Distributed Small Satellite Network and the Routing Protocols

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ABSTRACT---Availability of data anywhere, anytime and to anyone is the need of the current generation. One approach to cater this growing demand is using Satellite communication, especially Low Earth Orbit Small Satellites Network (LEOSSN) [14] [15]. LEOSSN with formation flying have worldwide coverage capabilities providing ubiquitous data. One of the technical challenges is in designing efficient routing algorithms to route network traffic in LEOSSN. The protocols are discussed with respect to traffic prediction, loading conditions, virtual network, QoS parameters, delay and packet loss. This paper provides the survey of the routing protocols which provides a baseline for improvisation or development of new routing techniques.

KeywordsSatellite Communication, LEO Satellite Network, Routing protocols, QoS parameters, Packet loss, traffic and loading conditions, Shortest Path Algorithm (SPT).

I. INTRODUCTION

Based on the Satellite orbital types, they are clasified into two categories: Geostationary Orbits (GEOs) and Non-geostationary Orbits (NGEOs) (like MEO and LEO). GEOs are placed of about 36000 km above the earth surface. A satellite in this orbit can cover a maximum of 30% of earth. GEOs have larger delays, such as 250 msec. Some of the challenges faced by GEO's are high power, big antenna requirements and the high cost of the satellite. On the other hand, LEO satellites are placed vey close to the earth. approxiamately of about 400-2000 km above the earth surface. Their round trip delay is about 20ms. Shorter delays give benefit to few applications where the satellites can communicate with low power capabilities, but the amount of time the satellite is visible to the ground station is very less (approximately 10 -15 mins) . Hence the data transfer to the ground for this short duration is limited and continuous data transfer becomes the bottle neck. Hence routing of data from one node to another in the network helps in continuous data transmission.

One of the approach for continuous transmission is by mathematical modelling of routing operations with systematic inferences using a network of satellite constellation. Satellites in LEO communicates with their neighboring satellites by inter-satellite links (ISLs). The source satellite send the packets to a specific destination satellite through a path which includes source address, destination address and intermediate satellites address through which the packets flow in the LEOSSN. When the traffic density exceeds a threshold, the packets are blocked/dropped/retransmitted based on the Qos of application mission. Hence an optimal path for data transfer between nodes in the network, must be determined. In this paper different routing protocols are discussed with respect to Low Earth Orbit satellite network. Various parameters MEO for and LEO constellation are as shown in Table 1.

Parameters	MEO	LEO
Height	hM=10390km	hL=700km
No.of planes	M_N=2	L_N=12
No. of satellite per plane	P_M=5	P_L=24
Angular velocity	M_W = 10min	L_W=3.60min
Angle of orbit inclination	45^o	NA
Angle of minimum elevation	emin = 10^o	NA

Table 1: LEO and MEO constellation parameters

II. ROUTING PROTOCOLS

Routing in LEOSN deals with providing paths for the transfer of data between the satellites in a network or to the ground station.Source node, destination node and intermediate nodes are connected through time-variant Inter-satellite Link. Dynamic nature ofsatellites (includes both source and destination) may be time variable and also the link path. Various services have different Quality of Service like file transfer gives more importance to packet loss, throughput, jitter and delay.

III. ASYNCHRONOUS TRANSFER MODE (ATM)

An asynchronous transfer mode (ATM) based idea to route the data in a LEOSSN is mentioned here. Virtual Routing Connections (VRCs) is useful in making virtual topology that connects every pair of end nodes in the Inter Satellite Links for entire duration before actual data transmission, just like implementing a collection of routing tables. Depending on Shortest Path algorithm the search on end-to-end routes is done in an ISL network capable of dealing with a Dynamic topology [1]. With relevance to ISL topologies , the choice of a path at the time of call setup time is optimized. User mobility and orbital satellite movement lead to dynamic satellite network configuration. Connections will be switched over to next satellite according to user path. Once they leave the outgoing satellites topographic point leading to the necessity for

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locating a new route through a sub-network. Ensuring Virtual Routing Connections, one could contemplate the precise case of getting one VRC for each source-destination satellite pair with n satellites within the constellation and n(n-1)/2 VRCs build a virtual topology. Here, the simulation approach is split into 3 steps:

Topology setup: This suggests that each potential ISLs may be calculated for the full system time in the design process much before the system gets started with its operation. Having these potential ISLs, the task is to proceed towards a fairly restricted connectivity. This means that remote satellites have to be dropped, for example those crossing many orbital planes. ISLs can't be maintained properly throughout the full periodin case if the satellites miss visibility.

VPC Path Search : Now, having ISLs known, next step is to look for the end-to-end routes. Based on Shortest path algorithm taking into account different cost metrics like Weight of Link (WL) and Total Weight of Link (TWL), Perm, Geogr,reknowned Dijkstra's algorithm is used to outline a set of the minimum-cost routes for every pair of satellites in the least time intervals. Every short link Virtual Route between one satellite and the other is supplied with a weight link showing its expected cost for a given interval of time. Weight of link can be calculated by the distance between two satellites: larger the distance, the higher is that the link hooked up.

A parameter namely Perm assigns cost to ISLs in such a way that permanent ISLs having lower costs. The duration of ISLs is viewed as a value indicated as parameter Perm, assigning least costs and therefore leading to preferrential routing over such links. Satellites crossing oceans or Polar regions get lesser calls than ground in a medium latitude region. This unequal traffic needs correct traffic distribution shaping in area to boost potency of traffic routing. Based on traffic demand a parameter Geogr assigns costs to ISLs of satellites usually higher costs will be assigned to higher traffic demand.

Optimization Procedure: Hand-overs with respect to Virtual Routing Connections must be minimized, which otherwise have abrupt effect on the traffic load of the related nodes. The load on satellite node if increased above a threshold value after re-arrangement, then it lowers Quality of Service of connections which are at present. Moreover, each VRC handover action is probably going to have an effect on the other single end-to-end connections (VCs), different path distances leads to a kind of sudden modification in path delay. Having a check on VRC-HO reduces both flow control and QoS degradation. Having all these factors, the objective of the conferred optimization procedure is minimization of the VRC handover (VRC-HO) rate for given period of time, but the after effects arising, for example, sudden higher costs is also evaluated in terms of TLW or TLW jitter.

Algorithm 1: Algorithm for Asynchronous Transfer Mode

Step 1: Virtual topology is made of virtual connections connecting every node with ISL in advance.

Step 2: End-to-end routes are determined in the network using M-DSPA

Step 3: Variable cost metrics like Weight of Link (WL) and Total Weight of Link (TWL), Perm, Geogr are considered to find the least-cost paths for a given satellite pairs at a given interval of time

Step 4: To avoid ill-effects on the involved nodes because of sudden changes in the traffic load, optimization procedure is carried out.

IV. DECISION ROUTING ALGORITHM WITH TRAFFIC PREDICTION (TPDRA)

In TPDRA, Neural Network (NN) is employed to predict satellite node traffic, whereas mobile carrier facilitate in collection of network data that is helpful in guiding transmission of data packets. Along with current state, future state of the network decides the routing path. Once the bursty traffic is returning, TPDRA predicts this alteration and receiving satellites node receives an advance notice. At present, statistical regression analysis, time series forecasting and wavelet prediction are normally used prediction algorithms [2].

As a hotspot of intellectual management methodology, Artificial Neural Network is extensively applied in several frontiers because of its capabilities of self-study (learning), self-adapting and multiprocessing. The combination and simulation of the hidden layer calculation unit in neurons, NN will efficiently connect the relationships between dependent and independent variables. In specific, NN is very effective and appropriate for non-linear situations. This routing prootcol with traffic prediction are often divided into two stages, traffic prediction and routing decision.

Traffic prediction: When a satellite moves at high speed on its orbit, the track of sub-satellite point will shift due to the rotation of earth. Hence two assumptions are introduced. State of satellite node represents its traffic load, i.e, the traffic density of satellite node depends on the queue length of link at satellite node and also the ISL capability. If queue length valueis nearer to ISL capability, then satellite node is in busy state. If an area under sub-satellite point has higher traffic, then nodes around them avoid forwarding data to that satellite. If an area under sub-satellite point is lower, for example over the desserts, proximity nodes of the source satellite will send the information.

TPDRA is answerable for traffic control and regulation. The importance of TPDRA lies in revising the traffic from earth stationusing NN and enhance the use of satellite network resources.

Routing decision strategy: In routing decision stage, Mobile Carriers (MC) is helpful in gatheringand exchanging information of satellite network. MCis classified into forward carriers and backward carriers. The idea behindrouting strategy is that forward carriers generated by satellites move among satellites. Once forward carriers hit destination satellite, they give rise to backward carriers. Later, backward carriers generated will move in opposite direction to estimate path value, finally update routing tables of the visited satellites. Forward carriers is answerable for network exploration and data assortment,

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whereas backward carriers take the routing data from the forward carriers and updates pheromone matrix.In TPDRA, every satellite node 's' has fivecomponents:

Pheromone matrix Ts: This routing table helps in selecting the next hop among neighbouring nodes towards the destination having entries identical to entries in distance-vector algorithms.

Data-routing table Rs: This routing table is a kind of random matrix and its entries are identical to pheromone matrix. It is helpful in transmitting data packets. The entries of Rs are obtained by re-normalization and exponential transformation to the corresponding entries of Ts.

Link queues Ls: Ls with respect to a node corresponds to its data structures. For a given interval of time, a sketch on the current status of the native link queues areprovided. Here Ts represents a long-term information collected by the mobile carriers of the network. **Prediction traffic Ps:** Ps is data structure that records the anticipated traffic from the earth station. The entries of Ps are obtained from radial basis function neural network and judge the future status of satellite nodes together with link queues Ls.

Statistical constant model Ms: Mscould be a vector of N-1data structures and represent the mean value of the samples and also the time variance traveledto arrive destination d from this node.

Algorithm 2: Algorithm for Traffic Prediction with Decision Routing

Step 1: Determine the network traffic of the nodes in the satellites using Queue length of ISL as the decision attribute.

Step 2: Forward the data through the satellite, based on traffic under sub-satellite point. If traffic is high,avoid forwarding else forward data to the node.

Step 3: Mobile carriers determines the routing path (intermediate nodes) using forward and backward path using RBFNN algorithm.

V. CONTROL ROUTE TRANSMISSION (CRT)

Most of the algorithms send packets using geographic positions, therefore it is expected that they either simply result in congestions or higher propagation delays. CRT accounts for network load and scale back packet loss &enhance the QoS and uses a mesh topology. Every satellite has N neighboring satellites and has M transmitters and M receivers and they will exchange information at the same time. A Virtual Node (VN) strategy is employed and CRT protocol focus mainly on scheduling of variable length message bursts to destination node from the sourcenode.

One such example is shown in the Table 2. The source satellite gets a message burst from earth station having the information about destination node in their header. Based on the acceptance or rejection of the request further transmission will be carried out. If accepted, then source node computes the fastest route from current node to destination, create a ''START"packet for the burst having the required information for routing, and all the packets insequence will continue to follow. A ''STOP" packet is generated by source node when the burst is complete, that is distributed on the identical route and signalling to any intermediate node at the end of message sequences [3].

To arrive at the fastest route, time instants of length dt (typically, 0.05s) are considered. Control Message (CM) is broadcasted to all the nodes within the network in the beginning. The optimised version of this protocol is mentioned in formation flying in relevance to small satellite network using clustering operation [16].

Table 2: Exchange of traffic Information between Source and Destination nodes

	Destination Nodes									
Source Nodes		0	1	2	3	4	5	6	7	8
	0		8	7	4			9		
	1	8		1		4			7	
	2	5	7				9			9
	3	2				5	9	1		
	4		5		5		7		8	
	5			0	5	0				8
	6	0			2				6	8
	7		1			0		9		4
	8			3			5	6	4	

CM indicatesnumber of bursts being sent at present on outgoing link of its source node. A graph may be drawn having nodes representing satellite and an arc (i, j) representing the ISL that connects the two satellites i and j. Weight on arc w(i, j) records burst count currently being sent on ISL (i, j).

And this directed graph records existing congestion status of the constellation. Initiallyall weights are zero. Upon receiving a control message to satellite node X from node Y, Graph is updated, new shortest routes is computes from X to all other routes and recorded in Shortest Path Table. The Control Messages are recorded in a congestion matrix M in which row is a representation of satellite node and a column represents outgoing link direction. Table 3 shows the congestion tablewhich showcase the congestion status.

Table 3: Congestion table

Satellite ID	North	South	West	East
0	0	5	8	9
1	8	5	9	2
2	0	0	9	6
3	3	2	0	6
4	6	9	6	8
5	1	9	1	6
6	3	1	9	7
7	1	2	0	5
8	6	4	5	7

This algorithmic rule chooses the simplest routes by using SPT considering congestion status.Every time a CM arrives the congestion table is updated. Hence the routes are dynamically adjusted bythe to ensure balanced traffic.

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The protocol shows good response to congestion havingrequired number of satellites to show enough number of
alternative links for a given data. In particular, the overhead because of CM in CRT is incredibly low, performance is best compared withnon adaptive algorithms for low traffic load, and end-to-end delay and node loss ratio are extremely reduced using CRT in case of medium traffic load conditions.

Algorithm 3: Algorithm for Routing in CRT

Step 1: Determine the network bursty traffic of the nodes in the satellite network.
Step 2: Send the control message to all the nodes on their willingness to act as an intermediate node.
Step 3: Determine the routing path using time epoch and send the burst to the nodes using start Command.
Step 4: Stop Message is sent when all the packets in the burst are completed.

VI. PREDICTIVE ROUTING PROTOCOL

High quality of the satellites and limited on-board processing ability needs the routing tasks to be executed at ground gateways. The information related to bandwidth availability on every ISL is stored by gateways and therefore the location and traffic patterns of users. Each and every call includes general traffic information such as user application type, packet generation rate, and the delay constraints.

Ifthere is a requirement of newconnection, a request is sent to gateway station. Geographical position information of the end users are sent in response along with requested delay bound. Limited capacity of ISL's and network resources are used in finding a route to ensure efficient resource utilization, still serving and maintaining largenumber of calls with varying QoS needs,delay jitter bounds. A call will be accepted by the system,if its QoS needsare satisfied during call life time. The network resources must beutilised to its maximum. The messaging and signalling overhead of the routing protocol must be reduced. Since on-board processingcapacity of satellites arerestricted, quantityof datastoredfor everyassociationwill bereduced.

A large ratio of calls are maintained compared to other techniques satisfying the resource constraints of the network. Initially, the entree determines a route for a given call according to the available satellite link bandwidths discovered at the moment call request is received. Because of satellite mobility, at time t > to, the satellite might serve users who may be required to use the same links as those used by the call under observation. This might lead to high load on these inter-satellite links. Any new call accepted must not degrade the QoS of on-going calls. Ongoing calls have higher priority than new calls, to ensure the qualityof service of on-going calls and the route chosen for anew call must be in such a way that it will not lead to congestion.

To predict future calls on the ISL, the link state information collected from satellites are utilized by the ground gateways. Bandwidth sufficiency on the links are checked to confirm that enough bandwidth are available for a call, for all times, t, such that to<t<to + Ts.

Algorithm 4: Algorithm for Predictive Routing Protocol

Step 1: Determine the network traffic of incoming calls to be routed to the destinationbased on resource capabilities and assured QoS to the user.
Step 2: Call routing is decided on various parameters of satellite node like jitter, ISL, QoS (CBR/VBR) and on-board computational capabilities of the node in the network.
Step 3: The routing paths are dynamic in nature and differs in paths periodically due to mobility in network and the users.
This protocol is mostly used based on geographical positions.

VII. PQWRR ROUTING PROTOCOL

PQWRR stands for Priority Queuing Weighted Round Robin. It's a hybrid schedulingalgorithmic rule combining PQ and WRR scheduling algorithm. In this protocol, all the packets are given priority and packets with higher priority are going to be served first. The good thing about giving priority is to have best delay and jitter performance meaning the delay & jitter kept minimum. However the packets with lower priority are seldom served thatcould be a limitation in this scheme.WRR schedulingpolicy ensure that there'sa fair allocation of bandwidth.

Traffic is made to pass through different streams based on its category, traffic category X are sent to high priority stream and waiting to be forwarded, traffic category Y are transferred to corresponding low priority streams. Oncepackets from X streamis completely forwarded, traffic category Y are sent in accordance with WRR scheduling policies. This leads to combined benefits obtained from algorithms WRR and PQ, also overcome their limitations and better multiservice traffic. This routing policy helps tocontrol traffic congestion and gives rise to balanced traffic distribution within the network and optimize resource allocation. Multipath routing willassign traffic to multiple routes, use a lot of nodes to complete the task of traffic transmission, improve network resource utilization and load balancing. The multipath routing mustcontemplatethe present traffic demand, if the traffic to be sent is small, multipath routing will be wasting resources. Also it must be able to provide different routing policies according to their traffic QoS.

Shortest path table is made with the help of virtual topology and is calculated offline with respect to network configuration within each timeslot. The link state and weights on the link between the network nodes are two major variables to explain the configuration, for LEO network, every satellite will have connection with four neighboring satellites, having couple of inter-satellite links (ISL) and a couple of inter-orbit links(IOL), ISL length will not vary over time,

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however IOL length varies because the satellite moves. Additionally, ISL connection is static, whereas IOL connection is dynamic. When a satellite reach

higher latitude, IOL connectionwillturn off, angle of visibility between satellites may reduce.

The rate at which the traffic arrives for a satellite is denoted by 'r' and has two thresholds: idle threshold x and busy threshold y. There is a need to always have a track on arrival rate of traffic for satellite nodes. When r<y means that satellite is in its busy state, when r<x means that satellite is in its idle state, defining x<r<y as a transition state. Monitoring the satellite condition, if there are any changes in state busy/idle occurs, they are noticed by routing control centre and neighbouring satellites. When neighbouring satellite getsbusy signal, traffic is lowered to avoid node congestion, and routing centre will ignore busy satellite node from the network topology and update routing table.

Algorithm 5: Priority Queuing Weighted Round Robin Routing Protocol

Step 1: Each node determines its own traffic (both self generated traffic and incoming traffic) Use priority queuing of the request (self generated/other nodes).
Step 2: Determine multipath routing based on the loading conditions to avoid congestion and packet loss.
Step 3: The data received and sent from the node depends on the availability of resources.
Step 4: If the congestion still occurs the process reiterates to recompute the routing paths again.

This protocol is mainly used when the traffic in the network is high.

Next hop towards destination is chosen according to the SPT table. Based on its current status, traffic will be forwarded if the next hop node is idle, else if the next hop node is in busy state, then based on the traffic category appropriate decision will be made on the forward direction: traffic category X are going to be sent to the next hop satellites looking up to backup table and look for an alternative for next-hop for category Y, if no next-hop node adapt to the conditions, traffic category Y are going to be placed into waiting stream and wait to be sent once routing table is updated.

FiniteState Automata(FSA) Algorithm

FSA routing algorithm resolves the routing in satellite networks, whose optimisation objective is to maximise ISL utilization. The satellite constellation described in FSA is classified based on predetermined time slices, and therefore the algorithm could be a connection-oriented routing algorithm. Every time slice is considered as a state and the respective network constellation as a finite state machine.

The system cycle is divided into different states depending upon the information with respect to ISL connection state , and

each state hasa fixed topology. Due to the restricted numberof states and periodic nature of satellite topology, the best path may be established in each statictopology. An FSA based link assignment technique is employed to simulate the satellite constellation as static network for a given time period.

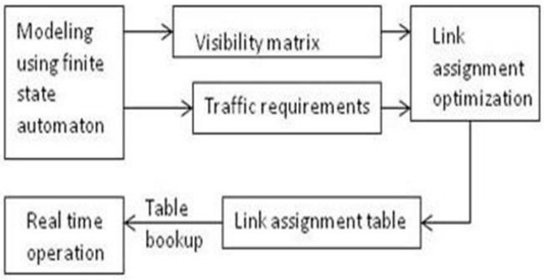

Figure 1: FSA based link assignment scheme

Thus, the satellite network routing drawback is remodeled into an optimisation problem of the virtual network link assignment topology in a finite state machine.An FSA based link assignment scheme is shown in Figure 1. The assignment of links for every state is set from the visibility matrix and traffic necessities.

This protocol has a combined solution for routing and linkassignmentusing a repetitive methodology, that provides best link allocation table, and has communication routes in each state for every node [6].The advantage ofFinite State Algorithm is its network resource optimisation techniques. The disadvantages are that the shortest path principle isn't the route selection customary and also allocating links dynamically. The FSAis an off-line routing algorithms, and belongs to the category ofvirtual topology based algorithm in a connection-oriented satellite network.Computations with respect to routing abide by the Newton's law of motion of satellite. With all the statistical characteristics of traffic,schemes are in such a way to adapt itself to ensure the standard of service and efficientresource allocation within the current network. As a result of advance preparation of routing table of satellite nodes, the network survivability is not sensible. If specific satellite link fails, the algorithm fails to see the presentnetwork state.

Algorithm 6: Algorithm for Finite State Automata

This technique is used to minimize the no. of packets lost and resent during transmission
Step 1: Initial Link Assignment Table is calculated offline based on the concept of keeping limited Round trip Time (RTT) wrt TCP timer granularity.
Step 2: Check if RTT is under threshold
Step 3: If Yes, then stop the algorithm, problem solved.
Step 4: If No, then a single link in the initial table is changed.
Step 5: Calculate RTT for this new link assignment table. Check if the number of RTT's under desired threshold.
Step 6: If the result is worse than the previous time then step back to step 5 else the new link assignment is kept as a reference.
Step 7: Repeat step 2 until all RTT is under threshold.

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VIII. COMPACT EXPLICIT MULTI-PATH ROUTING

The shortcomings arised due to multipath routing in a satellite network is addressed by CEMR. Here path encoding is done with the help of Route Identifier (RID). This RID has the details of transmission path with the help of which packets are sent through specific intermediate nodes. RID is composed of the ISL interface symbol segment used throughout the world.RID validation algorithm make sure that the accuracy is achieved along with the consistency.

A complete cycle is classified as a number of discrete time snapshots in a dynamic satellite network. For shorter time period satellite link cost is assumed to be constant. A shift in time period is understood as one transition state that is a change over from current time period to next time period.

Multipath CEMR routing includes 3 major divisions: route discovery, route maintenance, and traffic assignment [7]. The time delay and path cost shows routing performance. The time delay include both propagation and queuing delay. RIDis utilized to have the global path, that realizes the specific multi-path routing within the LEO satellite network. CEMR algorithmensures lower delay, proper load balancing and increased throughput, as a resulttraffic is split towards two or more possible adjacent routes.

Algorithm 7: Algorithm for Compact Explicit Multi-path routing

Assume Network configuration will not change in a given time interval.

Step 1: Encode the sequence of nodes and ISLs as a compact Route Identifier (RID) which is globally known and unique for every path.

Step 2: If the transmissionis completed within one timeperiod, the RID calculatedis assumed to be correct.

Step 3: If data packet experience transition throughout its transmission period, the intermediate satellites ought to validate the RID to point whether or not the packet experienced time interval transition before reaching destination satellite.

Step 4: On receiving a packet, current satellite can validate RID based on Transition Indication Field (TIF)

IX. ELB ROUTING ALGORITHM

It sometimes happens that the data packets are lost during its transmission. Predicting the chance of losing data packets has become a difficult task even when the delay time is closely observed and taken care of.Hence Explicit Load Balancing algorithm comes into picture which avoids the chance of losing data packets and achieve balanced load. Neighbouring satellites exchange the information data congestion more often. Suchexplicit communication helps avoid the satellite node getting congested. For example the congested node request to scale back the packet sending rate to the neighbouring satellites with the help of this routing algorithm.This makes the neighbouring satellite nodes to choose alternative path. In this technique, a smooth flow distribution is seen between the satellites, avoiding the congestion and ensuring information loss, hence this scheme is known as Load Balancing scheme. In this scheme, the satellite includes several parameters to describe the congestion status and ratio of information rate .

Different mathematical models are used to configure system parameters. ELB routing algorithm has the ability to solvetraffic flow cascade issue, which can occur throughout the traffic detour. Unenclosingthe backup path is helpful in forwarding a part of the information without node congestion. Fornow, the system mustmake sure that the selection of the transmission path doesn't have an effect on the transmission of the previous destination path.

Algorithm 8: Algorithm for Explicit Load Balancing

Step 1: Current status on congestion is exchanged by neighbouring satellites.

Step 2: If the nodes exceeds a pre-determined threshold (β) means they are likely to getcongested soon.

Step 3: To avoid congestion and packet loss, satellites running under higher loadsrequest their neighbouring satellites to scale back their information rate.

Step 4: In response, the neighbouringsatellites look forlesser congested routes and communicate a preset portion of their data through these path.

X. PAR ROUTING ALGORITHM

It ispossible that we have more than one shortest path for a givenpair of satellites in the non-synchronous satellite constellation. Priority-based Adaptive Routing take into consideration the link utilization and historical information so as to attain a uniformdistribution of load. A number of distributed path is set by the PAR towards the destination, employing a priority mechanism which depends on the historical utilization and cache information of the ISLsso as to avoid excess data traffic and acquire higher link utilization, the improved PAR algorithmis formed.

The source and destination most likely to have multiple shortest path. As soon as the data packet is received by a satellite, the search for destination node begins. If the end node is simply within the same latitude, then there will be only a single shortest path. If not (outside the latitude), four such adaptive paths are outlined, the choice in selecting direction among multiple path depends on the routing algorithm. The ePARis one such routing algorithms which is an enhanced version in the satellite networks [9].

Always the use of fewer links are preferred and is a priority mechanism followed in selection of paths and this is how hop nodes are carefully chosen for the transmission of packets. The ePAR rule provides few enhancements in searching identical links for a given pair of satellite nodes for packet transmission. PAR rule always look forminimum hop path, able to handle the ISL link length and also minimize the end-to-end delay. For improvization,

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it must be thought-about to merge ePAR with some more protocol to evolve to the continuous variations in the network configurations.

Algorithm 9: Priority based Adaptive Routing Algorithm

Step 1: Each source-destination pair has multiple short paths, hence path decision is made based on priority mechanism

Step 2: At each hop, one out of multiple link is chosen depending onhistory of utilization and buffering information of those links.

Step 3: Design parameters (α,β,δ) are adjusted properly according to traffic requirements and network characteristics to achieve load balance and avoid fluctuation in a congested link.

Step 4: Performance of PAR algorithm can be enhanced by the involvement of priority metric for traffic traversing.

XI. DDRA ROUTING ALGORITHM

The DDRA (Dynamic Detection Routing Algorithm) is a routing protocolsupporting a virtual topology strategy. The ACK (Acknowledge) helps in validating appropriate condition of a linkper and also counting the number of packets on the satellite outgoing stream. On top of that, it will find a link and build acceptable changes in time [10].

Majoradvantage of this algorithm is lower time delay. If an unknowing network condition arrives, this protocol to adapt to the situation and returns ACK, showing ability to avoid link congestion and failure in time virtualization schedule. To achieve multi layer satellite network, virtual topology strategy is a better option compared to virtual nodes. If the Routing tasks are done off-line by the ground gateway, then majority of load on LEO network is reduced. However this can also be done by satellite set within the higher level for a period of time . In this virtual topology, an outsized range of time slices is available, because of which estimation of the routing protocol willgo up and becomelot more difficult.

Algorithm 10: Algorithm for Dynamic Detection Routing

Step 1: An outsized range of time slices are generated in an exceedingly virtual topology and network is initialized based on the topology of time slices.

Step 2: Calculate routing path algorithm according to shortest path principle.

Step 3: Load new topology and recalculate routing table once there is a need to update

Step 4: In case of any modification, the communication link has to be deleted androuting path must be recalculated within the current satellite.

Step 5: If the engorged subqueue is empty, respective communication link is recovered.

XII. LZDR ALGORITHM

The LZDR (Localized Zone Distributed Routing) is a category of connection-basedrouting with a virtual node strategy. Polar orbit satellite network is modelledas a normal MSN network and has described localized zone distributed routing. The LZDR doesn't divide the routing zone in line with one virtual node,but combines the adjacent virtual nodes into single zone. The calculation includes intra-zone and inter-zone routing. For intra-zone routing, LZDR defines a virtual node in a zone for the routing controller within the zone and confirm the packet transmission between zones in accordance with the minimum hops metric.

For inter-zone routing, the nodes within the zone must exchange info with one another and also the packet must be sent in shortest path in line with the time delay [11]. TheLZDR protocol tries to scale back the overhead with respect to communication in the routing technique. However, the protocol solely describes the strategy for finding inter-zone routing in line with the minimum hop path.It fails to entail the categorization of the boundary region and information with respect to network loadis not exchanged between zones, thus, it cannot guarantee the optimality of the inter-zone routing. Moreover, the LZDR rule is not applicable to the inclined orbit satellite constellation but solely applies to the polar orbit of the LEO satellite network.

Algorithm 11: Algorithm for Localized Zone Detection Routing

Step 1: The rule has two-stage routing: interzone static and intrazone adaptive .

Step 2: In interzone routing rule, shortest interzone routes are determined with the help of modified MSN binary addressing methodology that may be a straightforward direction detection technique.

Step 3: The intrazone routing protocol routes the packets adaptively using the data received from the interzone routing algorithm and statistical traffic condition of the routing zone.

Step 4: When these packets reach the subsequent routing zone, the routing controller of that routing zone carries out another process of interzonerouting .

Step 5: The route and forward method repeats until the packets reaches the destination satellite.

XIII. LCPR ALGORITHM

The Low-complexity Probabilistic Routing Algorithm is an enhancement of the DRA routing algorithm. This technique always focus on finding next hophaving a data packet in hand by using the geographical information of the source node and destination node, the distributed computing methodology is employed to have the best path and therefore the queue delay is taken into account meaning having a packet in hand, Information

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analysis is made on the head of the packet to find out the location ofthe destination. By calculating the link between the Current node (Nc) logic number and the the destination (Nd), it's simple to understand the two logic number of the next hop candidate. The congestion status is shared with the neighbouringnodes which helps in finding the next hop. It is seen that the LCPR has reduced packet loss, queue delay and higher network performance compared to Dijkstra formula and DRA algorithm [12].

Algorithm 12: Algorithm for Low-complexity Probabilistic Routing

Step 1: Receive a packet with destination number from the packet head.
Step 2: If c/m < d/m, the candidate next hop in horizontal direction is Nc+n (where c &d are current & destination node and m is number of planes)Step
3: If suppose c mod n − d mod n < n/2, the following hop in vertical direction is North Carolina/n+(c−1) mod n (where Nc refers to logic range of current node).
Step 4: If the present node and the destination are within the same orbital plane, there's no alternative but to but to get closer to the destination vertically.
Step 5: If the currentnode is in a polar Zone, the packet can move to the neighboring node with lower latitude.
tep 6: If the currentnode and the destination are within the same relative position of various orbit planes outside the polar Zone, the packet can move nearer to the destination horizontally.
Step 7: If the destination is in polar Zone and the current node is in the special zone(where the latitude is between 70◦−360◦/n and 70◦), the packet has got to move horizontally tillit arrives the node in thesame plane with the destination.

XIV. RESULTS & DISCUSSIONS

Load Balanced Routing mainly focus on uniform load distribution. That is some of the links are fully loaded and others are idle. This reduces utilization efficiency of resource for a satellite. But again there are issues in load balancing. On one hand, these routing protocols cannot compute routes through satellite networks on real time basis. On the other hand, most of the protocols use a worldwide network status which is able to lead in an exceedingly high control overhead. The purpose of the Load Balanced Routing protocol is to realize higher load balancing to adapt to dynamic traffic variations. It limits the method of routing request within a rectangular area .The intermediate node load judgment mechanism and also the location help strategy are introduced into the route discovery method of the LBR protocol. LBR uses a dynamic threshold to mirror the real time state of the network average load.

Algorithm 13: Algorithm for Load Balanced Routing

Step 1: Every intermediate node compares its load with the dynamic load threshold.

Step 2: If it's value is larger than the threshold, it shows that the load on the intermediate node is more, and also the requested packet is discarded.

Step 3: Otherwise, the request packet is forwarded to the subsequent hop.

While forwarding the request packet towards the destination node, it is barely sent to the ISLs, that means route is well known. A path with lightest load is selected by destination node to make a respponse. The intermediate node load judgment theme is incredibly effective to realize load balancing and congestion avoidance. The location assistance strategy will scale back the controloverhead and lessens time for path discovery process. For node failures and alternative anomalies, using local repair strategy, LBR might repair the path on time efficiently, ensuring networks survivability [13].

XV. CONCLUSION

The routing protocols in satellite network are discussed in this paper. Few protocols like ATM, TPDRA, PAR, FSA focus on inter-satellite link capabilities required for routing of data from one node to another in the network and to the ground station. Other protocols like control route transmission protocol, ELB uses the control messages to compute routes based on the loading conditions in the network. Predictive Routing Algorithm emphasis on delivering deterministic QoS based on user application. CEMR (Compact Explicit Multi-path Routing) algorithm uses the concept of a globally familiar Route identifier, known as RID, that is a validating formula to ensure the packet forwarding to be correct and consistent at any instant of your time. PQWRR, DV-DVTR programming scheme performs uniform scheduling for expedited Forwarding traffic in terms of EF queuing delay and disturbance beneath a range of traffic conditions. These protocols emphasises on finding optimal path using topology, traffic conditions, Qos, link budget, time period, delay and jitter of the space environment and their comparison is as shown in Table 4.

		Load balancing	Delay/Jitter	Dynamic routing	Throughput	Ground Gateway Routing	computation	Packet loss
1	Asynchronous Transfer Mode			Yes, Time variant				
2	Decision Routing Algorithm with Traffic Prediction		Yes, Reduced delay			No		
3	Control Route Transmission	Yes, Balanced load	Yes, Reduced delay					
4	Predictive Routing Protocol					Yes		
5	PQWRR Routing Protocol		Low Delay & Jitter	No				
6	Dynamic Virtual Topology Routing (DVTR)			No				
7	Finite State Automata(FSA)	Not considered	Yes, high delay	No, Static Routing		Yes, using Earth-Satellite Link	Yes, high Computational complexity	
8	Compact Explicit Multi-path Routing	Yes, Balanced load	Yes, Reduced delay	Yes, Dynamic virtual topology	Yes, Increased throughput			
9	Explicit Load Balancing	Yes, Achieve Load balance	Not considered					Yes, Avoid data packet loss
10	Priority-based Adaptive Routing	Yes, Uniform Load	Yes, Reduced delay	No		No		
11	Dynamic Detection Routing Algorithm	Yes, Reduced Load	Yes, Low time Delay	Yes		Yes, Offline by ground gateway	Yes, more computation	
12	Localized Zone Distributed Routing			No				
13	Low-complexity Probabilistic Routing Algorithm		Yes, queue delay is considered					Yes, Lower packet loss
14	Load Balanced Routing protocol	Yes, Reduced Load	Not considered	Yes, Using Dynamic Load threshold				

Table 4: Comparison of different parameters related to Satellite Routing Protocols

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