Geographical QoS Routing Strategies for Multimedia Streams in MANETs with Network Capacity Considerations

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ABSTRACT

The Mobile Adhoc Network (MANET) support in anywhere and anytime wireless communication expands the multimedia applications' scope. Ever demanding task of multimedia applications to determine the quality of routers among huge number of portable devices is to improve Quality of Service (QoS). To support real time multimedia streams, several geographical based QoS routing protocols have been proposed; however, the portable devices' expansion leads to stringent QoS demands in MANET. The main reason behind the QoS demand is the dynamic network capacity which relies on network size, node mobility, density, node energy, and communication range. The existing protocols are inefficient to the delay sensitive multimedia applications over MANET due to the lack of attention on dynamic network capacity. This work presents a new Network Capacity based Geographical routing (NCG) along with several routing schemes such as Radio Range Regulation (RRR) routing, Virtual Destination Routing (VDR), and Virtual Void Routing (VVR) called NCG++. is called NCG++. The NCG++ routing estimates the network capacity in terms of QoS, facilitating minimum energy for every node to provide the QoS for varying network size, node mobility, and node density. Finally, this work simulates and compares the proposed NCG++ routing protocols performance with the existing QoS-GPSR. Thus, the performance evaluation illustrates that the NCG++ routing protocol outperforms the existing protocols.

Keywords: *Mobile Adhoc Network, QOS Routing, QOS Provisioning for Multimedia,Network Capacity, Scalability, and Mobility.*

I. INTRODUCTION

A set of wireless connected portable devices is composed of the infrastructure-lessMANET.The enormous growth in wireless technologies demands attention on the multimedia applications such as digital video, audio, and file transfer. The MANET supports the real time multimedia communications which requires an end-to-end data transmissionwithout any interruption. A key factor to support the uninterruptible data transfer is QoS which contains a set of service requirements such as delay, delay jitter, bandwidth, network resources and packet loss. To provide the QoS, the determination of communication links needs to satisfy the service requirements. Hence the geographical routing is preferred for multimedia streams more than the topology based routing. Several geographical based routing protocols have been proposed to provide the QoS guarantee for multimedia applications under MANET.

The existing protocols include multiple routing constraints such as delay, bandwidth, and link stability to assure the QoS provision. However, it does not allow the greater user mobility under a large scale network. Large number of highly portable devices expends the node energy owing to the node density, mobility, and the node movement. which in turn leads to frequent changes in the network capacity. The dynamic network capacity affects the highly sensitive QoS parameters such as delay and throughput resulting in noncooperative routing for the multimedia streams. The lack of attention on network scalability and node mobility induced dynamic network capacity is a main problem in the existing geographical QoS routing protocols. As a result, an effective routing protocol is needed to deal with the network capacity factors such as network area, node mobility, density, and node energy.

In this paper, a new geographical routing protocol which tolerates the dynamic network capacity namely NCG++ is proposed to provide the QoS over the delay sensitive multimedia streams. A single routing scheme cannot provide the routing quality under a highly dynamic network capacity. So, the proposed routing protocol NCG++ utilizes a core routing (NCG) coupled with a schemes such as RRR.To effectively handle the network scalability and node mobility effect on routing, the core NCG divides the network into several segments. Moreover, it determines the self-forwarding priority individually. In addition, the NCG++ measures the achievable network capacity in the aspects of network capacity dealing factors such as network size, mobility rate, node energy, and node density to trigger an adaptive routing scheme. Thus, the NCG++ routing performance gets improved even under a large scale with high mobility scenarios.

This work concentrates on the dynamic network capacity to provide the QoS over multimedia streams. It proposes and illustrates the performance of NCG along with several routing schemes such as RRR, VVR, and VDR under a large scale with highly dynamic topology. The performance of the proposed NCG++ is analyzed in terms of video delivery completion ratio, frame setback rate, and energy utilization per data flow, and is compared with existing routing protocols such as QoS-GPSR. Finally, the performance evaluation shows that the proposed NCG++ protocol provides QoS for multimedia applications over MANET.

Problem Statement

Recently, several MANET routing protocols are proposed for digital video and audio transfer but, the real time scenario limits the communication quality due to frequent changes in the network capacity. The dynamics in network routing capability rely on the network size, node mobility rate, and the node density which makes changes in the node capacity factors such as coverage area and the node power. In addition, the multimedia applications are more sensitive to the routing QoS parameters such as throughput and delay. The network capacity limiting factors such as node energy and communication range due to the network size, node mobility rate, and the node density make insufficient QoS provision which corrupt the digitized video and audio information. Moreover, the highly available portable devices cause collision due to the increased volume of neighbour's position and list updates during the data communication.

In real time, the network size, node mobility, and the node density are related with the application area. So, quality enhancement deals with other network capacity metrics such as node energy and communication range. A lot of routing techniques have been proposed to increase the quality links' availability i.e.connectivity through the communication range adjustment. However, the increased communication range makes changes in the node power level. As a result, the radio range adjustment affects the routing quality when the node energy is not enough to attain the required throughput. These are the major issues associated with the network capacity growth to achieve the QoS requirement for multimedia streams under a real time scenario. To overcome the routing QoS issues on considering the network capacity, the NCG++ geographical routing protocol is proposed. The proposed protocol contains a core NCG routing along with a schema RRR. Moreover, it selects the adaptive routing scheme based on the measured network capacity in terms of minimum energy requirement to support the routing QoS under dynamic network capacity. Thus, the NCG++ achieves better quality over multimedia streams than the existing protocols.

Main contributions of the paper:

The main contributions of the paper are:-

The QoS provision for multimedia application is achieved using the proposed NCG++ routing protocol which estimates the QoS facilitating minimum energy per node to deal with the network capacity factors such as the node energy and the communication range to attain sufficient throughput and delay.The prediction of network capacity condition through the network capacity estimation under minimum energy requirement supports adequate routing selection. In sufficient network conditions, the NCG is activated alone; otherwise, an adaptive scheme is activated along with the NCG based on the demand factor.

Under insufficient network capacity, the RRR scheme is activated to adjust the node energy based on the other demand factors.

In NCG++, the scalability and the node mobility effect on routing is reduced using the segment and an self forwarding priority detection concepts. In addition, the link quality is ensured using the packet loss measurement. The NCG++ routing performance is simulated and compared with the existing routing protocol such as QoS-GPSR in terms of video delivery completion ratio, frame setback rate, and energy utilization per data flow.

Paper Organization

The paper is organized as follows: The chapter 2 illustrates the previous related works on QoS provisioning under MANET for multimedia applications. The chapter 3 provides a brief introduction on the proposed NCG++ protocol. Moreover, it demonstrates the NCG along with the routing scheme such as RRR.The chapter 4 evaluates the performance of NCG++ routing protocol. The chapter 5 concludes the work.

II. RELATED WORKS

This section describes the existing QoS protocols over wireless communication. It explains the work which is relevant to the proposed protocol. The QoS routing open issues are surveyed. To provide QoS, the existing routing protocols incorporate the measurement of QoS metrics such as delay, bandwidth, resource allocation, and packet loss probability into the MANET routing. In addition, the multimedia streams are error sensitive applications and hence, it requires guaranteed packet delivery and provision for routing QoS.

QoS State and Stateless Routing Protocols

To provide QoS guarantee for multimedia streams, a new model based routing protocol introduces the bandwidth theory in statistical QoS routing .It selects shortest communication path to reduce the bandwidth consumption and proposes the traffic schedule algorithm to limit the delay time. In that, the Bellman Ford algorithm satisfies the routing QoS requirements under MANET environment. The main drawback is that in the Ford algorithm, bandwidth reservation leads to inaccurate measurement. A high speed network is demonstrated. It selects sufficient resource communication paths to improve the routing QoS. But, it needs to maintain the global network topology resulting in high routing overhead. An Adhoc QoS Routing (AQOR) is proposed. In order to improve the routing QoS, it introduces the routing based on the resource reservation and the admission control. The AQOR minimizes the channel deterioration; however, it fails to provide the effective throughput.

A QoS multi-channel routing scheme to meet the requirements is introduced. However, the dead end nodes lead to inefficient routing under high mobility rate.

QoS provision for Multimedia Applications

An adaptive QoS framework for multimedia applications is presented in called AQuaFWin. In that, the generic feedback scheme is used to support the QoS provision. To improve the routing performance, the stability estimation is introduced into the routing QoS under MANET. It selects high quality and stability links to improve the routing QoS. It is necessary to retain the stability information in every packet header but, it incurs high routing overhead. A system for QoS provision for multimedia streams is presented. It proposes the access control mechanism based on the preemptive priority which supports the QoS routing for multimedia streams through the integration of the stability metric into the QoS routing. In addition, it derives the permission and bandwidth allocation scheme for the proposed system. The necessity to maintain the polling list for data transmission leads to high routing overhead.

Network Capacity Constraints for QoS Routing

The existing protocols concentrate on the routing metrics such as delay, delay jitter, bandwidth, resource allocation, and packet loss probability to provide the routing QoS. The bandwidth estimation based QoS aware routing protocol is presented. It concentrates on the traffic allocation to improve the routing performance. Moreover, it incorporates the admission control through the feedback scheme which aids to improve the bandwidth requirement. Furthermore, it eliminates hello and listen packets to estimate the QoS metrics. Some of the existing protocols evaluate the energy consumption over multimedia streams. It extends the network model and the interference condition to calculate the energy requirement and the cost under ideal conditions But, it provides an inaccurate measurement when collision occurs.

A paradigm for QoS under MANET is presented. In that, the RF media using link abstraction provides the QoS. It describes the approaches of data packet route and access using synchronous signal, but, the unified state distributed routing increases the communication cost. A new protocol for adaptive multimedia streams under MANET is presented. It considers the traffic allocation to control the data flows individually. The call admission control to avoid the collision is achieved using bandwidth adaptation theory. It decides the label admission or rejection when a new call arrives into the network using the algorithm of connection admission control. Moreover, the routing QoS enhancement is achieved using reinforcement learning. However, it fails to avoid the channel deterioration. This is the main disadvantage of this routing scheme.

This section describes the existing QoS based routing protocols and their drawbacks. Several routing schemes are suggested to provide the QoS for multimedia applications under MANET. It does not consider the network capacity to overcome the routing issues such as delay, delay jitter, bandwidth, resource allocation, and packet loss. The main drawback in the existing protocols for QoS routing over multimedia applications is the lack of attention on dynamic network capacity. Thus, a new network capacity based protocol is needed to provide the QoS for multimedia applications.

III. INTRODUCTION TO THE PROPOSED NCG++ ROUTING PROTOCOL

The proposed NCG++ routing protocol includes one core routing (NCG) coupled with several routing schemes such as RRR, VVR and VDR to deal with the dynamic network capacity. The NCG ++ routing estimates the network capacity in terms of network size, node mobility, density, and energy to support the QoS provision for real time multimedia streams like video conferencing, bit torrents, and medical imaging under MANET. In addition, it divides the network capacity into two conditions based on the network capacity measurement in terms of minimum energy requirement to provide the QoS in routing. In former condition, it activates the core NCG routing when the network has adequate capacity factors to attain the routing quality.

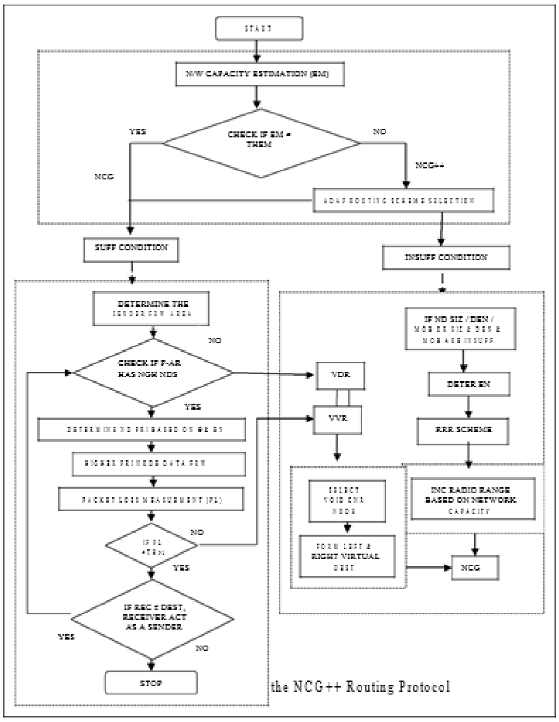
To reduce the scalability and the mobility effect on routing, the NCG introduces the segments and own forwarding priority detection methods. In case of inadequate capacity factors, the NCG is coupled with an adaptive routing scheme called NCG++. The proposed NCG++ routing decides the routing scheme based on the network capacity demand factor. In NCG++, the RRR scheme adjusts the node communication range to compensate the node mobility and the density effect on QoS metrics such as delay and throughput based on the node energy. In addition, the void node or a node which loses the packets more than the threshold range under sufficient capacity when using the virtual based routing schemes such as VDR and VVR. The virtual routing senses the destination node or void area to support the QoS NCG routing under void area and inadequate node resources. Moreover, the NCG++ routing is switchedback to the core NCG routing under less data delivery requirement period to minimize the unnecessary energy consumption. Thus, the proposed NCG++ routing, based on network capacity factors satisfies the multimedia streams' requirement under real time scenarios. The Figure 1 shows the flowchart for proposed system.

Steps to perform the NCG++ Routing:
Step 1: The network capacity based geographical routing computes the network capacity in terms of network size, node mobility, and density.
Step 2: The protocol ensures whether the capacity is sufficient to meet the QoS requirements.
Step 3: Based on the proposal, the network has two conditions. If the network capacity is enough to attain the multimedia stream QoS requirement, the network goes to first condition otherwise, goes to second condition. The second condition is switched back to the first condition, when the network has sufficient capacity factors to achieve the application requirements.

Condition 1:
Step 1: Determines the sender node forwarding area through the computation of destination direction and location.
Step 2: Ensures whether the sender node forwarding area has neighboring nodes or not.
Step 3: If the condition is satisfied, the sender node calculates the neighbour nodes offset angle and node energy.
Step 4: The higher priority node forwards the data packets to the next router. If the receiver

node is not a destination, it measures the packet loss to ensure the link quality. If the packet loss is less than the threshold range, the receiver node acts as a sender node. Again it continues the routing from step 1.
Step 5: If the sender node cannot determine the neighbouring nodes, it activates the VDR routing. In addition, the VVR is activated when the packet loss crosses the threshold range. These are the switchover conditions in NCG++ routing.

Condition 2:
Step 1: The node density/ node mobility or both the factors are insufficient to meet the QoS requirements, and to determine the node's available energy.
Step 2: The RRR scheme regulates the radio range to adjust the node energy level based on the insufficient capacity factors.



the NCG++ Routing Protocol

System Model and Assumptions

A general model for a network is represented as a graph G (N, C). In that, N represents the set of nodes N = {1, 2 . . . n} and C represents the set of direct connections C = {i, j}. Every node can make the direct connection with others which are placed within the radio range (□). The direct connection (i, j) □ C denotes that the node j is located within □ of node i called neighbouring node (NHI). Hence, it is assumed that the MANET relies on multilink communication and every device allows bi directional communication with the neighbouring nodes. In addition, every node attaches the Global Position Sensor (GPS) to obtain the location information which supports geographical MANET routing.

$$NH(i) = (i, j) \in C \wedge (j \in N) \quad (1)$$

$$(K/T) = (K-b)/(T+a) \quad (2)$$

$$E_M = \lim_{t \to \infty} 1/t \; *(\tilde{a}^n (\tilde{n} * S_{NW})) \text{ joules/node} \quad (3)$$

Consider a risk scenario for multimedia streams such as video transfer from one device to another device. A large size video's quality relies on the network capacity factors such as network size (SNW), density (□), node mobility (□), and node energy (EN) as it is delay sensitive. For instance, consider the video size increases from KB to MB. Assume that the highly portable devices (□) are placed sparsely but, it has capability to a direct communication (□) for few kilo metes. Assume that every node (i □ N) initially has *K* joules and *T* (□) km. For every data transmission the node obtains (*K*-b) reduction due to the increment of *T* as shown in equation (2). In addition, the node energy reduction for every data packet transmission (DT) is represented as *K*-E (DT). Moreover, the data transmission exists among the NI and NJ, if and only if, the NJ has *K*-E (DT) > EM where *K*-E (DT) □ data packet receiving power at node NJ and EM □ Minimum energy to receive the packet successfully as shown in equation (3). Thus, the proposed system relies on the network capacity factors to provide the QoS for multimedia streams.

NCG along with Adaptive Routing Schemes (NCG++)

The NCG++ routes the packets successfully when the NCG routing fails due to the unworthy network capacity. It activates an adaptive routing scheme based on the node energy (EN). The sender node starts to measure the NHI energy level to determine the adaptive routing when the □NW is insufficient. In addition, the initial energy level (EL) of mobile node obtains reduction for every act shown in equations (17-19). In NCG routing, every node expends some energy (EEXP) for neighbouring nodes detection (ENHD), own priority estimation (EOPD), overhearing of radio neighbours data communication (ENH (N-I)), data transmission (ETR), and the data reception (ERC).

$$E_{EXP} = \sum_{I=1}^{FN} E_{(NHD)} + E_{OPD} + \sum_{I=1}^{FN} (E_{NH(N-1)}) + \sum_{D_F-1}^{M} (E_{TR} + E_{RC}) \quad (17)$$

$$E_{EXP} = \sum_{I-1}^{FN} (C(i,j) \in \Re \wedge (j \in N)) + \sum_{I-1}^{FN} \lfloor \lceil D_F (E_{NHI}) \rfloor \rceil + \sum_{I-1}^{FN} E[\sum_{I=1}^{N} (D_F (E_M))] + \sum_{I=1}^{N} (E_N + [NH_{N-1}]) \quad (18)$$

$$E_{EXP} = \sum_{I=1}^{FN} (C(i,j) \in \Re \wedge (j \in N)) ++ \sum_{I=1}^{FN} (E+1)[\sum_{I=1}^{N} (D_F (E_M))] + \sum_{I=1}^{N} (E_N + [NH_{N-1}]) \quad (19)$$

$$E_N = E_L - E_{EXP} \quad (20)$$

Every node expends some energy to ensure the NHI direct connection and the location to determine the NHI list (E (NHD)). In NCG routing, NHI of every node's own priority determination needs EOPD to mitigate the mobility effect. Due to the overhearing capacity every node loses some energy (ENH (N-1)) for every data flows. In addition, every node requires (ETR + ERC) for every packet transmission and reception. Using the measured energy expenditure every node determines the available EN as shown in equation (20). The sender node overhears the EN (NHI) to determine the highly energetic node for data transmission. Moreover, an efficient data communication under □NW insufficient condition is possible when it has highly energetic NHI but, the delay sensitive multimedia streams may acquire risk due to other inadequate factors such as SNW, □, □, and □. Hence, the □ adjustment based on □ is achieved to manage other insufficient factors' effect on EN and neighbour connectivity using RRR scheme to satisfy the quality requirement.

Radio Range Regulation Scheme (RRR)

The RRR routing scheme which adjusts the node □ can reduce the effect of other capacity factors such as SNW, □, □, and □ on EN and neighbours connectivity. The node □ is expanded when □ and □ is inadequate to the □NW and vice versa. For one loop, the node adjusts the range in the rate of 'b' which increases/decreases 'a' joules in EN (equation 21) and 'Q' neighbours in NHI (equation 22). The adjustable rate of □ for one loop is determined using equation (22). It provides an easy way to the routing quality management. Thus, the EN and the connectivity are efficiently maintained due to the RRR scheme and hence; the NCG++ provides sufficient QoS than the NCG under the similar scenario.

```
If (ρ && γ || SNW && ρ) is insuff then,
        Sc --;
        ℜ++;
If (SNW && ϑ ) is insuff then,
        Sc ++;
        ℜ --;
Else (γ && SNW && ρ ) ∅ RQOS
    Activate VVR;
```

$$\log E_N - \log \Re = \log (E_N + b) - \log (\Re - a) \quad (21)$$

$$b = (\Re / NH_I)(NH_I \pm Q) m \quad (22)$$

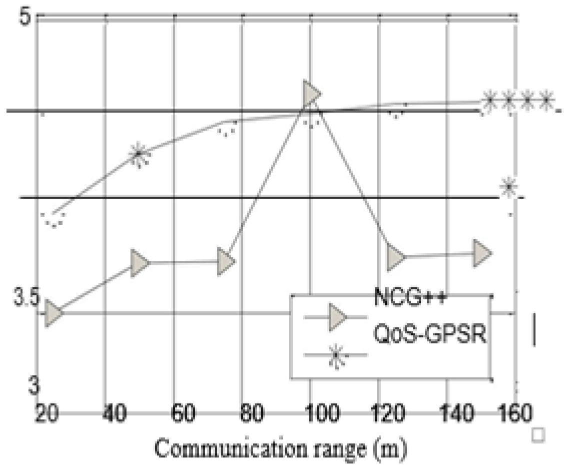
IV. SIMULATION RESULTS

Video Delivery Completion Ratio (VDCR)

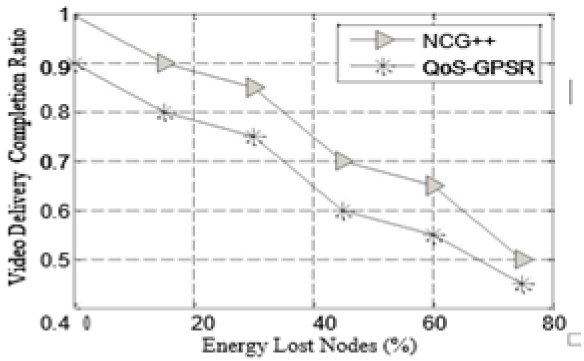
The VDCR is the ratio of number of completely delivered video streams to the number of transmitted video streams. The Figure 5 shows the Video Delivery Completion Ratio graph describes the completely delivered number of videos. It is degraded when the percentage of energy lost nodes is increased. . In networks, at the initial stage all the nodes are resourceful in terms of energy and hence the VDCR is high.

Energy Utilization per Data Flow

The energy utilization per data flow denotes the percentage of consumed energy for single data flow.



The Figure shows the energy utilization per data flow. The node spends less energy when the communication range is reduced. The NCG++ routing achieves the reduced energy utilization by reducing the communication range when the node energy is less than the EM than existing protocol. In the case of void area, to reduce the delay the NCG involves the VDR process which consumes high energy due to the expansion of forwarding area. In contrast, the QoS-GPSR employs perimeter path under void area which consumes less energy and high delay. Hence, in the communication range of 100m, the proposed work consumes higher energy than the existing protocol under the void condition. Even though the proposed work consumes high energy under void, the QoS is achieved in terms of less delay.



V. CONCLUSION

This paper presents a network capacity based routing protocol NCG++ for multimedia streams under MANET. The delay sensitive multimedia applications are affected due to the unpredictable node mobility, node energy, contention for channel access, and the node communication in under a large scale network. In existing protocols, the routing QoS is reduced due to the lack of attention on network capacity. Hence, the proposed NCG++ considers the network capacity to take the routing decision. In proposed work the network capacity metrics such as data rate, network size, average mobility rate, and node energy level are measured to estimate the minimum energy level (EM) to achieve the routing QoS.By using NCG++ routing, the data forwarders are effectively determined based on the network capacity. From the simulation results, the routing QoS is achieved in terms of high VCDR, reduced frame setback rate, and reduced energy utilization

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