Data Network Traffic Management Automation System

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Abstract

In offensive military operations, the fighting formations maneuver their forces dynamically to achieve superiority over the enemy. The communication hubs which provide command and control communications move swiftly to provide multi-media communications to the supporting forces. The moving fighting formations hook onto the nearest communication hub. The communications hubs move forward with the progress of operations. Existing dynamic routing algorithms update the configuration tables whenever there is a change in the system, but cannot converge quickly. Dynamic and adaptive reconfiguration of the communication system would make the system transparent to the movement of fighting formations and provide failure-proof communications.

In this paper, we present a dynamic adaptation reconfiguration model which enables the system to connect the formations which are on move and reconfigure the system as the communication hubs move from one place to another. The new adaptation model is an improvement over the existing dynamic routing algorithms like distance vector algorithm and link state routing algorithms, as new model is pre-emptive and adaptive to the network and load changes. The model is tested and the results showed an improvement over the existing algorithms

Key words: Dynamic reconfiguration, communication hubs, military operations.

1. Introduction

In battlefield, the armed forces conduct offensive operations to win over the enemy and occupy the ground. During offensive military operations, the forces move forward swiftly. The commanders at various levels communicate with one another to coordinate the movement of troops. Therefore communications take vital place in the offensive operations. In conventional warfare scenario, communication equipment was integral part of the formations and commanders at various formation headquarters were provided with radio sets to communicate with formations / troops under their command. The radio sets provided basic voice communication only. As the formation moves forward, the communication equipment which is integral to that formation also moves along with it.

Mobile Radio Engineering Network Communication Centers (MRENCC) were developed during 1980s to provide networked communication support to the troops on move to provide audio and data communications. It is based on the Radio Relay links networked using electronic switches and routers. The routing algorithms implemented on these routers were primitive.

Topology of the MRENCC

The MREN Communication Center (MRENCC) consists of MREN network terminals which are based on vehicles. These terminals are equipped with the radio relay links, switching / routing equipment. A formation hooks on to the communication center using the mobile communication terminals which are integral part of that formation. The MREN Communication centers are inter-linked with one another in mesh topology forming a grid which covers certain area of operations. As the formations move forward, they hook on to the nearest MREN center. As the operations progress and formations move forward, a new MREN center is moved ahead and established to extend the grid in the direction of offensive operations. Therefore, the formations are provided with communications continuously while on move.

Tactical Communication System (TCS)

As the technology changed, the conventional warfare has given way to modern warfare. Besides the three dimensions of war that is, land, water and air, two more dimensions are added. The additional two dimensions are electronic warfare and information warfare. These two dimensions of war are playing vital role in winning the battles. The commander needs data, video and information besides voice communications. Modern command and control systems like Battlefield Management System (BMS), Battlefield Surveillance Systems (BSS), Command, Information and Decision Support Systems (CIDSS) and tactical Command, Control, Communication and Information systems (C3I) are introduced to support fire power, night fighting, surveillance systems and night vision devices [1].

To support the above command and control system, Tactical Communication Systems (TCS) are developed. The TCS systems provide high bandwidth networked communication providing voice, data and video services. However, when-ever there is a change in the network topology, the network performance goes down as the routing algorithms are not suitable for the mobile operations.

In this paper, we presented an adaptation model which dynamically reconfigures the communications hubs and optimizes the performance of the network as and when there is a change in the network. The algorithm is pre-emptive to the changes and adaptive to the traffic load generated by the formation nodes.

This paper is organized into six sections. The next section reviews the related work in the routing algorithms and the adaptive techniques used in the network management. Section 3 deals with the theoretical background to the new modified algorithms. Proposed adaptation model is covered in Section 4. Section 5 deals with experimentation details, analysis of the output data. Section 6 gives the conclusions and future enhancements are discussed in section 7.

2. Related Work

Nachum Shacham et al. of US Army Research Center studied the algorithms for radio networks with dynamic topology and submitted a report in 1991 [2].

The existing dynamic routing algorithms have the disadvantage that they take a lot of time to converge. In fast dynamic topological network, like in offensive military operations, the network routing tables do not stabilize and therefore the packet losses will be unacceptably high [3, 4].

Brian Panneton and James Adametz analyzed High-Bandwidth Tactical-Network High-Performance-Computing (HPC) Environment in 2015 [5 - 10].

3. Proposed Solution

An adaptation model designed to address the problem of dynamic reconfiguration of the network hubs' is given in figure 3.1.

The adaption model has the following modules

Dynamic Load Warping (DLW) module: It measures the load pair distance and select the minimum load pair distance. The network configuration (NC) corresponding to the min distance is passed to the Resolution Module as the NC hypothesis.

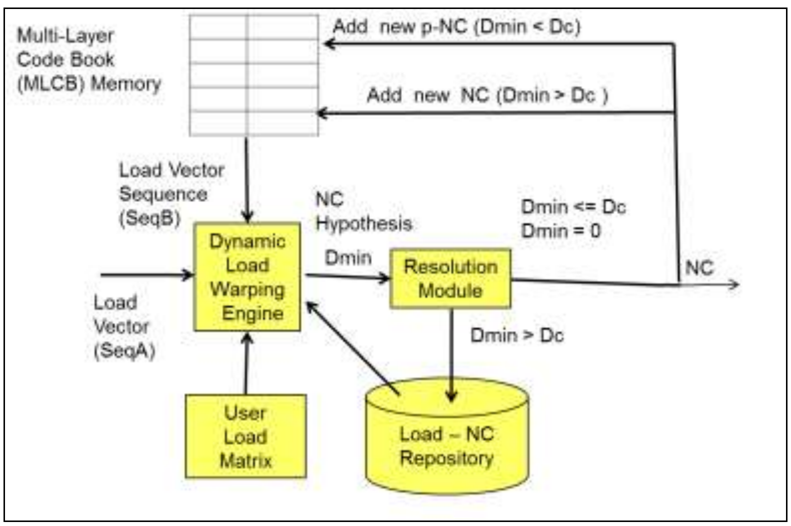

Figure 3.1: Adaptation model

Resolution Module: The module process the incoming load sequences and a classification is made in which the load an existing or a new load.

User Load Matrix: It gives the list of formations and its load on the network.

Resolution Module: It resolves whether the input load vector on the network is same as one of the loads in the MLCB memory, close to one of the loads or is it different load from the existing loads. The decision whether the load vector is close to the existing load vector or otherwise, is decided by the critical distance parameter. The critical distance parameter is empirically estimated.

Case 1: In case the input load vector is same as one of the load vectors already in the memory, it outputs the Network Configurations (NC) corresponding to that load vector.

Case 2: In case the input load vector is resolved as close to one of the load vectors in the memory, the NC corresponding to the nearest load vector is output. The input load vector is added to the repository.

Case 3: In case the load vector is resolved as new load vector, then the Load-NC Repository is searched for the nearest load vector and the steps of finding the distance and resolution are repeated. The new load vector is added to the MLCB memory as new NC class.

MLCB Module: This is a code book. It holds various load vector code words indexed to their NCs. It has four levels. All 'Most Frequently Used' and 'Most Recently Used' code words are kept in first level. 'Most Frequently Used' words are kept in second level and the 'Most Recently Used' code words kept in third level. Remaining code words are kept in fourth level. To keep the size of the code book to a manageable level, a time stamp is maintained for each code word. The code words are moved to the repository beyond a predefined 'Time to Live' period.

4. Experimentation

Experiment 1

The first experiment is carried out to estimate the critical distance (Dc) which classifies the load vectors into a variation of existing NC in the MLCB or the load vector corresponds to a new NC.

Experimental Setup: The experimental set up is given in figure 4.1.

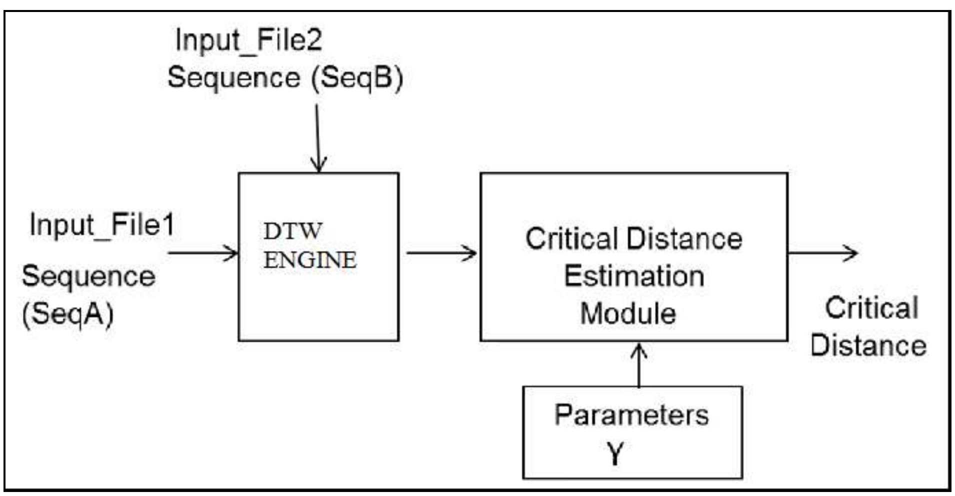

Figure 4.1: Experimental setup for estimation of critical distance

Datasets: The data sets used for the experiment No1 are the NCs and their load vectors (LVs). Ten load vectors are chosen for each NC. The data set consists of different number of ten to fifty thousand NCs.

Procedure: The NCs and their LVs are kept in two input files named Input_File1 and Input_File2. A LV from Input_File1 is compared with itself and its variations and also with LVs of different NCs. Based on the distance between a pair of LVs; it is classified as a variation of its NC or LV of different NC. The value of parameter gamma is varied between 0 to 1 in steps of 0.5. The errors are counted in each experiment. The results are given in Table 4.1. and graphically shown in figure 4.2.

Result Analysis: The results show that the errors in classification are the lowest at gamma equal 0.5. The curves B, C, D and E correspond to different datasets with varying number of comparisons. The Dc is re-estimated after every updation of MLCB memory.

Table 4.1: Results of classification

	Data Set			
γ	B	C	D	E
0.20	1.66	1.35	1.46	1.25
0.25	0.94	0.83	1.04	1.04
0.30	0.73	0.62	0.94	0.62
0.35	0.62	0.52	0.94	0.52
0.40	0.73	0.52	0.83	0.31
0.45	0.73	0.52	0.83	0.31
0.50	0.42	0.31	0.62	0.10
0.55	0.62	0.52	0.73	0.21
0.60	1.46	0.83	0.73	0.21
0.65	1.87	1.14	1.35	0.31
0.70	2	1.77	1.70	0.73
0.75	2.1	1.77	2.00	1.35
0.80	8.95	7.80	10.61	3.64

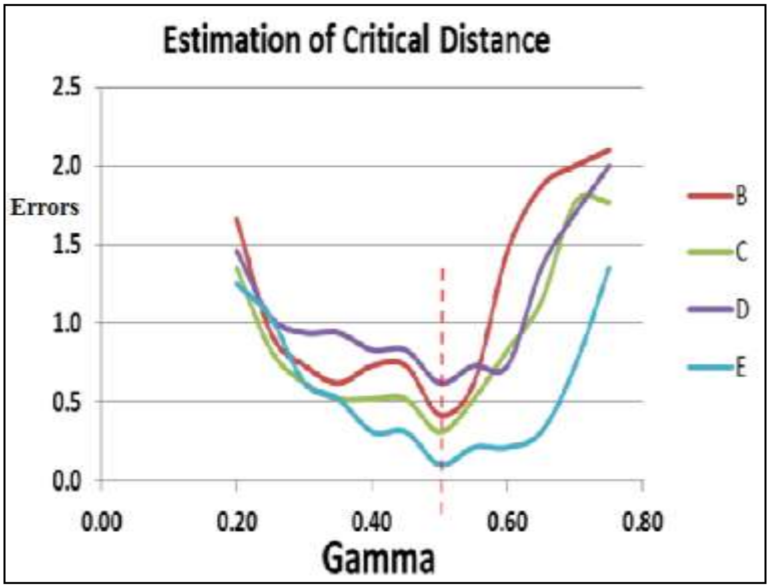

Figure 4.2: Graphical view of the results

Experiment No. 2

The second experiment is conducted to evaluate the adaptation model. The Dc estimated in the first experiment is used in the adaption model. The adaptation model given in figure 4.1 is used for experimental setup.

Datasets: The load vectors for different divisions are taken as the datasets. The network consists of seventeen communication centers and the formations hooked to the communication centers are taken as loads. The actual data during two different military exercises is used for inclusion in the datasets.

Procedure: The MLCB memory is kept empty at the beginning of the experiment. The first dataset consists of 25 load vectors. All the 25 load vectors are added to the memory. The NCs for these load vectors are taken from the LV-NC repository. Fifteen experiments are conducted with increasing number of load vectors. The number of variation of loads and new NCs are recorded. The network performance is measured as percentage of packet losses in the network.

Results and Analysis: The results are shown in figure 4.3. The performance of the system with adaption model is better than the performance of the network using non-adaptive dynamic algorithms like distance vector routing and link state routing.

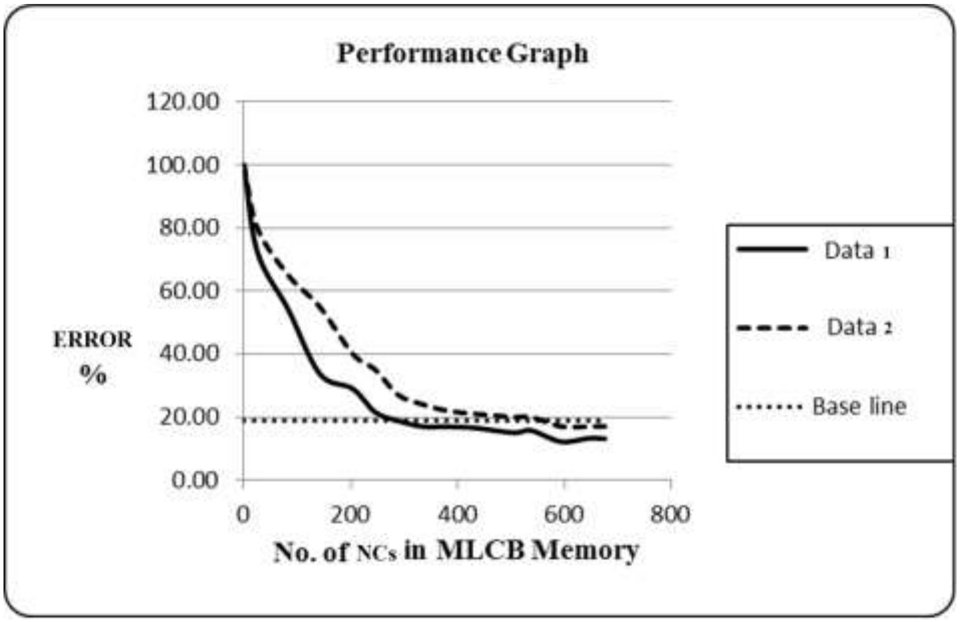

Figure 4.3: System performance testing

5. Conclusions

TCS is a networked communications system with dynamic network topology and dynamic changing load on the network. The existing dynamic routing algorithm cannot converge in offensive military operations due to rapid movement of military formations. An adaptation model is presented in this paper. The experimental results showed that the performance of the network with adaptation model is better than the network performance with existing routing algorithms.

6. Future Enhancements

The adaptive routing model is generic and can be used in any dynamically changing networks like road traffic control systems etc.

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