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Early Prediction of Congestion in GSM based on Area location using Neural Network.

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***Abstract*—The major issue in GSM while handling number of subscribers with voluminous data (voice and text) is the occurrence of congestion. Controlling such network congestion is one of the greatest challenges in the research field. This paper aims for early detection of congestion using specific location/area and usual call attempts made in that location. Artificial Intelligent technique of Neural Network has been used to manage such congestion that intelligently detects the call attempt failures in a particular area, given the area location. Some of the important evaluation measures have been used for checking the accuracy of prediction.**

***Index Terms*— SDCCH (Stand Alone dedicated Channel), TCH (Traffic Channel), GSM (Global System for Mobile Communication), ANN (Artificial Neural Network), MSE (Mean Square Error), QOS (Quality of Service)**

I. Introduction

Several techniques for compensation of packet loss due to congestion have been provided among which aggressive retransmission protocol was introduced [1]. However, this resulted in increase of congestion in the network. In Contrast, moving to network traffic analysis using previous experiences can help in monitoring the data traffic and predicting the congestion or failure in call attempts which in turn would serve as a helpful tool in introducing more data handling techniques in those specific areas[2][3].

II. GSM and Congestion in GSM

GSM (Global System for Mobile communication) is a TDMA based digital mobile telephony system that is widely used in Europe and other parts of the world. The GSM technology based Mobile service was launched first in Finland in 1991. GSM is the mobile network based system divided into three parts [7]:

i. MS (Mobile Station)
ii. BSS (Base Station subsystem)
iii. MSC (Mobile Switching Center)

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The call initiation starts with MS, dialing a number, after which the call is routed to the nearest BTS (base transceiver

Station) through the air Interface called as Um Interface. After receiving, it further amplifies the call signal and reroutes it to BSC (Base station Controller-authorized to control and manage multiple BTSs) through Interface known as ‘Abis’. Finally BSC communicates directly with MSC (Mobile Switching Center-dealing with authentication, identification and verification of credit status of subscriber) through the interface known as ‘A’ interface. Thus routing the call to the destination. The interface through which two MSCs communicate is known as ‘E’ Interface. Actually, all the signaling taking place from MS to MSC, is through SDCCH (Standalone dedicated control channel) which is a logical dedicated control channel, used in GSM for various purposes like call setup registration.

Fig.1. represents the process of GSM involving flow of data packets from MS towards the destination.

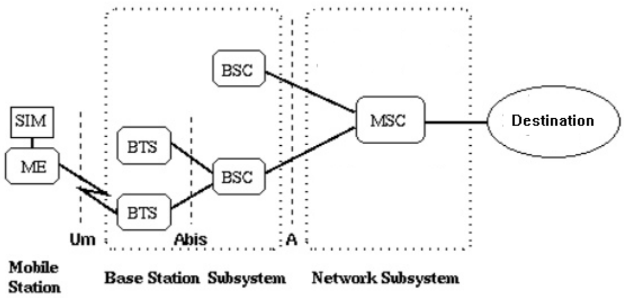

Fig1. Flow of data packets from MS to destination.

Despite of knowing the fact that GSM serving various cryptographic algorithms for security purposes (Ciphers being used for enabling over air voice privacy), we come across various issues associated with GSM in our day-to-day lives which may highly affect the call initiating process.

One such issue is the *network congestion.* Network congestion is considered to be the state of network communication devices (such as network switches, connectors and transmission links or channels) wherein the network is not able to meet the objectives of network performance for connection requests. This can result in the reduction of QOS (quality of service) and lead to queuing, data packet loss or blocking of communication links especially when the network node is carrying data more than its data handling capability.

The various factors contributing the occurrence of congestion are stated below:-

i. As the number of subscribers increase, the QOS gets decreased as new services are introduced[4]
ii. Simultaneous event detection at multiple nodes or link failure[5]
iii. Insufficient storage of link or node for arriving data packets thus decreasing the QOS [6]
iv. Network data packet load (number of data packets) is greater than the packet handling capacity of the network [1].

III. Artificial Neural Network

Artificial Neural Network is a paradigm of Artificial Intelligence that has taken its inspiration from biological neuron (human brain). It simulates the information processing capabilities and learning capability of the biological neuron. An ANN structure consists of interconnected artificial neurons that that usually consists of three layers [8]:

i. Input Layer for input variables
ii. Hidden Layer for processing the input data
iii. Output Layer for providing the output predicted data.

Each Layer consists of nodes or units that act in the similar way as biological neuron does. The output nodes take the weighted sum of outputs from the nodes or neurons of previous hidden layer.

Each neuron 'J' in an output layer receives the weighted input from neuron 'I' in the previous layer using the equation (1) below:

$$\text{Input to neuron:} \quad Ij = \sum wij\ Oi + \theta j \qquad (1)$$

where w_{ij} is the weight from node i to node j and Θ is the bias of node j that acts as threshold for varying each unit activity.
O_i is the output of node I in the previous layer
I_j is the input of the node j in the next layer
As the input is received by the node, the output is represented as following equation (2):

$$\text{Output to neuron:} \quad O = 1/(1+e^{-ij}) \qquad (2)$$

Matlab Simulator provides the neural network GUI (graphical user interface) as shown in the screenshot below (Fig 2)

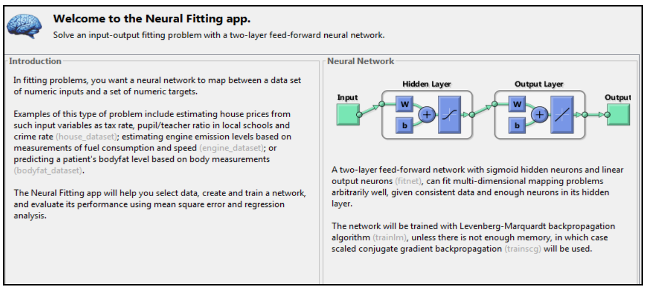

Fig2. Neural Network General Simulator in Matlab tool

Neural Network helps in determination of already existing congestion in the wireless network using real dataset that consists of recorded experiences of call attempts failures in a particular area.

IV. Neural Network as Predictor of Congestion

A GSM congestion prediction model based on multilayer perceptron neural networks using daily based traffic data has been provided .The trained multilayer network model was used to predict traffic congestion in a particular area.

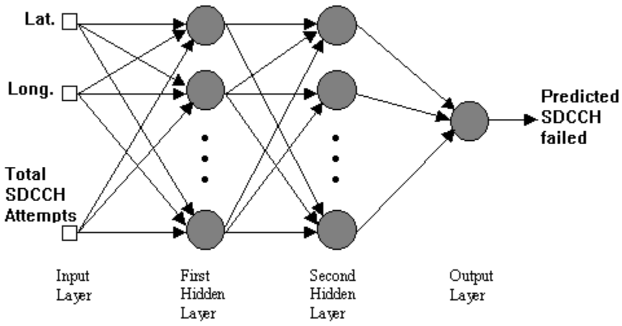

Fig 3. Neural Network Structure for input data set

Fig 3 above shows the neural network structure created using the real dataset with three inputs, the hidden layer with some 'n' neurons and the output layer that predicts the call attempt failure, given the latitude 'lat' and longitude 'long' of an area. The real dataset provided is preprocessed for further processing of ANN. Following Fig 4 shows the data flow architecture for prediction.

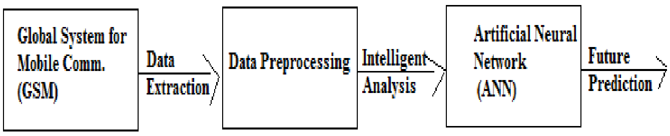

Fig 4. Data Flow architecture for congestion detection.

V. Experiment Based on Real Traffic Analysis

Traffic Data in BSNL (J&K): "TCH Congestion "Dataset-
(26th Dec 2015 to 31st Dec 2015)
Traffic channel (TCH) is the combination of voice and data signals (time slot assignment) that exist within a communication channel.

Table 1: Dataset Description

Dataset:	
Input	(14089x3 double)
Target	(14089x1 double)

The data has been recorded for six days and consists of 14089 instances or samples with 3 attributes i.e. Long, Lat and the total SDCCH attempts in the concerned areas. The above dataset is provided to the neural network simulator of Matlab as shown in the screenshot below Fig 5 below.

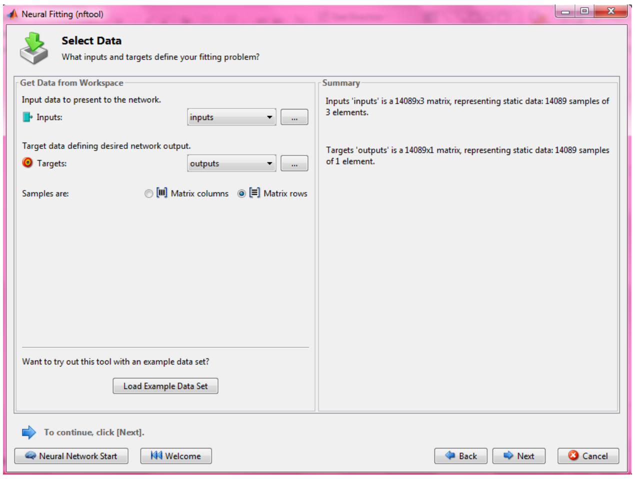

Fig5. Uploading of input dataset and target dataset in Neural Network Simulator

The input set is provided to the neural network simulator in the workspace and is trained for prediction of output. Further, the validation and testing datasets are provided for tuning up the neural network, thus making the prediction more accurate. For this the whole dataset is divided into training, validation and testing dataset as shown in the screenshot below. Fig.6.

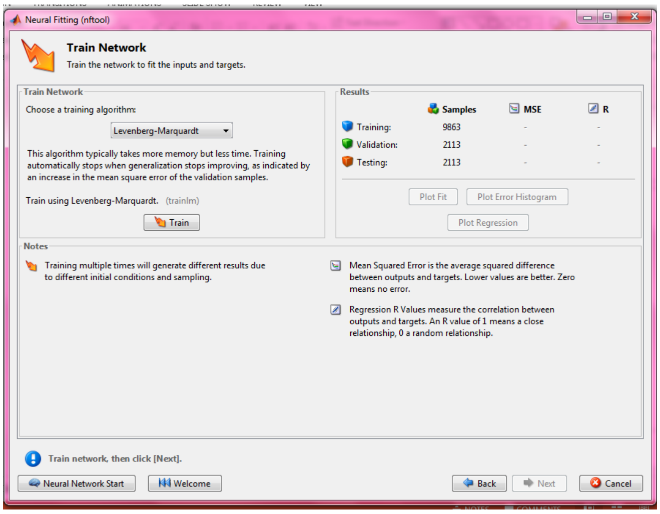

Fig.6. Data set divided into three- training, testing and Validation datasets

The dataset is being divided into three subsets as shown in the table 2 below:

Table 2: Dataset division

Dataset	No. of Samples /Instances
Training Dataset	9863
Validation Dataset	2113
Testing Dataset	2113

The training method of Levenberg-Marquarst is used in neural network for output prediction that takes less time in training. Applying this on the dataset, resulted in output prediction of SDCCH failed attempts in the particular area. The network structure was created with 3 input nodes in first layer and 10 nodes in the hidden layer. The output is evaluated using the various evaluation measure. We shall focus on Mean Square Error that is the average squared difference between the expected target value and the calculated output. Fig 7 shows the screenshot of the output.

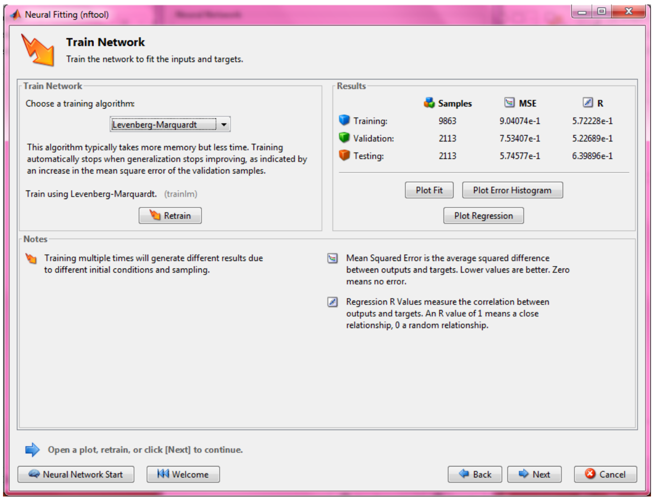

Fig 7: Output evaluation Mean Square Error Value

Mean Squared Error is the average squared difference between outputs and targets. Lower MSE values are indication of accurate prediction i.e. the lower the error, the better is the accuracy in prediction. Further we have an evaluation measure to check the correlation between the expected target outputs and the calculated output i.e. Regression (R) Value. The more the R-value the more is the correlation i.e. Value 1 indicates close relation and value 0 indicates no random relation. Table 6 below shows the evaluation values for each of the sets.

Table 3: Reduction of MSE and Increase of R-Value in Call attempt failure prediction.

Dataset	Samples	MSE Value	R Value
Training Set	9863	0.9040	0.5722
Validation Set	2113	0.7534	0.5227
Test Set	2113	0.5746	0.6990

After using the test dataset, with reduced MSE, the neural network is well trained for the prediction of call attempt failure leading to congestion in an area. This can help in being aware of failure attempts before a call is even being initiated and further protect the network from overload.

VI. CONCLUSION

Neural Network helps in prediction of congestion in the area, even if we don't have knowledge of how many attempts failed. On the basis of area, its Lat and Long, and average attempts of calling, it can help in prediction of congestion in that area. This can help the telecommunication analysts to resolve the congestion issues before the initiation of calls especially in those areas where the predicted congestion is of concern.

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