Guaranteeing Quality of Service in Mobile Ad Hoc Networks

Noureddine Kettaf
Haute Alsace University, France

Hafid Abouaissa
Haute Alsace University, France

Thang VuDuong
France Telecom R&D, France

INTRODUCTION

This article describes how resources are managed in MANETs (mobile ad hoc networks) so that quality of service (QoS) can be achieved to enable service differentiation. The article introduces in detail a QoS routing protocol called admission control enabled on-demand routing (ACOR) protocol. The article also presents the Global framework for functional architecture analysis in telecommunications (GAT) that is used to model ACOR and show its capability to provide different class of service for different mobile customers. For QoS routing protocols, this fashion of modeling is novel and investigates in details the relation between the customer and its provider and the complexity of the domain of MANETs.

DEFINING QoS

QoS is a network performance concept whose definition varies depending on the treatment given to the traffic belonging to a determined user's profile (Juliet Bates, 2006). For example, video applications require sufficient bandwidth and low packet loss. VoIP services need low latency, but can withstand a limited packet loss.

From a network perspective, QoS is characterized by a number of quantifiable attributes. The following are examples of the QoS commitments that a packet network can give:

- Within a call, the packet loss, end-to-end delay and latency are the main parameters. Such parameters can be explicitly specified in the service level agreement, giving rise to "hard" QoS commitments. Alternatively, "soft" QoS commitments may be given that imply priority of a user's traffic.

- The network maintains a model of resources management and decides, with respect to user's profiles, if it can admit traffic while achieving QoS. This is known as admission control.

For these mechanisms to achieve a quantifiable level of QoS, the profile of each user must be understood. In mobile networks, MANETs should know how to manage resources and meet the QoS commitments. The challenge in these networks consists in delivering the appropriate levels of QoS while ensuring that they can scale to all users and balancing this with the cost and risk of over-provisioning.

ADMISSION CONTROL ENABLED ON-DEMAND ROUTING PROTOCOL

Designing an efficient and reliable QoS routing protocol for MANETs is a challenging problem (X. Masip-Bruin, 2006; S.R. DAS, 2000). However, a simple routing mechanism is required to efficiently manage the limited resources while at the same time being adaptable to the changing network conditions.

ACOR (N. Kettaf H. A., 2006) was proposed to efficiently provide end-to-end support for QoS by introducing simple cost functions which represent QoS metrics. Inspired by the *colored* subgraphs formulation

presented in K.M. Konwar (2005), where each link of a MANET is divided potentially to sublinks represented by elementary cost functions for QoS metrics (i.e., bandwidth, delay, packet loss, etc.). For purposes of clarity, we only focus on bandwidth and delay. Firstly, the bandwidth at each node is represented by F_b, which is a ratio of the requested bandwidth B by an application to the supported bandwidth by a link B_{max} in addition to the residual bandwidth B_{res}. Secondly, the delay is represented by F_d which is also a ratio of supported delay D by an application to the accumulated hop-by-hop delays with the upper bound of delay D_{max}. The sum of the elementary cost functions (F_b and F_d) at each node is added to the global cost function F_g received in the route request packet during the route discovery to represent a route's end-to-end cost.

Bandwidth and Delay Estimation

To offer bandwidth guaranteed QoS, the residual bandwidth must be known (Carlos T. Calafate, 2005). In wired networks this is a trivial task (A.Ganz, 2003) because the underlying medium is a dedicated point-to-point link with fixed capability. In wireless networks, a node can successfully use the shared channel only when all its neighbors do not transmit or receive packets. A simple and efficient method to estimate residual bandwidth B_{res} by listening to the channel of the IEEE802.11 is used. This method is based on the ratio of free and busy times (N. Kettaf H. A., 2006).

Specifically, the DCF mode is based on the carrier sense multiple access with collision avoidance (CSMA/CA) algorithm combined with the network allocation vector (NAV) (W. Wang, 2006) to determine the busy/idle status of the medium. A mobile node must sense the medium before initiating the transmission of a packet. If the medium is sensed as being idle for a distributed interframe space (DIFS) period, the mobile node can transmit a packet. Otherwise, transmission is deferred, and a *backoff* procedure is started with a random value ranging from 0 up to the current CW size. Once the *backoff* expires, the node transmits the packet.

The MAC detects that its channel is free when the value of the NAV is less than the current time, "receive state" is idle, and "send state" is idle. On the other hand, the MAC claims that the channel is busy when the NAV sets a new value, "receive" and "send states" change from idle to any other state.

A node estimates its B_{res} as the channel bandwidth times the ratio of free time to overall time. B_{res} is cross layered to the network layer to compute F_b. The local elementary cost function F_b is given by:

$$F_b = \frac{B}{B_{max} - (B_{res} + B)} \qquad (1)$$

Where:
B: the requested bandwidth.
B_{max}: the maximum bandwidth supported by a link, for example,: 11Mb/s.
B_{res}: the residual bandwidth.

To admit bandwidth requirements B, the following inequality must be verified.

$$B_{res} + B \leq B_{max}$$

On the other hand, estimating end-to-end delay in MANETs is a crucial task due to the unsynchronized nature of the network. In ACOR, a "Hello" packet is used to estimate the delay to the next neighbor. When a node transmits a Hello packet, it starts a local timer d_{start}. Upon receiving the acknowledgement of the Hello, the node records again the receiving time, d_{ack}. However, to estimate an accurate delay, an error probability factor D_e is considered to represent the queuing delay at each relaying node, the packet transmission time and the propagation delay. Hence, the estimated delay at node i is $D_i = (d_{ack} - d_{start}) + D_e$. At each node, the elementary cost function is given by,

$$F_d = \frac{D}{D_{max} - (\sum_{i=1}^{j} D_i + D)} \qquad (2)$$

Where
D_i: the estimated delay to next hop.

D_{max}: the upper bound of delay supported by a flow.

$\sum_{i=1}^{j} D_i$: the accumulated delays from node i (e.g., source) to node j.

Also, to admit a delay D, the following inequality must be verified.

$$D_{max} \geq \sum_{i=1}^{j} D_i + D$$

Related Content

Tissue Image Classification Using Multi-Fractal Spectra
Ramakrishnan Mukundanand Anna Hemsley (2010). *International Journal of Multimedia Data Engineering and Management (pp. 62-75).*
www.irma-international.org/article/tissue-image-classification-using-multi/43748

Performance Analysis and Evaluation of IEEE 802.11E MAC in WLANs with Hidden Stations and Multimedia Applications
Mamun I. Abu-Tair (2009). *Handbook of Research on Mobile Multimedia, Second Edition (pp. 161-174).*
www.irma-international.org/chapter/performance-analysis-evaluation-ieee-802/21002

Understanding User-Curated Playlists on Spotify: A Machine Learning Approach
Martin Pichl, Eva Zangerleand Günther Specht (2017). *International Journal of Multimedia Data Engineering and Management (pp. 44-59).*
www.irma-international.org/article/understanding-user-curated-playlists-on-spotify/187139

Default Reasoning for Forensic Visual Surveillance based on Subjective Logic and Its Comparison with L-Fuzzy Set Based Approaches
Seunghan Hanand Walter Stechele (2011). *International Journal of Multimedia Data Engineering and Management (pp. 38-86).*
www.irma-international.org/article/default-reasoning-forensic-visual-surveillance/52774

Research Challenges in Multimedia WiMAX
Julio Aráuz (2009). *Handbook of Research on Mobile Multimedia, Second Edition (pp. 36-50).*
www.irma-international.org/chapter/research-challenges-multimedia-wimax/20993