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# A CONTEXT AWARE BASED PRE-HANDOFF SUPPORT APPROACH TO PROVIDE OPTIMAL QOS FOR STREAMING APPLICATIONS OVER VEHICULAR AD HOC NETWORKS – HOSA

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**Abstract**

Large variations in network Quality of Service (QoS) such as bandwidth, latency, jitter, and reliability may occur during media transfer over vehicular ad hoc networks (VANET). Usage of VANET over mobile and wireless computing applications experience "bursty" QoS behavior during the execution over distributed network scenarios. Applications such as streaming media services need to adapt their functionalities to any change in network status. Moreover, an enhanced software platform is necessary to provide adaptive network management services to upper software components. HOSA, a handoff service broker based architecture for QoS adaptation over VANET supports in providing awareness. HOSA is structured as a middleware platform both to provide QoS awareness to streaming applications as well to manage dynamic ad hoc network resources with support over handoff in an adaptive fashion. HOSA is well analysed over routing schemes such as TIBSCRPH, SIP and ABSRP where performance of HOSA was measured using throughput, traffic intensity and end to end delay. HOSA has been analysed using JXTA development toolkit over C++ implemented classes to demonstrate its performance over varying node mobility established using vehicular mobility based conference application.

Keywords: Quality of service, Streaming media, Handoff, VANET, Middleware policy management, Mobility, Context management.

## 1. Introduction

"Bandwidth on demand" streaming applications depend on underlying communication network infrastructure to provide access to user intensive services and utilization of resources. Ideally these applications do not concern about the networks used but focus only on the service functionalities being provided, which

**Nomenclatures**

| | |
|---|---|
| $C_i$ | Contour |
| $D$ | Distance between $T_{hmin}$ and $T_{hmax}$ |
| $ST$ | Signal strength |
| $T_{hmax}$ | Maximum handoff time |
| $T_{hmin}$ | Minimum handoff time |
| $T_{max}$ | Maximum time to expire |
| $T_{min}$ | Minimum time to expire |

**Abbreviations**

| | |
|---|---|
| AODV | Ad hoc On Demand Distance Vector Routing |
| API | Application Programming Interface |
| GPRS | General Packet Radio Service |
| GPS | Global Positioning System |
| HAND | Handoff Module |
| HOSA | Optimal QoS Middleware for Streaming Media over VANET |
| IETF | Internet Engineering Task Force |
| IrDA | Infrared Data Association |
| JXTA | Juxtapose |
| QoS | Quality of Service |
| TC | Traffic Class |
| TOS | Type of Service |
| VANET | Vehicular Ad-hoc Network |
| WLAN | Wireless Local Area Network |

is complex to support in practice. Large variations in network quality of service (QoS) (e.g. bandwidth, latency, jitter, reliability) may occur during media transfer over dynamic, highly volatile ad-hoc networks which lead to service degradation and increase the faulty nature of system.

Communication over mobile networks is established based on device portability [1] and wireless network connectivity [2]. The end user's terminal highly vary in terms of processing capabilities, input and output capacities, energy consumption, and networking technologies including error rate, signal fading and interference, etc. User mobility on a mobile or wireless device leads to consistent change of location, environment, network operator or service provider, and access networks. Issues such as handoff during a complete session add to the source of network variations in terms of session transfer, end to end delay, packet loss, jitter which contribute to latency factors of network.

In this paper, an optimal QoS scheme with resource reservation policy approach for VANET is discussed, with support over handoff reservation over a call session based on optimal service quality metrics, as well as consistent monitoring and controlling with binded quality during dynamic runtime environment. The objective of the model is to explicitly deal with the coexistence of ad-hoc networks built by multiple devices supporting distinct technologies and aiming to exchange media streaming messages. Based on this model, and assuming that in general, nodes are not able to directly communicate one with each another, a set of resource awareness services were devised to establish communication path among nodes through intermittent available nodes. The proposed set of services [3, 4] consider the policies for sharing network resources such as bandwidth, route capacity management along with service profile preferences, thus allowing to tailor the network services. Resource awareness services are layered under a set of communication services in a middleware architecture enabling communications among nodes belonging to distinct ad-hoc networks.

From the focus of research the following issues need to be addressed

- To analyse the aspects of providing QoS over VANET with support for pre hand- off.
- To design a middleware which needs to provide support over QoS, resource management and route control during a call session.
- Suggest mechanisms to handle handoff with optimal utilization of peer node resources and satisfy end-to-end QoS with minimal response time delay over media streaming applications.

To provide quality of service (QoS) with adaptable end-to-end delay, a middleware approach is proposed with support for handoff mechanisms. On analysis it has been identified that the current generation of commercial-off-the-shelf routing protocols lack in providing adequate QoS support and handoff brokerage in any changing, dynamic environments.

This paper contributes to the study of adaptive middleware by first suggesting how priority and resource reservation with network QoS management mechanisms can be coupled with the existing standard off-the-shelf distributed network, OS using distributed object computing framework to support dynamic run time applications with stringent end-to-end real-time requirements. The paper also discusses on the results of experimentation and validation activities being conducted to evaluate the objective of QoS and handoff mechanism over heterogeneous OS, network, and middleware capabilities.

Current QoS models with handoff support functionality such as TIBCRPH [5], ABSRP [4], and SIP [6, 7] are primarily oriented towards supporting QoS aspects in network layer and transport layer. But providing an end-to-end control from the low-level network parameters such as bandwidth, packet delivery ratio and transmission rate, up to application layer requires a transparent setup to support in QoS, termed as HOSA as shown in Fig. 1.

HAND is a handoff module which works as a middleware in communication with multiple VANET nodes on mobility. HAND provides support to optimal QoS with effective resource reservation and utilization among nodes on utilization. HAND defines network components as objects and provides a distributed binding among objects since there is an increasing need for network usage aware applications with focus on network performance and quality. The service and components should be more intelligent of network in order to adapt to various environments. On the other hand despite of the differences in the functionality of the applications, the main networking services can still be abstracted to common and unified interfaces to be used by diverse applications. Adaptation functions need to be rationally distributed into both specific applications and a general system platform, and then implemented with distinct mechanisms.

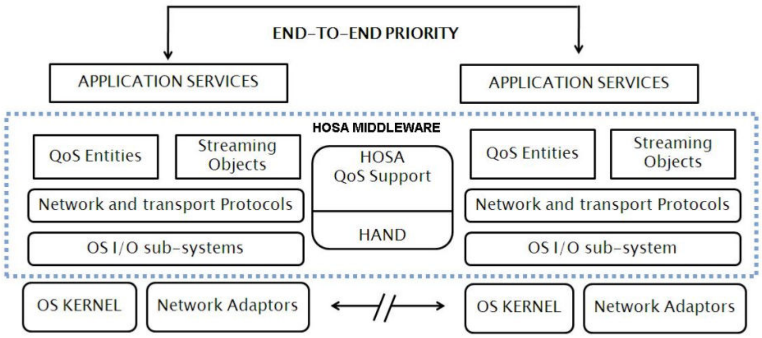


**Fig. 1. HOSA End-to-End QoS Architecture.**

HOSA (an Optimal QoS Middleware for Streaming Media over VANET) is middleware architecture for adaptive applications based on network resources and service awareness. The architecture works on physical, data-link and network layers of mobile devices. HOSA provides flexible network support to adaptive network applications with a set of functions and interfaces. The overall architecture of HOSA in this paper lays emphasis on the methodology of delegating the application and network components to form context aware and support in providing adaptive networking services to network-aware applications.

The rest of the paper is organized as follows: Section II presents the literature review on related handoff QoS architectures. Section III discusses on the HOSA architecture and the context issues adopted in HOSA as well the methods to realize context awareness. Section IV discusses the realization of adaptive network supports and the utilization of them in the adaptation of application. Section V concludes the paper.

## 2. Review of Literature

Singh et al. [8] had implemented GPS assisted low latency handoff scheme for 802.11 based wireless networks which adopts the longitude and latitude coordinates of its neighbouring mobile nodes during handoff. Even though this approach may support handoff with higher throughput this approach consumes high energy consumption since the mobile nodes are equipped with GPS and follows ADOV protocols which uses multiple request (REQ) and reply (REP) procedures to establish handoff.

Subramaniam et al. [9] modelled QARS as a set of high speed vehicles on straight highway in which any vehicle can establish connectivity with other vehicles which are travelling in variable directions of its motion. Vehicles which are within the range can communicate or help in forwarding the data to be transmitted. QARS uses the forwarding optimization which works in high contention scenario.

A service discovery approach for vehicular Ad-hoc networks - ABSRP [4] model adopts vehicle to vehicle communication without using RSUs as forwarding nodes. In this approach an intermediate node itself acts as routers to support in vertical handoff and session establishment. ABSRP adopts mobile nodes as vehicles in a city environment and adopts case studies on vehicular safety environment.

In [10], the authors had adopted neighbour graph procedure which dynamically captures pre-positioning of mobile nodes with support on service context which ensures that mobile node supports multiple services under low mobility conditions. An accreditable work on scheduler management [11] proposed adopts packet scheduling and the resource mapping algorithm, which is based on a cross-layer design. This algorithm suggests that the scheduler is aware of both the channel at the physical layer as well the queue state at the data link layer information of achieve proportional fairness while maximizing each user's packet level QoS performance. This algorithm strategies packet flow but does not effectively support in QoS update.

Mishra et al. [12] had carried out an empirical analysis of 802.11 with support for MCA layer during handoff process which observes that the handoff latency enthrals with significant impact on degrading the QoS performance for real time streaming and conference applications. Hosseini et al. [13] work focus on controlling and avoiding packet flooding in MANET, which uses Cluster Based Routing Protocol (CBRP). This protocol reduces the load of traffic intensity on network by minimizing the communication messages as advertisement from application layer to routing layer. CBRP focuses on only distribute the active services in the network between clustered nodes. The experimental result show cases its behaviour with minimal delay such that this method does not add any extra overhead to the network.

Alexandros et al. [14] proposed handoff mechanism with seamless service continuity which provides handoff in heterogeneous environment. This approach enables consistent QoS support in an integrated system with multiple access technologies. The work also focuses on network context information which needs to be considered during transition between distributed heterogeneous systems with fast handoff for the support of seamless service continuity. Although the mechanism lags in energy consumption, but basically it lags in middleware support which is considered as major work of HOSA.

This work also considers routing schemes such as Mobile IPV6 [15], SCTP [16] and UMTS [17] mobility protocols where the applications does not consider the mobility status of a node. The authors proposed a middleware solution, MUM [18] which supports the phenomenon of context-aware handoff management to avoid service interruptions during both horizontal and vertical handoffs. This approach exploits the visibility of wireless sessions available along with handoff implementations (handoff awareness), service quality requirements and handoff-related quality degradations (QoS awareness). MUM [15] approach provides solutions for handoff prediction, consistent multimedia transfer but with higher degradation quality of media streaming issues due to improper data buffering.

Wang et al. [5] had proposed TIBCRPH which adopts the network traffic infrastructure and clusters the node in network with support over routing with Handoff capabilities. This approach adopts the vehicular density with its speed (mobility), distance between vehicles and time taken to cross between vehicles. Even though cluster analysis provides support in QoS but pro-active support to handoff does not exist as handoff metric analysis is not effective in implementation. SIP [6] is a session management protocol supported as a standard by IETF for invoking multiple sessions over a communication scenario. SIP had been implemented over VANET [19] for maintaining a robust handoff over multiple intermediate nodes but this protocol does not claim to provide an efficient QoS mechanism. Musolesi and Mascolo [20] formulated on Context aware Adaptive Routing (CAR), which is a prediction based routing protocol with support over delay tolerant ad-hoc networks. A source node willing to send a message to a destination adopts Kalman Filter prediction with multi-criteria decision making theory to select next hop for message forwarding. Any node with high mobility is considered a good carrier of data since it follows multiple nodes during its transmission. Similarly the existing colocation pattern indicates that the node will meet the recipient again during next transmit.

Wang and Qian [21] proposed a mobility handover scheme called as MHVA for IPv6-based vehicular ad hoc networks. This scheme adopts mobility handover mechanism which demands completion of mobility handover operation in network layer before similar operation is carried out in link layer is performed. Yu-Doo Kim at al. [22] work on comparison of routing protocols analyses the performance of IEEE 802.11 and IEEE 802.15.4 standards for sensor and ad hoc networks. Though this work does not carry much importance on handoff issues, this work suggests various possibilities of working on identifying QoS.

Johann et al. [17] has discussed the development trend of VANET in the future, which addresses the key issues of mobility management in VANET, as well analysed the issues behind the existing technology which also focuses on Handoff issues in heterogeneous environment. Based on analysis and survey of literature work being carried out, HOSA is proposed.

## 3. HOSA

The need for middleware architecture with support to QoS with variable services and network resource utilization over VANET is a highly demandable research challenge among the erstwhile research issues. HOSA is modeled primarily as a middleware with an aim to provide optimal QoS over VANET and other network architectures.

### 3.1. Middleware architecture and functionality

HOSA Middleware Architecture together with Policy Controller, Service Manager and other components in the execution environment is shown in Fig. 2. The execution environment includes the adaptive application as the consumer of the HOSA's networking services, and underlying infrastructure that serves as the necessary supporting modules.

HOSA considers all nodes as VANET mobile / wireless nodes which communicate with each other as heterogeneous nodes or clients. The phenomenon of VANET network device monitoring includes core ad-hoc components such as adapter type, road side units in use, gateway interconnectivity and beacon signaling rate. To control the node on mobility, the basic protocol entities such as TCP, UDP and IP uses interfaces for management of multi-deterministic device drivers, protocol stack arrangement and routing information update. Nodes communicate with each other using Hello protocol [23, 24] and establish routing path such that a session is maintained and consistently updated over a period of time using query of context information. The node and service contextual information is being locally positioned in an end host and globally accessible as a central server. Section III discusses context and context awareness in more detail.

HOSA middleware is the software platform which is defined above operating system and other network resource infrastructure, providing adaptive network connectivity management to upper system modules and network applications.

The infrastructure shown in Fig. 2 comprises of components under the monitoring, control, and management of resources with extended services towards handoff brokering and providing QoS functionality for any service in use. HOSA's distributed node caller uses *QoS policy manager* to express adaptation rules, which enables an easier way to handle utilization of adaptive services functionality provided by HOSA, in which the application needs only to represent the requirements by policies. The detailed processing of the adaptation demands is managed and controlled by *Connection Controller* without the concrete concerns of service in use. *Connection controller* forms the management core of HOSA middleware. The service in use is realized by the creation and maintenance of *Service Event Handler*.

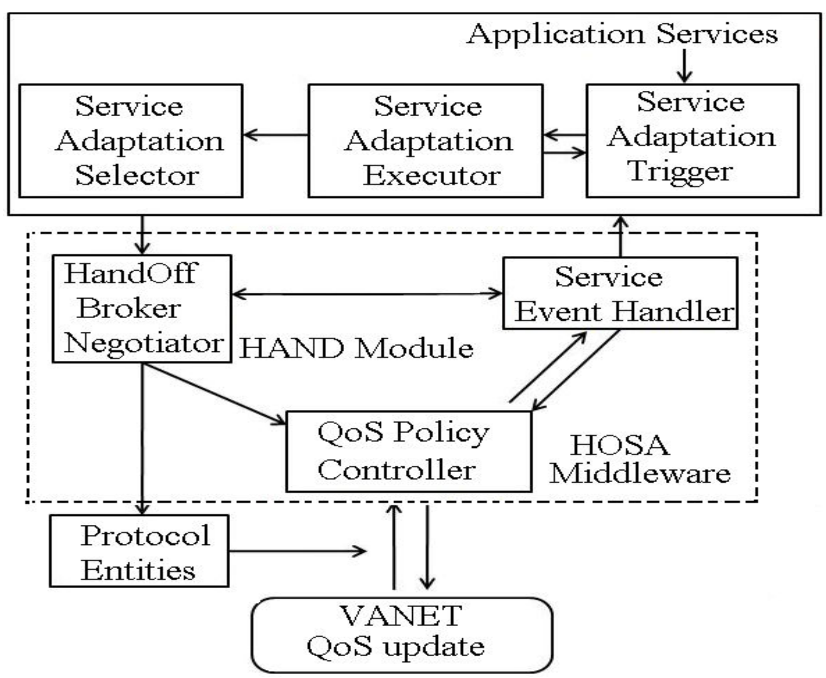


**Fig. 2. HOSA Middleware Architecture Space.**

The service based adaptation function is handled by *Adaptation Selector* and *Adaptation Executor* modules, which selects the service and used connection controller to adapt to network. The adaptation of a provided service can be realized through multiple serial stages, including adaptation triggering, approach selection and adaptation execution. Adaptation mechanisms are first triggered by some specific context according to the predefined matching criteria. Then a decision should be made on which adaptation approach will be used. Finally, service adaptation can be achieved by automatically or manually executing a command and/or changing the external behaviors (and possibly internal states) of an entity that provide the service. HOSA provides the adaptive network management services with a set of APIs to the upper network-aware adaptive applications. From HOSA's point of view and as the caller of the HOSA's functions, such applications are mainly end service applications but can also be other system level platforms at middleware layer e.g. file access system.

The main feature of the HOSA architecture is the clear partitioning of the whole adaptive functionality into different levels, in which each level only takes care of the functions that are most suitable to be concerned by it. The adaptation of the end application is separated into the application layer and the middleware layer. All the network adaptation mechanisms are abstracted and placed onto the HOSA middleware level, since the monitoring and control of network resources are mostly convenient to be implemented at this level. Semantic oriented adaptation mechanisms are then left to application level. This is due to the fact that application knows the content and the media that it consumes and processes the best.

## 3.2. Mode of operation

The VANET terminal node mobile host can be equipped with several network interfaces such as Bluetooth, IrDA, WLAN, and GPRS and the availability for each access technology dynamically changes due to mobility. Network performance may also be greatly fluctuant in terms of packet loss, latency, and bandwidth as the result of the wireless connection and handoff. Hence HOSA also updates context information such as energy consumption, user preference, and cost incurred for providing a service consistently. As a result, functions in terminal HOSA focus more on the adaptive management of networking resources inclusion of application level adaptation. In particular, the adaptive management of multiple communication channel or connection is the main task of HOSA terminal node. To manage connection channels is core functions of HOSA, which is realized by connection controller. *HAND Controller* functionality is defined which establishes hand off procedures between set of communicative peers engaged in session over a service.

## 3.3. HAND – Handoff Operation

HAND defines a logical connection between set of communicative peer entities, where a source VANET node initiates a Route Request and the destination node replies or the request. HAND component of HOSA supports both standalone operation mode and collaborative operation mode, over the set of VANET nodes engaged in communication.

HAND defines a wireless / mobile system with identical concentric circles of zones or contours as shown in Fig. 3. When a node moves from one contour division to another contour with a speed V at an equidistant D, then mobility range of nodes is updated at intervals of 50 ms consistently.

The signal strength (ST) of node helps to identify its "nearness" property and its variable distance provide the speed of node on "mobility". Any nodes can engage in handoff based on its equidistant property and the defined threshold to complete the handoff process. When a VANET node in contour region A initiates a handoff request whose signal strength is good, then another node in contour region-2, with an average signal strength can reserve for handoff process to forward. When node leaves C2 zone, its initiates the handoff since node is in $T_{hmin}$ zone while when node moves away from C2 to C3 zone then handoff initiation starts such that it can complete the process within $T_{hmax}$. The distance between $T_{hmin}$ and $T_{hmax}$ is D. Selection of $T_{hmin}$ and $T_{hmax}$ is based on the relative signal strength between set of nodes as well over the range of distance associated with intermediate nodes.

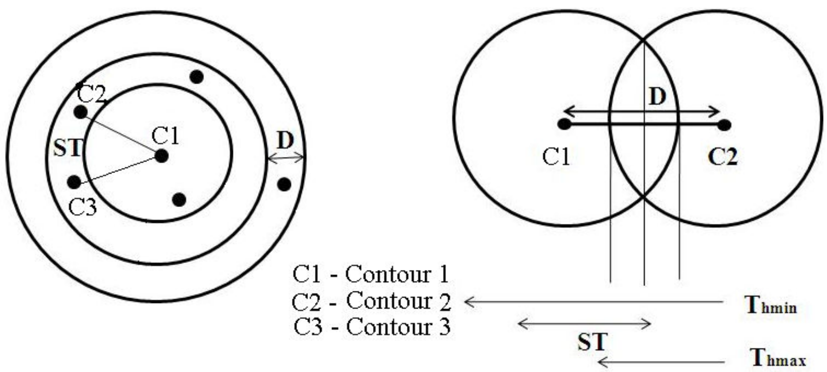


**Fig. 3. Execution of HAND Module.**

Handoff initiation algorithm given below in Algorithm -1 creates and controls multiple handoffs for vehicular node over IEEE 802.11p networks. The basic principle of this algorithm defines and updates the status of the neighboring VANET node at every 50 ms through the set of switching or forwarding nodes. Selection of the forwarding node is discussed in Algorithm-2 where the switching center maintains the current location and status of VANET node as well as other nodes related to source node. For each VANET node the corresponding $T_{hmin}$ and $T_{hmax}$ values are gathered and updated, where $T_{hmin}$ defines the minimal time limit to initiate a handoff and $T_{hmax}$ defines the maximum time allowed to complete the handoff. Each VANET node engaged in communication is updated on the information pertaining to next nearest VANET node with help of source node which acts as the switching center. The set of sessions and their frequencies are defined as Ci where i can vary from 1 to n.

```
Algorithm-1 : HandOff_Initiation ( )
Begin {
Pkts_transmit = 0 // has no packet to transmit
set Session Ci=1 // determine next contour to be selected
if (Pkts_Transmit_Flag=1) and Conn_Quality <=Thmin or > Thmax
{
   Set Sleep_Period= Thmax- Thmin  // acceptable pause period
   call Send_req(Node[i])
   call buffer(pkts)            // reserve buffer in node 'i'
  Pkts_transmit = 1            // has no packet to transmit
   while (!Pkts_transmit)
   {
      Transfer_Data(Node[i],Node[j])
   }
   clear buffer
}
select Alternate_Opt_Path // select another alternate path for handoff
call Send_Req(Node[i-1])  // request to another node
NextSession Ci=i+1          // use another session
}
```

The basic phenomenon of handoff initiation algorithm carries out scanning and discovery of every neighboring nodes to determine the optimal node engaged using parameters such as Bandwidth in use, Signal Strength, Bandwidth required, and Service priority as shown in Fig. 4. Identification of an optimal VANET node to engage in handoff is such that the selected node is being reserved for the whole session until the service is completed. This approach eliminates unnecessary scanning of other VANET nodes to be selected which are far away from the destined source or destination node. When a node does not receive any data or packets from its neighboring node then the status is updated by sending a probe request signal or Hello protocol. The operation of HAND handover initiation mechanism enables the node to enable multiple decisions making Instead of blind handoff between the nodes.

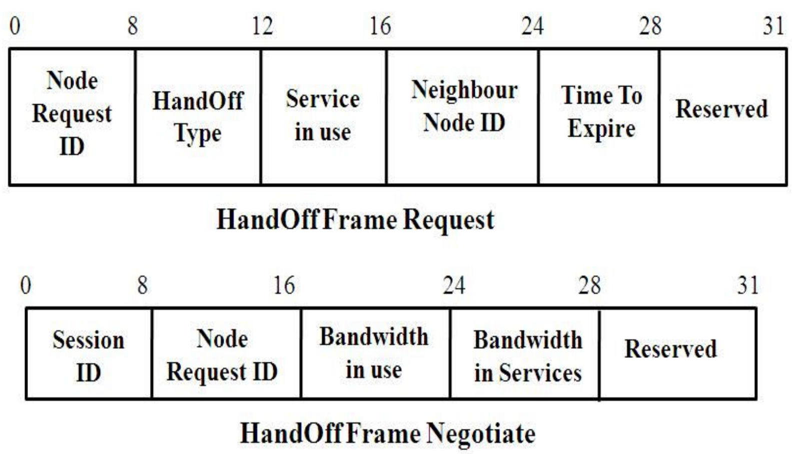


**Fig. 4. Handoff Request and Handoff Negotiate.**

```
Algorithm-2: HandOff Negotiation ( )
{
 while (Status.node[i] = TRUE )
  {
A:    If (node[i].bStr >Thmin )  // call handoff process
    {
       Node[i].bndWidth = bndWidth_Update ( ) // bandwidth in use
  B:   If (node[i].bndReq > = bndReq ( )) // bandwidth required
       {
          Sid = AssignNode (node[i]) // Session Identifier
       }
       else
         goto B
     goto A
  }
```

The handoff process is initiated and carried out over a Negotiate frame shown in Fig. 4 which communicates with each node neighboring and designates a node as optimal node for carrying out handoff process. On negotiation (Algorithm-2), the node whose status is active enough to carry out the handoff within the *TimeToExpire* limit then handoff process can be effective to contribute to the effective QoS. The *TimeToExpire* field can be defined on metrics such as priority of Service in use, distance ‘*D*’ and ‘*Tmin*’ or ‘*Tmax*’ metric of a node in a zone to establish handoff and available bandwidth to complete the process.

## 4. Context Management in HOSA

HOSA is middleware architecture for supporting optimal handoff transfer over context-aware network setup which is dependable on network, user and service applications in use. Two components are related to context awareness, i.e., connection monitor, policy manager which supports service based on policy as per user profile and service adaptation interface, hence binds the node to user requirement and service in use.

### 4.1. Service context aware

HOSA provides adaptive applications with the capacity of network awareness through the information provided by the *Connection Monitor* module, by considering the service aware rich context information while on execution. Additional context information of service can be specified based on time and event activity. Such information can be accessed through interfaces by connection controller and applications. HOSA also contributes to the service content in use by registering the current network information.

The service manager frame as shown in Fig. 5 organizes the service the required bandwidth to support based on their type, and QoS specifications binded to their policy list.

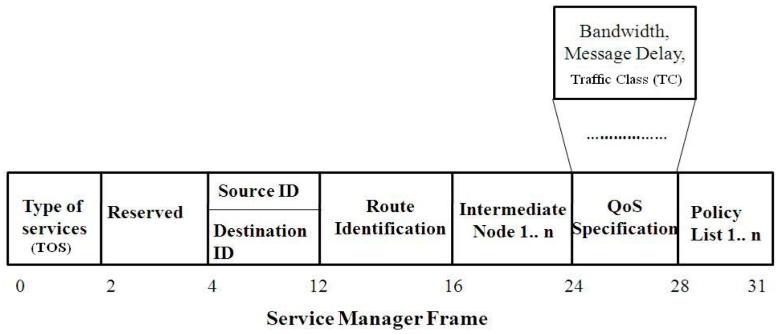


**Fig. 5. Service Manager Frame Adopted in HOSA.**

## 4.2. Contextual information

Context can be a well-recognized field or object whose tag or context data is manipulated, based on an activity or event instantaneous. Multiple context based information is being maintained by system related to a connection management, which includes:

**[i]** ***Static contextual network information***: Theoretical network capacities of network interface (type, typical bandwidth, cell size, handoff latency, power consumption, user speed, simultaneous user number of the access point), operator information. The static features allow a raw comparison between interfaces obtained as measurement during runtime performance through each interface.

**[ii]** ***User profile contextual information***: contextual information related to network management, based on user preference which includes priority of user interface, interface selection policies. User policies help to balance all the factors for the interface selection by user. Application policies are also part of user policy specified by each application which opens a channel for its traffic flow.

**[iii]** ***Network Context information***: Contextual information of network such as energy status, node speed, pause time within a location, distance between nodes and infrastructure access point are updated and maintained consistently. This information is highly critical for the adaptive management of network resources.

For example when the velocity of an end host is too high, the channel should select and maintain the best connection among the optimal connections available, and then reduce the quick switch between the two accesses.

## 4.3. Service adaptation

The adaptation mechanisms for the network management in HOSA are mainly realized by policy manager and connection controller. In particular as the object model shown in Fig. 6, the kernel of HOSA is the connection controller acting as a coordinator and executor.

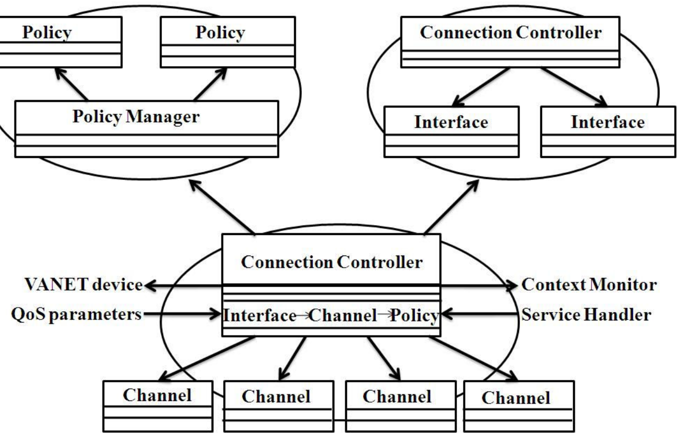


**Fig. 6. HOSA Connection Controller and Policy Manager.**

## 5. Policy Manager and Connection Controller

### 5.1. Policy manager

HOSA employs a policy mechanism to ease the adaptive management of network resources. Applications can just express their adaptation requirements with policies when they open new channels, and so totally disregard the detailed execution of adaptive mechanisms at the HOSA. A policy denotes the criteria for the selection of the best current network interface. Then the connection controller maintains each channel according to the corresponding policy. An application can also explicitly control the channel with exposed channel control interfaces.

A policy can be either static or adaptive. A static policy explicitly declares the network interface to be used. An adaptive policy is used to describe the access selection rule for one particular type of traffic flow. An adaptive policy can be represented by (traffic class, logic conditions, and weighted factors). Traffic class (TC) can take any value defines in Type of Service (TOS). Logic conditions are a series of comparison expressions connected by logic operators. Weighted factors are a set of 2-tuple (factor, weight).

Sub-policy for achieving optimal QoS over throughput can be defined as:

*(THROUGHPUT, (bandwidth>100kbps) and (delay<5s), (cost, 0.2), (trff_load <0.6), (pktdrop_rate< 0.6),( Service_Use = Audio))*

Here the expected bandwidth in use should be more than 100 kpbs with an acceptable delay of less than 5 seconds or 500 milliseconds and an acceptable packet load percentile value of less than 6 and variable packet loss between 0.3 kbps and 0.6 kbps.

To define a content delivery over VANET, end to end delay plays a vital role towards achieving an optimal QoS. Policy can be defined for END TO END DELAY as a parameter for achieving optimal QoS for variable services such as

*(OPTIMAL_QOS, (bandwidth_in_use < 100kpbs), (delay < 10ms), (traff_load>05), (pktdrop < 0.6), (Service_use=Content))*

Similarly to achieve an optimal QoS over highly variable node density, the following sub policy can be applied

*(OPTIMAL_QOS, (bandwidth_in_use < 135kpbs), (delay < 10ms), (node_speed < 5mts), (traff_load>10), (pktdrop < 0.4), (Service_use=Content))*

Policy manager is used by applications to supervise policies including policy creation and elimination. Policies are then accessed by connection controller during the channel operations. The evaluation determines which interface is currently the best to a policy can be done both periodically and immediately when special events happen. Some of the application policies may conflict with user preference policies stored previously in the local context server. It has been assumed that user preferences always have the highest priority, which is the default case.

## 5.2. Connection controller

Connection controller is the core component of the HOSA for the final realization of the network management adaptation. By acting as a coordinator and executor, it controls the activities of local HOSA components such as policy manager and connection monitor.

The functions of the connection controller are to maintain the information and manage the channel. Connection information maintained by connection controller includes both local information and global information. For local information, connection controller maintains the lists of the references of all the interfaces, channels and policies, along with the mappings. The lists and mappings are continuously updated in case of any specific event (e.g. a channel has switched the connection under using or a new channel is opened with a new policy).

Connection controller maintains global information of the end host the controller updates the global network contextual data. This update is performed periodically or when any related event (i.e., changes of numbers and addresses of interfaces) happens or when a specific event is identified.

## 5.3. Channel maintenance

Channel is defined as the logical link between physical application components which are located in different network devices such as terminal or network connected device being either uni-directional or bi-directional, over a specific type of connection to transfer data between nodes. The connection established for each channel can be dynamically updated, while its context values remains unchanged hence the service continues without any modification. The service may explicitly control each channel if necessary, through the control of policy manager.

Connection controller periodically re-evaluates the mappings between an interface and each channel according to the policy used for each channel. Moreover, the re-evaluation is also immediately done when special events (e.g. interface up or down, channel opened or closed) occur. If, according to the policy a better interface is found, then the connection controller initializes a channel switching session. The session needs the cooperation between controller peers through the signaling channel, as shown in Fig. 5.

Essential parameters that should be experimented include:

| | |
|---|---|
| 1) Network size | measured in the number of nodes |
| 2) Network connectivity | the average degree of a node (i.e., the average number of neighbors of a node) |
| 3) Topological rate of change | the speed with which a network's topology is changing |
| 4) Link capacity | effective link speed measured in bits/second, after accounting for losses due to multiple access, coding, framing, etc. |
| 5) Traffic patterns | protocol effectiveness in adapting to non-uniform or bursty traffic patterns |

## 6. Experimental Approach

The outdoor routing experiment took place on a rectangular athletic field (measuring approximately 200 (north-south) by 350 (east-west) meters. Since the athletic field was distant from the campus wireless network, this can as well help to reduce the potential interference. The traffic generator on each mobile node generated packet streams with a mean packet size of 1200 bytes (including UDP, IP and RTP headers), a mean of approximately 5.5 packets per stream, and a mean delay between streams of 15 seconds. These parameters generated an approximation of 423 bytes of data traffic (including UDP, IP and RTP headers) per node per second, with a modest traffic volume, but corresponding to the traffic volume observed during trial runs as one of a prototype media streaming applications [3]. The algorithms are implemented using C++ class based event controllers which share a core set of API. These classes include the event loop, as well as unicast and multicast, routing, and logging support.

### 6.1. Hardware platform

Experiments were conducted using differing IEEE 802.11 supported initially on set of 25 WiFi nodes as shown in Fig. 7. The experiment was re-defined and re-executed with 30, 35, 40, 45 and 50 nodes. The nodes were configured to control and work on ad hoc routing algorithms discussed in Section-2. WiFi cards can transmit at variable bit rates, the nodes should also auto-adjust the bit rate depending on the observed signal-to-noise ratio, and arrive at a consistent rate for all the nodes in network. The nodes are implemented in "ad hoc mode" setup in which the transmission rate was fixed at variable rate of 2 Mb/s to 200Mbps such that the channel can select the setup automatically. Specifically, the setup adopts Lucent (Orinoco) firmware version 4.32 and its proprietary ad hoc "demo" mode suggested by Lucent.

To ensure consistency with multiple series of ad hoc routing experiments "demo mode" is adopted. Fixed rate of data transmission is adopted to analyse the routing results. The multi-rate capabilities over the demo mode propose to use variable bit rate traffic. Each node enables the wireless communication channel through the serial port to support accurate distance between nodes throughout the experiment.

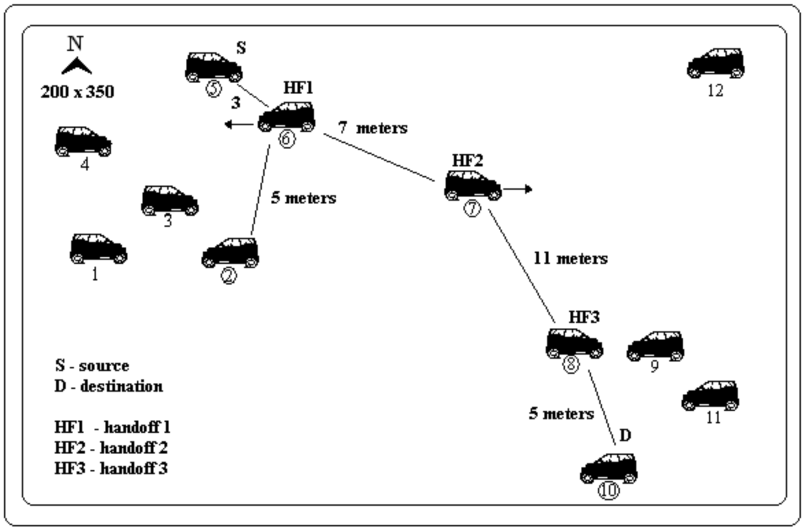


**Fig. 7. Experimental Test-bed.**

The algorithms are implemented in JXTA [25] which share a core set of classes to support event loop, unicast / multicast routing, scheduling and logging support. With these four key features, algorithm-specific code is confined to the packet handler classes that process incoming control and data packets, the timer handler classes that process timed actions (such as route expiration), the logging classes that log algorithm events, and utility classes that serialize and un-serialize the control packets.

The routing algorithms work in synchronization with a traffic generator which runs on each node, and sends a sequence of packet streams to randomly selected destination nodes, as part of experiment. Each stream contains a random number of packets of a random size. Gaussian distributions determine the packet numbers and sizes, along with the delay between streams and packets, while packets are uniformly distributed between the source and destination nodes with intermediate handoff nodes. The GPRS which runs on each node, reads and records the current node position from the other attached GPRS unit, as well broadcasts the beacons which contain the source node's position (as well as sequence-numbered positions that it has received from other nodes).

## 6.2. Performance analysis

The performance of HAND module was observed along with QoS analysis of streaming service. In Figs. 7 and 8 the handoff process between four nodes under communication is explained, where nodes S and R send data and receive data respectively, while HF1, HF2 and HF3 are three nodes, which are consistently “on mobile” and act as forwarding nodes to transfer data between the S and D but variable distances. The data transfer rate between the sender and the receiver with the help of forwarding nodes show gradual decrease in traffic intensity and packet transfer rate as shown in Fig. 8.

From the observed phenomena, it was identified that an average of 12% to 18% of packet drop was noticed between the S nodes to HF1 node. Similarly an average of 15% to 19% of packet drop was noticed between the receding HF1 to HF2 node, while an average of 18% to 22% of packet drop was noticed between HF2 to HF3 or D node.

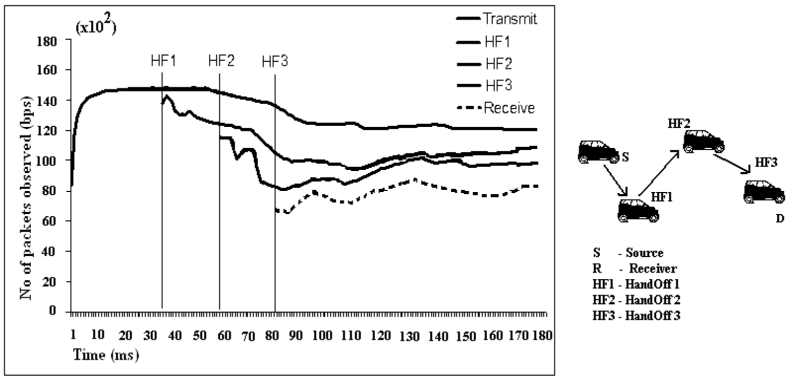


**Fig. 8. Execution of HAND Module over 4 Node Communication.**

Streaming services which uses log and trace files to account for the effect of traffic sent and received based on available bandwidth is consistently estimated. Figure 8 explains the traffic intensity generated over a streaming service for varying number of mobile nodes where HOSA is being supported with HAND. Any increase in number of VANET nodes increases the traffic intensity hence the bandwidth being used and network load. Hence streaming services could either account for their own traffic explicitly, or operating systems should support in scheduling methods to send packets at precise intervals without supporting the process.

Figure 9 supports in understanding the intensity of traffic generated for a specific service in use. It could be observed that when number of nodes are between 20 to 25 the traffic intensity generated varies between 80 to 200 bytes for HOSA approach, where as it shows an abnormal increase of 560 bytes to 700 bytes for TIBCRPH approach

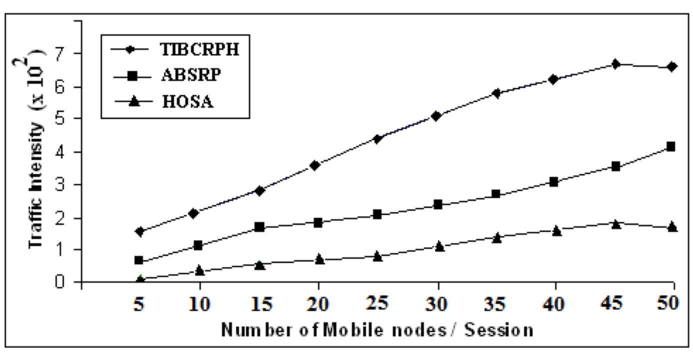


**Fig. 9. Traffic Intensity over Increase in Number of Nodes.**

Figure 10 explains the throughput of HOSA compared with TIBCRPH, ABSRP and SIP schemes. The throughput of HOSA with supported pre-handoff mechanism shows an increase in packet delivery for a fixed set of 25 nodes under mobility. The graph execution time had been gathered from 100 ms to 600 ms, considered as a long duration of execution window normally for any experiment. HOSA converges to optimal local minima due to packet transfer at each time interval. The experiment is also carried out over varying node density as 25, 50, 75 and 100 nodes. At each experimental run it was observed that HOSA performed better in throughout compared to TIBCRPH, ABSRP and SIP as shown in Fig. 11.

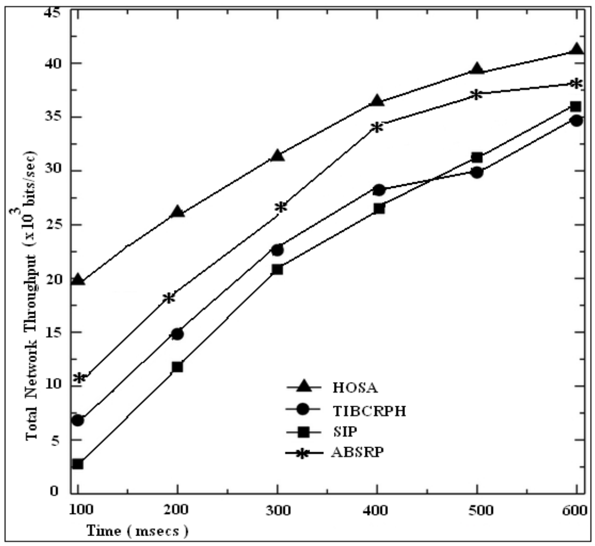


**Fig. 10. Throughput Observed.**

Fig. 12 shows the packet delivery ratio (PDR) at varying intervals of time for increase in node capacity. HOSA supports higher PDR compared to SIP or TIBCRPH schemes. The PDR varies from an average of 0.7 percentile whereas both SIP and TIBCRPH shows abnormal variance in PDR and low delivery rate with supported handoff components.

The throughput analysis of HOSA is extended over varying node density to understand behavior based on traffic intensity or load. The experimental run is carried out over 5, 25, 50, 75 and 100 nodes using ns2 [26] and VanetMobiSim [27]. Simulation run is adopted since implementing 100 VANET nodes on a real time setup is highly complex as well demonstrating QoS behavior of HOSA in a real time setup and simulation setup is highly demanding.

Figure 11 shows the throughput analysis for streaming content executed on varying node density for HOSA, ABSRP and SIP. Performance of HOSA was comparatively better than ABSRP and SIP, since SIP consumes more bandwidth for session establishment and forming the route. The phenomenon of handoff is improved in HOSA than compared to ABSRP, hence HOSA outperforms.

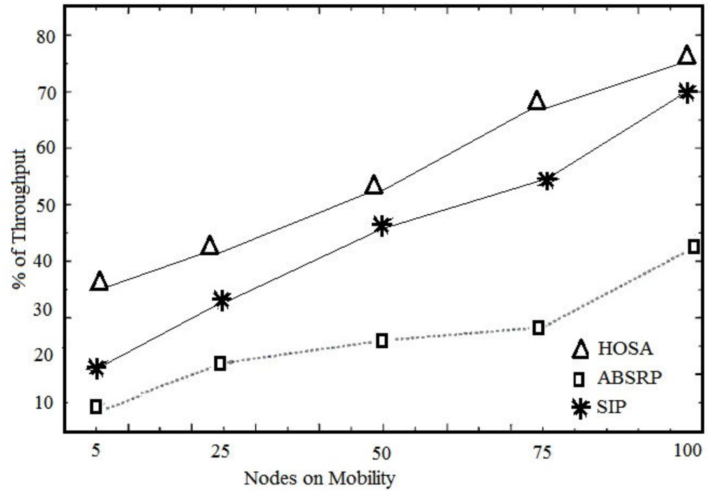


**Fig. 11. Throughput Analysis on Varying Nodes.**

The packet drop ratio as shown in Fig. 13(a) is low in case of HOSA due to fast pre-handoff support module which determines the intermediate node to handoff and service on demand. The routing schemes converge to higher packet drop when the nodes varies between 200 to 250 primarily due to an upsurge in traffic intensity, while SIP show an increase in packet loss compared to other schemes. Fig. 13(b) shows SIP to have minimal end to end delay compared to HOSA. Performance of HOSA for streaming services with multiple sessions maintained between variable users is better compared to TIBCRPH, but SIP invokes buffer at all intermediate nodes to perform an end to end delay achievable over multiple sessions.

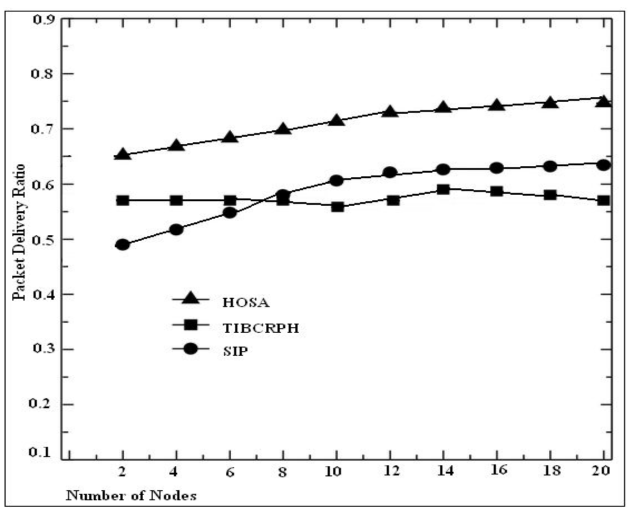


**Fig. 12. Observed Packet Delivery Ratio.**

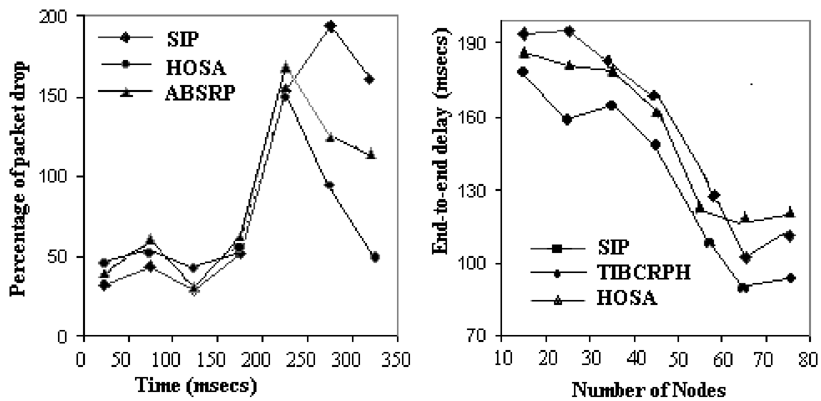


**Fig. 13. HOSA**
**(a) Packet Drop. (b) End to end Delay.**

## 7. Conclusion

Vehicular ad-hoc networks are typically dynamic in terms of node mobility, communication mechanism, network resource utilization, location management etc. However, the end-user vehicular nodes are heterogeneous, which can range, from high-end ARM processors to low-end PDAs or smart mobile devices. Traditionally, middleware is required to abstract from this heterogeneity and to enable the contextual network research challenges to focus on application issues.

The research work proposes to design and develop a QoS enabled middleware service architecture that can deliver adaptive quality of network service for media streaming applications between end to end nodes being engaged in session. Providing handoff over VANET is well supported with HAND module which adopts seamless transfer of media data using adaptive buffering technique based on service in use. It was observed that HOSA provides consistent QoS throughout the session as well maintains delay to be minimal. The aim is to identify solutions for this realistic setting and to quantify the Quality of Service (QoS) being supportable to user profile, service in use and network adopted. The work can be extended with session manageable QoS such that variable sessions adopt differential QoS architecture over the channel based call management approach.

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