern-matching to be 081 and then compare that outbound call number with the pattern-matching which has already been set. Finally, it will make a call to the identified channel.

Although, the outbound call method on IP-PBX phone system at the present can work with some satisfaction, there is a problem in this system. That is, it is not able to choose the channel for which the service provider is the same as the outbound call number. As a result, there is high traffic between the service providers. Hence, there is an increasing cost for calls over the network.

Therefore, this study proposes a model by adopting the principle of pattern matching to identify whether any outbound call number is the already-known mobile phone number. After that, researchers use USSD to make an outbound call that can select the same network service provider as the required mobile phone number by the results of the USSD which is sent back to the IP-PBX phone system to select the channel corresponding to the call.

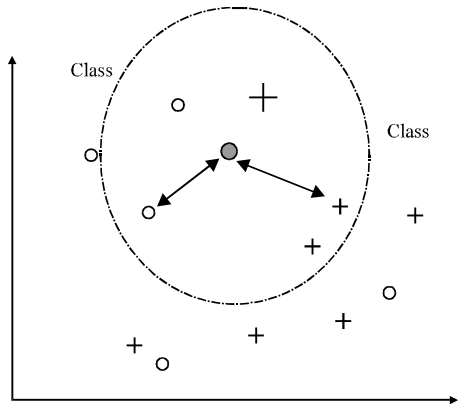


Fig. 1: K-Nearest Neighbor (KNN) algorithm

K-Nearest Neighbor (KNN) data mining: KNN is an algorithm or a technique which is used to organize data that are close enough to one another to be in the same group by configuring the K value which is the number of data to be considered. The K value should be an odd number in order to classify data correctly. For example, configuring K = 5 means that 5 pieces of data will be considered which group is near the interesting point. From Fig. 1, it can be found that in the interesting area there are 3 sets of + group and 2 sets of O group near the interesting point. The technique can also predict from these primary data that the interesting point is likely to be the same set of data as the group of (+) because the number of pluses (+) is bigger than the number of Os. This is illustrated in Fig. 1 (Tongpasuk, 2011; Singto and Paramapuneya, 2011).

This K-Nearest Neighbor algorithm can calculate the point which is near the interesting point which is a mobile phone number in this research.

MATERIALS AND METHODS

Proposed algorithm: Here, an algorithm to improve the performance of the outbound call route selection on IP-PBX is proposed. The algorithm applies the KNN algorithm as well as the USSD technique, are explained as follows:

KNN techniques for network operator name classification: One of the main tasks to be done when selecting an outbound call route is to choose the network operator of that particular phone number. Therefore, the purpose of the KNN algorithm here is to classify the network operator of the phone number. This can reduce the repeated inquiry and decrease the overhead as well.

According to the property of KNN technique (Suwannaraj, 2012), it was proposed to classify the group of the data which was interesting by considering the K value that was previously defined. From the result of previous research, this KNN technique could classify the data with 80.1% accuracy (Suwannaraj, 2012). In this case, the KNN technique is going to be applied to classify the service providers group of the phone number by setting K = 7. K is going to be set as 7 because in the previous research (Suwannaraj, 2012), this number was found to be the most appropriate.

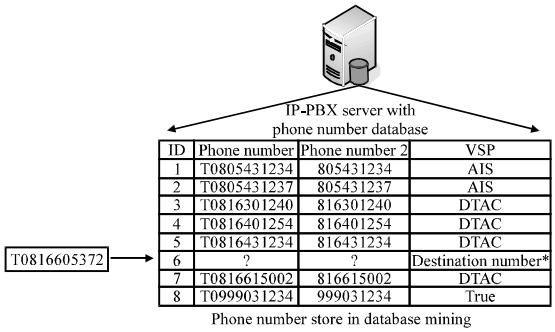
An example of this classification scheme can be seen from a phone number stored in the database in Fig. 2. In Fig. 2, the KNN technique was used to classify the data that were near the phone number of 0816605372 (or the destination number) by paying attention to the nearest number of K = 7 as shown in Fig. 2.

From the example in Fig. 2, queries submitted by users were checked by an SQL command in the KNN database with 0816605372 being the destination number. In this case, it was the first time that the number was looked up in the database. Hence, the number was not already in the database. It was found that the system displayed the value of the network operator name (Field: VSP) by counting the number of the phone numbers close to the destination number, i.e., DTAC = 4 numbers, AIS = 2 numbers and TrueMove = 1 number. This showed that the queried number of 0816605372 was classified to be in the DTAC network. Researchers could see the KNN_DISTANCE value to see the distance of each number in Fig. 3.

USSD technique for accuracy check and tools: Each service of the communication between USSD on GSM network has different structure and message length which is sent to be examined (Kassinen *et al*., 2009; Gupta, 2010). The service providers in Thailand use 16 bit messages including the special symbols: * and #. D_0 is used as Service number/Code (Yang *et al*., 2006; Dabas and Dabas, 2009) and uses 3 bits. D_1-D_{10} are used as destination mobile phone number and use 10 bits. The structure is shown in Fig. 4.

Each service provider of each network uses different Service number/Code as follows: service number of the AIS network is 727, service number of the DTAC network is 102 and service number of truemove network is 933. Table 1 shows USSD query in each operator. The main advantage of the USSD technique over SMS messages is that USSD messages are free of charge (Wang *et al*., 2008; Herwono, 2009).

When USSD query is sent to the system, there will be a response message to the IP-PBX System. For example, "the number 0816605372 is not in the AIS network."

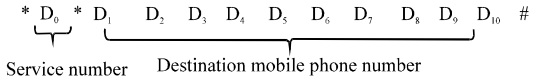


ID	Phone number	Phone number 2	VSP
1	T0805431234	805431234	AIS
2	T0805431237	805431237	AIS
3	T0816301240	816301240	DTAC
4	T0816401254	816401254	DTAC
5	T0816431234	816431234	DTAC
6	?	?	Destination number*
7	T0816615002	816615002	DTAC
8	T0999031234	999031234	True

Fig. 2: Example of KNN = 7 and 1 destination number in database

```
mysql>select id, phone number, phone number 2, vsp, abs (phone
number 2-0816605372) as KNN_distance from callout 2 order by
KNN_distance limit 8;
+-----+-------------+-------------+---------+--------------+
| ID  | Phone number| Phone number 2|  vsp    | KNN_distance |
+-----+-------------+-------------+---------+--------------+
|  6  | T0816605372 |  816605372  |  ?      |            0 |
|  7  | T0816615002 |  816615002  |  DTAC   |         9630 |
|  5  | T0816431234 |  816431234  |  DTAC   |       174138 |
|  4  | T0816301254 |  816301254  |  DTAC   |       304118 |
|  3  | T0816301240 |  816301240  |  DTAC   |       304132 |
|  2  | T0805431237 |  805431237  |  AIS    |     11174135 |
|  1  | T0805431234 |  805431234  |  AIS    |     11174138 |
|  8  | T0999031234 |  999031234  |  TrueMove|    182425862 |
+-----+-------------+-------------+---------+--------------+
8 rows in set (0 sec)
mysql>
```

Fig. 3: KNN_Distance values



D_0 = Service number (3 digits)
D_1-D_{10} = Destination mobile phone number

Fig. 4: USSD pattern for checking mobile phone number in Thailand

Table 1: USSD query for each mobile phone operator

Mobile phone operator	USSD query
AIS	*727*0816605372#
DTAC	*102*0816605372#
TrueMove	*933*0816605372#

Form the above example of checking the number 0816605372, Fig. 5 shows the process of USSD. It began with a user dialing "0816605372" which was the desired phone number into the IP-PBX Server. The number was then converted into the form of the USSD as *727*0816605372. Figure 5 shows that the USSD code was tested sent to the GSM network then to the USSD-APP to check whether the number was a number of the AIS network. The answer was then sent back to the GSM network and to the IP-PBX. If the answer was "yes", the call would be made via the SIP gateway.

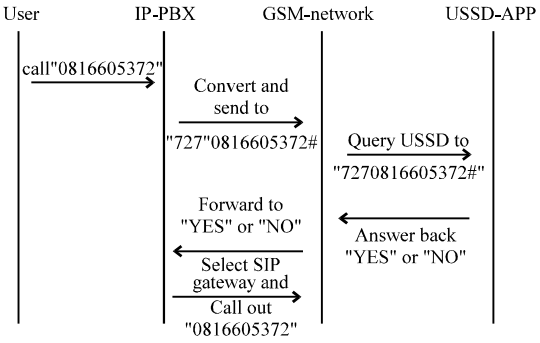


Fig. 5: Sequence diagram for the USSD process

Table 2: Overhead that incurred in the process of USSD

	Reference network operators		
Source network operators	AIS (SIM3000CZ-1)	DTAC (SIM3000CZ-2)	TrueMove (SIM3000CZ-3)
AIS	2 sec (2)	No query	No query
DTAC	2 sec	2 sec (4)	No query
TrueMove	2 sec	2 sec	2 sec (6)

KNN and USSD combination: In the previous research of choosing the call route (Suwannaraj and Boonkrong, 2013), researchers had studied and used USSD technique to select a route for a call. It was found that choosing the route by this technique was able to match a desired phone number and network operator accurately.

Although, the correctness of choosing the network was achieved, there was some overhead occurring. That is to query each network, 2 sec were needed (Wouters *et al*., 2009; Suddul *et al*., 2011). If the number was in the third network to be queried, TrueMove in this example, 6 sec would be needed. The USSD only algorithm can be seen in Fig. 6 and the overhead incurred in the USSD only technique can be seen in Table 2.

From Fig. 6, what has caused longer delay (4 and 6 sec) is that this USSD-Only algorithm/experiment works sequentially by first querying USSD string of the order: AIS, DTAC and TrueMove, respectively. The reason for querying the AIS network first is because it is the biggest network operator with more people than other networks. Therefore, statistically there is a better chance of finding the route there. As a proof, the market share of each of the three operators can be seen in Fig. 7.

Figure 7 shows the market share of each of the three mobile operators in Thailand. It can be seen that the AIS operator held the largest market share at 44%. The second largest mobile operator was DTAC with 31% of the market. The third was TrueMove which had 25% of the share. The statistics here were the main reasons behind the decision of making the USSD queries sequential.

It can be seen that using USSD-Only technique causes some delay (Mahler *et al*., 2012). Therefore, in this research, researchers would like to propose a method

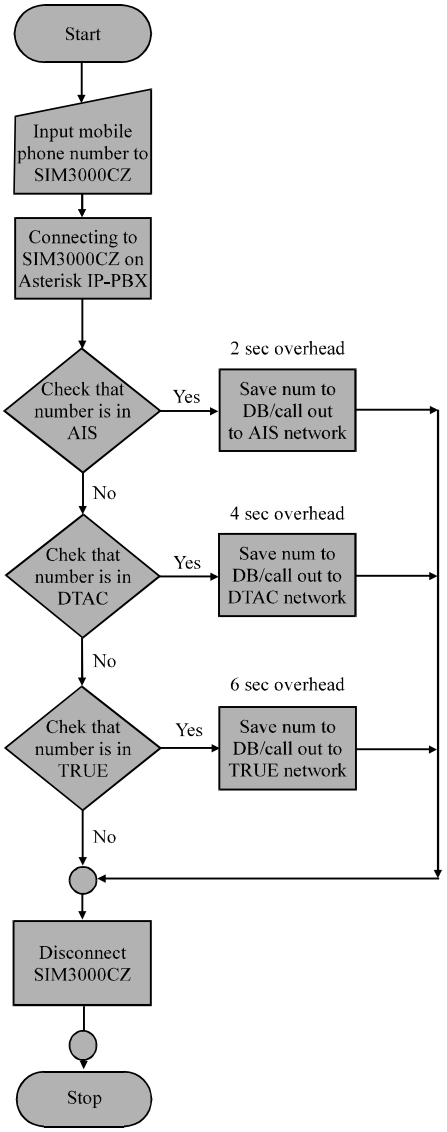


Fig. 6: USSD-Only technique

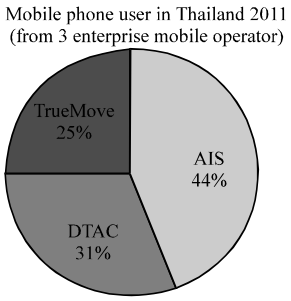


Fig. 7: Mobile operator market share; OBVOC and National Statistical Office: ICT

that can increase the efficiency of the outbound call routing by using the USSD technique in combination with the KNN algorithm.

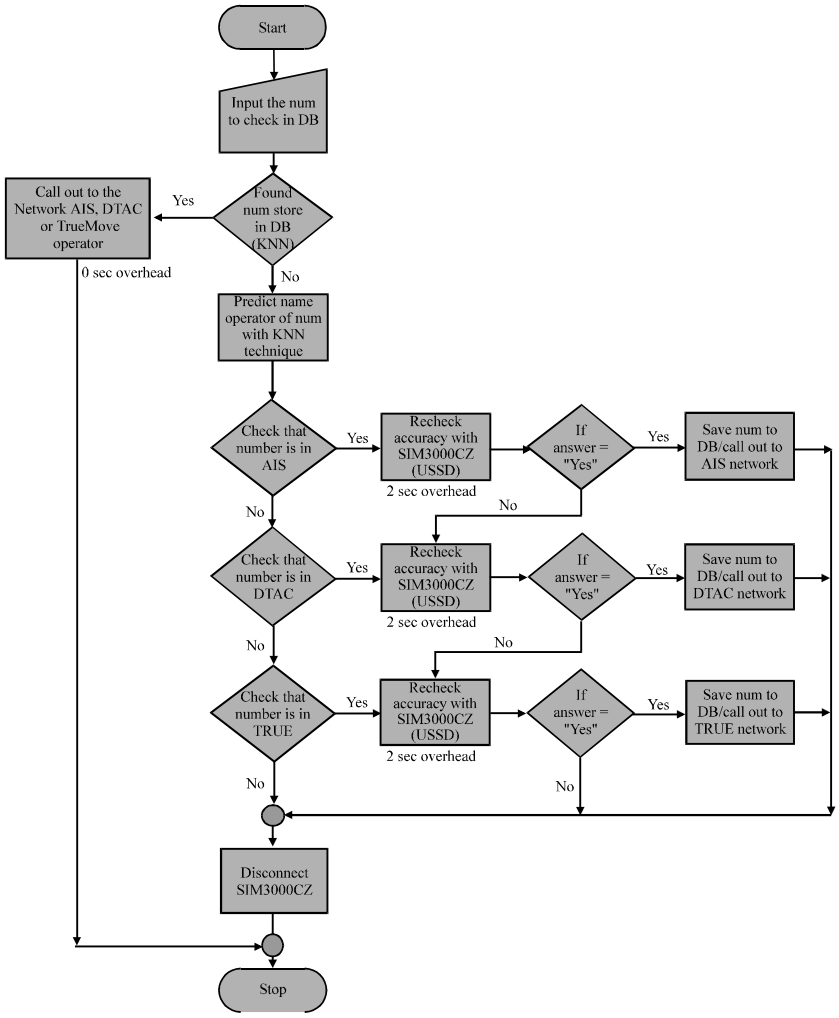


Fig. 8: Proposed algorithm

The proposed algorithm is divided into two parts. The first part uses the KNN technique to classify which network provider the destination phone number is in. It works by first, checking whether the phone number is already in the database. If so, the number will be dialed through the SIP gateway immediately. Hence, there will be no delay or overhead. However, if the destination phone number is not in the database, the second part of the proposed algorithm will be called into action.

The second part of the proposed algorithm uses the USSD technique to check which network provider the destination number is in. If the network provider is found, the phone number together with its network provider's name will be recorded in the database. The next time the same destination phone number is called, the USSD technique will not be called anymore. As explained earlier, the USSD technique will check the phone number against each provider in a sequential order-AIS, DTAC and TrueMove. Figure 8 depicted the proposed algorithm, the KNN and USSD combination.

Experiments: This study describes how experiments were set up and carried out. The experiments were run so that the performance of the proposed algorithm could be evaluated. Here, researchers attempted to compare the performance of two outbound call route techniques: USSD only and KNN with USSD are as follows:

Data samples: This research used a mobile phone number database from the Information Technology Center, Pibulsongkram Rajabhat University, Thailand. For the experiment, there are 5,500 phone numbers overall. They are divided as:

- 3,000 mobile phone numbers where 1,000 numbers are from the AIS network; 1,000 numbers are from the DTAC network and 1,000 numbers are from the TrueMove network
- 2,500 landline phone numbers which also include those with four-digit numbers

Tools and techniques: For the experiment, researchers used a SIM3000CZ Microcontroller board that operates at the frequency range of 900/1800/1900 MHz on GSM network. It is necessary to use this particular instrument with the USSD to check the network data (P-U-SS-R). The P-U-SS-R (Process Unstructured Supplementary Service Request/Response) is a string that is used to query the user and send to the network operator (Suwannaraj, 2008). Then, the network operator will send a response back via the GSM network which is similar to the SMS service. However, this message will not be stored like SMS on the mobile phone. SIM3000CZ is the tool which supports USSD to send and receive P-U-SS-R. It also has the ability to work with AT Command (or Modem Commands) for communication via RS-232 cable. Moreover, there is no charge from the network operators for using this technique. The SIM3000CZ Microcontroller board used in the experiments is shown in Fig. 9.

Selecting the route from the GSM network needs to use mobile phones to communicate with the USSD Protocol. Therefore, this test used three sets of SIM3000CZ Microcontroller board to be the mobile phones via RS-232 cable and Asterisk Server based on FreeBSD Network Operating System.

In Fig. 10, researchers used three sets of SIM3000CZ connected to COM1, COM2 and COM3 via RS-232 cables on the Asterisk Server. A USSD message/query was sent sequentially to the AIS, DTAC and TrueMove, respectively where SIM3000CZ-1 was connected to AIS Sim, SIM3000CZ-2 was connected to DTAC Sim and SIM3000CZ-3 was connect to TrueMove Sim. In each query, if the answer of (P-S-UU-R) were "YES", it would send the outbound call to that network.

Experimental setup: The network diagram used in the experiments, illustrated in Fig. 11, is showing the overview of IP-PBX System that was tested and connected to three SIM3000CZ sets for choosing the outbound call route. The principal uses can be described as follows: firstly, users have to use IP Phone or Smart Phone which is compatible with SIP Protocol to dial the required mobile phone number and send through the Asterisk Server. The system checks the wanted call number with the database by the KNN method (Fig. 8). It should be noted here that the most appropriate value of K has been found in the

Fig. 9: SIM3000CZ microcontroller board with RS-232 cable

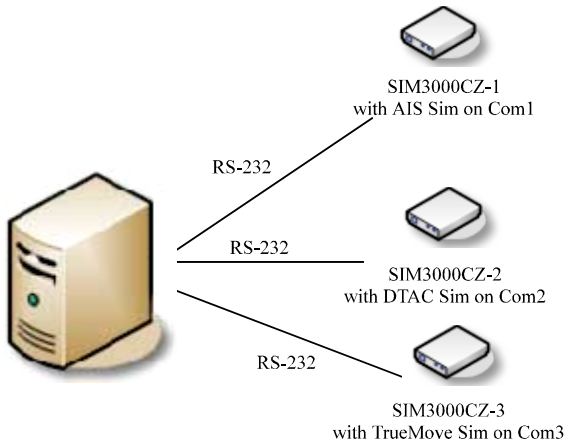


Fig. 10: Asterisk server connected SIM3000CZ on COM ports

previous research (Suwannaraj, 2012) to be 7 for this particular network setup. This number was also used in the present experiment. When the checking finds that number and hence knows the network operator of that number, it will immediately call out. If not, the USSD part of the proposed algorithm will be used.

RESULTS AND DISCUSSION

Accuracy rate: This study shows the results of the experiments when using IP-PBX telephony system together with the KNN Data Mining and USSD techniques to route the outbound call as set up in Fig. 11.

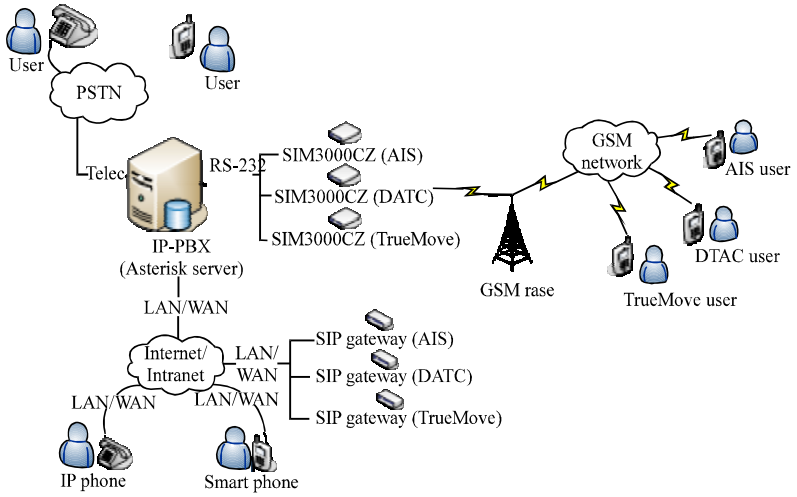


Fig. 11: Experimental setup

It is found that the IP-PBX phone system can select the route by checking the network provider for phone number and sending the data to SIP gateway of network provider correctly. This test used 1,000 telephone numbers of each GSM operators as mentioned. The results are shown in Fig. 12.

The results in Fig. 12 shows that the proposed algorithm, the KNN and USSD combination has given a high success rate, albeit with small inaccuracies. The errors occurred from the lack of response from the service provider when checking or looking up the information. From the results, it can be seen that researchers sent 1,000 USSD queries to each network. The results were as follows: The AIS network had 986 query successes or 98.6% success rate and 14 query errors or 1.4% error rate. The DTAC network had 976 query successes or 97.6% success rate and 24 query errors or 2.4% error rate. The TrueMove network had 958 query successes or 95.8% success rate and 42 query errors or 4.2% error rate.

Overhead: The accuracy rate from the proposed algorithm appeared to be satisfactory. Next, the overhead of the algorithm was examined. The results are shown in Table 3.

The results in Table 3 show the overhead incurred in the first round the outbound call was made for a particular destination phone number. The results show that with the USSD-Only technique, there is always an overhead. That is, if the destination phone number was found in the first network provider (AIS), there would still be a 2 sec delay. If it was found in the second operator (DTAC), the delay would be 4 sec. The longest delay was 6 sec in the case of the third network (TrueMove).

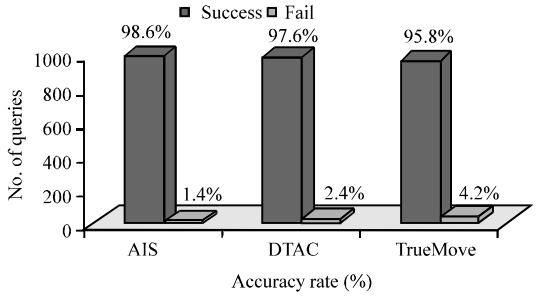


Fig. 12: Accuracy rate of the proposed algorithm (Success: AIS = 986, DTAC = 976, TrueMove = 958; Fail: AIS = 14, DTAC = 24, TrueMove = 42)

Table 3: Overhead comparison of round 1 outbound call routing between USSD-only and KNN with USSD

	Total of overhead comparison (sec)	
Network operator	USSD	KNN with USSD
Found number in DB (KNN)	Not used	0
AIS	2	2
DTAC	4	2
TrueMove	6	2

However, it is evident that if researchers used the KNN with USSD techniques, the overhead of the query would be better. It can be seen that if the destination number was already in the database, the delay was unnoticeable. If the destination number was not already in the database, it did not matter which network the number was on, the delay would always be 2 sec.

The time taken to find a correct network provider for a particular phone number was shortened when using the KNN and USSD combination. This was because the KNN technique had helped classify the network providers prior to testing with the USSD technique. The USSD-Only technique took longer because of the sequential process.

Table 4: Overhead comparison of round 2 to N outbound call routing between USSD-only and KNN with USSD

	Total of overhead comparison (sec)	
Network operator	USSD	KNN with USSD
Found number in DB (KNN)	Not used	0
AIS	2	0
DTAC	4	0
TrueMove	6	0

The first round of the outbound call presented a different result to the next rounds. This is because in the first round there was a possibility that the number was not already in the database. The second round and other rounds' results (or the next time the same phone number was called) are shown in Table 4.

The results in Table 4 still reflect that no matter which round the destination number was called, the USSD-Only technique would still cause a delay from 2 sec up to 6 sec. In contrast, there was no delay in the KNN with USSD techniques when the same destination phone number (same as in the first round) was called. This was because once the phone number had been recorded in the database, there was no need to run the KNN algorithm and the USSD process anymore.

From the results in both Table 3 and 4, it can be seen that there was more overhead incurred by the USSD-Only technique than the KNN with USSD. It can be said that the dominant feature of USSD technique was to give the correct result for a network operator name that the phone number belongs to. When this technique was combined with KNN technique, it could be seen that the overhead, especially in terms of speed and delay was reduced considerably. Based on this evidence, it can be claimed that the combination of KNN algorithm and the USSD technique can help with both the accuracy and efficiency of the outbound call routing on IP-PBX.

CONCLUSION

This study has provided an overview of existing mechanisms used to select an outbound route in the IP-PBX System. Researchers have explained that those existing mechanisms do have their problems such as lack of flexibility and scalability. Some techniques even lacked accuracy and efficiency.

Researchers have, therefore, proposed a new method for selecting outbound call route by applying the KNN data mining technique together with the Unstructured Supplementary Service Data technique (USSD). The KNN is used to find the possible network provider for any particular destination phone number. The USSD technique is then used in the decision making process for which route is to be selected.

The results of the experiments have shown that the accuracy in selecting an outbound route with three main mobile operators in Thailand was between 95 and 98.6%. With the accuracy comes a little overhead. The results have shown that there was some overhead and delay in selecting the outbound route.

Researchers claim that choosing the route by new KNN data mining with USSD techniques can be used with IP-PBX phone systems. Apart from the results illustrated as a side benefit the method would be able to reduce the amount of traffic occurring in internetwork connection significantly. Thus, this would lower the cost for users, too. Moreover, using the KNN method in the database lookup process can greatly reduce overhead in determining the network operator.

In the future, from the results obtained from the experiments, researchers will try to apply this proposed method into the two-sim or multi-sim to select outbound call routing on mobile smart phone environment.

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