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Development of QoS Signaling Protocols in the Internet

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***Abstract*— QoS signaling protocol is one of the key components in Internet QoS architectures to establish, maintain, and remove reservation states in network nodes. This paper gives an overview of the recent efforts underway on next steps in QoS signaling protocols, namely RSVP extensions with mobility support, QoS-conditionalized handoff protocol, the layered architecture RSVP Lite and the Cross-Application Signaling Protocol (CASP). These efforts address main issues with existing approaches differently : modularity, complexity and mobility support, with a focus on protocol behaviors based on different design principles. The paper also provides pointers to standards effort towards general Internet signaling and other service-specific signaling protocols.**

I. Introduction

QoS signaling protocol is necessary to establish, maintain, and remove reservation states in network nodes, and is essential for delivery an end-to-end ('e2e') QoS, especially for emerging IP-based networks with mobile wireless support. Note that QoS signaling is only part of a QoS architecture ; it needs interacting with traffic control, admission control, and QoS-aware applications.

As the probably best-known QoS signaling protocol, the Resource Reservation Protocol (RSVP) [1], [2] is based on the "soft-state" principles and has been also applied to some other scenarios besides IntServ QoS. However, current RSVP still lacks a modular framework to be extended for supporting a variety of signaling applications [3]. Moreover, RSVP's initial design of per-flow based reservation, optimal support for multicast, reliability mechanisms of signaling messages contribute to certain complexity and scalability issues to RSVP [4]. Another challenge with RSVP comes from its inability to support host mobility, for example, its flow identifier is subject to change in such scenarios and cause double reservation problem.

There are some other protocols designed after RSVP trying to be more light-weight. However, most of above issues have not been addressed in these protocols. The rest of this paper presents some recent work on this topic.

II. Design of Next QoS Signaling Protocol

Key design choices for next QoS signaling protocol can be identified as follows :

- In-path v.s. off-path : should the QoS signaling messages follow data path ?
- In-band v.s. out-of-band : should signaling messages be separated or piggybacked in normal data messages ?
- Reliable protocol v.s. unreliable protocol to transport signaling messages ?
- How long is needed to establish an e2e reservation, particularly in mobile environments ?
- Should it be based on a general signaling protocol ?

RSVP is essentially a two-pass, in-path and out-of-band protocol and performs receiver-initiated, simplex reservations. It uses raw IP or UDP with IP alert option to transport signaling messages.

We will further discuss these design choices for each developing protocol in subsequent sections.

A. RSVP Extensions with Mobility Support

To address mobility problems, RSVP extensions for mobile IP QoS signaling (RSVP-MIP for short) were presented (e.g., [5], [6]). They typically perform two-pass RSVP signaling after mobility management procedure and differ from upstream (mobile node(MN)→corresponding node(CN)) to downstream (MN←CN). Some optimization can be made based on local repair at a common router (CR) where the old and new paths converges, thus requiring 2×dist(MN, CN) + 2×dist(MN, CR) and 1×dist(MN, CN) + 2×dist(MN, CR), respectively, to complete MN→CN and MN←CN QoS signaling after a handoff.

B. QoS-Conditionalized Handoff

RSVP-MIP needs relatively long latency to establish e2e reservations. To minimize QoS interruption during handoffs, we presented a QoS-conditionalized handoff protocol (QCHP) [7]. Based on the "QoS option" piggybacked in the mobility messages and noticing that most handoffs are local, QCHP takes the advantage of micro-mobility. For both MN→CN and MN←CN reservations, typically QCHP signaling only needs 2×dist(MN,MAP), where MAP is the local common router). Recent experimental results [8] show that this faster QoS signaling approach added nearly negligible overhead to the underlying micro-mobility scheme. However, like any in-band signaling protocol, QCHP can cause more complicated error cases handling and add protocol complexity.

C. RSVP Lite−Layered Light-weight RSVP

Braden and Lindell [3] presented a two-level architecture, which consists of now so-called NSIS Transport Level Protocol (NTLP) layer, and an NSIS Service-Specific Level Protocol

(NSLP) layer. The NTLP provides common services for all NSLPs, while NSLPs provide specific services for particular signaling applications. Such an NTLP for general signaling, a QoS signaling NSLP and a firewall/NAT configuration NSLP are the goal of the undertaking efforts in the IETF Next Steps in Signaling (NSIS) working group [9].

Following this layered architecture, we present a layered light-weight RSVP (RSVP Lite) [10]. RSVP Lite NTLP reuses RSVP transport but removes multicast features (such as scope object, styles, blockade states) from RSVP which is unnecessary for majority of applications ; its NSLP layer handles all actual signaling tasks such as signal QoS and configure firewalls ; a clear interface between both layers allows common service interactions. Recent layered-RSVP proposal [11] added refresh reduction support [12] into RSVP signaling. However, in these approaches, the overhead to handle message reliability and large size signaling messages is still painful, due to usage of IP/UDP to transport RSVP messages.

D. CASP−Cross-Application Signaling Protocol

To overcome these problems, we presented the Cross-Application Signaling Protocol (CASP) [13] and its QoS NTLP − CASP QoS client protocol (CASP-QoS) [14]. Different from former proposals, CASP avoids overloading of messaging layer functionalities by separating next-hop discovery from the messaging layer and allowing reuse of existing reliable transport protocols (thus being also capable of off-path signaling due to new means of discovery) ; it further supports mobility by introducing a session identifier in addition to flow identifier, and efficient handling of mobility [15]. CASP can be used for both in-path and out-of-path signaling, allowing more flexibility. Essentially, CASP not only supports mobility, but also provides modularity and reduces complexity in message delivery by reusing existing transport protocols. Note if reliable transport protocols are used in CASP, it may introduce additional latency for an initial session setup between CASP neighbors ; by reusing the previous connections, however, the average latency for a session setup can be significantly reduced. Latest update of CASP NTLP is in [16].

The MN←CN and MN→CN CASP-QoS signaling latencies after detecting a mobility movement under CASP are 2×dist(MN,CN) + 1×dist(MN,CR) and 1×dist(MN,CN) + 2×dist(MN,CR), respectively.

III. Conclusion

Part of the appeal for next generation QoS signaling protocol would be mobility support, well-modularity and decreased complexity. RSVP-MIP, QCHP and CASP provide mobility support, while RSVP Lite and CASP add modularity for other signaling applications. CASP further reduces the complexity in handling of reliability and large size of signaling messages, and supports both on-path and off-path signaling. A comparison of these protocols is presented in Table I.

It is learnt that different design choices would have different solutions to the problem. By instead encompassing all this considerations in a single bundling protocol at one time, we struggled to develop, debug and exercise various approaches gradually. The work on QoS and general signaling protocol design would still need to be engineered with the Internet architecture principles in mind, nevertheless, at least these experiences have been and will continue to be used for further development. In addition, the prototype implementations and supporting software have been developed over the past few years. We plan to make the source code publically available as open source.

TABLE I
COMPARISON OF QOS SIGNALING PROTOCOLS

	inPath/ offPath	inBand/ outBand	Transport	Modu-larity	Mobility support
RSVP	iP	oB	IP/UDP	No	N/A
RSVP-MIP	iP	oB	IP/UDP	No	yes
QCHP	iP	iB	IP	No	yes,fast
RSVP Lite	oP	oB	IP/UDP	Yes	N/A
CASP	iP&oP	oB	TCP/SCTP/UDP	Yes	yes

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