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Admission Control in Wireless Ad-Hoc Networks: A Survey

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ABSTRACT:

Wireless mobile ad hoc networks (MANETs) have emerged as a key technology for next-generation wireless networking. MANETs are undergoing fast progress. However, many technical issues are still facing the deployment of this technology, and one of the most challenging aspects is the quality of service (QoS) provisioning for multimedia real-time applications. MANETs are expected to offer a different range of services to support real-time traffic and conventional data in an integrated fashion. One of the most important mechanisms for providing QoS support is admission control (AC). AC has the task of estimating the state of a network's resources and thereby to decide which application data flows can be admitted without promising more resources than are available and thus breaking previously made guarantees. In order to provide a better understanding of the AC research challenges in MANETs, this paper presents a detailed investigation of current state-of-the-art AC models in ad hoc networks.

Keywords:

Quality of service, wireless mobile ad hoc networks, Admission control.

Introduction:

Mobile ad hoc networks (MANETs) offers unique advantages and adaptablein certain environments and strategic applications. They are constructed by a set of mobile nodes which are independently connected via multihop wireless communication (Figure 1).They can be created and used 'anytime, anywhere.' In fact, since all nodes are allowed to be mobile, the composition of such networks is necessarily time-varying. MANETs can operate in several environments where conventional networks fail. Such perceived benefits drew out urgent attention in the early days among military and rescue agencies in the use ad hoc networks, especially under disorganized or hostile environments. One of the major factors in the growing interest in MANETs was the improving capacities and omnipresent nature of mobile devices, as well as the development of the improving capacities and many personal digital assistants now come with 802.11-complaint air interfaces. With the option to operate them in ad hoc mode,802.11 is the primary enabling technology of MANETs. Providing quality of service (QoS) to users in a MANET is a key interest for service providers. Many suggested applications consist of real-time voice and video traffic that require QoS support for effective communication.

The purpose of any QoS support model is to offer services with guarantees in terms of delay, bandwidth, jitter, or ad hocnetworks; the media access control (MAC) layer is responsible for bandwidth allocation at individual devices, while the networklayer must consider resources along the whole path of transmission. One of the most important mechanisms for providing QoS guarantees is admission control. AC aims to estimate the state of a network's resources and thereby to decide which application data flows can be admitted without promising more resources than available and thus not following previously made guarantees. AC has the task of controlling the usage and allocation of network resources for various applications requiring additional services. In order to provide a better understanding of the AC research challenges in MANET's, this paper presents a detailed investigation of current works regarding AC models for ad hoc networks. An outline of the admission function, feedback to route failures, as well as the pros and cons of each AC model presented in this paper are given. The rest of the paper is organized as follows: the 'Design challenges of AC models in MANET's section aims to provide an overview of some important issues regarding the design of AC models in ad hoc networks. Finally, the 'Conclusions' section presents some concluding remarks , summarizes the trends in the field, and highlights potential areas of future work.

Design challenges of AC models in MANET's

Due to the probabilistic nature of the wireless medium, admission control for ad hoc networks has many challenging problems to solve. The characteristics of the shared wireless medium do not provide a unified view of the medium to all nodes due to the physical differences between wired and wireless communication. Second, as for resource reservation, a medium access protocol is supposed to be able to resolve media contention and support resource reservation at the MAC layer. Some critical issues to considerin the design of AC models are the following:

- Node mobility: the mobile devices in MANETs may move randomly and independently. This means that the topology information has a limited lifetime and must be updated frequently to allow data packets to be routed to their destinations. Furthermore, the dynamic topology can also lead to violations of QoS assurance without breaking routes because a transmitting node may move into sensing range of another transmitter, thereby increasing its interference and reducing its channel access time.
- Channel contention: even if the MAC protocol in use is not the single-channel 802.11 scheme, mobile devices in ad hoc networks should communicate on a common channel. However, this leads to channel contention and interference problems, which can impact on the fraction of channel capacity available to a mobile device. Another consequence of channel between nodes on a route forwarding the packets of a data session.
- Unreliable wireless channel: received signals are prone to bit errors due to interference from other transmissions, thermal noise, shadowing, and multipath fading effects. Such errors may lead to increased packet delays and possibly to congestion, causing more packets to be dropped.
- Connectivity issue: a mobile device may lose connectivity with the rest of the group just because it has wandered off too far or its power reserve has dropped under a certain threshold. A session that was admitted based on the available route may be starved of transmission opportunities if some nodes lose connectivity with others. The session would then need to be re-admitted on a new route.
- Lower algorithmic complexity: one main design criterion of AC models is related to lower algorithmic complexity to facilitate limited-bandwidth and low-power QoS solutions that can be embedded into low-cost mobile devices' microprocessors and to extend the lifetime of the network without endangering efficient and reliable communications between mobile nodes. In a wireless ad hoc environment, this is further impacted by the fact the common medium is the wireless channel. Wireless links between mobile devices are 'dynamic' in that they come and go over time, i.e., two nodes which could speak to each other suddenly cannot, and vice versa.

AC models in ad hoc networks

The allocation of network resources is always necessary for communication over a shared medium in a multihop wireless network; this demands every different perspective on network QoS admission control management. In this section, we describe some current research in the area classified into two categories: single hop AC and multihop AC. Because of the simplicity of the single-hop wireless environment, we focus our survey mainly on multihop AC, where several considerations have been considered. Xiao and Li proposed a distributed asynchronous cooperation (DAC) protocol. In DAC, the QAP announces the transmissions budget via beacons, which is the additional amount of time available for each AC during the next beacon interval. Each station determines an internal transmission limit per AC for each beacon interval based on the successfully used transmission budget announced from the QAP. When the transmission budget for an AC is used up, a new flow will not be able to increase their transmission time too. The main weakness of the DAC model is that it can only protect existing flows when the traffic load is not providing a direct relationship between transmission opportunity (TXOP) parameters and QoS requirements related to user applications.The authors in proposed a similar DAC-based scheme which includes two-level protection and guarantee mechanisms. The principle of the first level is to protect each existing voice and video flows from the new and other existing voice and video flows.

As for the second level, it protects the existing QoS flows from the best-effort data traffic. When the number of active stations is large, the DAC-based on the DAC, it also has the problems of performance oscillation and lack of direct QoS relationship with applications. In, Zhang and Zeadally have proposed HARMONICA model in which the access point progressively chooses the best channel access parameters for every traffic class to ideally coordinate their QoS necessities. This protocol occasionally tests the link-layer quality indicator parameters for every traffic class. Two adjustment calculations over various time scales are utilized to choose the channel access parameters, which can best match the QoS needs and to ensure an insignificant bandwidth for best-exertion traffic. In any case, the way of finding the ideal augmentation or decrement in the estimation of channel access parameters remains the principle constraint of this AC model. Dennis and Tim proposed an admission control algorithm for the 802.11e EDCA that considers the dynamic wireless network conditions such as the number of active sessions and the parameters adopted for these sessions. In, Wu and Bertsekas considered problem of optimal admission control in a single-hop wireless infrastructure mode to determine whether or not to accept a new session request, given a particular configuration of users of various classes in various regions. The authors assumed the existence of an algorithm that can determine, forany distribution of users of various classes in various regions, whether there is a feasible power assignment satisfying the signal-to-noise requirements for all users and, if so, provide a unique power assignment for the distribution. They formulated the problem as a Markov decision process to provide a technique that is enough to be applicable and can be implemented in real time in a distributed manner between the cells. In, Abdrabou and Zhuang proposed a new approach to provide stochastic delay guarantees via a distributed model-based call admission control for IEEE 802.11 single-hop networks. The authors used a link-layer channel model to characterize the variability of the channel service process in a non-saturated case via a Markov-modulated Poisson process model (MMPP). The performance evaluation showed that this approach can be used in allocating resources with random delay guarantees. However, other parameters, such as throughput and packet loss, have not been considered in MMPP.

Multihop AC

To protect the existing sessions and satisfy the QoS requirements of new flows in multihop ad hoc networks, several admission control schemes have been proposed. In the following sections of this page; the protocol descriptions are grouped into sections based on the classification method.

Routing-decoupled AC schemes:

This sub-sections deals with AC schemes that are decoupled from routing schemes, which means that a route for a requesting flow has been explored prior to testing its resources. In such schemes, the decision of admission control is achieved based on ‘penetrating’ of the route by previously admitted flows or special penetrate packets. The authors proposed a penetrate-based call admission control scheme (PenetrateCast) with QoS guarantees for inelastic flows. In penetratecast, a path is penetrated for capacity availability. If an intermediate link along the penetrated path fails to meet the QoS requirement, the flow is ‘pushed back’ via back pressure extreme to an intermediate branch or possibly to the source. To achieve this, the penetrating scheme is associated with a distributed fairness scheme, Neighborhood Proportional Drop, which enforces uniform drop probabilities among flows competing in the same contention domain. Each node estimates own packet drop probability and propagates this information by piggybacking to neighbors. The received flow has, by design, a lower drop probability threshold than the serving flows. If during penetrating, the new flow drop rate increases beyond a certain threshold, the flow is backpressured on the way to the source node and the flow is re-routed.

If backpressure pushes the flow back to the source and all alternate paths exhausted, the received flow is rejected. Pagani and Rossi proposed an end-to-end penetrating call multicast admission scheme, named MCAMP. In MCAMP, a source node, before transmitting data stream, floods penetrating packets to check the bandwidth availability along a multicast tree. Only receivers take part in the admission control decision by sending an accept/refuse notification to the source based on the received quality. Three priority levels among the packets are used in MCAMP: real time, penetrate, and best effort. The level 2 (penetrating packets) does not affect existing QoS flows. To deal with the mobility issue, a new bandwidth penetrating process is launched to re-construct the path and the allocation. However, in such implicit reservation model, the number of flows into the network is restricted to those that can achieve the target QoS. Lin and Mong proposed a centralized admission control mechanism model based on the theory of conflict graph. The authors used a contention graph to model the contention situation in a multiple network, and they presented an analytical model to estimate the capacity for each maximal clique in the contention graph. A new session is admitted when the aggregated traffic load is less than the estimated network capacity. The model works well in a multiple single channel for a small-sized network. However, its main drawback is that the utilization of the conflict graph is highly complex; even for moderate-sized network, the number of interference constraints can be very big. Liu et al. proposed a call admission control (CMC) model based on IEEE 802.11 multiradio multirate multichannel wireless mesh networks. CMC relies on local information to estimate the residual bandwidth of a path and can be integrated into existing routing protocols. The authors argued that CMC can correctly predict the end-to-end residual bandwidths of paths, successfully protects existing flows from QoS violations, and fully utilizes the bandwidth on channels.

The contribution developed in is based on delay parameter instead of throughput. It uses regression equations in the calculation of transmission probability which varies with each scenario. The authors made an important observation that an admission control algorithm that employs delay predictions as a threshold for call admission achieves, in theory, better channel utilization than those based on throughput parameter. However, the work considers only a small network. The authors proposed FuzzyQoS, a stateless cross-layer AC protocol based on fuzzy logic theory for wireless ad hoc networks. The fuzzy approach aims to improve the control of traffic regulation rate and congestion of multimedia applications. FuzzyQoS uses fuzzy thresholds to adapt the traffic transmission rate to the dynamic conditions. By monitoring the rate of change in queue length (variation rate) in addition to the queue length, FuzzyQoS provides a measure of queue state. Furthermore, by using explicit rate congestion notification, Fuzzy QoS can make source nodes more responsive to sudden changes in the traffic volume. The performance evaluation has shown that FuzzyQoS can achieve stable end-to-end delay under different network conditions. However, FuzzyQoS does not deal well with route failures. While searching for a new route, it reduces the data rate of affected sessions. This implies that FuzzyQoS can only support real-time application with elastic throughput requirements. Valaee and Li proposed a distributed call admission controller using a service-curveprovisioning method, which reflects the status of network and depends on the number of active nodes, their activity index, and the back-off procedure use for contention resolution. The approach uses a sequence of small-sized penetrating packets to estimate the service curve of the network. Then, the estimated service is used to devise a call admission controller. Even the approach expresses a good performance under a small-sized network. The performance under high traffic load was not studied. Furthermore, the mobility factor was not considered in the approach. The authors proposed a stateless service differentiation AC model, Named SWAN.

SWAN uses sender based admission control in order to perform real-time traffic control. SWAN distinguishes between two traffic classes: real-time and best-effort, it cooperates with almost all routing protocols. When a source station wants to sends a real-time traffic to another station, it penetrates the path to the destination station to identify the bandwidth available for real-time traffic. SWAN relies on feedback information received from the MAC layer as a measure of congestion in the network by using mechanisms of rate control and source-based admission control. The AIMD perform the control algorithm is used at each node in order to perform the control of best-effort traffic. The rate control restricts the bandwidth usage of best-effort traffic so that real-time applications can exploit the required bandwidth; the bandwidth not used by real-time application can be exploited by the best-effort traffic. One limit of SWAN is that penetrating may cause a lot of overhead and packet loss. Calafate et al, proposed a distributed admission control for MANET environments (DACME) model that handles multiconstrained real-time flows by periodically assessing end-to-end conditions on the path. In DACME, the source node performs path penetrating to obtain different QoS measurements of the path, thus assuring that the transmission of traffic is achieved under good conditions. DACME takes advantage of the IEEE 802.11e standard to provide prioritized medium access. Even the model performs well in small to medium network; it suffers from fairness issue under high network load. The authors investigated distributed algorithms for joint admission control, rate, and power allocation aiming at maximizing the flow’s throughput. The admission decision is based on the statistical knowledge of the channel and on the exact knowledge of their own channel and buffer states. The authors also studied the benefits of a cross-layer approach compared to a conventional resource allocation ignoring the states of the queues.

Even the proposed work was designed for large interference systems; the performance evaluation was not studied under a large number of active sessions. In addition to the scalability issue, the model did not consider the impact of mobility. Routing-coupled AC schemes: This sub-section summarizes some routing-coupled AC schemes which require that all intermediate nodes have routing capabilities to achieve admission decisions. Zhang and Rubin, proposed a robust flow admission and routing (REAR) protocol which incorporates new route robustness metric. REAR aims to maximize the network ‘robust throughput’ which depends on the idea the more credit should be given when a session is completed without interruption, i.e., without violating its QoS requirements for its entire intended duration. In REAR, for each class of data, a threshold is set as a maximum tolerable probability that the route breaks before the requesting session ends. If, during the route discovery phase, the cumulative robustness of the partially discovered rot indicates a route failure probability surpassing this threshold, then the route request is not forwarded. The main drawback of REAR is that it relies on nodes being able to estimate their own speed, via GPS receivers or some location-determination system, and this may limit the application of REAR. Dong et al. proposed a hierarchical routing-based admission control (HRAC) protocol. In HRAC, a logical super-device network is established via periodic HELLO message broadcasts. This structure is an approximation of the dominating set notion, such that each mobile device is at most one hop away from a super-device. The HELLO messages also distribute device channel utilization information. Each mobile device estimates its available capacity in a simple manner by dividing the raw channel capacity by the MAC overhead parameter (estimated through simulations); it then subtracts the total channel utilization of its neighbors. The main weakness of HRAC is that it does not consider the intra-route contention when calculating a session's capacity requirements.

The authors proposed an admission control and simple class-based QoS system (ACSCQS) which incorporates some simple extensions to QoS-ad hoc on-demand distance vector (AODV). As in QoS-AODV, when searching for constrained route for a new arrival flow, the route request carries the session's throughput requirement. Once the new session is admitted, each intermediate node monitors the rate at which it is receiving the session's data. If this is less than the specified minimum throughput requirement, a route error message is sent to the source, which must find a new route. ACSCQS also periodically verifies that the session's end-to-end delay requirement is being upheld. The performance evaluation has shown that ACSCQS provides some improvements over the AODV protocol. However, the method of establishing a node's available capacity was not specified, and the admission control strategy was very simplistic. The authors proposed INORA (admission control employing in-band signalling and the temporally ordered routing algorithm) which is the combination of TORA and INSIGNIA protocols .In INORA, routing information, modeled as an acyclic-directed graph rooted at the destination node, are assumed to have already been discovered by TORA. When a flow request arrives, the data packets are automatically admitted and the INSIGNIA component attempts to set up soft-state reservations. The data packets follow a directed graph set up by TORA. If an intermediate mobile device detects that it has insufficient available resources (e.g., by comparison to the channel idle ratio (CITR)) or its queue is full beyond a certain threshold level, it notifies the previous device on the path. The device then attempts to route the session via different downstream devices. If all of the intermediate nodes' resources are sufficient to support at least the session's minimum required throughput, reservations are set up along the path, as in INSIGNIA. The authors proposed an ARACNE protocol which is an ant-based routing algorithm with AC and noise route selection (NE) mechanisms.

The AC and NE mechanisms aim to deal with congestion problem and shortcut problem, respectively. The AC mechanism detects the congestion of a route by estimating the delay and load information during route discovery and there by avoids utilizing those congested routes, while the NE mechanism introduces additive noise into route selection for discovering shortcut routes and thus improves route convergence. However, the work was tested only under low mobility and traffic in non-interference network. A contention-aware admission control (CACP) model is proposed by Yang and Karvets. This work provides admission control decision for flows in a single- and multiple-channel ad hoc network based on knowledge of both local resources at a node and the effect of admitting the new flow on neighboring nodes.

CACP introduced a c-neighbor (nodes in carrier-sensing range) to characterize contention in wireless networks. Information about c-neighbors is obtained through multihop querying packets or querying packets sent with increased transmission power. A node makes admission decision based on its c-neighbor available bandwidth of all of its c-neighbors. In CACP, the on-demand querying packets are crucial to effective admission control. The loss of these packets may lead to inaccurate and unreliable admission decisions. The authors proposed an AC mechanism which operates like CACP model, named perceptive admission control (PAC). PAC uses passive monitoring to estimate the available capacity at the current node and its neighbors. It addresses the admission control problem by monitoring the wireless channel using channel busy time and dynamically adapting admission control decisions to enable high network utilization while preventing congestion. This mechanism has the advantage that it can be used with any QoS-aware strategy. Furthermore, in the case of mobility causing imminent congestion, the source nodes of affected sessions attempt to pause traffic transmission for a random back-off period.

However, this protocol does not consider intra-flow interferences when making admission decisions. Hanzo and Tafazolli proposed a staggered admission control protocol (stAC) based on passive monitoring of the admission control protocol. stAC ensures the performance requirements of a new session are maintained in a multihop ad hoc network, where mobile devices check their local resources through CITR mechanism [3,40]. stAC is partially related to DSR, using its basic routing functionality. stAC strategy can be implemented using service that starts transmitting traffic with a low rate and then gradually increasing it until it achieves the required flow rate of the session. stAC strategy re-routes the session when a path failure occurs due to congestion or mobility, and it reserves some capacity for unseen interference. Cheng et al. proposed a mesh admission control and QoS routing with interference awareness (MARIA) to investigate the QoS support of real-time media applications. MARIA uses the conflict graph theory to capture both inter- and intra-flow interferences. Nodes exchange their flow information periodically and compute their available residual bandwidth is computed based on the local maximal clique constraints. Admission decision is made based on the residual bandwidth at each node. However, the authors assumed a distance-based model with fixed channel capacity; this means that MARIA should integrate a measurement method which accommodates varying channel capacity and captures interference more accurately. Chauhan and Nandi proposed s QoS-aware stable path routing scheme, named QASR, which finds out routes that satisfy delay and bandwidth constraints based on signal stability is achieved with the help of both signal strength and link stability. The bandwidth reservation is activated for the flow only when the real data flow arrives at the registered nodes. Nodes are QASR periodically share location and flow state information with their neighbors.

Even QASR considers the mobility as a main parameter in the admission control policy, the scalability of the model, in terms of both traffic load and nodes mobility; was not studied. Furthermore, QASR depends on known location information to determine the distance between nodes in the network. The authors proposed an interference-based fair call AC protocol (IFCAC). In IFCAC, as opposed to previously discussed protocols, the channel is not considered busy just because the sensed interference power exceeds the carrier-sensing threshold (cs-thresh). Each node allocates an equal amount of channel capacity to each of the transmitters in its cs-range. For each case of the possible relative interference source positions, IFCAC determines the capacity to allocate to each transmitter within the cs-range in the most appropriate way. However, the drawback of IFCAC is that the sessions requiring more than their fair share will not be admitted, or will have to decrease their transmission rate when new sessions arrive. Cano et al. proposed an adaptive admission control (AAC) which is an AC model that deals with many issues regarding QoS provisioning in MANET. The AC procedure in AAC is coupled with QoS-AODV-style route discovery. AAC provides accurate low-cost signaling technique to retrieve CS nodes' available bandwidth and includes a contention count calculation algorithm which adapts to the path's roughness. AAC defines the usable bandwidth as the smallest available bandwidth on the sensing range of a node. HELLO messages used to spread the bandwidth information are transmitted to only one hop containing the sender's bandwidth information and its one hop neighbour.

Lindgren and Belding-Royer proposed a multipath admission control for mobile ad hoc networks (MACMAN) which offers multiple paths/routes for the same data flow and thus improves the QoS. The source node selects the best route on some specified criteria and transmits the flow. The basic functionality of MACMAN is similar to CACP and PAC. The local residual capacity at nodes is tested in a manner similar to the PAC model, while the intra-route contention is taken into account in a way similar to CACP. One merit of PAC is that at any time, the backup paths are known by the traffic sources. This is ensured by the fact that each backup path is regularly tested to have adequate end-to-end capacity for the accepted session. Nevertheless, this testing process may generate an additional overhead.

Conclusion:

The admission control decision in MANET's is typically based on some predefined criteria, which depends on the network traffic state and the characteristics of incoming sessions. The design of AC models poses several challenges as described in the 'Design challenges of AC models in MANET's section.

References:

1.Chakrabarti S, Mishra A: QoS issues in ad hoc wireless networks. IEEE Commun. Mag. 2001, 39(2):142-148. 10.1109/35.900643.

2. Gupta P, Kumar PR: The capacity of wireless networks. IEEE Trans. Inf. Theory 2000, 46(2):388-404. 10.1109/18.825799.

3. IEEE Computer Society: IEEE Standard 802.11-2007: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications. Piscataway: IEEE; 2007.

4. Lajos H, Rahim T: Admission control schemes for 802.11-based multi-hop mobile ad hoc networks: a survey. IEEE Communications Surveys & Tutorials 2009, 11(4):78-108.

5. Yang Y, Kravets R: Contention-aware admission control for ad hoc networks. IEEE Trans. Mob. Comput. 2005, 4: 363-377.

6. Xiang X, Wang X, Yang Y: Stateless multicasting in mobile ad hoc networks. IEEE Trans. Comput. 2010, 59(8):1076-1090.

7. Zhang B, Mouftah HT: QoS Routing for wireless ad hoc networks: problems, algorithms, and protocols. IEEE Commun. Mag. 2005, 43(10):110-115.

8. Valaee S, Li B: Distributed call admission control for ad hoc networks. In Proceedings of the IEEE Vehicular Technology Conference (VTC). Vancouver; 24–28 Sep 2002.

9. Hanzo L, Tafazolli R: A survey of QoS routing solutions for mobile ad hoc networks. IEEE Communications Surveys & Tutorials 2007, 9(2):50-70.

10. Saunders S: Antennas and Propagation for Wireless Communication Systems: Concept and Design. New York: Wiley; 1999.

11. IEEE 802.11 WG: IEEE Std 802.11e-2005 (Amendment to IEEE Std 802.11, 1999 Edition (Reaff 2003). Piscataway: IEEE; 2005.

12. Lin Y, Wong VWS: An admission control algorithm for multi-hop 802.11e based WLANs. Computer. Communication 2008, 31(14):3510-3520.

13. Gao D, Cai J, Ngan K: Admission control in IEEE 802.11e wireless LANs. IEEE Networks 2005, 19(4): 6-13. 10.1109/MNET.2005.1470677.

14. Dennis P, Tim M: Call admission control for IEEE 802.11 contention access mechanism. In Proceedings of the IEEE GlobeCom. San Francisco; 1–5 Dec 2003.

15. Wu CC, Bertsekas DP: Admission control for wireless networks. IEEE Trans. Veh. Technol. 2001, 50: 504-514. 10.1109/25.923062.

16. Oh SY, Marfia G, Gerla M: MANET QoS support without reservations. Journal of Security and Communication Networks 2011, 4(3):316-328. 10.1002/sec.183.

17. Khan A, Khattak K: AC and QAR for provisioning of QoS in MANETs. Master thesis. Blekinge Institute of Technology; 2010.

18. Park V, Corson S: Temporally Ordered Routing Algorithm v1 Functional Specification. Fremont: IETF Internet Draft; 1997.

19. Perkins CE, Belding-Royer EM: Quality of service for ad hoc on-demand distance vector routing. IETF Internet Draft: Fremont; 2003.